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IGNITION DEVICES FOR PRESCRIBED BURNING

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This is one of a series of fact sheets authored by Dale Wade, a prescribed burn researcher and specialist in the South for over 45 years. They are designed to meld current technology with Dale's unequaled experience with fire and science. The fact sheet series is available within the "Prescribed Fire" section at www.southernfireexchange.org/SFE_Publications/Fact_Sheets.html. The Southern Fire Exchange thanks Dale for these contributions from his wit and wisdom, which, in Dale's words, "was sharpened by the many people he worked with over the years."

The prescribed burner has numerous tools at his/her disposal to start fire. Ground ignition devices continue to be developed and refined and include a wide range of options from kitchen matches to state-of-the-art hand-held 'ping-pong ball' launchers. This fact sheet describes many of these devices and includes a table to summarize advantages and disadvantages of various methods. More detailed information including suppliers and costs can be found in the *NWCG Standards for Ground Ignition Equipment* (2019) which is available online at https://www.nwcg.gov/sites/default/files/publications/pms443.pdf.

This fact sheet also provides a brief introduction to aerial ignition, but the use of these techniques involve considerable training; for more information, you can find complete details on the Missoula Equipment Development Center (MEDC) aerial ignition website at https://www.fs.fed.us/eng/aerial_ign/index.htm or you can visit the Encyclopedia of Southern Fire Science at http://fire.forestencyclopedia.net/p/p564 for an overview.

Figure 1: Hand-held drip torches are commonly used because they are economical, durable, and require little maintenance. Photo by David Godwin.

GROUND IGNITION DEVICES

Drip Torch

The ground ignition device of choice is typically a hand-held drip torch. It is rugged and durable, requiring little maintenance, and economical to use once the torch itself is purchased (see the *Interagency Ground Ignition Guide* for a partial list of suppliers). There are several designs, but all basically consist of a seamless extruded 1 to 1.25 gallon aluminum cylinder (about 6 inches in diameter and 15 inches high) with a handle, cover, lock ring and rubber gasket, a wand that dispenses the fuel, and a breather screw to adjust fuel flow. The wand has a full loop fuel trap which prevents flashback into the cylinder. The cover is comprised of a reversible top, flat on one side and the wand and sealing plug on the other. When stored, the wand is secured in a blind socket and extends into the cylinder to make the torch more compact (Figure 1).

To prepare the drip torch for use, unscrew the lock ring, remove the top and turn it over, unscrew both the sealing plug (which is on a short chain) and the wand, and interchange them so the fuel can flow through the wand; then replace the cover with the wand on the outside and tighten the lock ring. The wand ends in a removable tip consisting of metal mesh (think of a wad of coarse steel wool) in a cage.

To use, one tips the drip torch so that gravity will move the fuel through the wand and out the mesh tip. When the tip is saturated, the torch is held upright and a match or lighter used to light the fuel-soaked mesh. Once lit, the torch is tipped downward so fuel flows out the end and is ignited as it passes through the mesh. The flow is controlled by a small breather screw on the outside top of the torch. When closed no air can enter the cylinder and fuel flow is stopped; when wide open fuel flows through the mesh spout in a steady stream. If a steady stream pours out, the breather screw is opened too wide and the torch will be quickly emptied, necessitating many trips back to the staging area for refilling. The desired flow rate is usually a slow steady drip which maximizes the length of line that can be

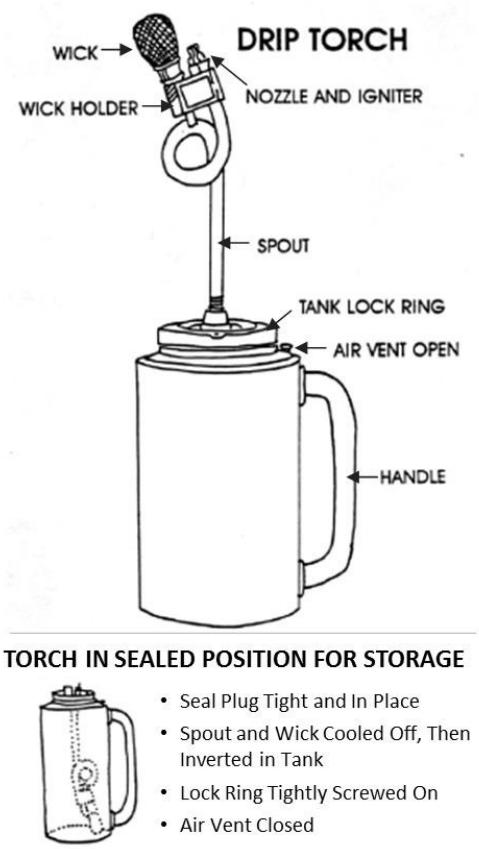

Figure 1. Schematic of a driptorch. Image modified from the Agriculture Document Library (ADLib), University of Hertfordshire.

ignited before refilling. When the air vent is correctly adjusted, a torch contains enough fuel to ignite about ¾ of a mile of line.

The torch person simply walks along dispensing a fairly steady stream of ignited fuel droplets which ignite the fine dead fuels on the forest floor. A continuous unbroken line of fire is not necessary, but wide gaps in the line are not wanted either; gently swinging the torch forward and backward as one walks will help prevent wide gaps in the ignited line. If the purpose is to space the spots at a specified interval, the torch is simply held upright while the person moves the desired distance and then tipped at that point, making sure that the surface fuels are actually ignited before moving on to the next point. Keep in mind that this burning fuel mix will attempt to ignite whatever it lands on, including your boot and pant leg.

A rubber gasket under the lock ring prevents leakage around the cover, but it deteriorates over time and will eventually begin to leak. This means the gasket should be replaced. In a pinch, a temporary replacement can be made from an old inner tube or even a piece of cardboard. Sooner or later some fuel will begin to leak out and ignite on the top of the torch. This does NOT pose a safety problem, and the torch is NOT in danger of exploding. If this small flame is bothersome, simply smother it with your gloved hand. You can also try tightening the lock ring, but if it was not loose, fuel will continue to seep out and reignite until the gasket is replaced.

When you have finished with the torch, place it upright. The flame will eventually go out, although many folks speed up this process by using a gloved hand to extinguish the flaming mesh. Some experienced personnel just take a deep breath and blow the flame out. If you choose to do this, make sure the torch is not near your mouth when you inhale or you will go to the hospital with seared lungs. Whatever you do, do not stick the wand into sand or mud to extinguish the torch; doing so will soon clog the mesh and the tip will need to be replaced.

When you set the torch down, do not set it in the burn unit or across the line in unburned fuel; set it instead in the plow line where it will be easy to find (just don't drive over it). It can be relit by using a match or by just sticking the tip into burning vegetation. When finished using the torch for the day, extinguish it, let it cool down, loosen the lock ring, remove the cover, interchange the wand and sealing plug, turn the cover over, replace it and tighten the lock ring. It is also a good idea to close the breather valve for storage. If you do not let the torch cool down adequately before getting it ready for storage, the hot wand will hiss when it is stuck back into the cylinder and makes contact with any fuel remaining in the torch, but I have never seen one reignite.

The fuel is typically a mixture of gasoline and diesel. Use No. 1 diesel rather than off-road diesel because the high sulfur content in off-road diesel will not give satisfactory results. I personally take an empty 5-gallon fuel container, dedicate it to torch mix by painting it orange; write "torch mix" in big letters on the outside, add 3 gallons of diesel and top it off with regular gasoline. Some people use up to a 50:50 mix (called a "hot" mix), but I don't for the following two reasons:

1) Gasoline has a lower flash point and faster combustion rate than diesel, so the burning globs of dispensed fuel burn up faster, sometimes before igniting the vegetation. In particular, this occurs when the dead grass/litter is slightly damp, with moisture content above approximately 14 to 16%.
2) On very hot days, a 50:50 mix will tend to change from a liquid to a gaseous state in the wand, making ignition virtually impossible. This is not dangerous, but it often makes a load popping noise which can startle nearby personnel. To avoid evaporation problems, use less gasoline in the mix or substitute kerosene or stove oil for gasoline (both have a lower flash-point). However, these fuels are not as readily available as gasoline and will require a mix closer to 50:50.

When filling the torch, leave an inch or two of air space so the torch can breathe. If you use gas containing ethanol, it is a good idea to drain the torch before storing it at the end of the season.

If experienced burners anticipate repeatedly igniting long distances along plowed lines, they often use a longer wand which allows the torch person to walk the plow line rather

The standard drip torch is the tool of choice in many ground-ignition situations, but other devices, ranging from expensive pistols to rolls of toilet paper, can be used where water, steep slopes, and safety issues limit access.

than the berm, but this puts more strain on your arm. Various ATV-mounted systems are also available, which allow one to keep both hands on the handlebars. Because these systems are expensive, some folks go to a local fabrication shop and have one made (see the *Interagency Ground Ignition Guide* for specifications).

Pine Branch and Rake

Simply break the top or branch off a small pine; ignite it and walk, spreading fire as you proceed. Live southern pine tops will easily ignite, but they also burn quickly so one has to continue to make new ones. When on a fire, I always have a suppression tool in my hand; whether a shovel or a leaf, garden, or McLeod rake, it can be used to move burning grass and litter into unburned fuel. In a pinch, either method can come in handy to spread (or extinguish) fire, but make sure the business end of your suppression tool is metal, not plastic.

Toilet Paper

When igniting from a boat, experienced burners often construct a cage to hold a roll of toilet paper, attach it to the end of a long, light pole (often bamboo, the end of which has been treated to make it fire resistant) to get it away from the boat and extend past the boat wake. Soak the roll in diesel fuel and ignite it when you are ready to start firing the unit. Carry a few extra rolls and fuel in the boat. I use about 85% diesel and 15% gas. Although harder to ignite, it lasts a lot longer than the typical gas/diesel mix. When finished igniting, simply dip the end in the water to extinguish the flame, but make sure you are really finished as it will not reignite.

Fusees

These are much like railroad flares, about 1 inch in diameter and 15 inches long, and a dull red color. They break apart at the joint and one end is ignited by striking it against the safety cap on the other piece. Sometimes the end has a tin ferrule that can be attached to a branch for greater reach, and some are adapted so the next flare can be attached to the first. The person using the fusee has to bend over so the roughly 4 to 5 inch chemical flame is in contact with the fuel. Fusees are inexpensive, lightweight, and can be easily stowed in a backpack just in case they are needed at some point on the burn. They have a wax coating which makes them water-resistant and once ignited, will last about 10 minutes. They will burn under water, but to my knowledge, cannot be extinguished and relit.

Although more expensive than a drip torch, they are often the ignition device selected in rough topography where a continuous line of fire is wanted because one does not have to traverse steep terrain or deep gullies to refill a torch. When a continuous line is not desired, gelled gas blivets are more economical (see Gelled Gasoline section below). If you have fairly long lines to ignite, your back will soon tell you to buy fusees that can be attached to a branch or another fusee.

Pen Flare/Very Pistol

The Very pistol looks like a snub-nosed revolver and shoots incendiary projectiles. The pen flare is a smaller hand-held device which also shoots incendiary projectiles. The range of each is several hundred feet, which can be useful in putting fire in locations where human access is difficult. Information on suppliers and use can be found in the *Interagency Ground Ignition Guide.* They are relatively accurate, but care must be exercised because near a corner of the burn unit, you might fire a projectile into an adjacent area. They can also ricochet off tree boles and bounce back across control lines. They are lightweight and easily carried, but the ammunition is fairly expensive.

Terra Torch

This commercially-manufactured flame thrower can shoot a steady stream of flaming gel up to 150 feet. The mix tank has to be mounted on a vehicle. The brand that I am familiar with is capable of operating with 150 feet of hose. The most efficient operation is with a thick gel mix. However, a thick mix can present problems if the burn unit is in steep terrain, because consistency and thus flow is very dependent on ambient temperature.

This device is well suited for low areas, such as pocosins along the Atlantic and Gulf Coastal Plains, and in other low-lying vegetation types where management units are typically bounded by ditches between the unit and the road.

Fusees (shown in left photo) and flare launchers (shown in right photo) are lightweight and can be useful ignition devices when fuel or topography pose safety issues. Photos: National Wildfire Coordinating Group.

These ditches are often full of water which means torch people have to wade or swim across holding the torch and matches above the water; a welcome experience during the summer, but no fun in the winter when temperatures can drop to freezing.

Gelled Gasoline

Over the years, fire managers worldwide have developed numerous devices that can be thrown or launched into a burn unit. Gelled gasoline is an inexpensive, safe, labor-saving, efficient ignition device where a continuous line of fire is not desired. One simply adds a pound of M-4 fuel thickener to 5 gallons of gasoline in a wide-mouth bucket, such as an empty drywall mud container, and then puts 2 tablespoons of the resulting gelled gas in a 1-pint freezer bag. Seal the bag and tie a length of type A igniter cord around the outside of the bag. Put the filled bags (called blivets) in a carrying sack, grab your lighter or matchbook, and head off down the line. The bags are safe and if one breaks, it is no big deal as the material is a gel rather than a liquid.

According to Melton & Marsallis (1982), ignition fuel consumption is cut in half, fewer people are required, and ignition personnel don't wear themselves out using a driptorch. The bags can be tossed 20 to 30 yards after lighting the igniter cord, thereby keeping ignition personnel from having to walk into dangerous fuel or topographic locations. Five gallons will make about 85 blivets, which should be more than enough for a 50 acre burn. The fires take longer to develop because they are point-source rather than a continuous line, but more than 80% of the area will burn with head and flanking fire (see also McKee & Ramberg, 1981). A commercial equivalent is available, which according to MEDC is safer, but one can add the fuel thickener at the gas depot and transport the gelled gas, which in my opinion is very safe. Using the commercial product eliminates mixing the ingredients, but increases costs and one still has to wrap the blivets with igniter cord.

DAID's (Delayed Aerial Ignition Devices)

The DAID (Delayed Aerial Ignition Device) system was developed for aerial ignition, but has been modified for ground use. The cheapest, readily available DAID's are about the size and shape of a ping-pong ball. They are constructed of high-impact polystyrene and contain several grams of potassium permanganate powder. When a sphere is injected with about 1 milliliter of common automotive coolant (ethylene glycol), a thermal reaction begins which results in flaming combustion 20 to 40 seconds later, depending on ambient temperature, size of the potassium permanganate granules, and purity of the coolant.

Some burners carry a few DAID's, a hypodermic needle, a vial of coolant, and a slingshot with them so they can ignite fuels in areas deemed unsafe or difficult for humans to traverse. The balls can be predrilled and the holes covered with scotch tape, which prevents any problems with piercing thick-skinned balls and bending the hypodermic needle. Make sure you are standing on a control line in case you inadvertently drop a charged ball. Two safer, although more expensive options, are a handheld and an automated DAID ground launcher. The automated launcher can be mounted on a vehicle such as an ATV or boat. Both azimuth (horizontal angle) and elevation are adjustable allowing the operator to shoot a maximum of 40 balls a minute up to about 225 feet in a 180 degree radius.

There are two hand-held versions (called Pyroshots). One is a single shot spring loaded option with a limited distance (about 75 feet), while the other (which resembles the old Thompson machine gun) will shoot balls up to about 300 feet. They are both simple to operate. If contemplating purchase of a launcher, the quicker ignition and thus reduced time to burn the unit will partially offset equipment costs. Burn crew members also like this equipment because it is both labor-saving (think ditches, canals, creeks, fences) and allows them to avoid entering potentially unsafe areas. Because burn crew members won't have to traverse relatively steep terrain or gullies and water-filled ditches, they will also have more energy left if a slop-over requires their attention.

AERIAL IGNITION DEVICES

Aerial ignition is complicated and too expensive for many private landowners, but new design innovations make it a safer and more economical option on large acreages or where multiple smaller units can be scheduled for treatment on a given day. Aerial ignition systems come in two designs: the DAID or ping-pong ball system and the helitorch or flying driptorch system.

DAID or Ping-Pong Ball System

The ping-pong ball dispensing machine is easily mounted in both fixed- and rotary-wing aircraft. When using an older machine, I always recommended using a leather strap to secure it and having a sharp hunting knife within reach so in an emergency the strap can be quickly cut and the machine jettisoned. Although current models all come with a more reliable self-extinguishing capability, it never hurts to have a plan B. The balls are dropped at a set interval, and although adjustable by varying aircraft flight speed or the machine dispersal interval (older machines were prone to jamming during adjustments on the fly), it is a pain when

Hand-held DAID launchers allow prescribed burners to quickly ignite fire without entering potentially unsafe areas. Photo by David Godwin.

Aerial ignition systems can be used for large burn units or multiple small units, and generally allow for more rapid smoke dispersion than with ground-based devices. Photo by Georgia Department of Natural Resources.

there are many random bare spots in the unit. Newer machines minimize this problem.

A company called Dragon Fire Ignition Products has decreased the size of the DAIDS (called Dragon Eggs) and made several design changes in the dispensing machine resulting in a safer, more efficient system. For more information, type "forestry dragon eggs" into your search engine or go to the MEDC aerial ignition web site. The decreased DAID size means larger hopper capacity, which translates into decreased time to complete ignition and thus lower cost.

A handheld device allows the operator to select various dispensing speeds so the pilot no longer has to change aircraft speed, which makes it easy to match dispersal speed to changes in terrain and horizontal fuel continuity. The dispenser also features a quick purge system that improves safety in the aircraft. A microprocessor controlled motor and feed gates detect jams and automatically initiate clearing, thereby eliminating machine-stopping jams. A new safety system uses a backup battery to provide continuous onboard fire protection. Spheres are now injected with the same amount of antifreeze irrespective of dispensing speed. Another welcomed improvement is that the smaller dragon eggs have less freefall drag and thus fall 20% faster, resulting in better canopy penetration under higher wind speeds. The new machines are lightweight, which facilitates handling, and smaller, which means more room inside the aircraft.

A 2nd person is required onboard to operate the dispenser and should have clear voice communication with the pilot to start and stop ball dispersal at the beginning and end of each line and to observe fire behavior so dispersal rate can be adjusted as needed. When properly spaced, spots within an ignition line reach the next downwind line before the flanks of the most recent ignitions coalesce. Rapid ignition of a block reduces both ignition time and the time needed to complete the burn.

Although the minimum recommended spacing of spots along a line is 150 feet, experienced burners sometimes start firing early in the day, before the fuel is dry enough to carry fire well. They may initially reduce the distance between spots to as close as 50 feet within a line and 50 feet between lines, keeping the grid square. The increased number of ignitions creates more heat and helps dry the surface fuels. The distance between spots must be expanded as the morning progresses and burning conditions improve. Otherwise, the spots will merge laterally forming lines of heading fire that can get too intense before reaching the next downwind line of ignition points. The distance between lines can and should also be adjusted as necessary.

Helitorch

The helitorch is simply a giant driptorch attached to a drum of gelled gasoline mounted or slung beneath a helicopter. The helitorch emits a steady stream of burning fuel globs and is thus the machine of choice in discontinuous fuels, such as clearcuts. It is very difficult to effectively regulate the spacing between these fuel globs when using older equipment. Any helitorch not modified to effectively control the timing between the globs of burning fuel should be considered a line-firing device. When used to ignite fuels beneath an overstory, some of the flaming gel gets hung up in the canopy, so one ends up with a line of randomly spaced spots which can result in pockets of fire behavior that exceed the fireline intensity called for in the prescription. Extra personnel are also needed at the heliport to mix the gasoline and thickener.

Both types of aerial ignition dramatically reduce the time needed for an area to burn out. Although roughly the same amount of smoke is produced, it is emitted over a shorter period and more of it is entrained in the convection column. This typically reduces adverse air quality impacts.

SUMMARY

Each of the ground-based and aerial devices or systems has been useful for prescribed fire ignition (Table 1), some much more commonly than others. Decisions on which to use depend on availability, burn unit size and topography, people and mechanical resources, and of course, cost.

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TABLE 1. FACTORS ASSOCIATED WITH VARIOUS GROUND-BASED IGNITION DEVICES.

METHOD	WHEN TO USE	ADVANTAGES	DISADVANTAGES
Drip Torch	Any time personnel have access to unit interior. Method of choice where prescription allows or dictates changes in firing technique.	Simple, rugged and inexpensive. Will produce spots or lines of fire. Easy to adjust pattern. Allows exact placement of fire; igniter can ride ATV.	Fairly slow. If not enough ignition personnel, potential fatigue on large units. Multiple refills necessary on large units. Personnel inside unit so potential safety issues.
Terra Torch	When patchy fuels present. When unit surrounded by water-filled ditches. Can ignite inaccessible areas within ~150 feet of line or when topographic or fuel conditions pose safety issues.	Fast. Gives depth to initial flame front. Can use with higher fuel moisture (18 to 22% in southern pine; 15 to 18% in hardwoods).	Expensive. Requires truck or dozer, so need to be able to drive control lines. Uses lots of fuel.
Fusees	To ignite scattered patches of unburned fuel. When inaccessible area is within ~30 to 40 feet of personnel or when fuel or topographic conditions pose safety issues.	Inexpensive; light and easy to stow in a backpack. Can be tossed 30 to 40 feet.	Interior access required unless tossed which becomes expensive. Very slow. If a holder is not used, personnel have to continuously bend over so fusee flame makes contact with vegetation.
Pen Flare, Very Pistol, Flare Gun, Etc.	When unit surrounded by water or otherwise inaccessible or when fuel or topographic conditions pose safety issues.	Lightweight and easy to carry.	Requires coordination and accurate firing. Potential for 'bounceback' if projectile hits a tree. Ammunition much more expensive than 'ping-pong' balls.
Gelled Gasoline	Anytime, especially when fuel or topographic conditions pose safety issues.	Inexpensive; safe; less strenuous than using a driptorch.	Interior access not necessarily required.
'Ping-Pong Balls'	When unit surrounded by water, or when topographic or fuel conditions pose safety issues.	Interior access may not be required as commercial launchers can shoot balls several hundred feet. Can utilize smaller prescription window. More of the smoke entrained in convection column reducing air quality issues. Balls are inexpensive and can be launched using a sling-shot. Many small areas can be burned in a day.	Each ball has to be injected with antifreeze which starts a delayed thermal reaction. Once started the reaction culminates in flaming combustion, which can be a potential safety issue if balls and antifreeze are near each other. Potential for 'bounce back' if a ball hits a tree.

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