THE CHAINSAW:

The chainsaw is a portable, mechanical, motorized saw used for cutting a variety of materials, particularly wood. Chainsaws are mainly used in the logging industry to fell, limb, and buck trees. Not long ago they were adopted into the fire service to assist in cutting firebreaks and fell snags for wildland fire suppression; and to assist in vertical ventilation and forcible entry in structural firefighting. Special chainsaws are also designed to cut concrete, brick and natural stone.

HISTORY:

The first chainsaw was believed to be developed by German Orthopedist Bernard Heine in the 1830’s. This instrument had links of a chain carrying small cutting teeth with edges set at an angle; the chain was moved around a guide blade by turning the handle of a sprocket wheel. The saw was called the Osteotome and was used to cut bone.

Andreas Stihl, Emil Ler, and Joseph Cox helped to develop the modern chainsaw. In 1927, Emil Ler developed the first gasoline-powered chainsaw. Stihl was the first to patent a gasoline-powered chainsaw in 1929 and founded a company to mass-produce them. Today, Stihl is the number one selling brand chainsaw worldwide.

The early models were heavy, two-person devices with long bars. Often chainsaws were so heavy that they had wheels. After World War II, improvements in engine design lightened chainsaws to the point where one person could carry them. Chainsaws now come in many sizes, from small electric saws intended for home and garden use, to large "lumberjack" saws.

HOW IT WORKS:

The Chainsaw can be broken down into three main components; the engine, the drive mechanism, and the cutting system. The saw explained here is the Stihl MS 310. However, this saw is very similar to those used in the fire service, and many components and concepts are the same.
The Engine

The Stihl MS 310 uses a two-stroke gasoline internal combustion engine. Most, if not all portable saws are two-stroke. There are two main advantages behind using a two-stroke motor. The first advantage is the power to weight ratio. Chainsaws with two-stroke motors are very light weight; about 15-20 lbs. Two-stroke engines do not have valves, which simplifies their construction and lowers their weight. Also, a two-stroke engine fires once every revolution, while four-stroke engines fire once every other revolution. This gives two-stroke engines a significant power boost. A typical chainsaw has about 4-6 horsepower. Secondly, since the fuel and oil are premixed (50:1), the saw will constantly be lubricated no matter what angle it is held. The oil follows the same path as the fuel, so it will still run even when operated upside down. These advantages make two-stroke engines lighter, simpler and less expensive to manufacture. The disadvantages to using a two-stroke motor are emissions and lifespan. Since, fuel enters the cylinder while the exhaust outlet is open, some unburned fuel does escape unburned. The additional combustion of oil in the fuel adds to the pollution. Two-stroke engines also wear a lot faster due to the lack of a dedicated lubrication system.

Fig. 1
Fig. 2
Fig. 3

This is how a two-stroke engine works in its simplest form. The two-stroke cycle begins with the fuel mixture entering the crank case though the reed valve. The fuel mixture contains oil, so the crank shaft is lubricated in the case. Once the fuel inlet is uncovered by the piston, the fuel enters the cylinder (Fig. 1). The piston compresses the fuel to the top of the cylinder, covering both the exhaust and intake, and at “top dead center” the spark plug ignites the fuel mixture (Fig. 2). The detonation sends the piston down, uncovering the exhaust outlet (Fig. 3). Exhaust gases are then allowed to escape and the cycle starts over again. The downward movement caused by the fuel igniting, transfers through the piston and creates the rotation force for the drive mechanism.
The Drive Mechanism

The chainsaw’s operating principle is by centrifugal clutch and sprocket. A centrifugal clutch takes the rotational forces of the motor and transfers them to rotate the sprocket and in turn rotate the chain. The chainsaw clutch consists of three “drums” or “shoes” held together by springs (Fig.4). At idle speeds (2800 rpm) the shoes are held together by spring tension. Once the user throttles the saw, the centrifugal force overcomes the springs and the shoes move out. At a certain speed (approximately 3000 rpm) the clutch shoes engage with the inside of the sprocket and the sprocket begins to turn. The sprocket then turns the chain.

The Cutting System

The cutting system is composed of the guide bar and the cutting chain. Guide bar lengths may vary depending on the application. In the logging industry bars can reach up to 50” or more. Most fire service guide bars are between 16”-24”. For wildland firefighting, a longer 24” bar would be useful, whereas, in structural firefighting ventilation a 20” bar is often the choice. The guide bar consists of an alloy steel bar with an edge slot to guide the chain. Most bars have a replaceable nose sprocket as wear can often occur. A good tip is to rotate and file your guide bar tip when cleaning your saw. This will help prevent large wear burs. At the other end of the bar is the mounting slot, the oilier hole, and alignment holes.
There are various types of chains used, again depending upon the users application. For cutting wood there are three basic styles; standard chipper, carbide, and bullet. The chipper is a basic chain used for cutting thin layers of wood and small trees. The carbide chains come as either carbide tipped or carbide tooth (Fig. 7). Carbide is often the choice of most fire departments. Last is the bullet chain (Fig. 8). The bullet chain works by first filing the wood with the bullet end prior to the cutting edge cutting. This saves on the life of the chain, but often cuts slower. There are also specific chains used to cut through concrete, rock, and natural stone. Most chains, however, are comprised of the same components.

Usually, each segment in the chain features a small sharp blade, called a "tooth." "Skip tooth" chains have a tooth on only every second link, and is used for reduced risk of the chain clogging when cutting very soft wood. For a commonly used 20" guide bar, there are 36 teeth and 72 total links. In most chainsaws the teeth are not straight blades; they have a forward section that first chips the wood, then another section, at a right angle to the first, cuts the wood. There are left and right-handed teeth, alternating in the chain.

Chains come in varying pitches and gauges; the pitch of a chain is defined as half of the length spanned by any three consecutive rivets (ex: 3/8"), while the gauge is the thickness of drive link where it fits into the guide bar (ex: .050"). On the underside of each link is a small metal finger that centers the tooth between the edge slot of the guide bar. The finger also helps to carry lubricating oil around the bar, and engages with the engine's drive sprocket inside the body of the saw (Fig. 11).
COMPONENTS:

1) Carburetor Twist Lock  
2) Carburetor Adjusting Screws  
3) Spark Plug Boot  
4) Chain Sprocket Cover  
5) Chain Sprocket  
6) Chain Brake  
7) Chain Tensioner  
8) Chain Catch  
9) Bumper Spike  
10) Guide Bar  
11) Saw Chain  
12) Oil Filler Cap  
13) Muffler  
14) Front Hand Guard and Chain Brake  
15) Front Handlebar  
16) Decompression Valve  
17) Starter Grip  
18) Master Control Lever  
19) Fuel Filler Cap  
20) Throttle Trigger  
21) Throttle Trigger Interlock  
22) Rear Handle  
23) Rear Handle Guard

MAINTENANCE:

A well maintained saw is a safe saw. Chainsaws should be cleaned and service after each use. For fire service saws, it is recommended that they are inspected at least weekly and run for at least 60 seconds.

Chainsaws require two sources of lubrication. Like most two-stroke engines, the engine is lubricated by its fuel and oil mixture. Separate chain or bar oil is used for the external lubrication of the bar and chain. The chain oil is depleted quickly because it tends to be thrown off the chain by centrifugal force. The chain oil reservoir is usually topped up at the same time as refuelling. The chain oil reservoir is large enough so that the saw runs out of fuel and stops before the chain oil runs dry. Specifically formulated chain or bar oil should be used only, as its viscosity is very important. A 30 weight motor oil may be used as a substitute only in emergency situations, but is not recommended.

On occasion, the air intake filter will clog up with sawdust. This must be cleaned from time to time. Most foam filters can be cleaned with mild soap and water. Paper filters should be cleaned with compressed air from the inside out, as not to imbed any contaminants. A light mist of machine oil is helpful after each cleaning.
Chains must be kept sharp to perform well. They become blunt rapidly if they touch soil, metal or stones. When blunt, they tend to produce powdery sawdust, rather than the longer, clean shavings. A sharp saw also needs very little force from the operator to push it into the cut. Chains should be replaced if 3 consecutive teeth are broken, or 6 teeth total. Chains should also be kept at the proper tension at all times. A good way to check chain tension is with a penny. Set the chain brake and pull up on the chain. A penny should be able to fit between the guide bar and the drive tooth (Fig. 14).

**Chainsaw Safety:**

The best way to be safe with a chainsaw is to KNOW YOUR SAW! Read your owner’s manual for specific information, prior to operating your chainsaw. There are many factors that can cause injuries while using a chainsaw. In addition to not knowing how your saw works, fatigue and in adequate protective equipment often play a large role in chainsaw mishaps. If you feel fatigued due to a long operation, switch operators. When using the chainsaw the minimum personal protective equipment (PPE) should be; snug fitting heavy duty pants, long sleeved shirt, leather gloves, eye protection, and steel toed shoes. When using the saw for structural firefighting, PPE should also include full turnouts, SCBA, and a helmet. Face shields are often not adequate eye protection. The user should don their SCBA face mask even if there is no need to breath air. Hearing protection is recommended but is an individual choice.

Footing is one of the most important safety factors when operating a saw. Make sure your footing is stable. If using the saw for ventilation operations, wet roofs or steep pitches may require the user to use a roof ladder. Remember that the roof ladder is for footing only and provides no structural support. Make sure the area around you is clear from bystanders and crew members. When cutting, never cut towards your body or your partner. Know where your saw is at all times. The chain speed on the Stihl MS 310 is 12,500 rpm, which equates to about 70 feet per second. Pay attention as the saw could cause considerable damage to you, your partner, or anything else in the way.

When carrying the chainsaw, the saw should be turned off (if not immediately intended to be used), with the chain brake engaged, and the chain pointing to the back. Grip the front handle bar in a balanced manor and keep the hot muffler away from your body (Fig. 15).
There may be some instances where you will need to pass the chainsaw to your partner. A good method to pass tools is first for the sawyer to make sure that the chain brake is engaged. The sawyer then passes the saw back with one hand and receives the new tool with the other. It is important for the team members to communicate when they receive the tool. Often times tools will go up on the fire or hole side and down on the opposite side.

Fig. 16

Fig. 17

STARTING PROCEEDURES:

There are three main ways of starting a chainsaw; the ground method (Fig. 18), the leg method (Fig. 19), and the drop start method (Fig. 20). The drop start method is a controversial issue. Stihl does not recommend drop starting the chainsaw. It is dangerous for the user and creates undue stress on the saw. Many fire departments also do not approve of the drop start method. However, the drop start method is useful in some instances where it is impossible to place the saw on the ground or roof, or unstable to start it between your legs. It is important to know your department’s standard operating procedures on starting up the chainsaw.

Fig. 18

Fig. 19

Fig. 20
Always use the proper PPE as discussed before starting the saw.

Step 1 - Inspect the chainsaw, checking the chain tension and teeth, and making sure the fuel/oil mixture and the bar oil are topped off.

Step 2 - “Shake and Brake”. Shake the saw as the fuel/oil mixture may have separated. Engage the chain brake.

Step 3 - Hold down the throttle trigger interlock and the throttle trigger with your right hand and place the master control lever in the cold start or full choke position. This position closes the butterfly valve on the carburetor, which assists in starting the saw by providing a rich air to fuel mixture. If the saw has recently been used and is still warm, skip this step and proceed to step 6.

Step 4 - Depress the decompression valve button if equipped.

Step 5 - Pull starter cord 2-3 times until a “cough” is heard.

Step 6 - Move master control switch to the warm start or half choke position. This opens the butterfly valve on the carburetor.

Step 7 - Pull the starter cord until saw starts.

Step 8 - Immediately tap the throttle interlock and throttle to release master control lever to run.

NOTE: If throttle is not taped immediately, the saw will try to run against the chain brake and may cause damage to the clutch and sprocket.

Step 9 - Release chain brake to cut.

Step 10 - Always cut at full throttle.

Step 11 - Allow chain to slow and engage the chain brake.

Step 12 - Move the master control lever to the off position.
CUTTING WITH THE CHAINSAW:

Depth, angle, and speed are very important when using the chain saw for ventilation operations. If the chainsaw is too deep in the roof there is a chance of hitting equipment in the attic, such as electrical lines, conduit, ducting, and even sprinkler lines. If the chainsaw is not deep enough, the cut may not go completely through the roofing material making the cut ineffective. A good rule of thumb is to cut as deep as the sprocket; about 5 inches (Fig. 22). This, of course, depends on the thickness of the roofing material.

![Fig. 22](image)

When using the saw for ventilation, the saw guide bar should be held as close to perpendicular as possible. In order to feel structural members a minimum of 3 teeth must touch. If the saw is held at less than a perpendicular angle the chain will cut through most of the structural member before the user is able to feel it (Fig. 22). If the saw is held perpendicular, 3 teeth strike it at the same time, making it more likely to feel the roof member (Fig. 23). Lastly, if the speed is too slow, the user will not feel the sudden stop caused by the support members and may continue, possibly cutting through it.

![Fig. 22](image) ![Fig. 23](image)
### CHAINSAW BRAND SPECIFICATIONS:

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<th>MODEL</th>
<th>DISPLACEMENT (cc)</th>
<th>HORSEPOWER (bhp)</th>
<th>WEIGHT (lbs.)</th>
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THE ROTARY SAW:

The rotary saw is an excellent multipurpose power tool that is versatile and effective in a variety of applications. Depending upon what type of blade and how the saw is configured, the user can cut anything from wood to metal to concrete. This allows the saw to be used for ventilation, forcible entry, and a variety of other rescue situations.

The design of a rotary saw is very similar to that of the chainsaw. The rotary saw is often powered by a two-stroke motor ranging from 90-100 cc with 5-8 horsepower. The drive principle is also similar with a centrifugal clutch and sprocket setup. However, instead to the sprocket driving the cutting chain, it drives a belt. This belt is attached to the saw blade via an additional sprocket. Rotary saws are different than circular saws due to the rotation of the cutting blade. Often times these terms are incorrectly transposed. With a circular saw, the blade cuts from the bottom up and the user pushes the saw away. With a rotary saw, the blade cuts from the top down and the user pulls the saw.

Rotary saw blades are divided into 3 different categories. The first category is Abrasives (Fig. 24). Abrasive blades are made to cut either metal or masonry. However, they are not interchangeable. Abrasive masonry blades should be kept wet when cutting. This will increase the blade life and keep down the dust. Abrasive blades will deteriorate as used, so the cut depth of the blade will decrease. The second category is Carbide blades (Fig. 25). Carbide rotary blades, like chainsaw blades, are used to cut wood and soft plastics. Diamond blades are the last category (Fig. 26). Diamond blades are used to cut concrete and can either be used wet or dry. Often, best results are achieved when diamond blades are used wet. The water helps to lubricate the blade and resist warping. Keep in mind, carbide and diamond blades are directional. Always read the label prior to installing a new blade.

Many of these rescue blades come in various sizes. The most popular sizes used today are 12”, 14”, and 16”. Depending upon the type of blade, they have various cutting depths. For fresh blades, a 12” blade cuts about 4” deep; a 14” blade cuts about 5” deep; and a 16” blade cuts about 6” deep. Blades should be replaced if more than 30% of the blade is used. A 14” blade should be replaced if the diameter is less than 10”.  

Fig. 24  Fig. 25  Fig. 26
Not only does the user have the option between different types of blades, he can also choose the position of the blade in relation to the saw. Most rotary saws will allow the blade to be mounted in the inboard (Fig. 27) or outboard (Fig. 28) position. Positioning is easily accomplished by rotating the bar that holds the blade. The blade position has its advantages depending upon the user’s application. Often, switching the blade position is time consuming and should be done prior to having to use it. If the saw is used for ventilation operations, mount the blade in the inboard position, as this will minimize the gyroscopic effect by centering the blade with the saw. If the saw will be used for forcible entry operations, the blade should be mounted in an outboard position. This may maximize the gyroscopic effect, but it will allow the blade to be inserted into areas with minimal space.

The safety considerations with a rotary saw are the saw as with the chainsaw. The user should still utilize all standard PPE as discussed earlier. However, unlike the chainsaw, the user must always start the saw using the ground start technique. Since most rotary saws do not have brakes, the blade can spin upon start up and continue to spin after the throttle is released, as well as after shut off. This makes drop starting or leg starting very dangerous.

**ROTARY SAW BRAND SPECIFICATIONS:**

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<th>MODEL</th>
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