

Chain Shot Resource Package



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BC Forest Safety Council

The BC Forest Safety Council has compiled the latest information on chain shot in this resource package. The following information contains 2 recent safety alerts on chain shot and links to additional resources on the topic.

What is the Chain Shot phenomenon?

When a saw chain breaks, it can scatter linkages into the surrounding area at high speeds. Most commonly the chain shot moves along the plane of the saw, which can cause a hazard to the operator if the saw is aligned with the cab or the body if using a chainsaw.

Chain shot whistling through the air has as much kinetic energy as a bullet fired from a rifle!

Chain shot can happen on processing equipment or a manual saw. A chain breaks for a number of reasons including:

- Improper tension – chain too loose
- Improper chain maintenance or repair (hammered rivets)
- Damaged sprocket, bar and/or chain
- Improper bar and chain lubrication
- Defective chain
- Excessive chain speed – new chainsaws can drive chains faster than their design and harvesters can be adjusted to push chain to excessive limits.
- Keep in mind that many chains fail at the instant they are damaged so chain shot cannot be totally avoided.



Linkages from a failed chain

How chain shot happens

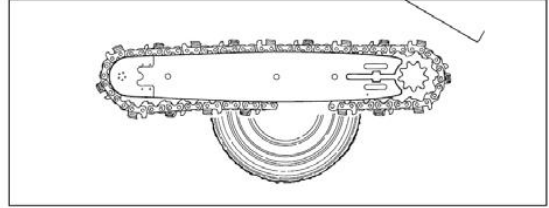
Chains on saws can travel 15,000 revolutions per minute (rpm). Higher chain speeds with attendant power input generally equates to faster cutting speeds but faster cutting speeds mean increased wear, shorter service life and increased chance of chain breakage and injury.



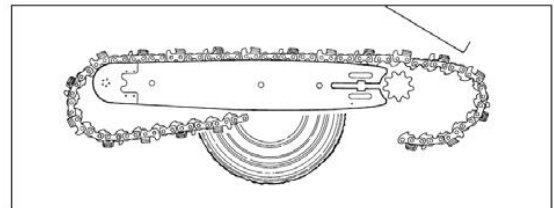
Chain link embedded in a cab window

The Mechanical Harvesting Handbook (Oregon, 2004) explains the phenomenon of chain shot.

After a chain break

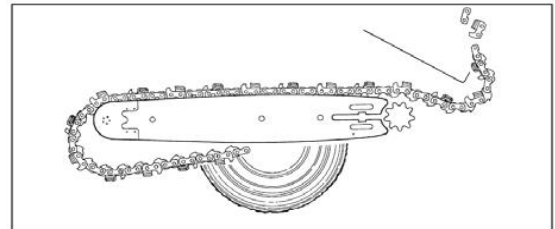


The free end of the chain begins to whip away from the breaks

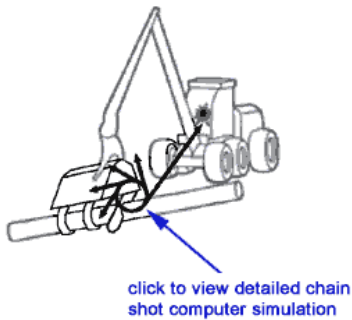


If the chain is not contained by the saw box or an energy-absorbing guard, the broken chain's free end can speed up rapidly and carry immense dynamic energy.

At the peak of the whip, chain parts may break loose and be ejected at high speed, especially if the free end of the chain strikes the saw box. Chain shot can cause chain parts to be thrown in many directions, especially along the plane of the saw bar.



Fragments have been measured at between **180 and 310 m/s** under laboratory simulated conditions



Chain shot can occur when chains are worn, damaged, repaired with used linkages or operated at speeds beyond the manufacturers recommendations.

The direct hazard to the equipment operator occurs when the plane of the saw bar is facing the cab, placing the operator in the line of fire should a chain failure occur.

Similarly, with a chainsaw, the operators body may be at risk if the chain were to fail.

Is chain shot a common occurrence?

There has been a number of investigated chain shot incidents in British Columbia and internationally in the forest industry. Swedish researchers estimate that a chain shot might occur in 1 in every 50 chain breaks (Hallonborg 2002).

In BC a harvester operator sustained severe abdominal injuries when he was struck by a chain link that had passed through a ½” polycarbonate cab window.

Another worker was using a manual chain saw to cut a dead stump when the chain broke. The broken linkages flew through



the air and struck another worker about 35' away. The chain piece removed in life saving surgery had caused injuries similar to being shot by a bullet. In addition, workers have reported near misses after nearly being struck by pieces of chain linkages released from equipment being operated up to 300' away.

How to reduce the chance of chain shot occurring

There are a number of ways to protect yourself from being injured by chain shot including:

- Follow Manufacturers Guidelines For Use
- Installing proper guarding
- Positioning & Training
- Purchasing Decisions

Follow Manufacturers Guidelines For Use

- Keep the chain tensioned properly
- Don't repair the chain with used linkages or hammered rivets, often these contain small fractures that weaken the link and increased the possibility of breakage
- Inspect the saw for damage/wear to the sprocket, bar or chain
- Keep the bar and chain adequately lubricated
- Inspect the chain before replacing, even new chains can be defective
- Check the chain to make sure it is designed for the cutting speed of your saw
- Don't overpower the chain. Higher cutting speeds wear the chain faster and may contribute to chain breakages.

Install Proper Guarding

Consider fitting the saw or harvester head with a chain catcher. This device may reduce the whip like action that produces chain shot by absorbing the kinetic energy released from the chain breaking.

Install Proper Guarding continued

Check to see windows are at least 1 ¼" thick polycarbonate, tests have shown that ½" was not thick enough to stop the penetration of chain shot. Findings showed that curved or larger windows were not more likely to fail but be particularly cautious if you operate at at lower temperatures (below -17C resulted in higher rates of failure of the panel windows).

Positioning & Training

While many operators cross cut the stems immediately in front to see if the cuts are being properly made this positions the saw blade toward the cab and directly places them in the line of fire should the chain break. Reposition the stem for crosscutting so the saw does not point towards the cab. **Pointing the saw blade at the cab is like pointing a loaded gun at yourself.**

Workers on the ground around the cutting area should be sufficiently far (70m/230 ft) from the cutting and aware of the direction of the chain so they can be positioned on the opposite side to avoid being struck should the chain break.

Consider making these standard operating policies for existing workers and include this when training new workers so they can recognize the hazard and adjust their work practices

accordingly. Ensure all workers know how to properly perform an inspection and are aware of the limitations of the equipment.

Purchasing Decisions

Perform a risk assessment when purchasing new equipment to consider if engineering designs can reduce the risk to the operator. Ask manufacturers what designs are in place to reduce risks to the operators.

Chain Shot Primer

While the risk of a chain shot event can't be eliminated, it can be reduced by following some simple operational recommendations.

by Jerry Locker



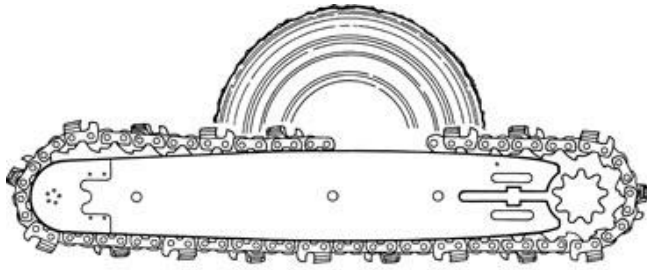
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“Chain shot” is not a new term to the forestry industry. However, events within the last two years have brought this term to the forefront of our industry.

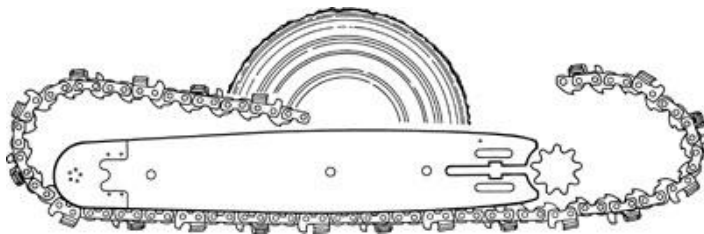
Chain shot is the high-velocity separation and ejection of a piece or pieces of saw chain from the end of a broken loop of saw chain in mechanized timber harvesting. Chain shot typically originates near the drive end of the cutting system, but can also originate from the guide bar tip area. In either case, it poses the same risk of serious injury or death to the machine operator, ground personnel and bystanders.

Saw chain pieces usually travel in the cutting plane of the guide bar, but can deviate to either side. Although the shot cone (a term used by Oregon) reflects the most likely chain shot path, deflection can occur, substantially expanding the distance saw chain pieces may travel.

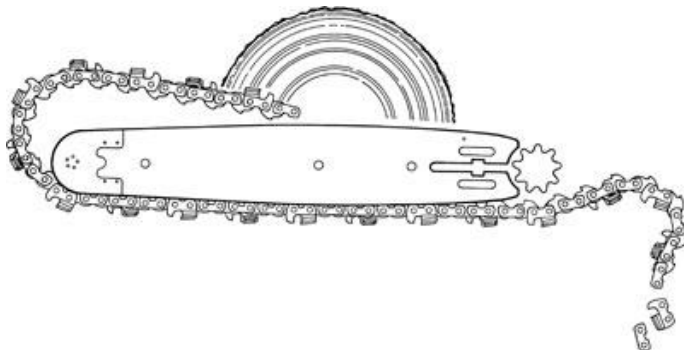
How Chain Shot Happens



1. After a saw chain break, the free end of the saw chain begins to whip away from the break.



2. If the saw chain is not contained by the saw box or by a chain shot guard, the broken saw chain's free end can speed up rapidly, carrying immense dynamic energy.



3. At the peak of the whip, saw chain parts may break loose and be ejected at high speed, especially if the free end of the saw chain strikes the saw box.

Can Chain Shot Be Eliminated?

In simple terms, no, it can't. Properly designed chain shot guards and shields reduce the danger of a chain shot from the drive sprocket area. However, there is currently no known way to place similar guards in the bar tip area without significant disruption to the cutting operation. Because no guarding is currently possible in the bar tip area, chain shots can be generated and pose the same risk of injury and death as those generated at the drive sprocket area.

To reduce the risk, your equipment should be designed with appropriate guards, shields, window enclosures and care should be taken to minimize the exposure of the machine operator, ground personnel and bystanders to the cutting plane of the cutting system and shot cone. The mechanical timber harvesting industry advises ground personnel and bystanders to stay at least 70 metres (230 feet) away and outside the shot cone of a working harvester. Chain shot projectiles travelling at the speed of a bullet can travel far beyond the recommended setback distance. The setback distance will help reduce the risk of a chain shot injury, but not eliminate it.

It is important windshields and windows be made of appropriate material. Test results from SMP Svenska Mankinproving AB found that 12 mm material is being penetrated by chain shot. For 19 mm Polycarbonate – LEXGARD MP750 Laminate, projectiles penetrated and caused a 5 mm deformation on the rear surface of the window. The test on 19 mm Polycarbonate / Acrylic – LEXGARD MP750 laminate found that projectiles penetrated the outer polycarbonate layer, but were contained by the acrylic layer and the rear polycarbonate layer partially delaminated.

As for 32 mm Polycarbonate – LEXGARD SP-1250, projectiles penetrated to a maximum depth of 18 mm.

Chain shot guards and chain catchers should be in place and in good working condition. Refer to your equipment manufacturer for details. Do not exceed the manufacturer's recommendations for chain speed.

Cutting systems must be inspected frequently. Cutting systems must be maintained in agreement with manufacturer's recommendations. Dull, damaged saw chains should be immediately removed from service for inspection, repair or replacement. Saw chain loops, which have broken twice, must be removed from service. Saw chains must be maintained in agreement with the manufacturer's recommendations. Guide bars must be cleaned and dressed on a regular basis in agreement with manufacturer's recommendations. Drive sprockets must be replaced when observed wear exceeds manufacturer's recommendations. Drive sprockets must be aligned with the groove of the guide bar. Ensure the saw chain/guide bar lubrication system is functioning properly: 0.404-pitch cutting systems should use approximately 7.6 litres (2.0 gallons) of guide bar/saw chain lubricant or more per eight-hour shift in harvesting operations – more when used in processing operations. Three-quarter-pitch cutting systems should use approximately 9.5 litres (2.5 gallons) or more per eight-hour shift in a harvesting application – more when used in processing operations.

Operational Recommendations

In general:

- Never engage in a cut with the machine operator, ground personnel or bystanders in the shot cone zone.
- Always engage in a cut as close to the ground as possible.
- Always use new parts when assembling and repairing saw chain.
- Maintain saw chain in agreement with your manufacturer's recommendations.

- Never force a dull saw chain to cut. Sharp chain places less wear and tear on the cutting system.
- Saw chain should be sharpened or replaced with a sharp chain at least once per operational shift, or more if damaged.
- Depth gauges (rakers) must be maintained through the life of a saw chain.
- Never exceed your saw chain manufacturer's operation recommendations.

In cold cutting conditions:

- Use a lighter-weight lubricant, if possible, doubling the flow rate.
- Periodically cycle the guide bar without cutting (air cuts) to increase lubricant present on the cutting system.
- Reduce bar feed force.

Conduct proper guide bar maintenance:

- Clean the guide bar groove from bar tip to bar tail, and keep the oil hole open.
- Turn the guide bar over to equalize wear on a daily basis.
- Cycle the guide bar several times to remove moisture from the guide bar tip.
- Ensure you maintain proper chain tension, checking it often.
- At breaks and at the end of each shift, relieve saw chain tension to prevent damage to the guide bar tip, saw motor and/or the saw chain as the saw chain cools and contracts.
- Reduce saw chain speed.

In simple terms, your harvester head, when operational, should be treated as if it is two loaded guns (the bar tip and the bar tail) that pose a risk of serious injury or death to the machine operator, ground personnel and bystanders.

The risk of a chain shot event cannot be eliminated, but the risks can be reduced by following the recommendations provided by your equipment manufacturer, your cutting system manufacturer, and the operational recommendations presented here.

Jerry Locker is the OEM Harvester Manager – North America for Oregon. Additional details regarding Harvester products, technical and safety information and Mechanical Timber Harvesting Service School, and links to websites offering additional information on chain shot are available at www.oregonchain.com/harvester

Resources – Links

[BC Forest Safety Council](#) - has a number of chain shot decals and warning labels available for interested companies. Digital versions also available for use

Thank you to Oregon for allowing us to use their artwork for distribution.

[The Chain Shot phenomenon](#) - A paper published by the Construction & Mining Equipment Industry Group outlining a study in preventing and minimizing the risks of chain shot

[Oregon](#) - Forest equipment manufacturer with chain shot prevention information

[WorkSafeBC](#) – Safety Alert on chain shot incident

[WorkSafeBC](#) – Hazard Alert on near miss chain shot incident

[WorkSafeBC](#) – Video of chain shot incident

[ISO Standard](#) – Chain shot glazing & panel

[ISO Standard](#) – Chain shot guarding