Purpose

This procedure sets out the requirements by the Company to minimise the risk of accidents and injury from chain shot.

Application

This procedure was initially developed by a working group of HVP contractors and employees and has been modified to align with HFMNZ's health and safety and operational systems. It applies to all Company employees, contractors, contractor employees and visitors. Contracting companies that have tree harvesting machinery incorporating chainsaws must as a minimum incorporate the "Major Chain Shot Rules' of this Model Safe Work Procedure into their procedures.

Major Chain Shot Rules

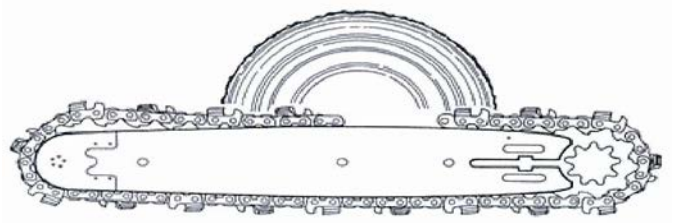
The details of the interpretation of these rules are contained in this document.

1. The installation of **chain catchers and chain shot guards** on all harvesting heads where practicable.
2. Always follow the **manufacturer's recommendations** for the **operation and maintenance of saw chain based cutting systems, in order to minimise the risk of a cutting system failure.**
3. **Never engage in a cut whereby the operator, ground personnel, and or bystanders are located in the shot cone zone.** Always perform cuts as close to the ground as possible
4. Inform all crew and bystanders/visitors of the **dangers of chain shot** through **site inductions and toolbox meetings.**
5. Install **19mm or thicker polycarbonate front windshields** into harvesters and processors where practicable. Where less than 19 mm polycarbonate is fitted, including curved windshields, then the machine **must** have a chain guard and chain catcher installed.

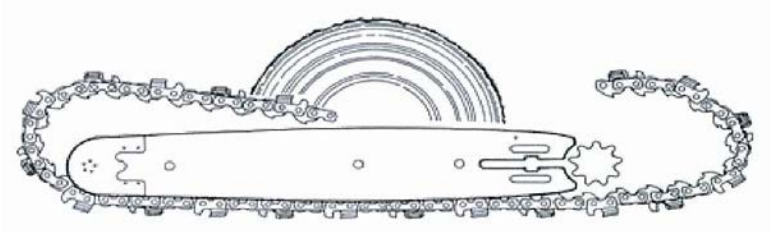
Introduction

Chain shot can cause serious injury or death to the machine operator, ground personnel and bystanders. It occurs when the chain breaks within the harvesting head and ejects a piece or pieces of chain at high velocity (similar to the speed of a bullet). Chain shot typically originates near the drive end of the saw bar but can also originate from the saw bar tip area. In either case it poses the same risk of injury.

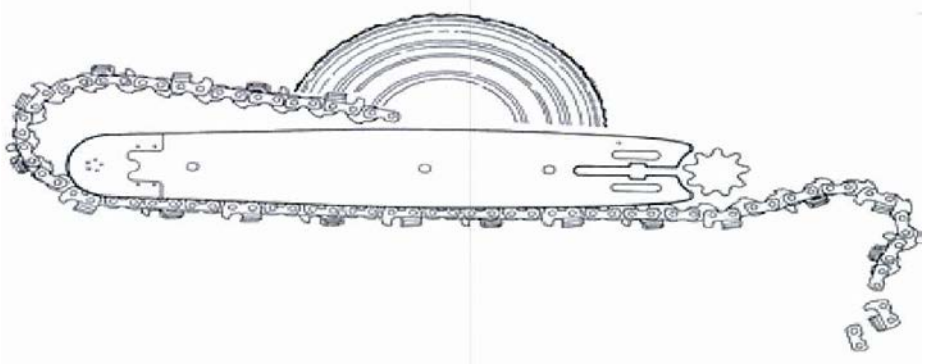
How chain shots happens -



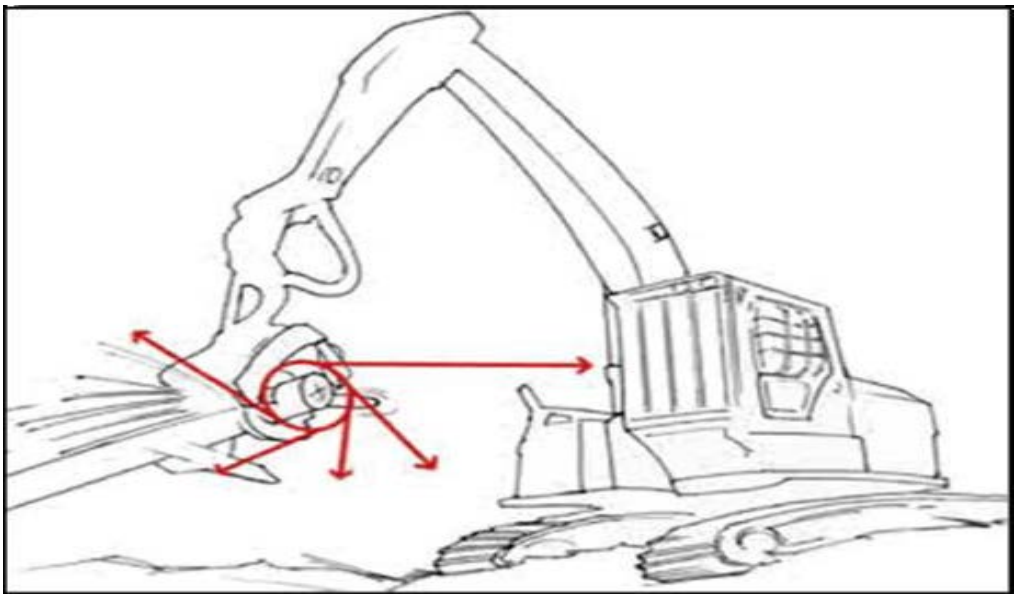
1. After a saw chain break, the free end of the chain begins to whip away from the break.



2. If the saw chain is not contained by the saw box or by a chain shot guard, the broken 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 chain strikes the saw box. Swedish researchers estimate that a chain shot might occur in 1 in every 50 chain breaks.



4. Chain shot is thrown in multiple directions along the plane of the saw bar. It can also ricochet off objects, which substantially expands where chain pieces may travel.

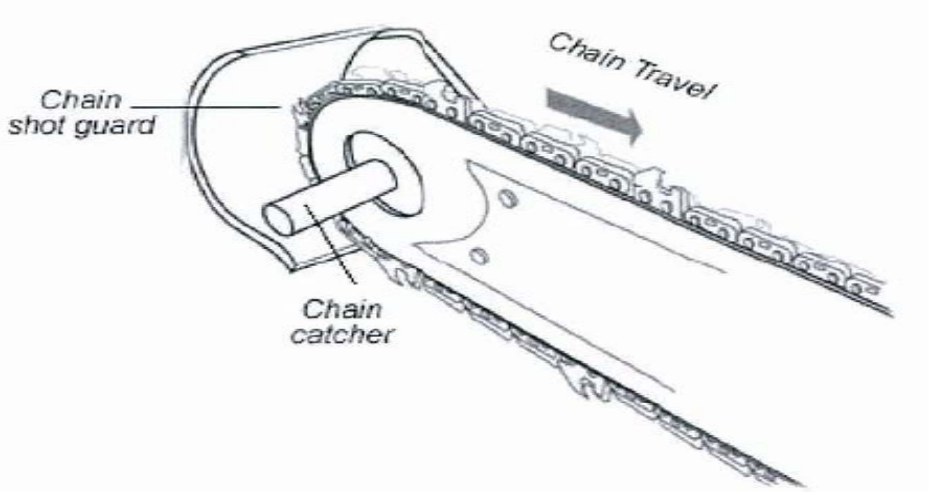
   The "Shot Cone" reflects the most likely path of chain shot and is an area about 15 degrees from either side of the plane of the saw bar when the saw is operating.

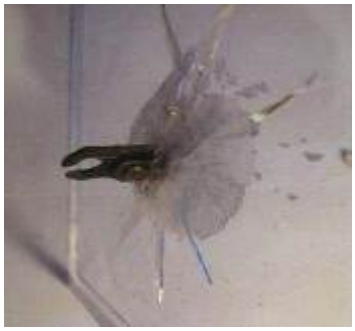
Chain shot risk from the drive sprocket area can be reduced with properly designed guards and shields. However there is currently no known way to place guards around the bar tip area which can also generate chain shot events and pose the same risk of injury or death. Therefore currently the risk of a 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.

The following safe work procedures are guidelines only and need to be used in conjunction with the Health and Safety in Employment Act 1992, the Approved Code of Practice for Safety and Health in Forest Operations (2012), other relevant regulations as well as manufacturer's recommendations.

Reducing Chain Shot Risk (Controls)

Competency	Harvester/processor operations are only to be carried out by persons accredited in harvester/processor and safe work practices, OR by: • Persons under training from a competent and accredited person (machine operator). • Persons under training must be under direct supervision. When the trainer considers them to be ready for assessment a certified assessor will assess the trainee and if deemed competent the trainee will be accredited for machine operations • Training notes must be recorded by the certified trainer detailing instruction, progress, times etc
Site Planning	• During pre-work safety meetings include a discussion on chain shot and the risks to operators, other workers and bystanders. • Review the methods workers are to use to minimize chain shot and establish areas of "shot cones" (i.e. no access zones). • Arrange the location and activities of machines and workers so no one enters a shot cone.

Minimum Machine Specifications	**Reducing danger of chain shot from drive sprocket area:** • Retro fit a chain shot guard and chain catcher (deflector) on older machines if available and safe to do so.  Fitting chain shot guards & chain catchers reduces the danger of chain shot from the drive sprocket area. The manufacturer must be contacted to find out if such an upgrade is available for the harvesting head. • Ensure all new machines are fitted with chain shot guards and chain catchers. • All chain shot guards and catchers shall be securely fastened and maintained in good working condition. • Close all snow holes on harvester and processor heads to reduce the openings the chain shot can escape through. • CMEIG (Construction & Mining Equipment Industry Group) found the chain guard prevented chain shot in 100% of tests (i.e. 22) and is a better design solution than a windscreen alone. **Operator Protective Structures:** • Currently there is no international standard for windscreens to prevent chain shot penetration into the cabin but there have been some test results published. • Appropriate windscreen material must be installed in all harvesters and processors. Upgrade flat windscreens to a minimum of 19mm thick polycarbonate, preferably laminated, where practicable. New machines shall be ordered with minimum 19mm polycarbonate. *CMEIG test results found that flat 12mm material is being penetrated by chain shot. For 19mm material the chain links are penetrating the first surface but being held up and deforming the rear surface. For 32mm polycarbonate the chain links penetrated to a maximum depth of 18mm.*



Chain link embedded in polycarbonate test window.

NOTES:

1. *Where 19 mm polycarbonate is not fitted then at a minimum the machine must have a chain guard and chain catcher installed until 19mm polycarbonate can be fitted.*
2. *Always check with the machine manufacturer to ensure that modifications are to their specifications and won't create other hazards or invalidate operator protection certification.*

- Polycarbonate windshields service life is affected by various factors such as UV exposure, cleaning agents and mechanical abrasion/damage. It is difficult to nominate a serviceable life but generally for visually undamaged polycarbonate a 5 year replacement interval should be considered.

- If any polycarbonate displays any of the following signs of aging or damage it should be considered due for replacement:
  - *Cracking*
  - *Discoloration or cloudiness*
  - *Crazed markings or frosting*
  - *Scuffing or marking (detectable by running a fingernail across the window's surface)*
  - *Any detectable mechanical damage or window distortion*

- Polycarbonate is attacked by some cleaning agents causing cracking. Steam cleaning, high temperature pressure washing or cleaning in the hot sun can lead to staining and clouding of the surface. When cleaning wash off loose dirt with water then use a soft cloth with mild soapy water to clean the surface. *IMPORTANT – Never use compounds that contain substances such as acetone, ammonia, brake fluid, gasoline, lacquer thinner, turpentine and xylene. These will cause damage.*

- Windshield checks should be part of daily machine checks by operator or immediately after any impacts. These checks should include:
  - Any damage to the window material or steel structure in the area of the window mounting.
  - The edges of the polycarbonate window must be evenly and fully supported on a flat surface around the entire window opening at all times. Bent or dented cab structures must be evaluated immediately for possible repair or replacement.
  - The edges of the polycarbonate window must be free from cracks or chips and must not be pinched or stressed. Windows with these defects must be replaced immediately.
  - Cracks, chips or scarring will decrease its impact strength. Windows with these defects must be replaced immediately.
  - Bent, dented or missing window retaining parts must be replaced

	immediately. × Rubber materials used in mounting the window must be maintained in good condition. × Discoloration due to chemical reactions, ensure there is good visibility through the polycarbonate. *See Appendix 1 Polycarbonate glazing: Inspection, maintenance and cleaning instructions.* Note that like Personal Protective Equipment, polycarbonate windows are the last line of defence and the other risk management practices listed in this procedure will help prevent chain shot incidents that result in reliance upon the polycarbonate for operator protection. **Signage:** • Harvesters/processors should have signs on them indicating to keep clear by at least 70m (distance chain shot can carry). • 
Chain Quality	• Using high quality chain will reduce risk of chain shot. Low quality chain can be made from softer steel and have thinner chrome plating causing it to become blunt quicker and increasing the risk of breaking.
Chain Maintenance & Operation	• Follow manufacturer's recommended maintenance practices for chain. • Inspect chain frequently especially after any unusual events for cracks, worn parts, stretch and poor riveting, and remove any damaged chains from service. • Use manufacturer's gauges to assess worn chain i.e. Use Oregon stretch gauge tools to measure excessive chain stretch. • Follow a proper change out schedule to remove worn-out chains from service before they break. • Use only chain components that meet manufacturer's specifications. Always use new parts when assembling and repairing saw chain. • Depth gauges (rakers) must be maintained through the life of a saw chain. If too high they will overheat and change color. • Keep chains sharp – sharpen or replace at least once per operational shift. Don't use dull chain or force them to cut. Sharp chain places less wear and tear on the cutting system. • Maintain proper bar and chain lubrication to prevent excessive wear: 0.404 pitch cutting systems should use approximately 7.6 litres of lubricant per eight hour shift in harvesting operations – more when used in processing operations. Three quarter pitch cutting systems should use

approximately 9.5 litres per eight hour shift in harvesting – more in processing.

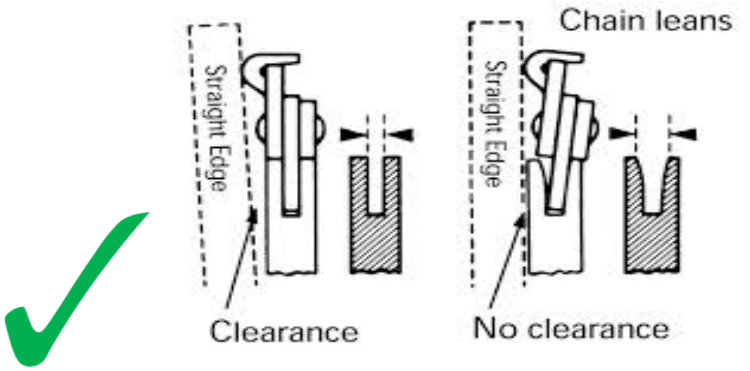
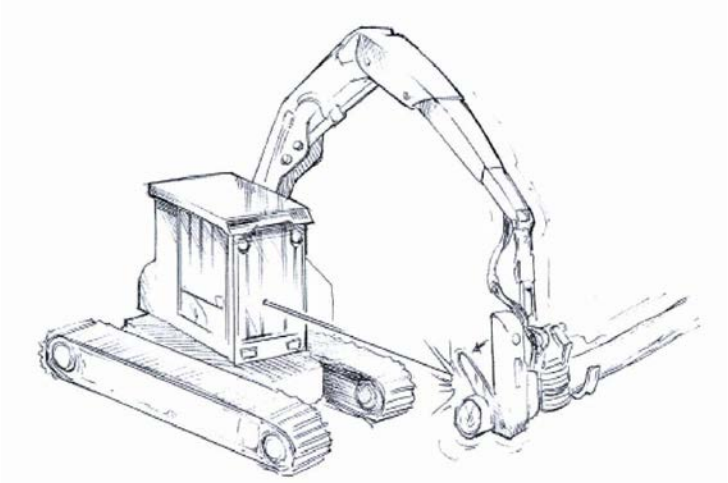
- Store or soak new and newly sharpened saw chains in lubricant prior to use, preferably overnight.
- Allow adequate time for the lubricant to reach the entire chain at start-up by running the chain slowly for several minutes.
- Periodically cycle the guide bar without cutting (air cuts) to increase lubricant present on the saw chain.
- In cold conditions use a lighter weight lubricant to increase flow rate.
- Ensure proper chain tension is maintained, checking it often. Incorrect tension can increase potential for chain shot.
- Don't repair or use chain that has broken twice, replace it.
- Train operators to properly inspect and report chain problems, and ensure any problems are fixed.
- Ensure chain speed does not exceed the chain manufacturer's recommendations. In general higher chain speeds result in increased wear, shorter service life and increased occurrence of chain breakage and potential injury. In the lab no chain shot could be generated at 30m/s but at 49m/s they obtained 100% chain shot from breakages. Recommended speeds to provide cutting power but not overly increase risk of chain shot are:

- Below 40 m/s for 0.404 chain
- Below 30 m/s for ¾ chain

- Replace the drive sprocket when visibly worn. Generally with .404 chain install a new sprocket after a maximum of each 10 chains, or when wear depth reaches 0.6mm or when damage occurs. For ¾ chain install a new sprocket after a maximum of 2000 hours or more frequently if excessive wear or damage occurs.

Brand new drive sprocket (left) and a worn sprocket (right)

- Drive sprockets must be aligned with the groove of the saw bar.

Saw Bar Maintenance	• Saw bars must be cleaned and dressed on a regular basis in agreement with manufacturer's recommendations. • Clean the saw bar groove from bar tip to bar tail, and keep the oil hole open. • Turn the saw bar over to equalize wear on a daily basis. • Relieve saw chain tension at meal breaks and at the end of each shift to prevent damage to the saw bar tip, saw motor and/or the saw chain as the saw chain cools and contracts. • Saw bar groove needs to be square and not worn at top, this is critical to the life of the chain.  If a "straight edge" is placed on the bar and chain and there is a gap between then the bar groove in good order (left hand side), if there is no gap and the chain leans then bar needs replacing (right hand side).
Operator Technique	• **Never use the saw with the saw bar directly in line with the cab or other persons.** Ensure no one is within the "shot cone". 

Operator Technique

Improper Operational Technique

The Shot Cone does not account for the possibility of a ricochet occurring in a chain shot event

Proper Operational Technique

- Investigate installing a warning device which alerts the operator that they are within the shot cone when engaging the saw. Strobe lights indicating the saw direction have been used for this.
- Sawdust from the saw being thrown in the direction of the cabin is a simple sign that the operator is within the shot zone and should change the direction of the saw.
- Reduce bar feed force – engage cut gradually, don't "wack" / "smack' tree with bar.
- Always engage in a cut as close to the ground as possible.
- Stop the operation of cut-off saws when other machinery comes within the shot cone.
- An effective form of communications should be in place between all operators with capability to inform all operators to cease work immediately if anyone is in the shot cone.

Training and Information

- Operators should be provided with training and information to reduce the risk of chain shot including periodic refreshers.
- Manufacturer's Operator Manuals with reference to chain shot to be kept in cab at all times.
- Install information labels in cabins to remind operators of chain shot hazard.

	 
Bystanders, visitors and crew	• Operators need to be aware of people in their vicinity when operating the saw. • Ensure visitors/bystanders keep at least 70m away when mechanical harvesting is in progress. Note that this distance will help reduce the risk of a chain shot injury but not eliminate it. • Ensure operators and crew/bystanders stay clear of the plane of the saw bar or the “shot cone” zone when harvester is operating. • The entire crew must be aware of chain shot and the shot cone zone. Discuss chain shot at crew toolbox meetings, and arrange the location and activities of machines & workers so no one is in a chain shot zone. All operators need to acknowledge (i.e. sign off) on these work site procedures to reduce risk of a chain shot injury. • Where other machinery in the vicinity of a harvester or processor is assessed to be at risk of a chain shot event then they should be fitted with polycarbonate windows to further reduce the risk of a chain shot injury. • In simple terms, the 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.
Incident and Near Miss Reporting	• Reporting of chain shot incidents including near misses to be mandatory to ensure HFMNZ and its contractors are aware of the incidence of chain shot, are able to investigate incidents and develop controls to prevent injuries.
Inductions	• All crew, visitors and other bystanders must be informed of the dangers of chain shot using the Crew induction process. • There should be a statement on the induction highlighting the risk of chain

	shot such as – "Chain shot can pose a risk of serious injury or death. It occurs when the chain breaks in the harvesting head and ejects piece(s) of chain at the speed of a bullet. These pieces can travel over 70m usually in line with the plane of the saw but they can also ricochet at different angles. Bystanders are asked to stand more than 70m away from operating harvesters/processors and outside of the plane of the saw or the "shot cone" (the most likely path of any chain shot event)".
Auditing	HFMNZ and its contractors should have procedures in place to check that the major chain shot rules are being followed, such as audit check sheets which include – • Machine requirements including chain guard and chain catcher installed, and windscreen type & condition. • Evidence of chains being maintained to manufacturer's recommendations. • Evidence of quality of chain being used. • Observation of operator technique including not pointing the saw at people or other machines. Evidence of toolbox meetings and site inductions including discussions on chain shot risk

Appendix One

Polycarbonate glazing: Inspection, maintenance and cleaning instructions.

Inspection and maintenance

Daily inspection and maintenance of the polycarbonate is essential to ensure that its protective ability has not been compromised. The following points detail some of the inspection and maintenance matters to be considered:

• Inspection of all windows should take place daily and immediately after any impacts.
• Any damage to the window material or steel structure in the area of the window mounting should be assessed.
• The edges of the shield should be free from cracks or chips and should not be pinched or stressed. Shields with these defects should be replaced immediately before work is allowed to continue.
• Cracks, chips, breaks or scars anywhere on the shield's surface will decrease its impact strength. Shields with these defects should be replaced immediately before work is allowed to continue.
• Bent, dented or missing shields retaining parts should be replaced immediately before work is allowed to continue.
• Rubber materials used in mounting the shield should be maintained in good condition.

Concealing hairline scratches

The appearance of scratches and minor abrasions on the surfaces of polycarbonate windows can be glossed over using a mild automotive polish such as Johnson's Paste Wax, Novus Plastic Polish #1 and #2 or Mirror Glaze Plastic Polish. The polycarbonate window should be cleaned as outlined below prior to the application of an automotive polish.

Cleaning

Polycarbonate should be kept clean to ensure operator visibility. The following should be adhered to when cleaning the polycarbonate:

- Do not use petrol, acetone, benzene, or solvents containing Butyl Cellosolve or Isopropanol.
- Never use strong alkali or abrasive cleaners.
- Never steam clean.
- Do not use brushes, razor blades, scrapers, squeegees or other sharp tools.
- Do not use abusive cleaning procedures either by hand or pressure washing on polycarbonate windows.
- Don't clean polycarbonate in the hot sun or at elevated temperatures as this can lead to staining.

The following step-by-step procedure should be followed for cleaning the polycarbonate:

1. Rinse the window thoroughly with lukewarm water.
2. Using a soft cloth, cellulose sponge or chamois, gently wash the window with a mild solution of soap or detergent in lukewarm water. Do not scrub or use brushes or squeegees. Polycarbonate manufacturers should be consulted as to the cleaning agents which should be used on the polycarbonate.
3. Rinse the window thoroughly with lukewarm water.
4. Dry the window with a moist soft cloth, cellulose sponge or chamois to prevent water spotting.

To remove grease or oil from the polycarbonate, first rub lightly with a good grade of VM&P Naphtha or isopropyl alcohol followed by the same rinse, wash, rinse and dry procedure described in steps 1 to 4 above.

Failure to follow the cleaning instructions outlined above will shorten the service life of the polycarbonate and may cause visual hazing, loss of light transmission and delamination of the polycarbonate hard surface coating.