Final Report
Project NS025

NATIONAL INSTITUTE FOR FOREST PRODUCTS INNOVATION

Development of best practice guidance for protective guarding of mobile plant used in Australian forests

2022

Mount Gambier Centre

Funded by the Australian Government, South Australian Government & Industry Partners.
nifpi.org.au

Development of best practice guidance for protective guarding of mobile plant used in Australian forests

Prepared for

National Institute for Forest Products Innovation

Mount Gambier

by

Prof Mark Brown, Dr Mohammad Ghaffariyan & Dr Michael Berry

Publication: Development of best practice guidance for protective guarding of mobile plant used in Australian forests

Project No: NIF103-1819 [NS025]

IMPORTANT NOTICE

ISBN: 978-1-922718-07-5

Researcher/s:
Brown, M., Ghaffariyan, M.R. and Berry, M.
University of the Sunshine Coast
90 Sippy Downs Drive, Sippy Downs QLD 4556

This work is supported by funding provided to Forest and Wood Products Australia (FWPA) to administer the **National Institute for Forest Products Innovation** program by the Australian Government Department of Agriculture, Water and Environment and the Government of South Australia in partnership with the University of South Australia.

Australian Government
Department of Agriculture, Water and the Environment

Government of South Australia
Department of Primary Industries and Regions

Introduction

This report was commissioned by The National Institute for Future Forest Products Innovation (NIFPI) to review and evaluate industry cabin-protection related concerns, make appropriate recommendations and develop an associated industry-wide cabin protection guide. As such, this report is not intended as or designed to be a comprehensive best practice guide for machine operation but rather a best management guide on the protective structures designed to safeguard machine occupants (FOPS [Falling Object Protective Structures], ROPS [Roll Over Protective Structures, OPG [Operator Protective Guards]).

Project objectives: The objective of the project was to provide the Australian forest management industry with a common industry best practice guideline for cabin protection equipment of mobile forestry machines based on current national and international standards and best practices, to ensure consistency in safety of equipment selection, modification and purchase.

Methodology

Extensive industry consultation was held within the first months of starting this project. Several forest companies and technology providers (including Forico, HVP, PF-Olsen, STT, John Deere, Komatsu…) were selected as industry steering committee members. The industry committee reviewed the proposed study plan and provided useful recommendations on the feasibility of the plan and expectations of the industry users about best practice guidance for protective guarding of mobile plant used in Australian forests. Following activities were undertaken by the USC Forestry research team to prepare the best management practices guidelines (Forest Equipment Guarding Best Practice Guidelines) for the Australian forest industry:

1. Reviewing Australian and international best practice guidelines and standards on protective guarding of mobile plants.
2. Collecting and reviewing Australian incident reports related to the cabin protection, which were provided by the forest growers.
3. Re-formatting PF-Olsen best practices guidelines using literature review and incident reports.
4. Consulting with the industry steering committee to prepare the first draft of the best management practices.
5. Conducting 3 webinars with several industry participants to collect the feedback on proposed best management practices.
6. Finalising the document and laying it out according to the safety standards and the forest industry preferences.
7. Delivering final document to the industry steering committee members

Results & Discussion

The guidelines set out best practice for machine selection, modification, and purchase within Australian forest operations. They aim to provide guidelines for equipment to provide safe and protected working environments for forest equipment operators including roll-over protective structures, falling object protective structures and operator protective guards in the form of canopies or cabin equipment. It is applicable to equipment operating in Australian forest operations. The best practice speaks specifically to the installation of the guarding but does not include any specific guidance on maintenance of the equipment or operational practices that should be implemented to minimise the risks the cabin guarding is intended to provide protection from. Equipment owners and managers should refer to their equipment manufacturer recommendation and other relevant company and industry best practice in these cases.

Conclusions & Recommendations

For future research and developments, the industry and research team agreed that this document should be updated on a regular basis based on the type and nature of future cabin protection incidents. The industry and USC will be cooperating to find a governing mechanism and suitable resources to keep this best practice guideline updated.

Appendix 1: Industry document output

Best Practices Document

NATIONAL INSTITUTE FOR
FOREST PRODUCTS INNOVATION

Forest Equipment Guarding Best Practice Guidelines

2020

Forest Industries Research Centre
University of the Sunshine Coast
90 Sippy Downs Drive
Sippy Downs QLD 4556

For more information contact:

Professor Mark Brown
mbrown2@usc.edu.au
07 5459 4483

Dr Mohammad R. Ghaffariyan
mghaffar@usc.edu.au
07 5456 5447

Dr Michael Berry
mberry@usc.edu.au
07 5459 4643

CONTENTS

SUMMARY

INTRODUCTION

These guidelines were prepared by the Forest Industries Research Centre, Forestry Research Institute – USC (FIRC-FRI-USC) based on an earlier Protective Guarding Structures Best Practice Guidelines document produced by PF Olsen (Aus) Pty Ltd (PF Olsen Australia). The guidelines are intended to provide the Australian forest industry with a best practice guide to facilitate safer and more efficient machine selection, modification and purchase within Australian forest operations. Forestry equipment is often equipment, new or second hand, that is modified to undertake specific forestry tasks and it is critical that these modifications meet or exceed the best practice presented in this document.

Individual companies would be expected to have safety management policies in place to address situations where a piece of equipment within their operations are not at or above the best practice detailed in these guidelines. These forest machine guarding best practices are intended to be applied to machines working within Australian forest operations operating with appropriate management, safety systems and processes and training. While these best practices apply the best current knowledge on cabin guarding and protection, they cannot guarantee the safety of an operator, particularly where good training and management practices are not in place.

FIRC as a member of FRI at USC acknowledges that AS and ISO identified in this document are not stand-alone requirements but rather complementary to the wider risk management of the equipment and operations.

SCOPE

These guidelines set out best practice for machine selection, modification, and purchase within Australian forest operations. They aim to provide guidelines for equipment to provide safe and protected working environments for forest equipment operators including roll over protective structures, falling object protective structures and operator protective guards in the form of canopies or cabin equipment. It is applicable to equipment operating in Australian forest operations. The best practice speaks specifically to the installation of the guarding but does not include any specific guidance on maintenance of the equipment or operational practices that should be implemented to minimise the risks the cabin guarding is intended to provide protection from. Equipment owners and managers should refer to their equipment manufacturer recommendation and other relevant company and industry best practice in these cases.

OBJECTIVE

The objective of this document is to provide the Australian forest management industry with a common industry best practice guideline for cabin protection equipment of mobile forestry equipment. This is based on current national and international standard and best practices to ensure consistency in safety of equipment selection, modification and purchase.

REQUIREMENTS

Equipment must be fitted with operator protective structures, designed to the appropriate standard, that eliminate or reduce (as far as practicable) the risk of operator injury due to:

- Rollover and consequent cabin impact damage (ROPS)
- Objects penetrating the cabin space, such as logs and chain shot (OPS)
- Objects including trees, logs and branches falling on or over the cabin (FOPS)

Equipment operator protective structures must be evaluated against the relevant identified hazards to determine if they provide sufficient control of the risk. Particular operating conditions need to be considered to ensure the protections put in place are adequate and requirements for a particular machine can change between different operations and operating conditions (i.e. potential for chain shot, expected log size, etc).

BACKGROUND

CONCEPT

This report was commissioned by The National Institute for Forest Products Innovation (NIFPI) to review and evaluate industry cabin-protection related concerns, make appropriate recommendations and develop an associated industry-wide cabin protection guide. As such, this report is not intended as, or designed to be a comprehensive best practice guide for machine operation but rather a best management guide on the protective structures designed to safeguard machine occupants (FOPS [Falling Object Protective Structures], ROPS [Roll Over Protective Structures, OPS [Operator Protective Guards]).

METHODOLOGY

To achieve this objective, input from the Australian forestry industry around current machine design, safeguards and operational standards were collected along with representative standards and specifications for operations overseas. This initial review became the groundwork for updating and developing this document, an Australian industry best practice guide for cabin protection. This report is largely extended from existing work completed by PF Olsen in cabin protection best practices developed over the last decade. Furthermore, associated incident reports where collected from throughout Australia to help refine and guide potential recommendations regarding the need for protective measures based on Australian conditions.

INCIDENT REPORTS

From a high-level incident investigation and industry collaboration, it was found that:

1. OPS appears to be the cause of the greatest concern for industry,
2. There is concern around the adequacy of forwarder cabin protection standards, particularly when loading forwarders with slippery logs and on slopes where incidents of cabin intrusion and cracked window has occurred.
3. Harvesting and excavator protective strategies appear generally adequate although specific operating conditions can create adverse hazards and chain-shot provisions need to be met,
4. Roadwork, loading and trucking cabin protection appears adequate with occasional strikes, roll overs and others occurring, and
5. Equipment failures are very rare and generally not correlated to specific safety issues.

Overall, it was found that most cases tend to be low severity and part of routine operations with higher severity (breakage/ intrusion) incidents associated with less ideal operating conditions, human error and/or operator inexperience.

GENERAL RECOMMENDATIONS

Given the incident investigation and supporting logic, it is important to emphasize that the most effective way to reduce the likelihood of safety issues has to do with better operator training under a range of conditions; avoiding incidents that put cabin protection systems into action is always the preferred outcome. It is recommended that industry continues to conduct targeted operational training especially for operations on steep slopes, sub-par conditions (poor visibility, rain, etc.), slippery logs and otherwise differing conditions (poor quality tree forms, high volume of slash, abundance of wildlings, etc.) as these conditions have a much higher probability of incidence. In any case, no matter the referenced standard, a degree of reason and logic must always be considered for the specific conditions of the work (i.e. size of logs, canopy conditions, etc.) as part of risk assessment.

The standards referenced herein are to be applied to both purpose-built and upfitted equipment with existing equipment recommended to be upgraded as appropriate. PCBU should be aware that specific conditions may warrant alterations to safety standards referenced in this document. Specific recommendations for advanced training and regional variations to cabin protection safety guidelines are outside the scope of this report.

DEFINITIONS

Rollover Protective Structures (ROPS)

The system of structural members whose primary purpose is to reduce the possibility of a seat belted operator being crushed should the equipment rollover. Structural members include any sub-frame, bracket, mounting, socket, bolt, pin, suspension or flexible shock absorber used to secure the system to equipment frame but exclude mounting provisions that are integral with the equipment frame.

Falling Object Protective Structures (FOPS)

A structure designed to be attached to, or form part of, mobile equipment for the purpose of reducing the possibility of an operator seated beneath the structure in the driving position being harmed should the FOPS receive a blow from a falling object.

Operator Protective Structures (OPS) including Operator Front Protective Structures (OFPS)

Operator protective guarding is attached to, or forms part of the equipment to provide protection from flying objects intruding into the machine. The type and configuration of guarding must be determined by available standards and/ or a risk assessment.

The OPS is intended to provide protection to the front, sides, rear and top of the operator compartment.

In some cases where machines (e.g. excavators) operate on terrain where stability cannot be assured a certified Cabin Operator Protection Structure (COPS) should be applied.

REGULATIONS AND STANDARDS

Table 1 lists the protective structures that must be applied to equipment used in Australian forest operations for each machine type.

Table 1: Protective structures for Australian forest operations machines

Machine	Type	ROPS ISO 3471	ROPS ISO 8082-1-2009	ROPS ISO 8082-2-2011	FOPS ISO 8083	OPS ISO 8084
Bulldozers	Enclosed cabin	✓			✓	✓
	Open - Canopy with attachments	✓			✓	✓
Modified Hydraulic Excavators and Log Loaders	Landing unit-log-log grab & cut off saw			✓	✓	✓
	Landing unit-log grab only	✓			✓	
	Off-landing-shovel logging			✓	✓	✓
	Feller buncher - processing head			✓	✓	✓
	Construction excavator-Hydro hitch, buckets and rock drill and rock grab	✓			✓	✓
Purpose built forestry units	Tracked feller buncher			✓	✓	✓
	Wheel type feller buncher		✓	OR[1] ✓	✓	✓
	Tracked type harvester			✓	✓	✓
	Wheeled type harvester		✓	OR[1] ✓	✓	✓
	Grapple skidder		✓		✓	✓
	Cable skidder		✓		✓	✓
	All forwarders		✓		✓	✓
	Yarders (excavator based with rotating platform and boom)			✓	✓	✓
Wheel loaders	Wheeled loader fitted with a falling or bunching head		✓		✓	✓
	Articulated-enclosed cabin, quick coupler and attachments	✓	✓		✓	
	Articulated-enclosed cabin, pin or multipurpose bucket	✓	✓		✓	
	Articulated-enclosed cabin, onion general purpose bucket	✓	✓		✓	
Skid Steer loaders	Enclosed cabin multi-purpose bucket	✓	✓		✓	
	Open-canopy multi-purpose bucket	✓	✓		✓	
Compact truck loaders	Enclosed-cabin multi-purpose bucket	✓	✓		✓	
	Open-canopy multi-purpose bucket	✓			✓	
Backhoe loaders	Enclosed cabin multi-purpose bucket, 4x4 extendable dipper, quick hitch and buckets – on road only with no over cabin obstacles	✓			✓	
	Enclosed cabin multi-purpose bucket, 4x4 extendable dipper, quick hitch and buckets – working in forested area		✓		✓	✓

1 Either ISO 8082-1 or ISO 8082-2 may apply depending on the design

EQUIPMENT GUIDELINES

This document provides guidance on aftermarket modifications to machines to bring them in line with best practice machine guarding for forestry equipment. For factory integrated machine designed protection systems in forestry built for purpose machines, these requirements should be met through the certified engineering design in line with the relevant ISO standards and should be labelled accordingly. These best practices are intended to be applied within operations using good practice and safety management protocols that aim to minimise the risk of cabin incursion and/or operator injury in the case of an incident.

All ROPS, FOPS, and OPS equipment shall always be maintained in good condition:

- Frame members are undamaged and in a similar shape and form as originally installed.
- All welds are free from cracks.
- All protective materials are properly secured to the canopy / cabin frame.
- Canopy / cabin mountings are in good condition with all the holding bolts in position and tightened to the appropriate torque.
- Where the protective structure has been damaged and effectiveness is compromised, the person conducting a business or undertaking (PCBU) in control of the equipment must take all practicable steps to repair or replace the structure with one that complies with an appropriate design standard.
- Where damage has occurred, the PCBU must ensure that the damaged structure is assessed by a competent person trained with the appropriate technical skills to carry out the assessment and repairs to deem whether the machine may continue to be used or requires repair or replacement before further use. All repairs must be carried out by a competent person, who is to ensure that the repaired equipment maintains its original design specification (Safe Work Australia - Forestry operations guidance material).
- Re-assessment of repairs shall be performed by competent persons trained with the appropriate technical skills to carry out the assessment and repairs before machine is re-used after an incident involving the cabin/ canopy that may have caused any damage to the protective systems.
- Polycarbonate sheeting (i.e. Lexan® or Marguard) is commonly used in the forest industry. This is an integral component in the safety structure of the machine and must be inspected, cleaned, maintained and repaired, where required, strictly within manufactures recommendations. As even minor damage and imperfections can significantly decrease the ability of the polycarbonate to provide the required protection and therefore should be replaced after a recorded impact incident or upon the identification of minor damage during maintenance inspections. In general terms, unless recommended other wise by the manufacturer, if there is any visible marks or cracks or if the screen is more than five years old the screen should be replaced with new.
- Polycarbonate sheeting is to be of a suitable strength and thickness, as provided by the manufacturer, to withstand the size and force of identified hazards (e.g. chain-shot or log) for the operating environment. A job risk assessment will be required prior to work commencing to identify hazards and impact protection required.
- A FOPS canopy should prevent the operator from injury from branches / timber falling above.
- OPS should protect the operator against external penetrating objects such as but not limited to broken chain links, limbs, branches, and logs.

TIMBER FELLING AND PROCESSING EQUIPMENT

Feller Buncher and Directional Fellers

Figure 1: Felling machines

A Feller Buncher or Directional Feller can be purpose build forestry machines or modified for purpose from an excavator base. They fell the trees and typically present them for processing to logs or extraction in bunches.

Notable Cabin protection risks

- Machine rollover due to slope and/or unstable terrain.
- Cabin impacted by falling limbs or entire trees.
- Where equipped with a disc saw “hotsaw” impact from broken/dislodged saw teeth particularly in the discharge zone, similar to the chain shot zone for bar saw heads.
- Where equipped with hydraulic powered saw impact from chain shot of broken chain particularly in the chain shot zone.
- Dislodged saw teeth can be thrown 1000 m (Garland and Rummer, 2009).
  - > Small chunks of wood and rocks can be thrown 100 m.
  - > The warning signage on the machine can be read from a safe distance (200m).
  - > Properly designed guards and shields should be installed as per manufacturer’s recommendation to reduce the risk of a tooth dislodgement event.
  - > Industry research suggests materials less than 19 mm laminated polycarbonate, or its equivalent may not provide sufficient protection within 70 m of the bar saw head.

Cabin – ROPS – FOPS – OPS

For machines that do not have the appropriate ISO 8082 ROPS, ISO 8083 FOPS, ISO 8084 OPS, and SAE J1356:2013 OFPS certification and labelling as part of the original manufacturer design, the protective systems will need to be verified and/or upgraded to at least meet the guidelines as follows:

- Polycarbonate sheeting windows must be equipped on all machines fitted with a hydraulic powered saw or disc head.
  - > The entire front screen, where impact from chain-shot is the greatest risk, there should be polycarbonate sheeting 19 mm thickness minimum and where it is an available option a greater thickness is preferred, particularly for larger felling/processing heads that have a higher energy potential chain shot. For machines being modified for purpose in forest operations 22 mm or greater thickness (e.g. 32 mm) is recommended in line with recommendations in Washington State Fatality Assessment and Control in 2014.
  - > Side and rear windows should be polycarbonate sheeting 12mm thickness or greater where it is not possible for these screens to be in the direct chain shot zone, Figure 2, while the machine is operating (harvester/processor head can only be positioned forward of the operator cabin). Where the harvester/processor head position is not restricted to the front of the operator cabin all polycarbonate sheeting should be 19 mm thickness minimum and where it is an available option a greater thickness is preferred, particularly for larger felling/processing heads that have a higher energy potential chain shot.

    For machines being modified for purpose in forest operations 22 mm or greater thickness (e.g. 32 mm) is recommended in line with recommendations in Washington State Fatality Assessment and Control in 2014.
  - > Polycarbonate must be mounted securely as per original OEM installation or in the case of modified for forest operations purpose with appropriate bolts rather than rubber seals.
  - > Where polycarbonate does not meet minimum thickness recommendation with original manufacturer design and conversion to recommended thickness is not feasible, an appropriate risk assessment is required to determine if adequate secondary shields and guarding can be installed to allow the machine to continue to operate safely.
- Polycarbonate sheeting windows must be equipped on all machines not fitted with a hydraulic powered saw or disc head that is 12mm thickness or greater and the risk is assessed as likely that the machine will work within 100 m **of an identified chain shot zone** should be equipped with polycarbonate sheeting at least 19 mm thickness and where available a greater thickness is required, particularly working around larger felling/processing heads that have a higher energy potential chain shot.

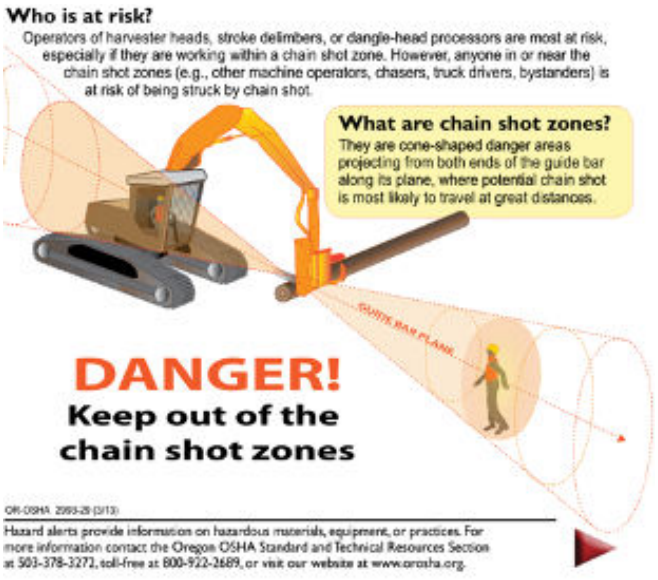

Figure 2: Description of chain shot zone

- ROPS structure
  - > Not less than 75mm x 75mm RHS low carbon steel. Minimum wall thickness 6mm and a maximum unsupported span of 800mm and where the machine exceeds 20,000 kg can not be less than 100 x 100mm RHS frame with wall thickness >6mm.
  - > Flat low carbon steel sheet having a minimum thickness of 6mm and a maximum unsupported span of 800mm continuously welded. (Thicker plate material may allow for increased span where structural performance is equivalent).
  - > Re-enforced polycarbonate with a minimum thickness of 12 mm **or** greater and stiffening bars 50mm x 10mm on their edge placed at a maximum 100mm apart.
  - > After market ROPS fittings should be attached with plates of not less than 32mm thickness and secured by high tensile steel bolts (grade 8) of not less than 32mm diameter with a minimum of 4 bolts per footing placed in a non-sheer position.
- FOPS & OPS structure
  - > The cabin shall be fully enclosed by either steel mesh or a combination of horizontal or vertical bars and polycarbonate clear sheeting.
  - > For a front guard steel mesh 50mm x 50mm wire mesh x 5mm diameter where the front screen is not 12mm polycarbonate or thicker tested to meet OPS. Using vertical or horizontal bars, complying to these guidelines the maximum clear area between a set of bars should not exceed 100mm apart unless used in conjunction with polycarbonate sheeting 12 mm thickness or greater and be tested for OPS.
  - > For a side guard Steel mesh covers the window area using 50mm x 50mm wire mesh x 5mm diameter **or** polycarbonate clear sheeting of minimum of 12mm on the front and rear quarter. Using vertical or horizontal bars, complying to these guidelines the stiffening bars should be on their edge: 50mm x 10mm and the maximum clear area between a set of bars should not exceed 100mm apart unless used in conjunction with polycarbonate and tested for OPS.
  - > The roof structure should be steel sheeting 6mm thickness or polycarbonate clear sheeting of 12mm thickness.

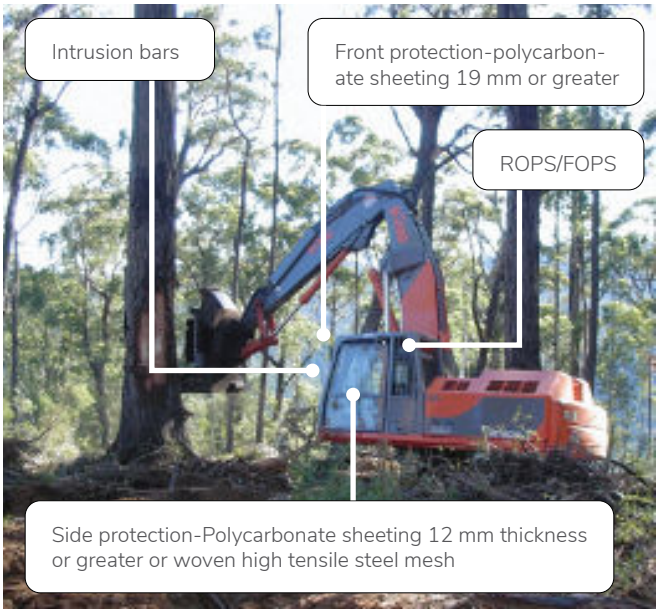

Figure 3: Mechanical harvester – excavator modified

Access/egress

- Cabin structure shall be fitted with an emergency exit in addition to the primary entrance / exit door. They should permit operators to get out of the cabin during a foreseeable emergency for example, rollover, submersion, fire, etc. The emergency exit shall be capable of being operated from inside and outside the cabin.

Harvesters and Processors

Figure 4: Harvester and processors

A Harvester or processor can include purpose-built forestry machines or modified for purpose from an excavator base. Harvesters are able to fell the trees and then process them by removing limbs and sometimes bark, then cut the tree into product lengths in one step. Harvesters typically present the cut-to-length log products for extraction by a forwarder. A processor may be capable of felling but typically are used to process already felled trees by removing limbs and sometimes bark then cut the tree into product lengths.

Notable Cabin protection risks

- Machine rollover due to slope and/or unstable terrain
- Cabin impacted by falling limbs, logs or entire trees
- Where equipped with hydraulic powered saw impact from chain shot of broken chain particularly in the chain shot zone

Cabin – ROPS – FOPS – OPS

For machines that do not have the appropriate ISO 8082 ROPS, ISO 8083 FOPS, ISO 8084 OPS, and SAE J1356:2013 OFPS certified and labelled as part of the original manufacturer design, the protective systems will need to be verified and/or upgraded to at least meet the guidelines as follows:

- Polycarbonate sheeting windows must be equipped on all machines fitted with a hydraulic powered saw.
  - > The front screen, where impact from chain-shot is the greatest risk, should be polycarbonate sheeting 19 mm thickness minimum and where it is an available option a greater thickness is preferred, particularly for larger felling/processing heads that have a higher energy potential chain shot. For machines being modified for purpose in forest operations 22 mm or greater thickness (e.g. 32 mm) is recommended in line with recommendations in Washington State Fatality Assessment and Control in 2014.
  - > Side and rear windows should be polycarbonate sheeting 12mm thickness or greater where it is not possible for these screens to be in the direct chain shot zone, Figure 5, while the machine is operating (harvester/processor head can only be positioned forward of the operator cabin). Where the harvester/processor head position is not restricted to the front of the operator cabin all polycarbonate sheeting should be 19 mm thickness minimum and where it is an available option a greater thickness is preferred, particularly for larger felling/processing heads that have a higher energy potential chain shot. For machines being modified for purpose in forest operations 22 mm or greater thickness (e.g. 32 mm) is recommended in line with recommendations in Washington State Fatality Assessment and Control in 2014.
  - > Polycarbonate must be mounted securely as per original OEM installation or in the case of modified for forest operations purpose with appropriate bolts rather than rubber seals.
  - > Where polycarbonate does not meet minimum thickness recommendation with original manufacturer design and conversion to recommended thickness is not feasible, an appropriate risk assessment is required to determine if adequate secondary shields and guarding can be installed to allow the machine to continue to operate safely.
- Polycarbonate sheeting windows must be equipped on all machines not fitted with a hydraulic powered saw that is 12mm thickness or greater and the risk is assessed as likely that the machine will work within 100 m **of an identified chain shot zone** should be equipped with polycarbonate sheeting at least 19 mm thickness and where available a greater thickness is required, particularly working around larger felling/processing heads that have a higher energy potential chain shot.

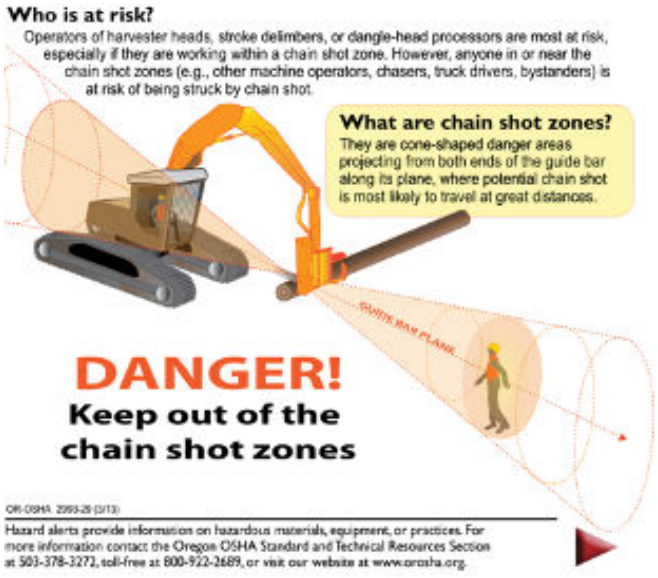

Figure 5: Description of chain shot zone

- ROPS structure
  - > Not less than 75mm x 75mm RHS low carbon steel. Minimum wall thickness 6mm and a maximum unsupported span of 800mm and where the machine exceeds 20,000 kg can not be less than 100 x 100mm RHS frame with wall thickness >6mm.
  - > Flat low carbon steel sheet having a minimum thickness of 6mm and a maximum unsupported span of 800mm continuously welded. (thicker plate material may allow for increased span where structural performance is equivalent).
  - > Re-enforced polycarbonate with a minimum thickness of 12 mm or greater and stiffening bars 50mm x 10mm on their edge placed at a maximum 100mm apart.
  - > After market ROPS fittings should be attached with plates of not less than 32mm thickness and secured by high tensile steel bolts (grade 8) of not less than 32mm diameter with a minimum of 4 bolts per footing placed in a non-sheer position.

Figure 6: Excavator – timber processing working off the landing fitted with a hydraulic powered saw, fitted with a harvesting or processing head
– in an "uncontrolled" environment

- FOPS & OPS structure
  - > The cabin shall be fully enclosed by either steel mesh or a combination of horizontal and/or vertical bars, polycarbonate clear sheeting
  - > For a front guard steel mesh 50mm x 50mm wire mesh x 5mm diameter where the front screen is not 12mm polycarbonate or thicker tested to meet ROPS and OPS. Using vertical or horizontal bars, complying to these guidelines the maximum clear area between a set of bars should not exceed 100mm apart unless used in conjunction with polycarbonate sheeting 12 mm thickness or greater and be tested for OPS.
  - > For a side guard steel mesh covers the window area using 50mm x 50mm wire mesh x 5mm diameter or polycarbonate clear sheeting of minimum of 12mm on the front and rear quarter. Using vertical or horizontal bars, complying to these guidelines the stiffening bars should be on their edge: 50mm x 10mm and the maximum clear area between a set of bars should not exceed 100mm apart unless used in conjunction with polycarbonate and tested for OPS.
  - > The roof structure should be steel sheeting 6mm thickness or polycarbonate clear sheeting of 12mm thickness.

Access/egress

Cabin structure shall be fitted with an emergency exit in addition to the primary entrance / exit door. They should permit operators to get out of the cabin during a foreseeable emergency for example, rollover, submersion, fire, etc. The emergency exit shall be capable of being operated from inside and outside the cabin.

Chippers, Flails and Grinders

Figure 7: Chippers

Chippers, flails and grinders are mobile equipment that typically work at roadside to process trees or logs into wood chips, or ground wood material.

Notable Cabin protection risks

- Cabin impacted by mishandled logs or trees
- Small chunks of wood, splinter and chips can be thrown 100 m

Cabin – ROPS – FOPS – OPS

For machines that do not have the appropriate ISO 8082 ROPS, ISO 8083 FOPS, ISO 8084 OPS, and SAE J1356:2013 OFPS certification and labelling as part of the original manufacturer design materials the protective systems will need to be verified and/or upgraded to at least meet the guidelines as follows:

- The cabin shall be fully enclosed by either steel mesh or a combination of horizontal and or vertical bars, polycarbonate clear sheeting (ISO 8082, ISO 8083, ISO 8084).
  - > Polycarbonate sheeting having a minimum thickness 12mm thickness or greater, where chain-shot impact is identified as a likely risk 19mm thickness or greater is preferred in line with recommendations in Washington State Fatality Assessment and Control in 2014;
  - > Woven high tensile steel mesh of 5mm outside diameter and having 50mm square aperture unless used in conjunction with polycarbonate and tested for OPS.; OR
  - > Vertical or horizontal bars, complying to these guidelines the maximum clear area between a set of bars should not exceed 100mm apart unless used in conjunction with polycarbonate and tested for OPS
  - > Non-window cabin surfaces will use flat low carbon steel sheet having a minimum thickness of 6mm and a maximum unsupported span of 800mm.

> When working in a harvesting system where the risk is assessed as likely that the machine will work within 100 m **of an identified chain shot zone** it should be equipped with polycarbonate sheeting at least 19 mm thickness and where available a greater thickness is preferred, particularly working around larger felling/ processing heads that have a higher energy potential chain shot.

> Polycarbonate must be mounted securely as per original OEM installation or in the case of modified for forest operations purpose with appropriate bolts rather than rubber seals.

> Where minimum thickness is not met with original manufacturer design and conversion to recommended thickness is not feasible, an appropriate risk assessment is required to determine if adequate secondary shields and guarding can be installed to allow the machine to continue to operate safely.

Access/egress

- Cabin structure shall be fitted with an emergency exit in addition to the primary entrance / exit door. They should permit operators to get out of the cabin during a foreseeable emergency for example, rollover, submersion, fire, etc. The emergency exit shall be capable of being operated from inside and outside the cabin.

EXTRACTION EQUIPMENT

Skidders

Figure 8: Skidders

A Skidder is a wheel based articulated tractor equipped with a grapple or cable winch used to pick up one end of a tree, log, or group of trees and drag them from the harvest site to the road side either for subsequent processing into cut-to-length products, to be chipped, and/or to be transported.

Notable Cabin protection risks

- Machine rollover due to slope and/or unstable terrain
- Cabin impacted by logs or entire trees

Cabin – ROPS – FOPS – OPS

For machines that do not have the appropriate ISO 8082 ROPS, ISO 8083 FOPS, ISO 8084 OPS, and SAE J1356:2013 OFPS certification and labelling as part of the original manufacturer design, the protective systems will need to be verified and/or upgraded to at least meet the guidelines as follows:

- Cabin front, side and rear should be 12mm polycarbonate or thicker tested to meet FOPS and OPS or steel mesh from top roof top to the curve of the sweep leaving the front section open for maximum visibility for the operator: 50mm x 50mm wire mesh x 5mm diameter
- Note: Leave room for operator access on both sides of the machine if guards are not fitted to door i.e. open canopy bulldozer.
- The roof should be steel sheeting 6mm thickness or polycarbonate clear sheeting of 12mm thickness tested to meet OPS.
- When working in a harvesting system where the risk is assessed as likely that the machine will work within 100 m **of an identified chain shot zone** it should be equipped with polycarbonate sheeting at least 19 mm thickness and where available a greater thickness is preferred, particularly working around larger felling/processing heads that have a higher fenergy potential chain shot.
- Polycarbonate must be mounted securely as per original OEM installation or in the case of modified for forest operations purpose with appropriate bolts rather than rubber seals.
- Where minimum thickness is not met with original manufacturer design and conversion to recommended thickness is not feasible, an appropriate risk assessment is required to determine if adequate secondary shields, administrative controls and guarding can be installed to allow the machine to continue to operate safely.
- Sweeps may be added and are additional protection fitted to the machine primarily to protect the machine from the forestry environment and secondarily to aid in the protection of the cabin and operator. Sweeps are generally not certified and should not be attached to, interfere with, or in any way compromise the function of the ROPS / FOPS/ OPS.
- **Note:** Sweeps should be inspected for damage and cracking. Damaged or cracked sweeps will not protect the machine adequately and may break resulting in the machine being unserviceable. Mounting bolts and mounts should be inspected regularly to ensure they are serviceable.

Figure 9: All wheeled drive skid steer skidder – front view

Figure 10: All wheeled drive skid steer skidder – side view

Access/egress

Cabin structure shall be fitted with an emergency exit in addition to the primary entrance / exit door. They should permit operators to get out of the cabin during a foreseeable emergency for example, rollover, submersion, fire, etc. The emergency exit shall be capable of being operated from inside and outside the cabin.

Crawler Tractors

Figure 11: Crawler tractors

A crawler tractor is a tracked based tractor equipped with a grapple or cable winch used to pick up one end of a tree, log, or group of trees and drag them from the harvest site to the road side either for subsequent processing into cut-to-length products, to be chipped, and/or to be transported. They are typically based on a bulldozer and include structures and frames on the front to push trees and debris to assist with site access.

Notable Cabin protection risks

- Machine rollover due to slope and/or unstable terrain
- Cabin impacted by logs or entire trees

Cabin – ROPS – FOPS – OPS

For machines that do not have the appropriate ISO 3471 ROPS, ISO 8083 FOPS, ISO 8084 OPS, and SAE J1356:2013 OFPS certification and labelling as part of the original manufacturer design, the protective systems will need to be verified and/or upgraded to at least meet the guidelines as follows:

- Cabin front, side and rear should be 12mm polycarbonate or thicker tested to meet OPS **or** steel mesh from roof top to the curve of the sweep leaving the front section open for maximum visibility for the operator: 50mm x 50mm wire mesh x 5mm diameter
- Note: Leave room for operator access on both sides of the machine if guards are not fitted to door i.e. open canopy bulldozer.
- The roof should be steel sheeting 6mm thickness or polycarbonate clear sheeting of 12mm thickness tested to meet OPS.
- When working in a harvesting system where the risk is assessed as likely that the machine will work within 100 m **of an identified chain shot zone** it should be equipped with polycarbonate sheeting at least 19 mm thickness and where available a greater thickness is preferred, particularly working around larger felling/processing heads that have a higher energy potential chain shot.
- Polycarbonate must be mounted securely as per original OEM installation or in the case of modified for forest operations purpose with appropriate bolts rather than rubber seals.
- Where minimum thickness is not met with original manufacturer design and conversion to recommended thickness is not feasible, an appropriate risk assessment is required to determine if adequate secondary shields, administrative controls and guarding can be installed to allow the machine to continue to operate safely.

- Sweeps may be added and are additional protection fitted to the machine primarily to protect the machine from the forestry environment and secondarily to aid in the protection of the cabin and operator. Sweeps are generally not certified and should not be attached to, interfere with, or in any way compromise the function of the ROPS / FOPS/ OPS.
- Note: Sweeps should be inspected for damage and cracking. Damaged or cracked sweeps will not protect the machine adequately and may break resulting in the machine being unserviceable. Mounting bolts and mounts should be inspected regularly to ensure they are serviceable.

Figure 12: Crawler tractor fitted with snigging winch or log grapple

Access/egress

- Cabin structure shall be fitted with an emergency exit in addition to the primary entrance / exit door. They should permit operators to get out of the cabin during a foreseeable emergency for example, rollover, submersion, fire, etc. The emergency exit shall be capable of being operated from inside and outside the cabin.

Forwarders

Figure 13: Forwarders

A Forwarder is a wheel based articulated tractor equipped with knuckle boom loader and set of bunks so that cut-to-length log products can be loaded on the bunks in the forest and extracted to road side where they are presented for further processing and/or transport.

Notable Cabin protection risks

- Machine rollover due to slope and/or unstable terrain
- Cabin impacted by logs or entire trees during loading process
- Load shifting on bunks and impacting cabin

Cabin – ROPS – FOPS – OPS

For machines that do not have the appropriate ISO 8082 ROPS, ISO 8083 FOPS, ISO 8084 OPS, and SAE J1356:2013 OFPS certification and labelling as part of the original manufacturer design, the protective systems will need to be verified and/or upgraded to at least meet the guidelines as follows:

- Cabin front, side and rear should be 12mm polycarbonate or thicker tested to meet OPS **or** steel mesh from top roof top to the curve of the sweep leaving the front section open for maximum visibility for the operator: 50mm x 50mm wire mesh x 5mm diameter.

- The roof should be steel sheeting 6mm thickness or polycarbonate clear sheeting of 12mm thickness tested to meet OPS.
- When working in a harvesting system where the risk is assessed as likely that the machine will work within 100 m **of an identified chain shot zone** it should be equipped with polycarbonate sheeting at least 19 mm thickness and where available a greater thickness is preferred, particularly working around larger felling/processing heads that have a higher energy potential chain shot.
- Polycarbonate must be mounted securely as per original OEM installation or in the case of modified for forest operations purpose with appropriate bolts rather than rubber seals.
- Where available from manufacturers for rear windows of forwarders operating on sloping terrain, it is suggested that additional engineered controls such as higher standard polycarbonate or intrusion bars are fitted.
- Where minimum thickness is not met with original manufacturer design and conversion to recommended thickness is not feasible, an appropriate risk assessment is required to determine if adequate secondary shields, administrative controls and guarding can be installed to allow the machine to continue to operate safely.
- For a front and rear cabin guard using vertical or horizontal bars, complying to these guidelines the maximum clear area between a set of bars should not exceed 100mm apart unless used in conjunction with polycarbonate sheeting 12 mm thickness or greater and be tested for OPS.
- Sweeps may be added and are additional protection fitted to the machine primarily to protect the machine from the forestry environment and secondarily to aid in the protection of the cabin and operator. Sweeps are generally not certified and should not be attached to, interfere with, or in any way compromise the function of the ROPS / FOPS/ OPS.
- Note: Sweeps should be inspected for damage and cracking. Damaged or cracked sweeps will not protect the machine adequately and may break resulting in the machine being unserviceable. Mounting bolts and mounts should be inspected regularly to ensure they are serviceable.

Figure 14: Forwarder

Access/egress

- Cabin structure shall be fitted with an emergency exit in addition to the primary entrance / exit door. They should permit operators to get out of the cabin during a foreseeable emergency for example, rollover, submersion, fire, etc. The emergency exit shall be capable of being operated from inside and outside the cabin.

Shovel Loggers

Figure 15: Shovel loggers

A Shovel logger can be a purpose build forestry machine or modified for purpose from an excavator base. It has a grapple and tends to work in steeper slopes using the grapple on a knuckle boom loader to handle bunches of trees or logs in incremental steps towards the road where they are presented for further processing and/or transport.

Notable Cabin protection risks

- Machine rollover due to slope and/or unstable terrain
- Cabin impacted by falling limbs, logs or entire trees

Cabin – ROPS – FOPS – OPS

For machines that do not have the appropriate ISO 8082 ROPS, ISO 8083 FOPS, ISO 8084 OPS, and SAE J1356:2013 OFPS certification and labelling as part of the original manufacturer design, the protective systems will need to be verified and/or upgraded to at least meet the guidelines as follows:

- Cabin front, side and rear should be 12mm polycarbonate or thicker tested to meet OPS **or** steel mesh from top roof top to the curve of the sweep leaving the front section open for maximum visibility for the operator: 50mm x 50mm wire mesh x 5mm diameter.
- The roof should be steel sheeting 6mm thickness or polycarbonate clear sheeting of 12mm thickness tested to meet OPS.

- When working in a harvesting system where the risk is assessed as likely that the machine will work within 100 m **of an identified chain shot zone** it should be equipped with polycarbonate sheeting at least 19 mm thickness and where available a greater thickness is preferred, particularly working around larger felling/processing heads that have a higher energy potential chain shot.
- Polycarbonate must be mounted securely as per original OEM installation, or in the case of modified for forest operations purpose with appropriate bolts rather than rubber seals.
- Where minimum thickness is not met with original manufacturer design and conversion to recommended thickness is not feasible, an appropriate risk assessment is required to determine if adequate secondary shields and guarding can be installed to allow the machine to continue to operate safely.
- For a front and rear cabin guard using vertical or horizontal bars, complying to these guidelines the maximum clear area between a set of bars should not exceed 100mm apart unless used in conjunction with polycarbonate sheeting 12 mm thickness or greater and be tested for OPS.
- Sweeps may be added and are additional protection fitted to the machine primarily to protect the machine from the forestry environment and secondarily to aid in the protection of the cabin and operator. Sweeps are generally not certified and should not be attached to, interfere with, or in any way compromise the function of the ROPS / FOPS/ OPS.
- Note: Sweeps should be inspected for damage and cracking. Damaged or cracked sweeps will not protect the machine adequately and may break resulting in the machine being unserviceable. Mounting bolts and mounts should be inspected regularly to ensure they are serviceable.
- ROPS framing/structure
  - > Not less than 75mm x 75mm RHS low carbon steel. Minimum wall thickness 6mm and a maximum unsupported span of 800mm.
  - > Flat low carbon steel sheet having a minimum thickness of 6mm and a maximum unsupported span of 800mm continuously welded (thicker plate material may allow for increased span where structural performance is equivalent).
  - > Re-enforced polycarbonate with a minimum thickness of 12 mm or greater and stiffening bars 50mm x 10mm on their edge placed at a maximum 100mm apart.
  - > After market ROPS fittings should be attached with plates of not less than 32mm thickness and secured by high tensile steel bolts (grade 8) of not less than 32mm diameter with a minimum of 4 bolts per footing placed in a non-sheer position.

Access/egress

Cabin structure shall be fitted with an emergency exit in addition to the primary entrance / exit door. They should permit operators to get out of the cabin during a foreseeable emergency for example, rollover, submersion, fire, etc. The emergency exit shall be capable of being operated from inside and outside the cabin.

Yarders

Figure 16: Yarders

Yarders can be classified as tower, swing yarder or excavator based. In Australia the main technology employed is large swing yarders with grapples.

Notable Cabin protection risks

- Cable whip and impact if a cable breaks under tension.
- Machine rollover due to slope and/or unstable terrain.
- Cabin impacted by logs or entire trees.

Cabin – ROPS – FOPS – OPS

For machines that do not have the appropriate ISO 8082 ROPS, ISO 8083 FOPS, ISO 8084 OPS, and SAE J1356:2013 OFPS certification and labelling as part of the original manufacturer design, the protective systems will need to be verified and/or upgraded to at least meet the guidelines as follows:

- Cabin front, side and rear should be 12mm polycarbonate or thicker, tested to meet OPS or steel mesh from roof top to the curve of the sweep leaving the front section open for maximum visibility for the operator: 50mm x 50mm wire mesh x 5mm diameter.
- **Note**: Leave room for operator access on both sides of the machine if guards are not fitted to door i.e. open canopy bulldozer.
- The roof should be steel sheeting 6mm thickness or polycarbonate clear sheeting of 12mm thickness tested to meet OPS.

- When working in a harvesting system where the risk is assessed as likely that the machine will work within 100 m **of an identified chain shot zone** it should be equipped with polycarbonate sheeting at least 19 mm thickness and where available a greater thickness is preferred, particularly working around larger felling/processing heads that have a higher energy potential chain shot.
- Polycarbonate must be mounted securely as per original OEM installation, or in the case of modified for forest operations purpose with appropriate bolts rather than rubber seals.
- Where minimum thickness is not met with original manufacturer design and conversion to recommended thickness is not feasible, an appropriate risk assessment is required to determine if adequate secondary shields and guarding can be installed to allow the machine to continue to operate safely.
- Guards should be fitted to protect the operator from flying ropes, broken shackles, machine tip over or other rigging components which may break during operation. Transmission, machinery and hazardous moving parts on yarders should be securely fenced or totally enclosed in accordance with AS 4024.1201-2006.

Access/egress

- Cabin structure shall be fitted with an emergency exit in addition to the primary entrance / exit door. They should permit operators to get out of the cabin during a foreseeable emergency for example, rollover, submersion, fire, etc. The emergency exit shall be capable of being operated from inside and outside the cabin.

OTHER FOREST OPERATIONS EQUIPMENT

Log loaders

Figure 17: Log loaders

A log loader can be a purpose build forestry machine, a truck mounted crane, or modified for purpose from an excavator base. It has a grapple on a knuckle boom crane and tends to work at or near road side. They are used to pick up and move trees and logs for sorting, measuring and processing or to load the logs on a truck for transport.

Notable Cabin protection risks

- Machine rollover due to slope and/or unstable terrain.
- Cabin impacted by falling limbs, logs or entire trees.

Cabin – ROPS – FOPS – OPS

For machines that do not have the appropriate ISO 8082 ROPS, ISO 8083 FOPS, ISO 8084 OPS, and SAE J1356:2013 OFPS certification and labelling as part of the original manufacturer design, the protective systems will need to be verified and/or upgraded to at least meet the guidelines as follows:

- Cabin front, side and rear should be 12mm polycarbonate or thicker tested to meet OPS or steel mesh from top roof top to the curve of the sweep leaving the front section open for maximum visibility for the operator: 50mm x 50mm wire mesh x 5mm diameter.
- The roof should be steel sheeting 6mm thickness or polycarbonate clear sheeting of 12mm thickness tested to meet OPS.
- When working in a harvesting system where the risk is assessed as likely that the machine will work within 100 m **of an identified chain shot zone** it should be equipped with polycarbonate sheeting at least 19 mm thickness and where available a greater thickness is preferred, particularly working around larger felling/processing heads that have a higher energy potential chain shot.

- Polycarbonate must be mounted securely as per original OEM installation, or in the case of modified for forest operations purpose with appropriate bolts rather than rubber seals.
- Where minimum thickness is not met with original manufacturer design and conversion to recommended thickness is not feasible, an appropriate risk assessment is required to determine if adequate secondary shields, administrative controls and guarding can be installed to allow the machine to continue to operate safely.
- For a front and rear cabin guard using vertical or horizontal bars, complying to these guidelines the maximum clear area between a set of bars should not exceed 100mm apart unless used in conjunction with polycarbonate sheeting 12 mm thickness or greater and be tested for OPS.
- Sweeps may be added and are additional protection fitted to the machine primarily to protect the machine from the forestry environment and secondarily to aid in the protection of the cabin and operator. Sweeps are generally not certified and should not be attached to, interfere with, or in any way compromise the function of the ROPS / FOPS/ OPS.
- Note: Sweeps should be inspected for damage and cracking. Damaged or cracked sweeps will not protect the machine adequately and may break resulting in the machine being unserviceable. Mounting bolts and mounts should be inspected regularly to ensure they are serviceable.
- ROPS framing/structure
  - > Not less than 75mm x 75mm RHS low carbon steel. Minimum wall thickness 6mm and a maximum unsupported span of 800mm.
  - > Flat low carbon steel sheet having a minimum thickness of 6mm and a maximum unsupported span of 800mm continuously welded (thicker plate material may allow for increased span where structural performance is equivalent).
  - > Re-enforced polycarbonate with a minimum thickness of 12 mm or greater and stiffening bars 50mm x 10mm on their edge placed at a maximum 100mm apart.
  - > After market ROPS fittings should be attached with plates of not less than 32mm thickness and secured by high tensile steel bolts (grade 8) of not less than 32mm diameter with a minimum of 4 bolts per footing placed in a non-sheer position.

Access/egress

Cabin structure shall be fitted with an emergency exit in addition to the primary entrance / exit door. They should permit operators to get out of the cabin during a foreseeable emergency for example, rollover, submersion, fire, etc. The emergency exit shall be capable of being operated from inside and outside the cabin.

Excavators and Backhoes (earthmoving)

Figure 18: Excavators and backhoes

An excavator or backhoe are primarily used for earth moving activities related to forest operations. The excavator will have a boom arrangement with different attachments fit for purpose such as rakes and buckets. The backhoe tends to be a smaller machine and, in addition to the boom with different attachments, includes a front end loader attachment for digging, pushing and lifting material.

Notable Cabin protection risks

- Machine rollover due to slope and/or unstable terrain.
- Cabin impacted by falling rocks, limbs, logs or entire trees.

Cabin – ROPS – FOPS – OPS

For machines that do not have the appropriate ISO 8082 ROPS, ISO 8083 FOPS, ISO 8084 OPS, and SAE J1356:2013 OFPS certification and labelling as part of the original manufacturer design, the protective systems will need to be verified and/or upgraded to at least meet the guidelines as follows:

- Cabin front, side and rear should be 12mm polycarbonate or thicker tested to meet OPS or steel mesh from top roof top to the curve of the sweep leaving the front section open for maximum visibility for the operator: 50mm x 50mm wire mesh x 5mm diameter.
- The roof should be steel sheeting 6mm thickness or polycarbonate clear sheeting of 12mm thickness tested to meet OPS.
- When working in a harvesting system where the risk is assessed as likely that the machine will work within 100 m **of an identified chain shot zone** it should be equipped with polycarbonate sheeting at least 19 mm thickness and where available a greater thickness is preferred, particularly working around larger felling/processing heads that have a higher energy potential chain shot.

- Polycarbonate must be mounted securely as per original OEM installation, or in the case of modified for forest operations purpose with appropriate bolts rather than rubber seals.
- Where minimum thickness is not met with original manufacturer design and conversion to recommended thickness is not feasible, an appropriate risk assessment is required to determine if adequate secondary shields and guarding can be installed to allow the machine to continue to operate safely.
- For a front and rear cabin guard using vertical or horizontal bars, complying to these guidelines the maximum clear area between a set of bars should not exceed 100mm apart unless used in conjunction with polycarbonate sheeting 19 mm thickness or greater and be tested for OPS.
- Sweeps may be added and are additional protection fitted to the machine primarily to protect the machine from the forestry environment and secondarily to aid in the protection of the cabin and operator. Sweeps are generally not certified and should not be attached to, interfere with, or in any way compromise the function of the ROPS / FOPS/ OPS.
- Note: Sweeps should be inspected for damage and cracking. Damaged or cracked sweeps will not protect the machine adequately and may break resulting in the machine unserviceable. Mounting bolts and mounts should be inspected regularly to ensure they are serviceable.
- ROPS framing/structure
  - > Not less than 75mm x 75mm RHS low carbon steel. Minimum wall thickness 6mm and a maximum unsupported span of 800mm.
- For hydraulic excavators:
  - > Mass greater than 20,000kg - not less than 100 x 100mm RHS low carbon steel. Minimum wall thickness 6mm and a maximum unsupported span of 800mm.
  - > Mass less than 20,000kg - not less than 75mm x 75mm RHS low carbon steel. Minimum wall thickness of 6mm and a maximum unsupported span of 1500mm.

Access/egress

Cabin structure shall be fitted with an emergency exit in addition to the primary entrance / exit door. They should permit operators to get out of the cabin during a foreseeable emergency for example, rollover, submersion, fire, etc. The emergency exit shall be capable of being operated from inside and outside the cabin.

Bulldozer

Figure 19: Bulldozers

A Bulldozer is a tracked based tractor equipped with a blade or rake for pushing, ripping and moving earth, rocks and harvest residues.

Notable Cabin protection risks

- Machine rollover due to slope and/or unstable terrain
- Cabin impacted by logs, rocks or entire trees

Cabin – ROPS – FOPS – OPS

For machines that do not have the appropriate ISO 3471 ROPS, ISO 8083 FOPS, ISO 8084 OPS, and SAE J1356:2013 OFPS certification and labelling as part of the original manufacturer design, the protective systems will need to be verified and/or upgraded to at least meet the guidelines as follows:

- Cabin front, side and rear should be 12mm polycarbonate or thicker tested to meet OPS or steel mesh from roof top to the curve of the sweep leaving the front section open for maximum visibility for the operator: 50mm x 50mm wire mesh x 5mm diameter.
- Note: Leave room for operator access on both sides of the machine if guards are not fitted to door i.e. open canopy bulldozer.
- The roof should be steel sheeting 6mm thickness or polycarbonate clear sheeting of 12mm thickness tested to meet OPS.

- When working in a harvesting system where the risk is assessed as likely that the machine will work within 100 m **of an identified chain shot zone** it should be equipped with polycarbonate sheeting at least 19 mm thickness and where available a greater thickness is preferred, particularly working around larger felling/processing heads that have a higher energy potential chain shot.
- Polycarbonate must be mounted securely as per original OEM installation, or in the case of modified for forest operations purpose with appropriate bolts rather than rubber seals.
- Where minimum thickness is not met with original manufacturer design and conversion to recommended thickness is not feasible, an appropriate risk assessment is required to determine if adequate secondary shields and guarding can be installed to allow the machine to continue to operate safely.
- Sweeps may be added and are additional protection fitted to the machine primarily to protect the machine from the forestry environment and secondarily to aid in the protection of the cabin and operator. Sweeps are generally not certified and should not be attached to, interfere with, or in any way compromise the function of the ROPS / FOPS/ OPS.
- Note: Sweeps should be inspected for damage and cracking. Damaged or cracked sweeps will not protect the machine adequately and may break resulting in the machine being unserviceable. Mounting bolts and mounts should be inspected regularly to ensure they are serviceable.

Access/egress

Cabin structure shall be fitted with an emergency exit in addition to the primary entrance / exit door. They should permit operators to get out of the cabin during a foreseeable emergency for example, rollover, submersion, fire, etc. The emergency exit shall be capable of being operated from inside and outside the cabin.

LABELLING REQUIREMENTS

Information indicating the suitability of a structure added to a machine aftermarket should be marked on an identification plate and should include:

- The name and address of the manufacturer or modifier,
- Date of certification,
- The test number of the ROPS/FOPS,
- ROPS complies with AS/NZ 22.94.1,
- FOPS comply with ISO 8083,
- The serial number of the machine to which it is fitted, and the label is fixed to focal point where it is visible for inspection,
- Certified labels can only be provided by the machine operator/ attachment supplier or manufacturer, or certified engineer. All ROPS/FOPS to be certified, compliance labelling must be attached to the structure as noted above.

Factory integrated designed cabin protection should be labelled with ISO labelling.

Figure 20: Labelling requirements

OPS

Machines fitted with OPS may not always have a compliance label fitted.

Where this is the case, documentation must be readily available on request detailing compliance to an Australian or International Standard (AS/ISO) or an approved risk assessment. Any modification done to the machine must not interfere with or compromise the existing safety systems.

RISK ASSESSMENT

A comprehensive risk assessment must be carried out on each piece of equipment prior to commencing operations. This risk assessment will be consistent with the National Standard for Equipment [NOHSC:1010(1994)] clause 65.

A comprehensive risk assessment must also be carried out on the site or compartments the equipment is to be used on prior to commencing operations.

Risk assessment requirements for equipment

Equipment assessment - documented risk assessments should include but not be limited to:

- Confirm the equipment is fit for the purpose and provides the appropriate level of protection for operators and meets all legislation, standards, and best practice for the working environment.
- Confirm the maintenance of the equipment is current and up to date.
- Inspect the machine for existing damage or repairs that may compromise the operator's safety.
- Verify all safety and mechanical features are functioning properly.
- Verify the operator holds an appropriate certificate of competency, issued by an RTO for the operating environment and equipment.

Site or compartments assessment - Documented risk assessments should include but not be limited to:

- **Terrain** – risk of the equipment rolling over, sliding or the operator losing control.
- **Ground conditions** – add further risks or introduce new risks to the operations i.e. slippery conditions can increase the risk of the loss of control of equipment.
- **Erosion** –check if erosion is present on the site which could increase the likelihood of equipment roll over.

- **Exclusion zones** – confirm that any present on site have been well marked and conveyed to the contractor.
- **Trees** – size of trees and average log size within the work area or residual native vegetation can increase the risk of falling objects in the operation.
- **Debris on the ground** – if debris on the ground is travelled over by the equipment there may be a greater need for ground clearance and operator protective guarding.
- **Stumps or stump holes** – can adversely affect the stability of equipment often causing sideways movement off the stump and a greater risk of roll over or of injury to the operator by the sudden movement or jarring when the equipment strikes or moves off the stumps.
- **Second rotation** sites - in particular require greater care in the selection of equipment to be used on these sites, things such as operator comfort, sudden movement off stumps, jarring the operator while travelling over the stumps, requirement for the operator to be looking behind, seat belts, operator protection from falling and flying objects, operator fatigue, ground clearance and working in isolation should be considered.

Table 2: Summary of requirements for all machines[2]

	Required for best practice	Recommended for best practice
ROPS (Rollover Protection)	✓	
FOPS (Falling objects protection)	✓	
OPS Side & Rear Mesh Guarding and or Polycarbonate Windows if fitted with a hydraulic powered saw	✓	
Seat belt if fitted by the manufacturer	✓	
Equipment Risk Assessment	✓	
Fire Extinguisher/s	✓	
Fire suppression system		✓
Log books/ Daily inspection sheets	✓	
Maintenance records and machine inspections	✓	
Operators Manual instructions	✓	
Equipment registration where applicable	✓	
First Aid equipment (on machine or nearby)	✓	

2 safety helmets not required while in a properly guarded cab

APPENDIX A – RELATED DOCUMENTS

AS 2294.1 Supplement 1-2003	Earth-moving machinery - Supplement 1: Operator protective structures fitted to equipment used in the timber industry (forest operations)
AS 2294.2 - 1997	Earth-moving machinery - Protective structures, laboratory tests and performance requirements for rollover protective structures
AS 2294.4	Earth-moving machinery - Protective structures, specifications for defecting limited volumes
AS 1636.1	Tractor - rollover protective structures (ROPS). Criteria and tests - conventional tractors
AS 4100 - 1998	Steel structures
AS 4988:2002	Earth-moving machinery - Hydraulic excavators - Laboratory tests and performance requirements for operator protective guards
ISO 3449.3:2005 (replaces AS 2294.3:1997)	Earth-moving machinery - Protective structures, laboratory tests and performance requirements for falling objects protective structures
ISO 3471:2008	Earth-moving machinery — Roll over protective structures — Laboratory tests and performance requirements
ISO 80821:20093	Self-propelled machinery for forestry — Laboratory tests and performance requirements for roll over protective structures — Part 1: General machines
ISO 8082-2:2011	Self-propelled machinery for forestry — Laboratory tests and performance requirements for roll over protective structures — Part 2: Machines having a rotating platform with a cabin and boom on the platform
ISO 8083:2006	Self-propelled machinery for forestry - Falling object protective structures, laboratory tests and performance requirements
ISO 8084:2003	Machinery for forestry operator protective guards (OPS) - Laboratory tests and performance requirements
ISO 10262	Earth-moving machinery — Hydraulic excavators — Laboratory tests and performance requirements for operator protective guards
ISO/DIS: 21876	Machinery for forestry — Saw chain shot protective windows — Test method and performance criteria
ISO/CD: 11839	Machinery for forestry — Glazing and panel materials used in operator enclosures for protection against thrown saw teeth — Test method and performance criteria
J1040	Minimum performance requirements for rollover protection for purpose-built forestry machinery
SAE J1194	Minimum performance requirements for rollover protection structures (ROPS) designed for wheel-type tractors
SAE J1356	Minimum performance criteria for falling object guards for excavators
SAE J2267	Minimum Performance Criteria for Operator Front Protective Structure (OFPS) for Certain Equipment

OTHER REFERENCES

Forest Growers Research. 2016. Harvesting Technology Watch – Excavator Yarders for New Zealand. Available Online: https://www.fgr.nz/documents/download/3765.

FITC. 2005. Best practice guidelines for Cable Logging. Available Online: https://www.competenz.org.nz/assets/Uploads/Cable-Logging.pdf.

Garland, J., Rummer, R. 2009. Understanding the hazards of thrown objects: Incidents, research and resolutions. 2009 Council on Forest Engineering (COFE) Conference Proceedings: "Environmentally Sound Forest Operations." Lake Tahoe, June 15-18, 2009. USA.

Garland, J., Rummer, R. 2009. Understanding the hazards of thrown objects: Incidents, research and resolutions. 2009 Council on Forest Engineering (COFE) Conference Proceedings: "Environmentally Sound Forest Operations." Lake Tahoe, June 15-18, 2009.USA.

Oregon Products. 2013. Harvester chain shot. Council of Forest Engineering Seminar, October 2013. USA. 108 p.

Safe Work Australia - Forestry operations guidance material. Available online: https://www.safeworkaustralia.gov.au/collection/forestry-operations-guidance-material.

Visser, R.; Harrill, H. 2017. Cable Yarding in North America and New Zealand: A Review of Developments and Practices. Croatian Journal of Forest Engineering 38: 209–217.

Washington State Fatality Assessment and Control (WA FACE). 2014. Timber harvester operator killed following a chain shot incident. 27 p. Available online: https://lni.wa.gov/safety-health/safety-research/files/2014/52302014HarvesterOperatorChainShot.pdf

Work Safe Victoria. 2007. Industry standard, safety of forestry operations (harvesting and haulage). 77 p. Available online: https://www.worksafe.vic.gov.au/resources/safety-forestry-operations-harvesting-and-haulage.

ACKNOWLEDGEMENT

The Forest Industries Research Centre would like to recognise Owen Spicer and PF Olsen Australia for the significant contribution made in providing the base document used to produce this best practice.

The authors, **MR. Ghaffariyan, M. Berry, and M. Brown** from the Forest Industries Research Centre would also like to acknowledge the extensive review input provided by all the forest growers, contractors and equipment suppliers that contributed to the project advisory committee, with a particular thanks to Laura Maddock for coordinating the advisory committee