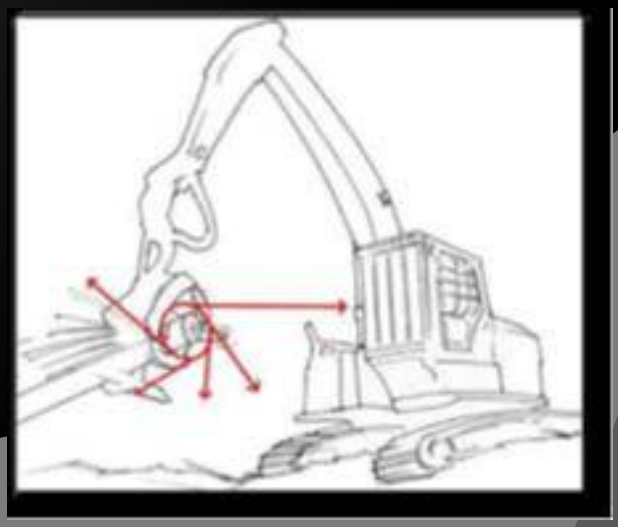
FORESTRY PLANT & EQUIPMENT

GUARDING OF EXCAVATOR BASED MACHINES IN FORESTRY OPERATIONS

INTRODUCTION

- Mechanised equipment in the forestry sector provides a safer working environment with fewer people infield that manual operations.
- Operators must however be protected against falling, flying or intruding objects or material by means of suitable cabs, screens, grills, shields, deflectors, guards and/or structures.
- Machines used in forestry can include equipment from construction manufacturers e.g.excavators, agricultural manufacturers e.g. tractors and forestry equipment manufacturers .



INTRODUCTION

- Most machines come standard with the following applicable to the industry for which it was designed and built :
  - ROPS: roll-over protective structures
  - FOPS: falling object protective structures
  - TOPS: tip over protective structures
  - OPS: operator protection structures
- When equipment from one industry is introduced into a different industry, the machine specifications may no longer be sufficient to meet the new industry's safety requirements.

RISK ASSESSMENT

- The reason for having to fit additional safety features on excavators introduced into forestry operations is found in the OHS Act where an excavator cab is regarded as an “operator’s workplace”.
- A typical equipment operator workplace (cab) is subjected to four main risks:

  - The machine rolling over
  - The cab being hit by falling objects
  - Flying objects penetrating the cab
  - The machine tipping over onto its side

OBJECTIVE

- To meet safety requirements, a purpose-built machine designed for forestry operations could be sourced.
- However, in South Africa it is normally more economically feasible to source machines designed for generic applications and modify them for forestry operations.
- The following risk control measures can be evaluated and implemented:

  - Install sufficient ROPS, FOPS and cab protection
  - Define operational capabilities on the machine, for example slope limitation.
  - Ensure operators are trained and competent in the use of the machine
  - Maintain machine and components to an acceptable standard

Operator Protective Structures

- Protective structures should be fitted to excavator-based machines used in forestry.
- These structures must be designed and installed to provide an adequate view for the operator.

OPERATOR PROTECTIVE STRUCTURES

- The matrix that follows is based on the technical capability of the attachment fitted to the machine.
- The only other criteria used will be if small flying objects (chain teeth etc) are present or not.
- It has been assumed in the matrix that machines will adhere to accepted safe working distances from other forestry machines during operations.
- Note that the matrix specifies the minimum requirements.

OPERATOR PROTECTIVE STRUCTURES

Machine Type	ROP	FOP	OPS	OP Guards (e.g bars Mesh)	OP Guards (polycarbonate Glazing)	OP Guards (Chain catchers & energy absorbing chain shot guards)	Operator Restraint (Safety Belts)
Harvester	Y	Y	Y	Y	Y	Y	Y
FB	Y	Y	Y	Y	Y	Y C/saw	Y
Processor Roadside	N	N	Y	N	Y	Y	Y
Processor Infield	Y	Y	Y	N	Y	Y	Y
Debarker Delimbing	Y / N	Y / N	Y	Y	Y	N	Y
Shovel Logging	Y / N	Y / N	Y	Y	Y	NA	Y
Log Loading	Y / N	N	Y	Y	N	NA	Y

Operator Protective Structures

- ROPS: All machines which are going infield should have ROPS.
- FOPS: Not needed for processors, de-barkers, shovel logging and log loading, unless going infield.
- OPS: Bars/mesh: Machines that should have bars/mesh include all machines, unless polycarbonate glass is thick enough for it to not be necessary.

Operator Protection Structures

- The ISO (International Organization for Standardization) standard descriptions for:
  - Roll Over Protection Structures (ROPS)
  - Falling Objective Structures (FOPS)
  - Operator Protection Structures (OPS)
  - Operator Protective Guards

  were used as a guide to determine the required safety features.

OPERATOR PROTECTIVE GUARDS

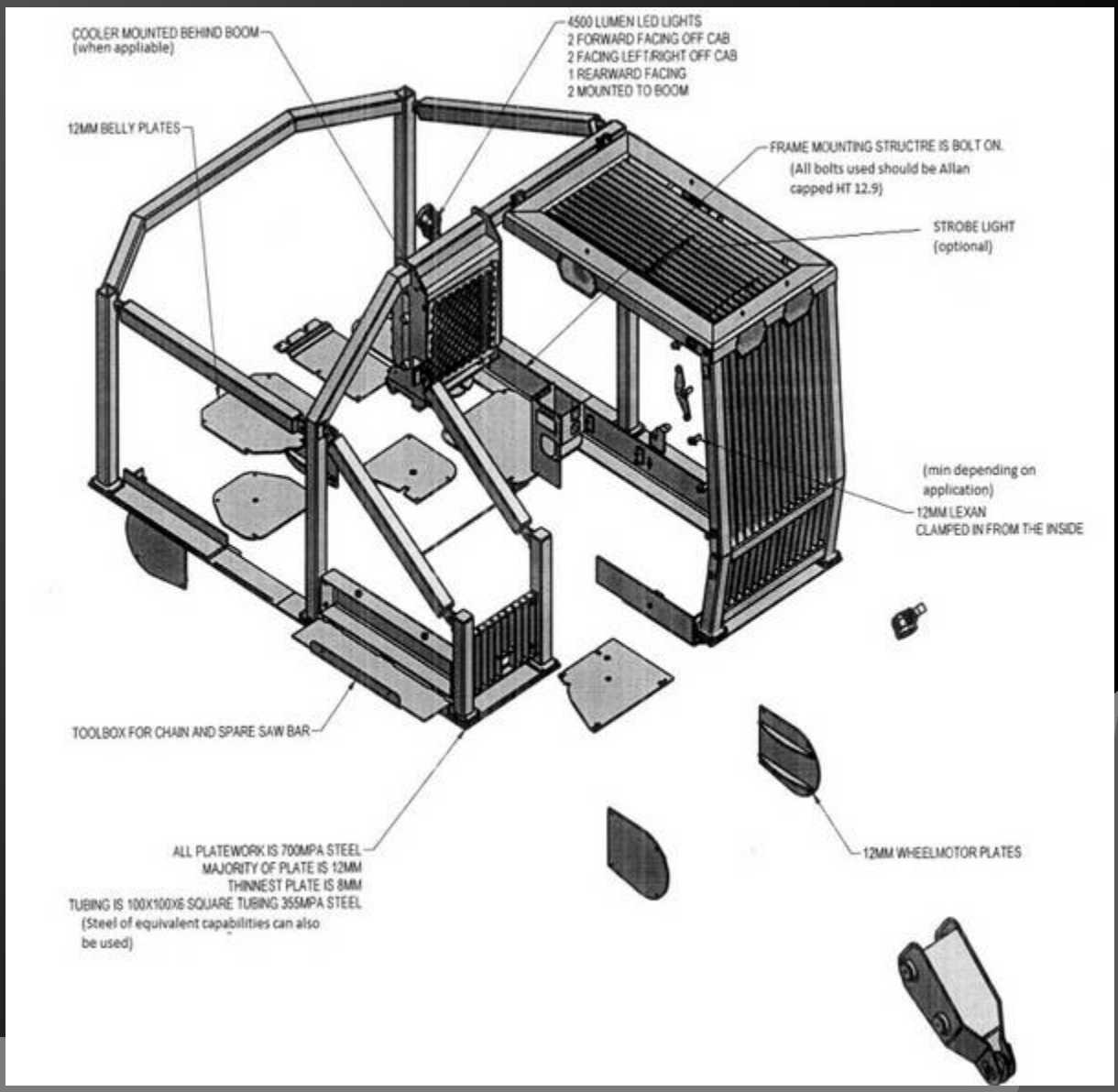
- Each machine must have a cab that is fully enclosed with mesh material/vertical bars with openings no greater than 50mm.
- The cab may be closed with other material where it can be demonstrated that such material provides equivalent protection and visibility.
- Guards must be installed in front of all window areas exposed to flying or intruding hazards.

OPERATOR PROTECTIVE GUARDS

- The enclosure of the upper portion of the cab must allow maximum visibility.
- Visibility is not required for the lower portion of the cab where there are control panels.
- The guards should be a minimum of 100mm and a maximum of 200mm from the window.

OPERATOR PROTECTIVE GUARDS

- The diagram of FOPS and OPS below only serves as an example. The final design will depend on the type and excavator manufacturer.



OPERATOR PROTECTIVE GUARDS (polycarbonate glazing)

- When transparent material is used to enclose the upper portion of the cab, it must be made of safety glass that provides equivalent protection and visibility.
- Safety glass that is cracked or broken may create a hazard for the operator and must be replaced before work is permitted to continue.
- The safety glass should be fitted on the outside of the machine cab, if possible.
- Safety glass (polycarbonate) should be at least 12mm to 32mm thick depending on application used.
- Curved or angled safety glass appears to guide flying object away more easily when hitting the glass.

TIP OVER PROTECTION STRUCTURE (TOPS)

- Operator protective structures must have a minimum of two exits, allowing for exit after a roll over.
- The alternative emergency exit must be clearly marked both inside and outside the cab.
- Where damage has been sustained to any structure, the machine should be assessed by the original designer or other suitable qualified and experienced personnel.
- Doors and hatches must be closed during operations.

OPERATOR PROTECTIVE GUARDS

Guards and Shields

- Due to high speeds, high stress, heavy loads, wear factors, and varying levels of repair and maintenance given to saw-chain and disc saw based equipment, there is a possibility that chain or chain pieces can be thrown from the machine at high speed.
- Operators and bystanders are exposed to a risk of serious injury.
- Machines should be designed with appropriate guards and shields, and care should be taken to minimize the exposure of users and bystanders to the cutting plane of the saw.

OPERATOR PROTECTIVE GUARDS

Guards and Shields

- All operators must be protected either by machine guarding or by work position from hazards such as being injured by chain shot.

- For maximum protection, machines should be equipped with a Chain Catcher, and an energy absorbing chain shot guard.

OPERATOR PROTECTIVE GUARDS

Chain Catcher

- A Chain Catcher can help contain thrown chain links, and is a complement to guards and shields.
- The Chain Catcher is a sturdy rod placed perpendicular to the centre of the drive sprocket.
- It can be mounted either to the drive shaft, or to the saw box, with a narrow gap to allow for chain installation and removal.

Deflector and chain catcher peg

OPERATOR PROTECTIVE GUARDS

Chain Shot Guard

- A Chain Shot Guard is an energy-absorbing piece of material (such as heavy rubber) mounted behind the drive sprocket.
- This guard absorb's the energy of a broken chain coming in contact with the saw box, and prevents chain parts from breaking off and being ejected.
- It also acts as an extension of the saw box, reducing the opportunity for thrown chain or chain parts to escape the saw box.

OPERATOR PROTECTIVE GUARDS

Chain Shot Guard

- The table below summarizes typical values with comparative ballistic benchmarks.
- Chain shot has properties similar to a 9 mm bullet.
- Saw teeth and mulcher teeth, while similar in energy to a shotgun slug, are heavier and slower.

Type of object	Mass (g)	Velocity (M/S)	Energy (J)
.404 c/saw tooth	11	300	495
50mm saw tooth	300	85	1084
60mm saw tooth	800	110	4840
Fixed tooth mulcher	1800	46	1904
9mm bullet	8	358	513
12-gauge rifled slug	28	483	3266

OPERATOR PROTECTIVE GUARDS

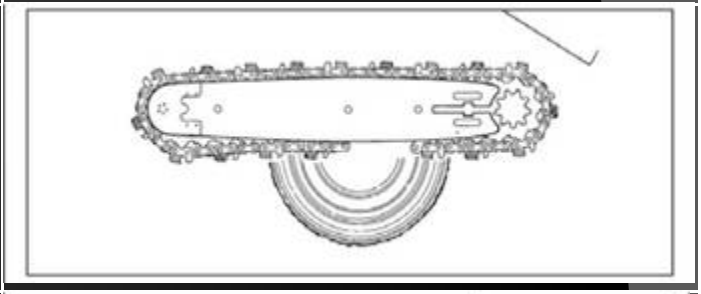
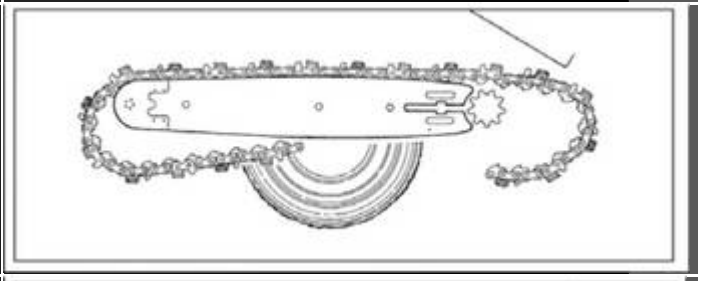
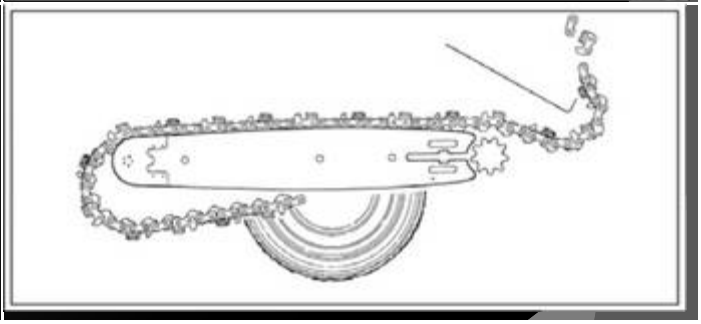
- Three window configuration testing results:

Type	Thickness In mm	Description
1	19	Polycarbonate - LEXGARD® RC-750 laminate - three-ply LEXAN® polycarbonate
2	19	Polycarbonate / Acrylic - LEXGARD MP750 laminate is a three-ply LEXAN® polycarbonate and acrylic laminate
3	32	Polycarbonate - LEXGARD® SP-1250 laminate - four-ply LEXAN® polycarbonate laminate

Type	No of Tests	Observations
1	10	Projectiles were able to penetrate the material and cause a 5mm deformation on the rear surface on the window.
2	7	Projectiles where able to penetrate the outer polycarbonate layer, but were contained by the acrylic layer. The rear layer of polycarbonate was not penetrated, however it was partially delaminated.
3	9	Projectiles were able to penetrate the material to a maximum depth of 18 mm.

OPERATOR PROTECTIVE GUARDS

- The Mechanical Harvesting Handbook (Oregon 2004) explains the phenomenon of chain shot:

Sequence of events	Diagrammatic representaion
After a chain break ……	
The free end of the chain begins to whip away from the break.	
If the chain is not contained by the saw box or an energy-absorbing guard, the broken chain's free end can speed up rapidly and carry immense dynamic energy.	
At the peak of the whip, chain parts may break loose and be ejected at high speed, especially if the free end of the chain strikes the saw box. Chain shot can cause chain parts to be thrown in many directions, especially along the plane of the saw bar.	Fragments have been measured at between 180 and 310 m/s under laboratory simulated conditions.

OPERATOR PROTECTIVE GUARDS

- Examples for flying objects:

- There is a wide variety of cutting tools with teeth that range in mass.
- Operating speeds also vary depending on the type of cutter and the intended application.
- Each of the illustrated objects has become detached although there is no information on frequency of occurrence or incident rate.
- While failure modes are unclear, the general assumption is that thrown objects have an initial velocity equal to the tip speed of the cutting tool.

SEAT BELTS

- A seat belt must be provided for all machines.
- Each machine seat belt must meet the requirements of the SABS/SANS.

LIGHTS

- Additional lights should be fitted to the cab. Good visibility at night is essential for safe operation.

SUMMARY

- Perform a risk assessment when purchasing new equipment to consider if engineering designs can reduce the risk to the operator.
- Ask manufacturers what designs are in place to reduce risks to the operators.
- Ultimately, selection of a machine depends upon things like the intended use, operational environment, economic considerations and availability of machines.
- It is the responsibility of those who select the machine to determine the relevant information to be provided to a supplier so that both parties can make a well-informed decision on machine suitability and associated safety risks.