Approved Code of Practice for

OPERATOR PROTECTIVE STRUCTURES

ON SELF-PROPELLED MOBILE MECHANICAL PLANT

OCCUPATIONAL SAFETY & HEALTH SERVICE

New Zealand Contractors' Federation [Inc.]

DEPARTMENT OF LABOUR
TE TARI MAHI

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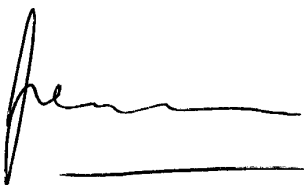
ABOUT THIS CODE

This code of practice has been prepared jointly by the Occupational Safety and Health Service and the New Zealand Contractors' Federation, in consultation with the construction and forestry industries. It provides best practice measures for employers to consider when managing mechanical plant roll over hazards in a way that meets the requirements of the Health and Safety in Employment Act and Regulations.

All the code's requirements are based on Standards produced by the International Organisation for Standardisation (ISO) or joint Australian/ New Zealand Standards. All referenced Standards are listed in Appendix A.

NOTICE OF ISSUE

I have issued this *Approved Code of Practice for Operator Protective Structures on Self-Propelled Mobile Mechanical Plant,* being a statement of preferred work practices or arrangements for the purpose of ensuring the health and safety of persons to which this code applies and persons who may be affected by the activities covered by this code.



J. M. Chetwin
Secretary of Labour
February 1999

FOREWORD

I have approved this statement of preferred work practices, which is an *Approved Code of Practice for Operator Protective Structures on Self-Propelled Mobile Mechanical Plant,* under section 20 of the Health and Safety in Employment Act 1992. When a code is approved, a Court may have regard to it in relation to compliance with the relevant sections of the Health and Safety in Employment Act. This means that if an employer in an industry or using a process to which an approved code applies can show compliance with that code in all matters it covers, a Court may consider this to be compliance with the provisions of the Act to which the code relates.

Hon. Max Bradford
Minister for Enterprise and Commerce
February 1999

A SUMMARY OF THE HEALTH AND SAFETY IN EMPLOYMENT ACT 1992

OBJECT OF THE ACT

The principal object of the Health and Safety in Employment Act 1992 (HSE Act) is to prevent harm to employees at work. To do this, it imposes duties on employers, employees, principals and others, and promotes excellent health and safety management by employers. It also provides for the making of regulations and codes of practice.

REGULATIONS

Regulations are promulgated from time to time under the HSE Act. The HSE Regulations 1995 impose duties on employers, employees, designers, manufacturers, suppliers and others relating to health and safety. These regulations apply to places of work, plant, processes or substances and have been made to deal with particular problems that have arisen. They provide minimum acceptable standards.

APPROVED CODES OF PRACTICE

'Approved codes of practice' are provided for in the HSE Act. They are statements of preferred work practice or arrangements, and may include procedures which could be taken into account when deciding on the practicable steps to be taken. Compliance with codes of practice is not mandatory. However, they may be used as evidence of good practice in court.

EMPLOYERS' DUTIES

Employers have the most duties to perform to ensure the health and safety of employees.

Employers have a general duty to take all practicable steps to ensure the safety of employees at work. In particular, they are required to take all practicable steps to:

- Provide and maintain a safe working environment;
- Provide and maintain facilities for the safety and health of employees at work;
- Ensure that machinery and equipment is safe for employees;
- Ensure that working arrangements are not hazardous to employees; and
- Provide procedures to deal with emergencies that may arise while employees are at work.

Taking 'all practicable steps', in relation to achieving any result in any circumstances, means all steps to achieve the result that it is reasonably practicable to take in the circumstances, having regard to:

(a) The nature and severity of the harm that may be suffered if the result is not achieved; and

(b) The current state of knowledge about the likelihood that harm of that nature and severity will be suffered if the result is not achieved; and

(c) The current state of knowledge about harm of that nature; and

(d) The current state of knowledge about the means available to achieve the result, and about the likely efficacy of each; and

(e) The availability and cost of each of those means;

to ensure safety.

HAZARD MANAGEMENT

Employers must identify and regularly review hazards in the place of work (existing, new and potential), to determine whether they are significant hazards and require further action. Employers are required to record details of harm or situations that could have caused harm in their place of work. Employers are also required to investigate incidents where serious harm occurs to determine if it was caused by or arose from a significant hazard.

'Significant hazard' means a hazard that is an actual or potential cause or source of:

- Serious harm; or
- Harm (being more than trivial) where the severity of effects on any person depend (entirely or among other things) on the extent or frequency of the person's exposure to the hazard; or
- Harm that does not usually occur, or usually is not easily detectable, until a significant time after exposure to the hazard.

Where the hazard is significant the HSE Act sets out the steps employers must take:

- Where practicable, the hazard must be *eliminated.*
- If elimination is not practicable, the hazard must be *isolated.*
- If it is impracticable to eliminate or isolate the hazard completely, then the employers must *minimise* the hazard to employees.

Where a hazard cannot be eliminated or isolated, employers must in addition, where appropriate:

- Ensure that protective clothing and equipment is provided, accessible and used;
- Monitor employees' exposure to the hazard;

- Seek the consent of employees to monitor their health; and
- With informed consent, monitor employees' health.

INFORMATION FOR EMPLOYEES

Before employees begin work, they must be informed by their employer of:

- Hazards employees may be exposed to while at work;
- Hazards employees may create which could harm other people;
- How to minimise the likelihood of these hazards becoming a source of harm to themselves and others;
- The location of safety equipment; and
- Emergency procedures.

Employers are also required to inform employees of the results of any health and safety monitoring. In doing so, the privacy of individual employees must be protected.

EMPLOYERS TO INVOLVE EMPLOYEES IN THE DEVELOPMENT OF HEALTH AND SAFETY PROCEDURES

Employers need to ensure that all employees have the opportunity to be fully involved in the development of procedures for the purpose of identifying hazards, dealing with significant hazards, dealing with or reacting to emergencies and imminent dangers.

TRAINING OF EMPLOYEES

Employers must ensure employees are either sufficiently experienced to do their work or are adequately supervised by an experienced person. In addition, employees must be adequately trained in the safe use of equipment in the work place and including protective clothing and any safety equipment.

SAFETY OF PEOPLE WHO ARE NOT EMPLOYEES

Employers are also responsible for the health and safety of people who not employees. Employers must take all practicable steps to ensure that employees do not harm any other person while they are at work, including members of the public or visitors to the place of work.

EMPLOYEES' AND SELF-EMPLOYED PERSONS' DUTIES

Employees and self-employed persons are responsible for their own safety and health while at work. They must also ensure that their actions do not harm anyone else. However, their responsibilities do not detract from the employer's or principal's responsibilities.

DEFINITION OF EMPLOYERS IN RESPECT TO THE HEALTH AND SAFETY IN EMPLOYMENT REGULATIONS 1995 (REGULATIONS 19 & 20)

For the purposes of the regulations, the definition of the term employer in the Health and Safety in Employment Act 1992 has been extended to include a person who controls a place of work. In respect to self-propelled mobile mechanical plant, this would include the owner of such machines.

PRINCIPALS AND CONTRACTORS

In regards to principals, the HSE Act requires every principal to take all practicable steps to ensure that no employer of a contractor or subcontractor; and if an individual, no contractor or subcontractor; is harmed while doing work that the contractor is engaged to undertake.

ACCIDENTS AND SERIOUS HARM (RECORDS AND NOTIFICATION)

The HSE Act requires employers to keep a register of all work-related accidents and serious harm. This includes every accident that harmed or might have harmed a person.

Employers are also required to investigate all accidents, harm and near-misses to determine whether they were caused by a significant hazard.

Employers are required to notify serious harm that occurs to employees while at work to the Secretary of Labour (in practice, the nearest OSH office), as soon as possible. In addition, the accident must also be reported in the prescribed form within seven days. (Forms are included in the Workplace Accident Register, available from OSH offices and selected stationers).

If a person suffers serious harm, the scene of the accident must not be disturbed unless to:

- Save or prevent suffering;
- Maintain public access for essential services, e.g. electricity, gas or telecommunications;
- Prevent serious damage or loss of property;

or unless permission has been given by an OSH inspector.

The OSH office will advise whether it wishes to investigate the accident and what action may be taken in the meantime.

1: INTRODUCTION

Every year, deaths and serious harm accidents occur in the forestry and construction industries due to the toppling and roll overs of self-propelled mobile mechanical plant.

The Health and Safety in Employment Act 1992 (HSE Act) promotes responsibility for the self-management of safety and health issues in industry, and requires employers to take "all practicable steps" to eliminate, isolate or minimise work site hazards. It is the task of the employer under the HSE Act to implement measures which will satisfy the requirement that "all practicable steps" are taken to eliminate, isolate or minimise the hazard. The HSE Regulations specify that all practicable steps shall be taken to fit a roll over protective structure and a seatbelt to self-propelled mobile plant.

Examples of work hazards associated with mobile mechanical plant include roll over, tip over, objects falling on the machine, and also objects penetrating the operator's cabin.

This code has been prepared to assist employers and others by providing acceptable means of complying with their obligations under the HSE Act and its regulations. It aims to provide guidance to employers as to what is meant by *all practicable steps* in terms of fitting protective structures to mobile mechanical plant.

1.1 OBJECTIVE

The objective of this code is to provide designers, manufacturers, owners suppliers, employers and users of self-propelled mobile mechanical plant with guidance, and technical means, to minimise the risks to the health and safety of employees and others working with or near mobile mechanical plant.

1.2 DEFINITIONS

Cabin Operator Protective Structure (COPS) means a structure designed to be attached to or form part of, a mobile plant for the purpose of reducing the possibility that an operator wearing a seatbelt in the driving position from being harmed should the plant roll, receive a blow from a falling object, or tip over, or where there is the possibility of an object entering the cabin. In some cases, the falling object protective structure (FOPS), roll over protective structure (ROPS), cabin operator protective structure (COPS) or tip over protective structure (TOPS) could be the same structure.

Construction Work means, for the purpose of this code, work as detailed in section 2 of the Health and Safety in Employment Regulations 1995 and includes:

1. Any work in connection with the alteration, cleaning, construction, demolition, dismantling, erection, installation, maintenance, painting, removal, renewal, or repair of—

(a) Any building, chimney, edifice, erection, fence, structure, or wall, whether constructed wholly above or below, or partly above and partly below, ground level:

(b) Any aerodrome, cableway, canal, harbour works, motorway, railway, road or tramway:

(c) Any thing having a purpose of drainage, flood control, irrigation or river control:

(d) Any distribution system or network having the purpose of carrying electricity, gas, telecommunications, or water:

(e) Any aqueduct, bridge, culvert, dam, earthwork, pipeline, reclamation, reservoir viaduct:

2. Includes any work in connection with any excavation, preparatory work, or site preparation carried out for the purposes of any work referred to in paragraph 1 of this definition.

3. Includes the use of any material or plant for the purposes of any work referred to in any paragraphs in (a) to (e) of this definition; and

4. Includes any inspection or other work carried out for the purposes of ascertaining whether any work referred to in any paragraphs (a) to (e) of this definition should be carried out; but

5. Does not include any work in any mine, quarry, or tunnel.

Deflection-Limiting Volume means an orthogonal approximation of a large, seated, male operator wearing normal clothing and a hard hat.

Design Reviewer is a person who undertakes a review of the design of any Operator Protective Structures design prior to that piece of plant being put into use. The Design Reviewer is defined as an Engineer registered under the Engineers Registration Act 1924 or a member of the Institutions of Professional Engineers New Zealand (IPENZ) in the classes of Member or Fellow.

Engineer/Design Engineer is an engineer registered under the Engineers Registration Act 1924 or the Engineering Associates Act 1961, or a member of the Institutions of Professional Engineers New Zealand (IPENZ) in the classes of Member or Fellow.

Falling Object Protective Structure (FOPS) means a structure designed to be attached to, or form part of, mobile plant for the purpose of reducing the possibility that an operator seated beneath the structure in the driving position from

being harmed should the FOPS receive a blow from a falling object. FOG is a new type of protection and is the same as the known FOPS: the term FOG stands for Falling Object Guard. In some cases, the FOPS (FOG) and ROPS or TOPS could be the same structure.

Forestry Work includes any work in connection with silviculture, logging, transportation of forest produce, tree work, and solid wood processing, whether for commercial purposes or not, and also includes commercial firewood production and work in wharf log storage areas and the handling of logs to the ship's side.

Logging includes tree felling by manual or mechanical means, preparation and extraction of logs to an area for processing and/or loading out.

Hirer of Plant means a person who hires out plant for use at work.

Hiree is someone who may be an employer or employee who hires an item of plant.

Humping means the loading or unloading of an excavator from a transporter or truck without the use of a ramp or ramps.

Machine Mass means the manufacturer's maximum recommended mass for the machine including attachments with all reservoirs full to capacity, tools and operator protective structure fitted but does not include:

(a) any equipment towed by that machine; or

(b) kingpins, hitches or steering components attached to hitches or towed units; or

(c) material dug, carried or handled in any manner by a machine.

Operator Protective Structure (OPS) means a structure designed to be attached to, or form part of, mobile plant for

the purpose of reducing the possibility of an operator, when wearing a seatbelt, from being injured by an object entering the cab.

Roll Over Protective Structure (ROPS) means a structure meeting an ISO Standard, designed to be attached to, or form part of, mobile plant for the purpose of reducing the possibility of an operator, when also wearing a seatbelt, from being injured should the plant roll over.

Silviculture includes the establishment and tending of tree crops and includes land preparation, planting, blanking, releasing from ground or air, protection, pruning, thinning, seed collection, nursery work, use of agricultural chemicals, controlled burning and fire fighting.

*S***olid Wood Processing** includes further processing of logs into rough finished products and includes work of a portable nature such as sawmilling, chipping, peeling, splitting, drying, mulching, and treatment plants.

Seatbelt Systems covers belt, buckles and anchorages and any other components which transfer seatbelt loads to the machine.

Self-Propelled Mobile Mechanical Plant means any mobile mechanical plant designed to move under its own motive power with an operator at its controls.

Seller means a person or company who sells or re-sells plant or protective structures in relation to this code.

Tip Over Protective Structure (TOPS) means a structure designed to be attached to, or form part of, a machine for the purpose of reducing the possibility of an operator when wearing a seatbelt, from being injured should the machine tip over.

Transportation means the loading, cartage and unloading of plant from a transporter.

Tree Work means any work on trees outside a forest situation and includes willow layering; any other work with trees in catchment or soil erosion operations; maintenance of shelter belts for horticulture, agriculture or farming; maintenance of trees in the vicinity of overhead power lines; and arboriculture (that is, the management and care of trees in the general community).

1.3 ROLL OVERS AND TIP OVERS

As noted in the introduction, there are a number of work hazards associated with mobile mechanical plant, and correspondingly there are a number of management measures that should be considered by employers in managing these hazards.

In the case of a roll over hazard, for example, employers can consider:

(a) improving machine stability;

(b) levelling the work area;

(c) using a different machine;

(d) hand-working the task;

(e) removing the operator from the danger area;

(f) protecting the driver in the event of a possible roll over.

The main role of this code of practice is to set out at risk situations where mobile machinery should have some form of protective structure.

2: HEALTH AND SAFETY IN EMPLOYMENT REGULATIONS 1995

Regulation 20 of the Health and Safety in Employment Regulations 1995 requires every employer to take all practicable steps to fit a suitable roll-over protective structure and a suitable seatbelt to any self-propelled mechanical plant to which the regulation applies.

The regulation does not apply to:

- Any agricultural harvester;
- Any bus;
- Any car;
- Any crane;
- Any drag line;
- Any forklift with a telescopic boom;
- Any log hauler;
- Any paving machinery;
- Any power-operated elevated work platform;
- Any tractor used in agricultural work;
- Any truck;
- Any van;
- Any machinery that has a mass of 700 kilograms or less
- Any machine used in a mine, quarry or tunnel machinery (Refer to Mines and Quarry Regulations).

The regulation does not apply to any self-propelled mobile mechanical plant that is designed to be used on level ground at all

times, if the employer takes all practicable steps to ensure that the employee at every place of work so uses the self-propelled mobile mechanical plant.

The Secretary may exempt any machinery from the requirements of regulation 20 if satisfied that the provision is not reasonably practicable or not reasonably necessary for the protection of employees using the machinery (see regulation 19 (4) and (5)).

3: PROTECTIVE STRUCTURES

Tables 1A and 1B (over page) set out the recommended guidelines as to when certain types of protective structures should be fitted to machinery.

The tables match the environment in which the machinery is to operate against the stability of the machine. As well, other risk environments are noted, such as falling, penetrating objects.

The recommendations in the tables, however, do not displace an employer's statutory obligation to manage the hazard. In considering whether all practicable steps are taken in respect to the protection of persons required to operate self-propelled mobile mechanical plant, it is important that employers fully consider:

- the hazards associated with any particular operation/task;
- the environment in which the machine will be required to work;
- the nature and harm that could occur to an operator should a protective structure not be fitted;
- whether or not because of the age or design of the machine it is impracticable to fit a suitable protective structure;
- other means of eliminating, isolating or minimising the hazard.

Where required by this code, all new plant and newly imported plant should be fitted with appropriate protective structures from 31 December 1999. All other plant should be fitted with appropriate protective structures by 31 December 2000. In the interim, plant owners, operators and hirers must do all that is

possible to limit the use of unprotected plant to low-risk work and implement other controls such as those listed in Clause 1.3. Plant issued with exemptions from fitting operator protection must similarly have hazards controlled by means such as those listed in Clause 1.3.

Where it is not mechanically possible to fit the required protective structures to mobile plant used in forest operations, the plant shall only be used in situations where hazard identification has established that protective structures are not needed, or exemption has been granted.

TABLE 1A: RECOMMENDATION FOR OPERATOR PROTECTIVE STRUCTURES IN THE CONSTRUCTION INDUSTRY

Risk of work situation **Risk of plant**	**Low** Level stable ground	**Medium** Road shoulders Stock piles Low embankments	**High** Steep and/or unstable ground Clearing operations Demolition
CATEGORY 1 (High) Rollers Loaders Skid steer Motor scraper	TOPS/FOPS/ COPS Caution required Protective structure advisable	TOPS/ROPS/FOPS OPS/COPS Protective structure strongly recommended	ROPS/FOPS/ OPS Extreme risk Protective structure strongly recom-mended
CATEGORY 2 (Medium) Excavators Dozers Tractors Commercial lawn mowers	Not essential	TOPS/ROPS/FOPS/ OPS/COPS Protective structure advisable	TOPS/ROPS/FOPS/ OPS/COPS Protective structure strongly recom-mended
CATEGORY 3 (Low) Graders Road-sweepers	Not essential	TOPS/FOPS/COPS Caution required Protective structure advisable	TOPS/ROPS/FOPS OPS/COPS Protective structure advisable

ROPS may include FOPS and/or OPS. TOPS may include FOPS and/or OPS. COPS may include FOPS and/or OPS.This list is not exclusive. (For further information, consult an OSH inspector or the New Zealand Contractors' Federation.)

Abbreviations

ROPS: Roll Over Protective Structure
TOPS: Tip Over Protective Structure
FOPS: Falling Object Protective Structure
COPS: Cabin Operator Protective Structure
OPS: Operator Protective Structure

TABLE 1B: RECOMENDATION FOR PROTECTIVE STRUCTURES IN THE FORESTRY INDUSTRY

Excavators High-risk	Machines used for log extraction, mechanical harvesting, shovel logging, mobile tail holds, land preparation, including road construction and maintenance.	COPS designed to Grade 3, including OPS and FOPS
All other plant High-risk	Machines used for log extraction, tree felling, mechanical harvesting, shovel logging, mobile/tail holds, construction of forestry roads/maintenance tracks, fire breaks and landings where there is danger from falling debris and trees. Machines used for land preparation.	ROPS, FOPS,OPS
Medium-risk	Machines, including excavators, used on landings, log yards, and shelter belt maintenance.	OPS,FOPS
Low-risk	Cable haulers (all areas), purpose-built log stackers, i.e. wagners (log yards).	FOPS,OPS

4: OPERATOR TRAINING

Investigations have shown that a major cause of machinery accidents is a lack of adequate training of the operators. Employers must ensure operators are provided with a good knowledge of the working procedure of any machine they are expected to operate and any hazards they are likely to encounter. Trainees must be closely supervised until they prove they are competent to work on their own. It is recommended that operators obtain appropriate qualifications for the class of machine they are expected to operate.

Employers who undertake work within the forestry industry would also have to comply with the *Code of Practice for Safety and Health in Forest Operations*.

TABLE 2: OPERATOR COMPETENCY GRADES AND NATIONAL ITO QUALIFICATIONS

Competency grade	**National ITO qualification or equivalent**
Beginner Under supervision	**CG 1 Trainee**
Trainee Can be left for limited periods at set tasks	**CG 2 Trainee**
Competent Recognises limitations, independent operator	**CG 3 National Certificate**
Trainer/Supervisor Competent operator, capable of all operations	**CG 4 National Certificate: Supervisor**

CG: Competency Grade

Only operators with suitable training and experience shall operate machinery in medium-risk and high-risk areas (see Tables 1A and 1B).

It is recommended that operators wear protective helmets while operating machinery.

5: LOADING OF MACHINERY FOR TRANSPORTATION

The mere fact that machinery is being loaded onto a transportation unit does not necessarily mean that the machinery is in a high-risk environment and therefore requires a protective structure. However, despite the fact that no protective structure may be required, employers are still required to manage the hazard that machinery might topple from their mode of transportation. All practicable steps shall still be taken to avoid the risk of injury.

More specifically, the practice of "humping" machinery onto transportation without the use of ramps is not recommended to load machinery. Instead, proper ramping equipment should be used, or other alternative and safer means must be used. The New Zealand Contractors' Federation's *Operator's Safety Manual: Earthmoving Machinery* sets out the best practice for the safe loading of machinery for transportation.

6: OPERATOR PROTECTIVE STRUCTURES

These are operator protective structures, which can be incorporated either singly or combined as required on all self-propelled mobile mechanical plant, according to the operational risk (see Table 1).

Operational Risk	Protective Structure Required
Machine roll over	ROPS
Machine tip over	TOPS
Falling object risk	FOPS
Operator intrusion risk	OPS
Hydraulic excavator operator risk	TOPS or COPS

There are four grades available, which should be used in a prioritised manner. That is, all practicable steps should be taken to ensure that grade one is used. Only when it is not practicable to use grade one may grade two be used. Cost alone is not an acceptable reason for using a lower graded structure.

Priority Grade Chart for Fitting of Protective Structures

* If unable to attain or fit, then move from left to right - Grade 1 is ideal.

*Grade 1	*Grade 2	*Grade 3	§Grade 4

§Special circumstances

This structure is to cover all self-propelled mobile mechanical plant whether new, existing or second-hand. Note that for all machines except hydraulic excavators you can read FOPS, OPS, ROPS, and TOPS interchangeably. Whether plant is new, second-hand or current and if already fitted with a protective structure, it will need to be appraised for suitability under this code.

For hydraulic excavators, the only protection standards currently available are (ISO) FOPS, OPS, and TOPS and as detailed in section 6.1 of this code.

GRADINGS OF PROTECTIVE STRUCTURES

GRADE 1

An operator protective structure of an appropriate grade to the risk present (as defined in Table 1) that is in full compliance with the appropriate ISO Standard, including the requirement to prove performance in accordance with the specification by physical test of the prototype.

GRADE 2

A protective structure which is locally made and complies with all the original designer's requirements for an ISO manufactured unit. These include meeting the material specifications, bolts and fittings, welds and welding procedures, surface finish, and quality assurance. Such a structure would, for example, be likely to be a copy of a plant manufacturer's standard frame. Certification would be to confirm that the specifications had been adhered to. Grade 2 structures would not be proved by testing, but would be subject to a design reviewer certifying that they comply with these requirements.

GRADE 3

A protective structure which is locally made and designed to meet the requirements of the relevant ISO Standards, and which is designed on the alternative static force resistance basis allowed in this code of practice. This structure will be then known and recorded as Cabin Operator Protective Structure (COPS). Designers will need to have the skills and resources to model structures computationally to the extent that they can prove compliance with the relevant ISO Standards on a calculated basis. This procedure could allow a structure that would otherwise be a Grade 3 structure to be upgraded to a Grade 2 structure, but this could only be undertaken by design organisations prepared to have their computational models, techniques and quality control reviewed by a design reviewer approved by IPENZ's Structural Section.

GRADE 4

A structure which is designed by a professional experienced design engineer (registered under their Act) and based on the engineer's opinion of the best practicable means of providing an appropriate level of protection to an operator. This could include structures on plant that already exist at the time the code is implemented.

Typically, these structures would be fitted to older plant and would be dependent on the duty called for. These should be the "structure of last resort" and should only be used in special circumstances.

EXCAVATORS

When there are ISO Standards for protective structures for self-propelled mechanical plant either including or specifying "excavators", then this protection shall be provided in accordance with Table 1A and 1B. At present there is limited protection

available in Grades 1 and 2; therefore it is necessary to provide structures that comply with an appropriate ISO Standard for operator protective structures, keeping in mind that the minimum required will be TOPS, FOPS, OPS or a combination of these, as detailed under Section 7: Structural Requirements..

At present there is an ISO TOPS for excavators.

Such a locally designed and built structure would be known as a Cabin Operator Protective Structure (COPS). This structure would not be called a ROPS because no ISO Standards exist at the time of publication for excavators and will probably not come into existence for some considerable time.

At present, the best that can be provided for an excavator is ISO TOPS or Grade 3 COPS depending on the machine's mass (M).

7: STRUCTURAL REQUIREMENTS

Structural requirements for an operator protective structure need to comply with the relevant ISO Standard. In the case of a COPS, the criteria are as listed below and in Appendices A to D. (Design requirements in this section are based on ISO 3471).

7.1 THE STRUCTURAL DESIGN CRITERIA FOR STRUCTURES

Sound engineering principles and reasonable assumptions, consistent with acceptable professional practice, shall be applied in the design of any structures. A valid prediction of the ultimate load-carrying capability of the safety structure and the machine assembly should be derived. Care must be taken to ensure that the energy introduced to the safety structure in an actual roll over situation would be largely dissipated by deflection of the safety structure rather than the mounts and machine frame. The safety structure designer should carefully inspect the machine frame components to determine their ability to support and carry the design loads without the frame or riser parting from the machine.

The structure is to be designed, fabricated, fitted and checked in a manner which will resist the forces that would be transferred into the structure during testing and in a roll over situation.

The design, construction and attachment of each model of the protective structures are to be certified by a Registered Engineer and the structure is to comply with the identified ISO Standard or the equivalent standard in this code of practice.

All documentation and certification relating to the design should be kept and made available when requested by an authority.

7.2 STEEL DESIGN CRITERIA

Steel from which any protective structure is manufactured including the mounts shall have a Charpy V-Notch Impact strength at -30 degrees Centigrade of or not less than:

11 Joules if the specimen is 10mm x 10mm; or

9.5 Joules if the specimen is 10mm x 7.5mm; or

7.5 Joules if the specimen is 10mm x 5mm; or

5.5 Joules if the specimen is 10mm x 2.5 mm.

and the largest of these sizes that can be obtained from the material shall have been cut for the test. Specimens are to be "longitudinal " and taken from flat stock, tubular or structural sections before forming or welding for use in the structure. Specimens from tubular or structural sections are to be taken from the middle of the side of greatest dimension and are not to include welds. (Refer to ISO 148.)

For structures designed and constructed after the issue (*Gazette* date) of this code of practice, then the above Charpy V-notch shall apply. When undertaking an audit of existing frames for design purposes, the engineer should base calculations on the minimum yield tensile strength of the material used in the structure, to which an appropriate safety factor is applied. (It is suggested that a value of working stress for mild steel be 165MPa. Refer to any recognised standards for steel properties and consider the other factors that may be relevant such as safety factors, fatigue and the effects of temperature as they may alter the above figure. But the minimum Charpy values are to be adhered to.)

The Charpy V-Notch evaluation is primarily a quality control check and the indicated temperature does not directly relate to operating conditions.

7.3 ALTERNATIVE TEST

Alternatively, the performance tests shall be carried out at -18C^{O} and meet the provisions of ISO 3471, section 7.1 "Steel design criteria".

7.4 FORCE-ENERGY AND LOAD REQUIREMENT

To assure structural integrity at low temperatures, material selection, design and weld considerations shall emphasise high ductility and toughness, i.e. the ability to resist brittle fracture of the structure.

The following requirements shall be met within the deflections permitted by the deflection-limiting volume (DLV) as defined in ISO 3164. The requirements are related to M, the machine manufacturer's maximum declared mass in kilograms.

ROPS and COPS shall be designed to withstand the following loads:

Machine Mass = *M* kg	Lateral load force F N	Lateral load energy U J
$700<M\leq4630$ $4630<M\leq59500$ $M>59500$	$6M$ $70{,}000\ (\frac{M}{10{,}000})^{1.2}$ $10M$	$13{,}000\ (\frac{M}{10{,}000})^{1.25}$ $13{,}000\ (\frac{M}{10{,}000})^{1.25}$ $2.03M$

Vertical load force F N	Longitudinal load F N
$19.61M$	$4.8M$ $56{,}000\ (\frac{m}{10{,}000})^{1.2}$ $8M$

Sourced from ISO 3471/AS2294 Table 1 No.1 Crawler tractors and loaders

The only limitation on the order of loading is that the vertical loading of members shall be applied after the lateral loadings, and the longitudinal loading of members shall be applied after the vertical load. Refer ISO3471 or AS2294 for any further assistance.

Energy absorption shall exceed 1.4 M joules for longitudinal load.

It should be noted that all other relevant requirements as in ISO3471 or equivalent Standard shall also be met.

NOTE: Alternative Protection for Hydraulic Excavators

The ISO Standards Committee is reconsidering the design criteria for TOPS for excavators for an upper limit of 60,000 kg (currently 6000 kg) mass weight of machine. As an alternative to the above requirements, the following design criteria can be used. These structures will require physical testing.

It is anticipated that manufacturers will progressively incorporate safety structures within the design of the cab or the machine.

If ISO adopts a new standard for rollover structures for hydraulic excavators at some time in the future, then this new standard will become the minimum standard for operator protective structures.

	Excavator with Vertical Pivoting Boom	**Excavator with Horizontal Pivoting Boom**
Construction/ Earthmoving	ISO 12117 regardless of machine mass regardless of machine mass	ISO 12117
Demolition	ISO 10262, 12117	ISO 10262, 12117 plus FOPS/OPS
Forestry	ISO 12117 and ISO 8084 with polycarbonate	ISO 12117 and ISO 8084 with polycarbonate

7.5 WELDING REQUIREMENT STANDARDS

Any welding of the structure and attachments is to be undertaken only by a currently certified welder and must comply with the requirements of the NZ Standards such as AS/NZS 1554.1.1995.

7.6 DESIGN ANALYSIS FOR COPS

The design analysis allows for the use of a computer-simulated test to assess compliance with the force and energy-absorption performance requirements of the relevant standard, using suitable software to analyse three-dimensional statically indeterminate structures. All reference material should be kept on file together.

TOPS, ROPS, FOPS and COPS are unique in that they are intended to perform their function only once, and while they may bend, they must not break in performing this function. The yield strength of the material to which a safety factor is then applied (see last paragraph of item 7.2) must always be considered during design to ensure against buckling or collapse of the structure when subjected to performance criteria forces.

8: IDENTIFICATION OF PROTECTIVE STRUCTURES

In order to allow for identification of the type of protective structure being provided, a permanent-type label shall be displayed. It shall be permanently attached in a location where it can be easily read and is protected from damage by weather.

The label shall contain the following information:

(a) the name and address of the structure's manufacturer;

(b) the structure's type and serial number, if any;

(c) the serial number, make and model of the plant that the structure is designed to fit;

(d) the maximum machine mass, M, for which the structure was designed;

(e) the relevant ISO or otherwise performance standard for which the structure meets all the performance requirements;

(f) other such information as deemed appropriate (for example, installation date, repair, or replacement information).

9: DAMAGE TO PROTECTIVE FRAMES

Where a protective frame has been damaged to the extent that the effectiveness of the structure and/or the mounting system has been impaired, which could include rust, then the employer of the machine to which the structure is fitted shall not be deemed to be taking all practicable steps until the machine is repaired or replaced by a structure that complies with this code of practice.

Where damage has been sustained (e.g. a structural member may have a side wall buckle in it, or a weld show cracks) then this must be assessed by the original designer or another suitably qualified registered mechanical or structural engineer experienced in this class of work.

10: SEATBELT REQUIREMENTS

Seatbelts must be provided and shall be worn by all operators of self-propelled mobile mechanical plant, when fitted with a protective structure, where there is a risk of roll over or tip over.

Seatbelt systems must meet the requirements outlined in Appendix D.

Seatbelts that comply with a reputable overseas performance standard that embodies the same, or more stringent, criteria will be accepted without further testing provided a certificate from a recognised authority is produced verifying that to be true (Design Engineer).

The Standards are listed in Appendix A and D.

Seatbelts and anchorages must be maintained and kept in an effective condition at all times.

Other operator restraint devices which embody the same or more stringent criteria may be fitted to the mobile plant and worn or used at all times by the operator while the machine is at risk of a roll or tip over. (Exemptions may be permissible during some forestry operations, as described in the *Forest Operations Code of Practice*).

A seatbelt warning sign must be prominently displayed in every protective structure cabin, warning that if a roll over or other such hazard exists, then the operator shall wear the seatbelt or other such device.

11: DUTIES OF DESIGNERS, MANUFACTURERS AND SUPPLIERS

The duties of designers, manufacturers, and suppliers of self-propelled mechanical plant or protective structures are as set out in Regulations 66 and 67 of the Health and Safety in Employment Regulations 1992, which are reproduced below (for further information, refer to the regulations themselves).

11.1 DUTIES OF DESIGNERS OF PLANT

(1) Every designer of plant shall take all practicable steps—

(a) To design any plant or structure in accordance with applicable ergonomic principles, including (without limitation) any such principles in relation to the placement of any power controls; and

(b) To design any plant in such a way that, if the plant is—

(i) Manufactured in accordance with the design; and

(ii) Used for the purpose for which it was designed; and

(iii) Installed, adjusted, used, cleaned, maintained, repaired, or dismantled accordance with the designer's instructions,—

there is no likelihood that the plant or structure will be a cause or source of harm to any person, or the likelihood that the plant will be a cause or source of harm is minimised as far as practicable.

(2) Every designer of plant shall take all practicable steps to ensure that every manufacturer of the plant receives comprehensive and comprehensible information, including, where relevant, detailed instructions about—

(a) The use for which the plant has been designed; and

(b) How to install, adjust, use, clean, maintain, repair, and

dismantle the plant in accordance with the designer's instructions; and

(c) Any other matters about which the manufacturer needs information from the designer in order to be able to carry out the manufacturer's duties under regulation 67 of these regulations.

11.2 DUTIES OF MANUFACTURERS AND SUPPLIERS OF PLANT

(1) Every manufacturer and supplier of plant shall take all practicable steps to ensure that any plant manufactured by the manufacturer or supplied by the supplier is so designed that, if the plant is—

(a) Manufactured in accordance with the design; and

(b) Used, for the purpose for which it was designed; and

(c) Installed, adjusted, used, cleaned, maintained, repaired, and dismantled in accordance with the designer's instructions,—

there is no likelihood that the plant will be a cause or source of harm to any person, or the likelihood that the plant will be such a cause or source of harm is minimised as far as practicable.

(2) Every manufacturer and supplier of plant shall take all practicable steps to ensure that any plant manufactured by that manufacturer or supplied by that supplier is so manufactured and tested that, if the plant is—

(a) Used for the purpose for which it was designed and

(b) Installed, adjusted, used, cleaned, maintained, repaired, and dismantled in accordance with the designer's instructions,—

there is no likelihood that the plant will be a cause or source of harm to any person, or the likelihood that the plant will be such a cause or source of harm is minimised as far as practicable.

(3) Every manufacturer of plant shall take all practicable steps to

ensure that every supplier of the plant receives comprehensive and comprehensible information, including, where relevant, detailed instructions, about —

(a) The use for which the plant has been designed; and

(b) How to install, adjust, use, clean, maintain, repair, and dismantle the plant in accordance with the designer's instructions; and

(c) Any other matters about which the supplier needs information from the manufacturer in order to be able to carry out any duty of the supplier under this regulation.

(4) Every supplier of plant shall take all practicable steps to ensure that every purchaser or hirer of the plant receives comprehensive and comprehensible information, including, where relevant, detailed instructions, about —

(a) The use for which the plant has been designed; and

(b) How to install, adjust, use, clean, maintain, repair, and dismantle the plant in accordance with the designer's instructions; and

(c) Any other matters about which the purchaser or hirer needs information from the supplier in order to be able to carry out any duty of the purchaser or hirer under this regulation.

12: SPECIAL STRUCTURES

Special structures may be required in circumstances where a special hazard exists, in addition to ROPS, FOPS, TOPS, OPS or COPS. For example, this could be where an excavator is used in a ship's hold to stack or stow cargo such as logs or any other situation where an operator could be subjected to side/rear intrusion hazards. Such machines would be required to be fitted with side/rear intrusion bars to protect the operator. Further information can be sought by contacting an inspector who deals with port undertakings at the nearest Occupational Safety and Health office or by referring to the *Port Safety Guidelines*.

13: ASSESSMENT OF EXISTING OPERATOR PROTECTIVE STRUCTURES

Where a machine is already fitted with a protective structure and concern exists as to its suitability as an acceptable protective structure under this code, employers should engage the services of a suitably qualified engineer/designer to assess the protective structure against the criteria set out in this code. A structure meeting the criteria shall display a suitable identification plate as referred to in Section 8 of this code.

Note: Any structure that complies fully with any of the enlisted performance standards in Appendix A or more stringent criteria will be accepted without further testing.

14: EXEMPTION FROM REGULATIONS

Applications for exemption from any or all of the provisions of Regulation 20 of the Health and Safety in Employment Regulations should be forwarded to the Secretary of Labour, PO Box 3705 Wellington. Attention: ROPS Co-ordinator.

APPENDIX A: REFERENCES TO STANDARDS

ROPS, FOPS, OPS, TOPS and seatbelt assemblies that comply with a reputable performance standard that embodies the same or more stringent criteria will be acceptable without further testing. This code is based on the following ISO Standards or Australian/ New Zealand Standards.

Those standards acceptable are listed below:

ISO 148: *Steel - charpy impact test (V-Notch)*

ISO 898: *Mechanical properties of fasteners -*

Part 1: *Bolts, screws and studs*

Part 2: *Nuts with specified proof load values - course threads.*

ISO 3164: BS 6912, Part 7, *Earthmoving machinery - Laboratory evaluation of roll over and falling object protective structures - Specifications for the deflection-limiting volume*.

ISO 3411: *Earthmoving Machinery - Human physical dimensions of operators and minimum operator space envelope*

ISO 3449: BS 6912, Part 6: *Earthmoving machinery - Falling object protective structures - Laboratory tests and performance requirements*

ISO 3463: *Agricultural and forestry wheeled tractors - Protective structures - Dynamic test methods and acceptable conditions*

ISO 3471: *Earth moving machinery - Roll over protective structures - Laboratory tests and performance requirements*

ISO 5700: *Agricultural and forestry wheeled tractors - Protective structures static test method and acceptance conditions*

ISO 6165 *Earth moving machinery - Basic types - Vocabulary*

ISO 7132: *Earthmoving machinery - Dumpers - Terminology and commercial specifications*

ISO 8082: *Self-propelled machinery for forestry - Roll over structures - Laboratory tests and performance requirements.* (This standard may only used by special permission from The Secretary of Labour, PO Box 3705, Wellington, ROPS Co-ordinator. This is because this standard does not have any longitudinal calculations.)

ISO 8083: *Machinery for forestry - Falling object structures - Tests and performance requirements*

ISO 8084: *Machinery for forestry - Operator protective structures - Laboratory tests and performance requirements*

ISO 12117: *Tip over protective structures for hydraulic excavators*

SAE J231: *Minimum performance criteria for falling object protective structures, (FOPS)*

SAE J1043 *Performance criteria for falling object protective structures for industrial machines, (FOPS)*

SAE J1040: *Performance criteria for roll over protective structures for construction, earth-moving, forestry, and mining machines, (ROPS)*

SAE J1084: *Operator protective structure performance criteria for certain forestry equipment*

CAN/CSA -B352-M: *Roll over protective structures for agricultural, construction, earth-moving, forestry, industrial and mining machines*

AS 2294: *Earth moving machinery - Protective structures*

AS 2664 *Earth moving machinery - Seatbelts and seat anchorages*

NZS 5101: *Specifications for safety frames and safety cabs for attachment to agricultural wheeled tractors*

DR 94382 DRAFT Australian/New Zealand Standard: *Wheeled tractors - Roll over protective structures - Criteria and tests,* Part 1: *Conventional tractors* (revision of AS 1636-1984) to be (AS/NZS 1636.1)

DR 95040- 95041 DRAFT Australian New Zealand Standard: *Wheel tractors - Roll over protective structures - Criteria and tests*

DR 95040, Part 2: *Rear mounted for narrow track tractors*

DR 95041, Part 3: *Mid mounted for narrow track tractors*

APPENDIX B: ACCEPTANCE AND TESTING CRITERIA FOR COPS

For any other criteria not already mentioned previously in this code, the criteria are as per section 8 of ISO 3471, allowing for the use of computer programme analysis, as mentioned in Section 7.6.

APPENDIX C: LOCATION OF DEFLECTION-LIMITING VOLUME

(Based on ISO 3164. (E).)

C1. The seat be adjustable to the rearmost position first and then to lowest position. The position of seats with suspension systems shall include the static deflection of the suspension systems which a 100 kg seated operator would impose on the suspension system, with all mechanical, hydraulic, or gas elements to be at the manufacturer's recommended settings for this size of operator.

C2. For machines which have multiple seat positions, either rotate or multiple locations, the seat for mobile operation, i.e. the seat position used by the operator to move the machine in the travel mode, shall be used.

C3. The locating point (LP) shall be determined as follows:

C3.1 The LP shall be in the middle vertical plane which is parallel to the longitudinal axis of the seat.

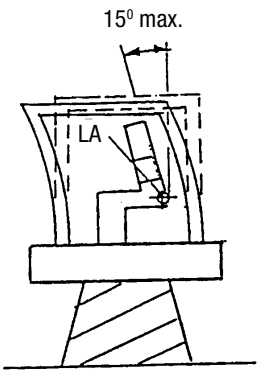
C3.2 The LP shall be at the intersection of the following two lines in this plane (see Figure 1):

H-H - the horizontal line which is tangent to the highest point of the seat cushion in this plane,

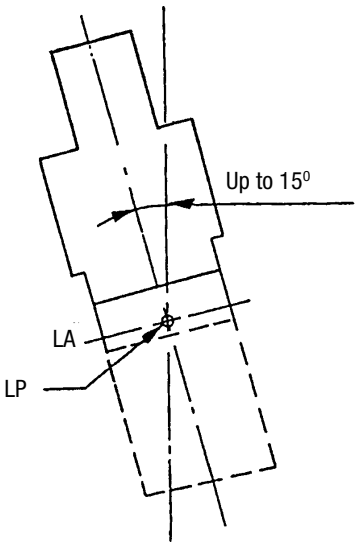
V-V - the vertical line which is tangent to the most forward point of the seat back in this plane.

C4. The DLV shall be positioned such that the line LA shown in Figure 1 passes through the LP defined in C3. The DLV shall be centred transversely at the seat location, and its principal axes shall be parallel to lines HH and VV, as defined in C3. (This position takes nominal compression of the seat cushion and back into account.)

C5. The location of the LA of the DLV shall remain coincidental with the LP, even though that line may move during any or all of the laboratory or computer simulation loadings.



Allowable rotation of upper DLV about the locating axis



Allowable lateral deviation of upper DLV about the DLV longitudinal centre line through the LP

Figure 1 Deflection-limiting volume (DLV) (Source: ISO 12117)

APPENDIX D: SEATBELT SYSTEM CRITERIA

D 1. The buckled seatbelt system shall withstand a force of not less than 15Kn for 10 seconds minimum when loaded in a forward and upward direction at (60 + 15) from the horizontal through the H point (see Fig. 3).

The seatbelt assembly shall not elongate by more than 20% when subjected to this force.

D 2. Webbing shall be durable and have a minimum width of 75 mm for pelvic restraint, and 46mm for upper torso restraint where this is provided.

D 3. Belt buckles must be able to be released without undue force in a single motion when subjected to operator loading.

D 4. Metallic seatbelt components and anchorages shall be corrosion-resistant and free of sharp corners and edges.

D 5. Each seatbelt assembly or part assembly shall be permanently and legibly marked with the following:

(a) The manufacturer's name and trademark;

(b) Date of manufacture by month and year;

(c) Manufacturer's identification code.

The effects of the environment on seatbelts, and exposure to ultraviolet rays, must also be considered.

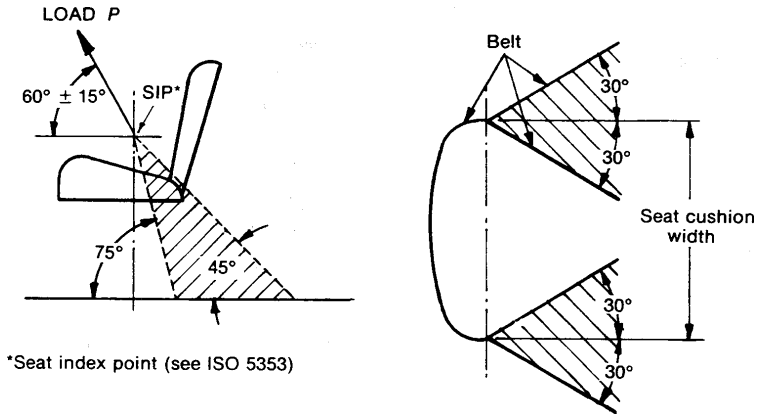


Figure 2 Seatbelt anchorage areas

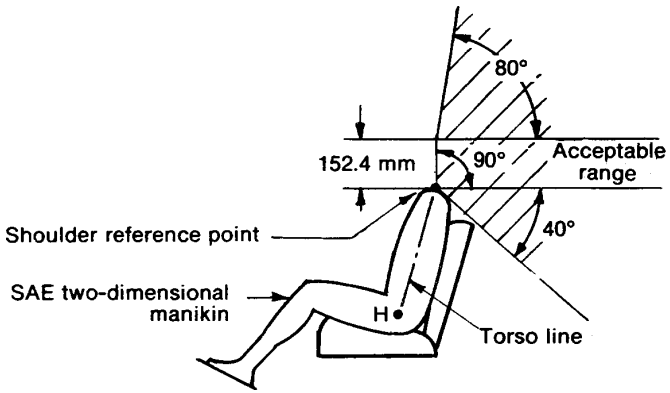
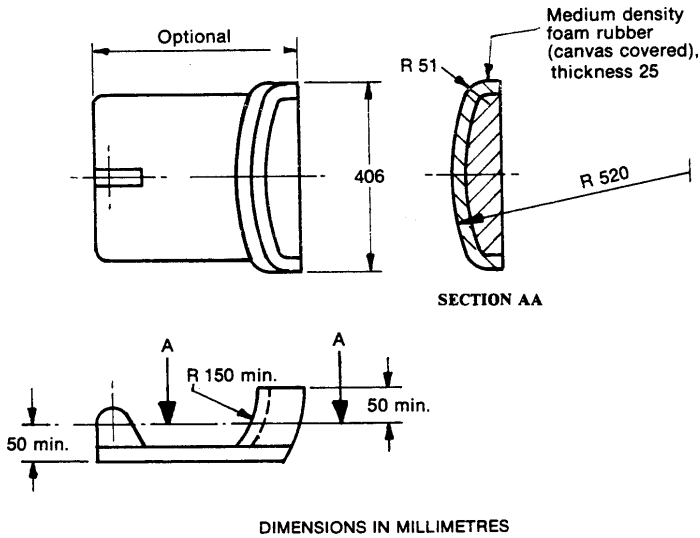


Figure 3 Anchorages for upper torso belts (see SAE J383)



(Source: AS 2664:1983)

Figure 4 Body block method of load application