PROPOSED INTERIM PERFORMANCE
REQUIREMENTS FOR:

Cab Protection Guards for Logging Trucks

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SYNOPSIS

A working group representing the interests of the Department of Labour and log transport operators has proposed new performance criteria for cab guards fitted to logging trucks. These specify minimum energy absorption and strength requirements and recognize that the method of mounting the guard on the truck must be adequate.

The recommendations arise from a desire by the industry to be innovative, adopt new technology, and cater for changing circumstances; they are based on a testing programme in which the performance of fifteen different cab guard designs was measured.

CONTENTS

1. INTRODUCTION

This report describes a proposed performance requirement for cab guards fitted to logging trucks. It outlines the reasons why a change to the current Code is considered necessary and how, through a programme of testing, the proposed requirements have been established.

2. PROPOSED PROVISIONAL PERFORMANCE REQUIREMENT FOR LOGGING TRUCK CAB GUARDS

At a meeting of industry and government representatives at Rotorua on 25 July 1988, the following provisional performance requirements for new or reworked cab guards fitted to logging trucks were agreed to.

When progressively loaded by a horizontal force applied to one upright of a cab guard at a height of 1.6 m above the top of the chassis rail, the following requirements shall be met:

(i) the maximum load supported by the guard shall exceed 55000 newtons;
(ii) loading shall continue until the energy absorbed exceeds 9000 joules;
(iii) at the point when the energy absorbed equals 9000 joules, the force must not be less than 0.95 F_{max} *where* F_{max} *is the maximum force so far recorded;*
(iv) the method of fixing to the truck must be demonstrated in the test to withstand the loads that can be generated by the guard.

Cab guards meeting the existing Code will continue to be approved for a period of time yet to be finalized. Where it is desired to rework such guards, acceptable procedures may be made available.

It will be noted that the requirements being proposed are described as provisional. This is in recognition of the fact that a major change has been introduced in the way cab guards are expected to perform. The new requirements relate to the ability of the guard to absorb energy, a concept new for cab guards for logging trucks. It is also not known how typical the proposed test requirements are of the most severe incident that it is practicable to protect the driver from. For these reasons a provisional standard has been recommended to enable changes to be introduced if early experience suggests this is necessary. In any case, the requirements should be reviewed after two to three years and confirmed either with or without amendment.

3. CURRENT REQUIREMENTS FOR LOGGING TRUCK CAB GUARDS

The Safety Code for Bush Undertakings requires that a cab protection frame shall be fitted to every truck used for transporting logs. The purpose of the guard is to protect the cab during loading, and the driver in a rollover or from sudden movement of logs in an emergency stop.

The Code describes how the guard shall be built and this, together with relevant LIRA Technical Bulletins approved by the Department of Labour, forms the basis upon which Inspectors either approve or reject a guard fitted to a logging truck. The performance of the guard under load does not have to be demonstrated or assessed.

It is understood that this design was first adopted by the Department in the late 60s early 70s. Among other things the design specifies the size of the main uprights of the guard and how they shall be stayed. However it does not specify in detail how the guard is to be attached to the truck.

4. LIMITATIONS OF CURRENT REQUIREMENTS

In recent years, changes in the logging industry have resulted in pressure to dispense with the stays supporting the main uprights; these now increasingly interfere with the types of logs being carried and the way they are loaded. In addition, because the Code does not provide for alternative designs, innovations in response to the changing needs of the industry and access to new technology make the task of inspectors responsible for approving guards increasingly difficult.

5. DEPARTMENT OF LABOUR INITIATIVE

After some initial delays, a meeting of representatives from different sections of the industry was convened by the Department of Labour to address these problems. It was held on 3 November 1987.

The aims of the meeting were essentially to identify the role of the cab guard, to discuss difficulties being experienced with the current Code requirements, and to determine how to provide for alternative designs.

Present were:

J. Galbraith (LIRA) Chairman
R. Goldsack (LIRA) Secretary
C. Bailey (NZFP Forests Ltd)
M. Lambert (Mike Lambert Ltd)
R. West (A.R. West Logging Ltd)
R. Clotworthy (Maroa Logging Ltd)
G. Manson (Pacific Haulage Ltd)
B. Pritchard (Pan Pac Ltd)
M. Johns (Department of Labour)
G. Garden (NZAEI)

It was agreed that:

(i) the primary purpose of a cab guard is to protect the driver from logs moving under emergency braking;
(ii) in the absence of internationally adopted standards or design codes, the basis for an acceptable design should be either satisfactory industry experience or a testing programme or a combination of both;
(iii) the NZAEI should prepare a proposal for a suitable test programme;
(iv) the issues should be resolved as quickly as possible for which everyone present committed their full support.

6. TEST PROGRAMME

Proposals for a test programme were discussed by the working group at the offices of Mike Lambert Ltd, Mt Maunganui on 9 December 1987. Because no relevant overseas procedures had been identified, the following programme was agreed to:

(i) a guard meeting the current requirements of the Safety Code for Bush Undertakings should be tested to measure its performance characteristics;
(ii) the test should measure the strength of the guard at a height approximately in line with the head of the truck driver - 1.6 m above the top of the chassis rail was chosen as a representative value;
(iii) the guard should be progressively loaded by a horizontal force applied to one upright and a continuous record kept of the load and the corresponding deflection;
(iv) tests should then be carried out on modified or other designs to identify acceptable alternatives - methods of gusseting and mounting would be assessed at the same time;
(v) inherent in this test programme is the need to develop a test procedure and establish performance criteria that could form the basis of amendments to, or a replacement for, the current Safety Code.

It was recognized that, to carry out this programme, a test rig would be required. It would have to allow for:

(i) attaching in a characteristic manner guards with a variety of mounting arrangements;
(ii) adjustments to the lateral and vertical position of the load to cater for guards of different dimensions;
(iii) accurate measurements of the applied load and guard deflection which are to be unaffected by the behaviour of the rig itself.

The advantages of being able to conduct the tests where there is ready access to workshop facilities was also recognized.

Mike Lambert Ltd generously offered to provide the venue for the test programme and any workshop facilities and services that were required; equipment and components to build the body of the test rig and a selection of cab guards to include in the programme were also made available.

It was left to the NZAEI to undertake the detailed design of the test rig and arrange for its construction and commissioning.

7. EQUIPMENT

The test rig consisted of the upturned chassis of a dismantled, articulated trailer to which the guard under test could be bolted. Vertical columns were welded and stayed to the suspension mounting blocks to support a horizontal beam from which the loading on the guard could be applied. The position of the beam was adjustable both horizontally and vertically.

A tension rod passing through the beam and attached to one upright of the guard by a yoke and saddle was drawn through the beam by a "Simplex" hand pumped hydraulic puller.

A precalibrated, cylindrical compression load cell, placed over the rod between the beam and the base of the "Simplex" ram, measured the applied load which was displayed on an analogue indicator. Deflection of the upright was measured with a steel tape between the saddle and a vertical bar clamped to the chassis close to the point where the guard was attached.

8. PROCEDURE

The guard under test was attached to the chassis. Intermediate mounting brackets were made up if required to reproduce the normal method of mounting.

The loading beam was positioned so that the tension rod, attached at one end to an upright of the guard, was parallel to, and at the required height above, the chassis. The load cell and hydraulic puller were assembled over the rod on the other side of the beam and retained by a nut threaded onto the rod.

Load was recorded at one, two, five or ten millimetres deflection increments depending on the behaviour of the guard. Loading was controlled by the speed of pumping with frequent pauses to examine and photograph the condition of the guard.

Force and the corresponding deflection were subsequently plotted for each test, and the area under this curve, which represents energy absorbed by the guard, was calculated.

9. DESCRIPTION OF GUARDS TESTED

In all, 29 tests were carried out on a total of 15 different configurations of cab guard or main upright assembly. These can be described as follows:

(i) current Safety Code design with both medium and heavy wall pipe stay;
(ii) all-pipe frame with top of stay curved;
(iii) 125 x 65 mm rolled channel upright with short and tall triangular plate gusset;
(iv) folded, tapered channel upright;
(v) folded, tapered box upright;
(vi) folded, tapered channel guard manufactured by Evans Engineering Co Ltd, Tokoroa - four base designs;
(vii) folded aluminium tapered box upright manufactured by Harrier Manufacturing Ltd, Rangiora - two base designs;
(viii) folded aluminium parallel box upright manufactured by Harrier Manufacturing Ltd, Rangiora - two base designs.

10. TYPICAL RESULTS

It is not proposed to present the results of all the tests in this report; instead, six tests have been selected to illustrate some of the more important principles which must be considered when contemplating the design and testing of guards that have to withstand a high energy impact loading.

The results of these six tests are presented in Figs 1, 2 and 3 as graphs on which load, in newtons, and deflection, in millimetres, are plotted on the vertical and horizontal axes respectively. The area under each curve is proportional to the energy absorbed by the guard as it deflects.

FIGURE 1 compares the behaviour of guard A, complying with the current Safety Code, with that of B, which is the same guard but modified by replacing the pipe stays with a triangular plate gusset 970 mm high.

The following points should be noted with respect to each guard.

Guard A:

(i) is relatively strong;

(ii) failure was catastrophic - the pipe stay broke after only 28 mm deflection of the structure;

(iii) once failure occurs, no significant protection from moving logs can be expected;

(iv) the energy absorbed up to the point of failure is small - only 1960 joules;

(v) very high loads were imposed on the mounting detail by this guard - the chassis rail of the test rig had to be supported to allow the test to continue.

Guard B:

(i) failure is by progressive bending of the upright;

(ii) the strength achieved depends on the geometry of the gusset - it would need to be modified to meet the proposed performance criteria;

(iii) testing was discontinued when a deflection of 200 mm was reached - at this point the maximum strength of the guard had not been reached;

(iv) at a deflection of 200 mm, 8240 joules of energy had been absorbed.

FIGURE 2 highlights probably the most important lesson to emerge from the testing programme - **mounting detail is critical to the successful performance of a guard**. More tests were stopped because of inadequacies in the way the upright was attached through to the truck chassis than for any other reason.

On guard A, the upright was welded to an angle section which was in turn bolted to the chassis rail. This is a common method of fixing. The test was terminated because of excessive deformation of the upper, unbolted leg of the angle. At that point the guard had deflected 75 mm and absorbed 2480 joules.

Graph B illustrates the behaviour of the same guard but with a mounting arrangement appropriately matched to its strength. The test was discontinued when the deflection reached 200 mm. At that point, the energy absorbed had exceeded 12200 joules.

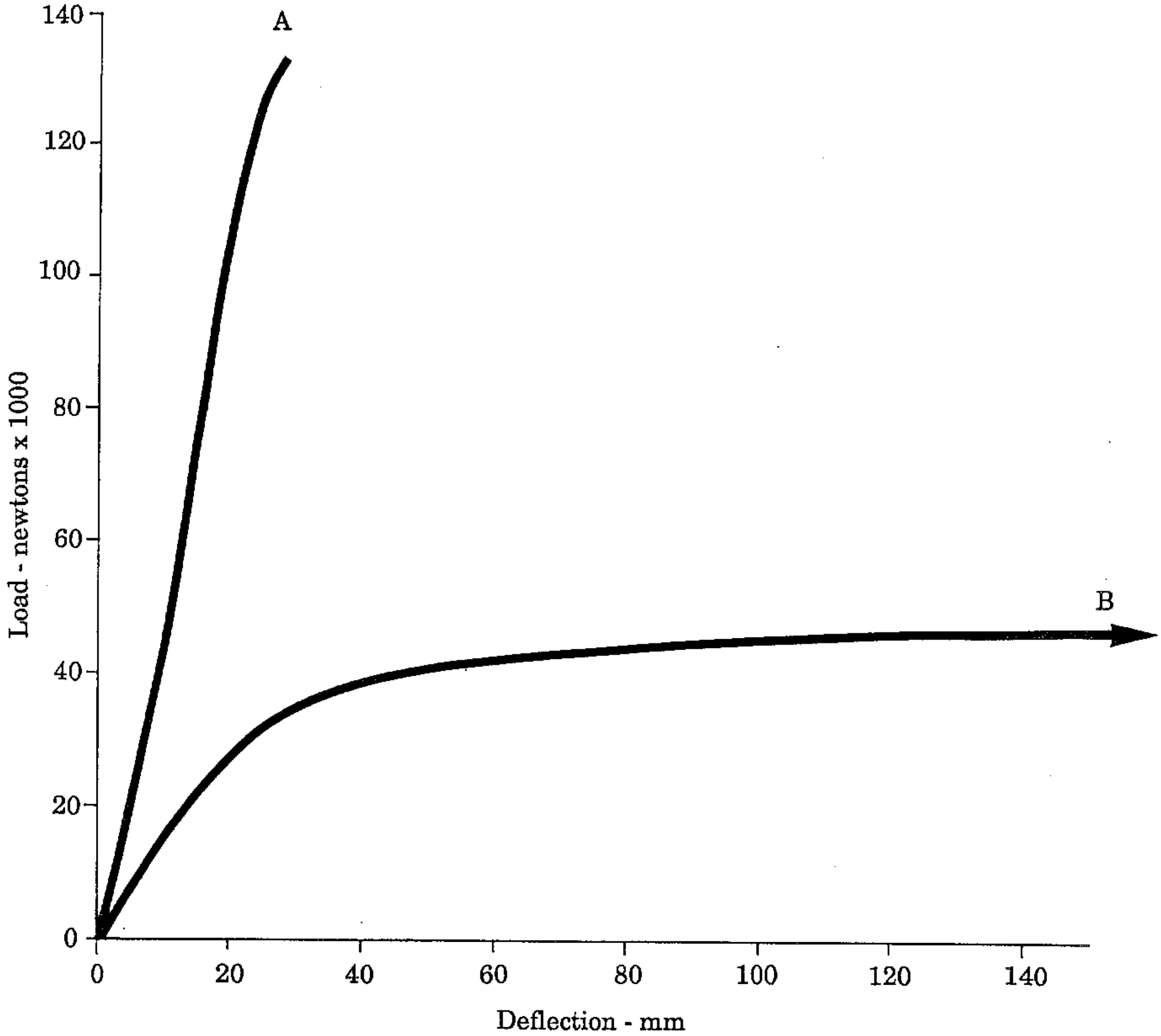

Figure 1: Comparison between current Bush Code design (A) and one modified to absorb energy (B).

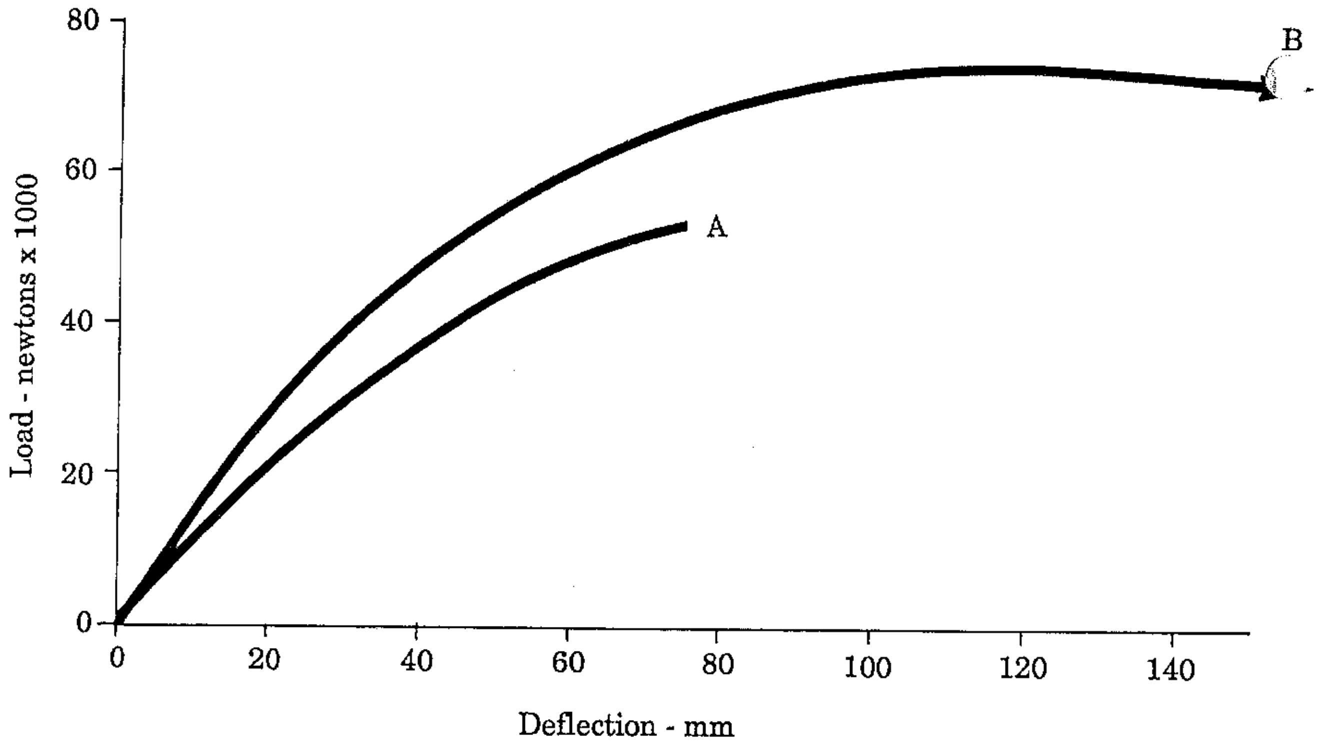

Figure 2: The effect of changes in mounting detail

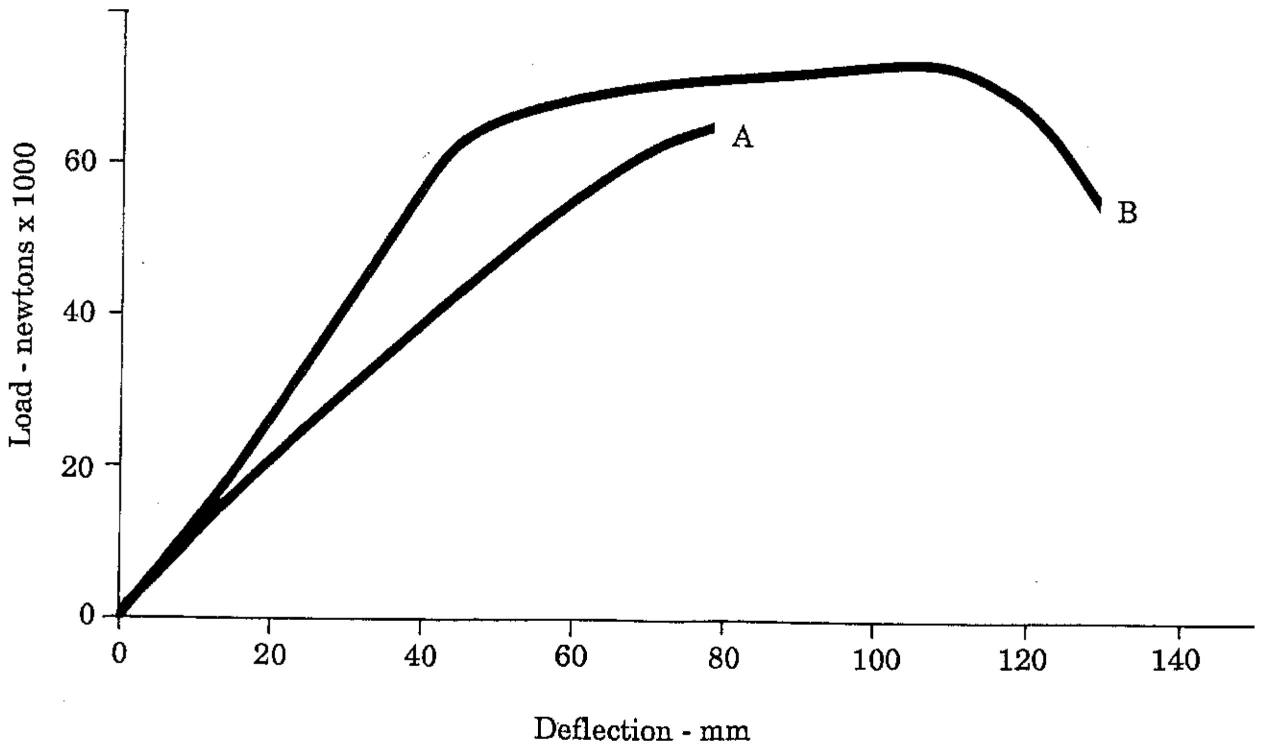

Figure 3: Premature failure

FIGURE 3 is included to demonstrate that performance criteria based simply on the strength of a guard are not necessarily sufficient to ensure its satisfactory performance. Tests were carried out consecutively on the same guard. Test A was stopped when mounting bolts failed. At this point, the energy absorbed by the guard was 2,880 joules.

Loading recommenced when bolts with a higher strength grade were substituted for those that had been damaged, but was again stopped when one upright failed; the hole for the horizontal pipes had been made too close to the flange. The energy absorbed in this test (shown as B in Fig. 3) was 6,100 joules.

Although in both tests the proposed minimum strength requirements were exceeded, the design proved to be inadequate in two separate areas, each of which would lead to premature failure of the guard in an emergency, and reduced protection for the driver. One way to minimize this possibility in practice is to require that a guard actually demonstrate its capacity to absorb energy levels representative of those from which protection in an emergency might be expected.

11. BASIS FOR THE PROPOSED PERFORMANCE CRITERIA

This final section describes briefly the basis upon which the choice of the proposed performance criteria for cab guards was made.

If it were possible to accurately specify the type of loading an acceptable standard of cab guard would have to withstand, either because empirical data are readily available, or because operating conditions are narrowly defined, the task of selecting appropriate performance requirements would be relatively simple. Such is not the case. Performance of guards in service is not well documented; the type of log and the conditions under which it can be transported vary enormously; and several different types of accident, from which the driver could be protected, are possible. It was against this background that the working party faced the task of arriving at acceptable recommendations.

The first decision was to consider only those accidents involving emergency braking. The guard would not be expected to protect the driver if the truck rolled or crashed head on. If a truck rolls, it is supported by existing strong points such as the load, stanchions, bolster ends and the front axle assembly; all are significantly stronger than what would be practically acceptable for a cab guard. The greater risk of injury from causes other than sliding logs did not appear to justify consideration of crash accidents.

Under emergency braking the event exposing the driver to the greatest risk was considered to be a log or logs sliding forward out of the load at approximately the height of his head. Logs higher than this are likely to be deflected or pass above the driver; those lower down will be increasingly held by adjacent logs, particularly with the requirements for load securing now in force.

An examination of a number of trucks revealed that, typically, the driver sits almost in line with the right upright of the guard and that his head is approximately 1.6 m above the top of the chassis.

It was therefore agreed that an appropriate test procedure for a cab guard would be to load one upright of the guard horizontally at a height of 1.6 m above the top of the chassis rail and measure the load and the corresponding deflection. Obviously, the guard would need to be mounted for the test in the same way as it is on the truck.

Having made that decision, the outstanding problem was to decide what performance under this test would be acceptable. This was approached in two ways. On the one hand it was agreed to test representative samples of the current Safety Code design and use this information as a datum against which to compare the performance of a number of alternative designs.

Secondly, accident information, particularly on the current Code design, was sought as a guide to the severity of typical accidents. As already mentioned, this was not available. The alternative was to attempt to calculate for different sizes of log, the behaviour which could be expected under a range of accident conditions, load securing etc., and then choose the most severe event which it was considered the driver should be protected from.

Members of the working group were present throughout the testing. From viewing the tests and discussing the behaviour of each guard, opinions formed on what performance would be considered acceptable. For example, guard A (Figure 1) was considered to be too strong with insufficient energy absorption; guard B on the other hand was too weak although its deflection and energy absorption were acceptable.

Eventually, a minimum performance requirement was arrived at which reflected the collective view of the working group; it also recognized that commercially available guards could differ widely in performance. Although not rigorous, calculations suggest that the level chosen corresponds approximately to a requirement that the cab guard stop a one tonne log travelling from a distance of 2.5 m under emergency braking within a deflection of approximately 200 mm. The calculations assume that there is a difference of 0.4 between the coefficients of friction for logs sliding on one another and for tyres sliding on the roadway. A stronger frame would be required if this difference increases. Simplifying assumptions have also been made about the way a guard responds as it is loaded.

12. SUMMARY

A working group representing government and industry interests has agreed upon and recommends interim performance and test criteria for cab guards fitted to logging trucks. These have evolved from a testing programme in which fifteen different guard configurations, including one meeting the requirements of the current Safety Code for Bush Undertakings, were subject to static loadings.

The test represents approximately the effect of a one tonne log sliding in line with the driver's head a distance of 2.5 m under emergency braking before striking the cab guard. The performance required of the guard is that it deflect no more than about 200 mm in stopping the log, and that its method of attachment to the truck be able to satisfactorily withstand the resulting forces.

All new designs of cab guards will be required to demonstrate this level of performance. A copy of the test report to be completed by a testing institution and submitted to the Department of Labour by the manufacturer of the guard is included in Appendix I.

These criteria introduce the concept that the cab guard must absorb energy whilst protecting the driver. This is not a requirement of currently approved designs; indeed, tests suggest their ability to do so is limited.

Because of the lack of well documented information on the frequency and severity of emergency braking incidents, and because of recent changes in the requirements for load securing, it is not known how typical the proposed test is of the most severe accident that it is practicable to protect the driver from. For this reason, the recommendations of the working group are in the form on an interim proposal to enable changes to be introduced if experience suggests this is necessary.

APPENDIX I

Logging Truck Cab Guard

Strength Test Report

LOGGING TRUCK CAB GUARD STRENGTH TEST REPORT

REPORT NO. ....

This is to certify that I have tested a logging truck cab guard according to the provisional requirements of the Design Requirements for Logging Truck Cab Guards.

Submitted for testing by : ....

Address : ....

....

Manufactured by : ....

Address : ....

....

Cab guard designation/model No. : ....

Cab guard drawing No(s) : ....

Test No. : ....

Date of test : ....

Chassis on which cab guard was tested:

Make : ....

Model : ....

The minimum strength and energy absorption requirements were met. Test results are presented on the attached graph.

Testing Offficer: ....

Authorising Officer: ....

Testing Institution: ....

Date: ....