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Testing of a ROPS of a tractor with a flame proof canopy

11249 AIM (Testing of tractor ROPS)

Prepared for

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Document No: IM-TR348

Revision: 0.1



Date: 10 July 2007



Document information

Project Name:	11249 AIM (Testing of tractor ROPS)
Title:	Testing of a ROPS of a tractor with a flame proof canopy
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Document Number:	IM-TR348
Filename:	IM-TR438 11249 AIM (Testing of a tractor ROPS) TR RL1
Creation Date:	10 May 2007
Revision:	0.1
Revision Date:	10 July 2007

Approval

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DCC	Investmech (Pty) Ltd	Original

Summary

This report presents the results of conformance testing that was done on the ROPS of a tractor that is equipped with a flame proof canopy for use in a coal mine. The test was done according to the ISO 3471 standard.

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List of symbols and abbreviations

ROPS	Roll Over Protective Structure
DLV	Deflection limiting volume

1. INTRODUCTION

Mr. Hans Fourie of AIM Off Road Equipment contracted Investmech to test a Roll Over Protective Structure (ROPS) of a tractor according to the requirements of the ISO 3471 standard. The ROPS is designed to be mounted behind the fully enclosed cabin of the tractor and connects directly to the machine frame of the tractor. The tractor cabin is shown in the photograph in Figure 1. For the purpose of the test the ROPS was mounted rigidly to the test floor. The test loads were applied using a hydraulic jack and the force magnitude was measured with a 20 ton load cell with serial number 49854 connected to a strain amplifier with serial number 170011. An inductive displacement transducer was used to measure the deflection of the ROPS. The remainder of this report describes the test method and presents the test results.



Figure 1. Tractor with enclosed cabin – manufactured for use in the mining industry.

2. IDENTIFICATION

The identification information (as supplied by AIM Off Road Equipment) of the tractor and ROPS is given in Table 1 on the next page.

Table 1. Identification information

Machine Identification	
Type:	Flameproof tractor
Manufacturer:	AIM Off Road Equipment
Model:	Massey Ferguson 475
Serial number:	220654
Machine frame part number:	ROP-1
ROPS Identification	
Manufacturer:	A&D Cabs cc
Model:	2007
Serial number:	07-0001
Machine frame part number:	ROP-1

3. TEST METHOD

The test load sequence for industrial wheeled tractors prescribes that the transverse load should be applied first, followed by the longitudinal and then the vertical loads. The ISO 3471 standard states that the required force and energy values should be attained without any part of the ROPS penetrating the Deflection Limiting Volume (DLV). A further requirement is that the vertical and horizontal simulated ground planes may not penetrate the DLV at any time during the test. The test was done with the ROPS at room temperature (23°C) for more than 4 hours.

3.1. Test load force and energy requirements.

The test forces and the energy absorption requirements are calculated based on the mass, M , of the tractor in kilograms using the formulae in Equations 1 to 5 below (ISO 3471, 1994.8). The total tractor mass as supplied by AIM Off Road Equipment is 5,480kg.

$$\text{Lateral load force [N]} \quad F_{lw} = 6M \quad 32,880 \quad (1)$$

$$\text{Lateral load energy [J]} \quad U_{lw} = 12,500 \left(\frac{M}{10,000} \right)^{1.25} \quad 5,893 \quad (2)$$

$$\text{Longitudinal load force [N]} \quad F_{long} = 4.8M \quad 26,304 \quad (3)$$

Longitudinal load energy [J]	$U_{\text{req}} = 1.4M$	7,672	(4)
Vertical load force [N]	$F_{\text{req}} = 19.61M$	107,500	(5)

4. TEST RESULTS

4.1. Lateral load test

The lateral load was applied in increments of 5kN at the upper corner of the ROPS frame and the resulting deflection of the ROPS was measured in line with the point of load application. The energy absorbed by the ROPS was calculated as the test progressed. The lateral load force requirement of 32.88kN was met with a total lateral deflection of 22mm. The total energy absorbed by the ROPS at this stage was 400J. Loading was continued in increments of 5 kN up to 80kN at which point plastic deformation started. From this point onwards the plastic yielding of the ROPS would have resulted in large displacements associated with a 5kN load increment and therefore further data points were collected at fixed displacement increments. The lateral load energy requirement of 5,893J was reached at an applied load of 83.2kN and a total deformation of 111.1mm. There was no penetration of the ROPS or the lateral simulated ground plane into the DLV. The test data is presented in graphic format in Figure 4 in Appendix A. In the figure the requirement of total energy absorbed is represented by the horizontal yellow line. The intersection of the cumulative energy line (blue line) and the horizontal yellow line represents the point of conformance to the lateral energy absorption requirement of the ISO 3471 standard. The penetration of the ROPS and the lateral simulated ground plane into the DLV was evaluated under the load and deflection conditions corresponding to this point of intersection. The test set-up for the lateral load test of the ROPS at an applied load of 30kN is shown in Figure 2 below.



Figure 2. ROPS under load during the lateral load test.

4.2. Longitudinal load test

The longitudinal load was applied in increments of 5kN via a load spreading interface that spanned less than 80% of the width of the ROPS. The resulting deflection of the ROPS was measured in line with the point of load application. The energy absorbed by the ROPS was calculated as the test progressed. The lateral load force requirement of 26.3kN was met with a total lateral deflection of 14mm. The total energy absorbed by the ROPS at this stage was 200J. Loading was continued in increments of 5kN up to 70kN at which point plastic deformation started. From this point on the plastic yielding of the ROPS would have resulted in large displacements associated with a 5kN load increment and therefore further data points were collected at fixed displacement increments. The lateral load energy requirement of 7,672J was reached at an applied load of 78kN and a total deformation of 137.3mm. There was no penetration of the ROPS or the longitudinal simulated ground plane into the DLV. The test data is presented in graphic format in Figure 5 in Appendix A. In the figure the requirement of total energy absorbed is represented by the horizontal yellow line. The intersection of the cumulative energy line (blue line) and the horizontal yellow line represents the point of conformance to the longitudinal energy absorption requirement of the ISO 3471 standard. The penetration of the ROPS and the longitudinal simulated ground plane into the DLV was evaluated under the load and deflection conditions corresponding to this point of intersection. The test set-up for the lateral load test of the ROPS at an applied load of 75.1kN is shown in Figure 3 below.

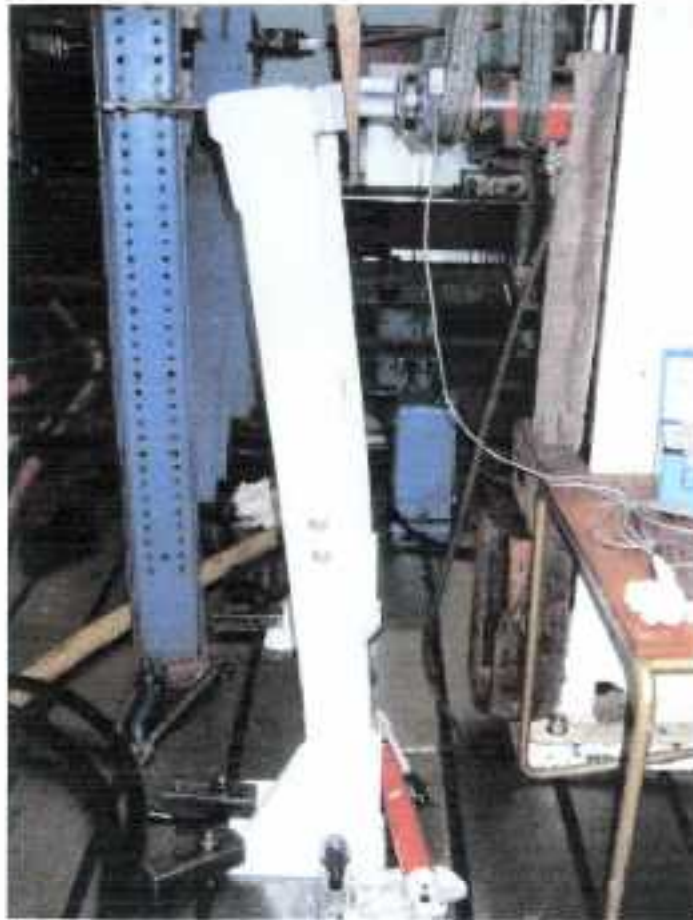


Figure 3. ROPS under load during the longitudinal load test.

4.3. Vertical load test

The vertical test load was applied in the centre of the upper ROPS cross member. The required vertical load of 107.5kN was applied and a total vertical displacement of 12mm was measured in line with the applied load. The ROPS did not penetrate the rearward projection of the deflection limiting volume under maximum applied vertical load. The test set-up for the lateral load test of the ROPS is shown in Figure 3 below.



Table 2. Test set-up for the vertical load test.

5. CONCLUSION

Investmech tested the ROPS (serial number 07-0001) manufactured by A&D Cabs cc for the AIM Flame proof tractor according to the ISO 3471:1994 standard. The results of the tests carried out confirmed that the ROPS in question conforms to the minimum requirements of the ISO 3471 standard.

6. APPENDIX A - GRAPHS OF TEST DATA

Lateral load test

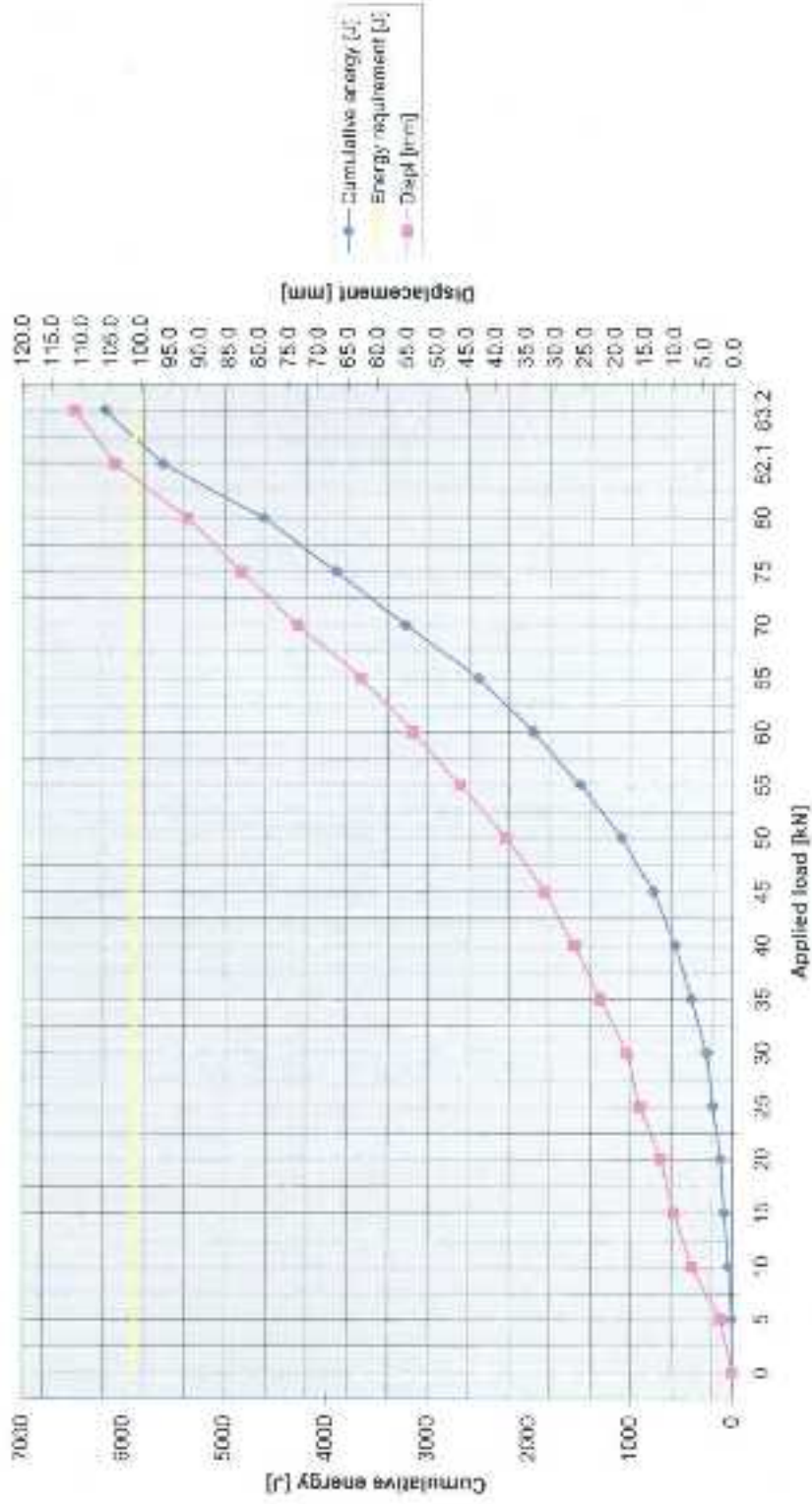


Figure 4. Lateral load test data.

Longitudinal load test

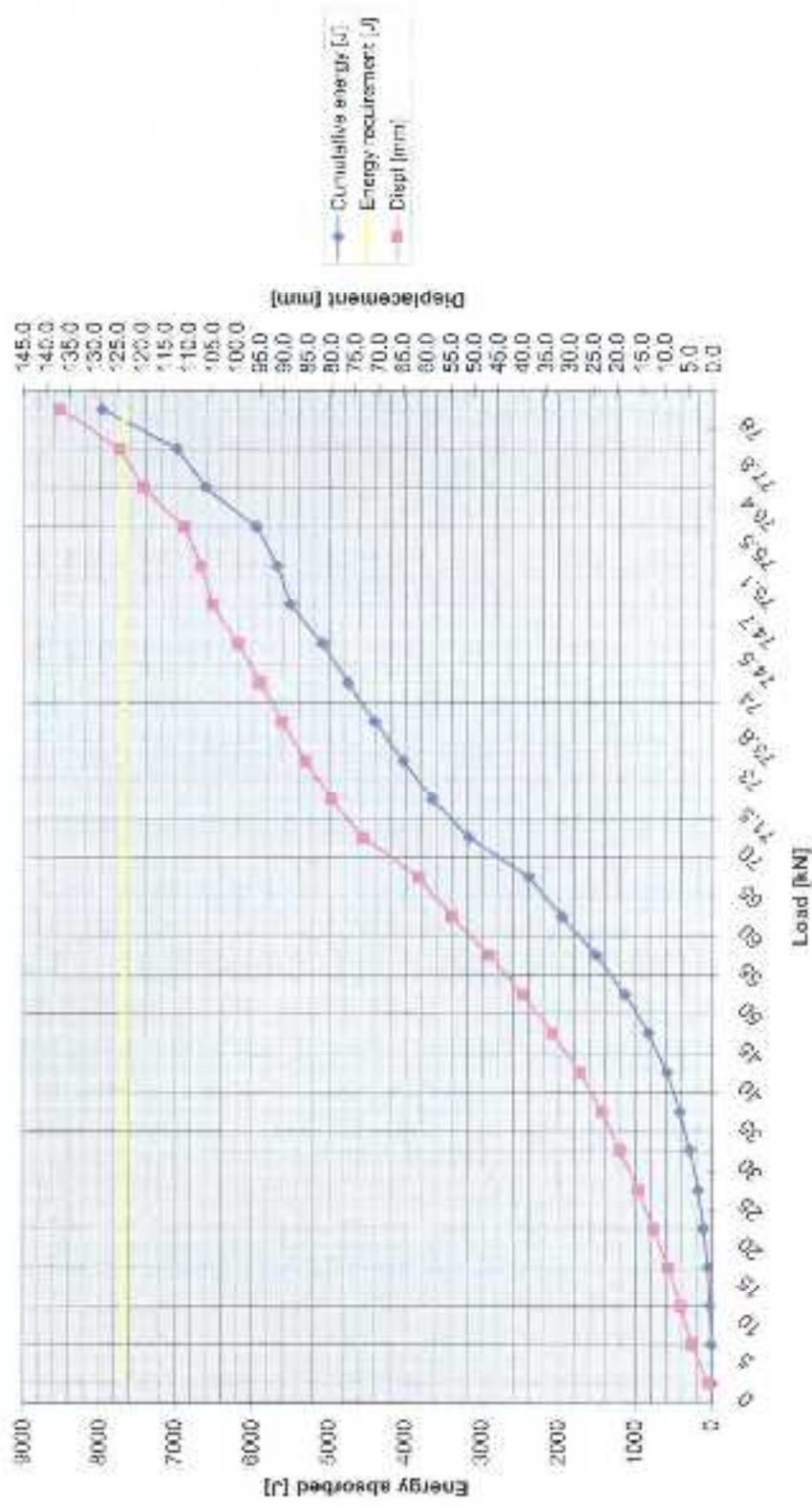


Figure 5. Longitudinal load test data.