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Technical Report – N22023

# Cardan Shaft Park Brake – Testing in Roller Brake Machines

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Transport and Mechanical Consulting

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Prepared for:  
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## 1 INTRODUCTION

This report, on the testing of heavy vehicles fitted with transmission mounted park brakes (Cardan shaft park brakes (CSB)) in roller brake machines (RBM) is a continuation of an earlier test program that determined the feasibility of using RBM to test CSB [1].

The purpose of this testing was to gather additional data to allow the development of a recommended RBM test procedure for CSB. This procedure, to be finalised by Waka Kotahi, would be used in certificate of fitness (COF) brake inspections.

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## 2 CARDAN SHAFT PARK BRAKE TESTING PROGRAM

Twenty-four vehicles were tested across three COF inspection facilities, VINZ Palmerston North, VTNZ Seaview and ITAS Te Rapa. The VINZ and ITAS testing sites used MAHA<sup>1</sup> roller brake testers and the VTNZ testing site used a BM<sup>2</sup> brand roller brake tester.

The park brake was tested using the same axle load used for the testing of the service brake. The park brake was gradually applied (with one hand) to near lock up or full lever application if wheel lock was not imminent. This procedure followed the in-service test for transmission mounted park brakes used in the United Kingdom [2]. However the minimum required test axle load and pass/fail criteria in the United Kingdom test is different to New Zealand requirements.

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<sup>1</sup> Manufactured by MAHA Maschinenbau Haldenwang GmbH & Co. KG, Germany

<sup>2</sup> Manufactured by BM AUTOTEKNIK A/S, Denmark

### 3 RESULTS

Table 1 lists the park brake efficiency of each of the vehicles tested, the efficiency listed has been calculated based on the GVM. Three vehicles out of the twenty-four vehicles that were tested had a park brake efficiency of less than 18%, these are highlighted in red in Table 1. If the test weight was used as a basis for calculating the efficiency, then only one vehicle would have failed the 20% efficiency requirement specified in the Heavy Vehicle Brake testing protocol – this is highlighted in red in Table 3.

Additional details and results for each of the vehicles that were tested are listed in Appendix A and Appendix B respectively.

**Table 1: Park brake efficiency**

Test No.	Make	Year	Odometer (km)	GVM (kg)	Lever setting (clicks)	Lever force (kg)	Efficiency
1	Hino	2015	253677	8500	NR	NR	14.6%
2	Mitsubishi	2014	252529	5995	6	24	24.6%
3	Mitsubishi	1994	178980	14500	5	30-34	20.7%
4	Mitsubishi	2011	329005	7500	11-12	30-34	37.0%
5	Hino	2016	117759	8500	10		23.1%
6	Mitsubishi	2015	151000	7500	11	48	33.4%
7	Daihatsu	2003	209857	4100	6-7	21	35.1%
8	Hyundai	2021	33976	5995	8	18	18.1%
9	Mitsubishi	1991	283352	8780	12	38	11.0%
10	Hyundai	2021	2036	8500	6	18	21.9%
11	Isuzu	2003	349569	4490	8	22	30.2%
12	Toyota	2013	126178	4955	11	43	30.2%
13	Fuso	2019	44234	5995	8	49	32.7%
14	Mazda	1998	324254	4000	13	16	18.8%
15	Isuzu	1998	540474	8500	14	22	14.3%
16	Mazda	1998	363602	5800	8	30	25.6%
17	Isuzu	2009	374211	4955	7	17	24.3%
18	Isuzu	2002	303944	4945	9	23	27.6%
19	Fuso	2021	10106	5995	11	21	25.3%
20	Hino	2008	242102	6625	9	23	24.3%
21	Nissan	2009	147185	4400	7	18	43.0%
22	Hino	2018	18924	8500	9	21	24.1%
23	Fuso	2022	14	5995	NR	NR	23.9%
24	Nissan	2013	56228	5935	NR	NR	35.4%

Key:

Red text	Axle ratings derived from type capacity
Green background	Tests conducted at VINZ Palmerston North – day 1
Brown background	Tests conducted at VINZ Palmerston North – day 2
Blue background	Tests conducted at VTNZ Seaview
Pink background	Tests conducted at ITAS Te Rapa
NR	Not Recorded

Key observations noted during the testing were:

- Ten of the vehicles were tested with a rear axle load that was more than 5% lower than the 60% required by the heavy vehicle brake testing protocol
- Four of the tested vehicles did not have axle group ratings on their loading certificate
- Tyre load ratings were being used as a basis for determining test axle loads at some inspection sites
- The currently mandated CSB test ('stall test') was not being carried out in accordance with the heavy vehicle brake testing protocol

Table 2 highlights the RBM tests where the static test load was less than 60% of the maximum rated axle mass.

**Table 2: Test weight as a percentage of GVM**

Test No.	Test weight as a percentage of GVM		
	Front	Rear	Park
1	NR	65.8%	65.8%
2	93.8%	54.2%	54.2%
3	62.5%	57.2%	49.5%
4	74.0%	61.3%	55.7%
5	NR	NR	59.7%
6	72.6%	64.2%	60.3%
7	68.3%	63.3%	31.1%
8	73.6%	51.9%	51.7%
9	72.8%	64.8%	64.8%
10	78.4%	61.4%	59.4%
11	63.5%	63.0%	64.8%
12	75.7%	56.9%	56.9%
13	74.2%	61.0%	62.3%
14	63.6%	40.8%	40.0%
15	67.1%	50.3%	55.2%
16	68.9%	55.7%	54.3%
17	83.5%	64.6%	65.6%
18	99.0%	52.3%	53.7%
19	74.7%	59.1%	59.1%
20	96.8%	106.8%	106.8%
21	NR	93.3%	93.3%
22	NR	NR	60.0%
23	NR	NR	57.8%
24	103.5%	66.7%	66.7%

Key:

Red text	Rear axle test load less than 06%
Green background	Tests conducted at VINZ Palmerston North – day 1
Brown background	Tests conducted at VINZ Palmerston North – day 2
Blue background	Tests conducted at VTNZ Seaview
Pink background	Tests conducted at ITAS Te Rapa

**Table 3: Park brake efficiency, based on the test weight and GVM**

Test No.	Park brake efficiency	
	Test weight	GVM
1	NTW	14.6%
2	30.7%	24.6%
3	33.8%	20.7%
4	50.9%	37.0%
5	NTTW	23.1%
6	40.0%	33.4%
7	46.4%	35.1%
8	24.6%	18.1%
9	15.1%	11.0%
10	28.1%	21.9%
11	27.9%	30.2%
12	55.8%	30.2%
13	36.0%	32.7%
14	29.8%	18.8%
15	20.0%	14.3%
16	35.5%	25.6%
17	27.9%	24.3%
18	30.3%	27.6%
19	32.0%	25.3%
20	20.9%	24.3%
21	38.0%	43.0%
22	NTW	24.1%
23	NTW	23.9%
24	38.4%	35.4%

Key:

Red text	Park brake efficiency less than 18% of GVM
Green background	Tests conducted at VINZ Palmerston North – day 1
Brown background	Tests conducted at VINZ Palmerston North – day 2
Blue background	Tests conducted at VTNZ Seaview
Pink background	Tests conducted at ITAS Te Rapa
NTW	No test weight recorded



## 4 PROPOSED CARDAN SHAFT BRAKE TEST

The current heavy vehicle brake testing protocol – used by COF inspection facilities requires laden brake testing of heavy vehicle brakes, with laden being defined as a minimum test load of 60% of the maximum rated axle load. On drive axles<sup>3</sup>, the 60% load requirement is most commonly achieved by applying a form of load simulation – either chassis or axle pull down.

Testing a heavy vehicle braking system up to its gross vehicle mass would give the highest level of assurance that the vehicle met the minimum brake performance requirements of the Land Transport Rule: Heavy Vehicle brakes. However, in most cases this would not be feasible as the GVM loads may exceed the legal axle loads and the forces required in applying the load simulation could be excessive.

Land Transport Rule: Heavy Vehicle Brakes [3] requires a minimum park brake performance of 18% of the GVM – this was set to align with the minimum requirements of the jurisdictions that we import heavy vehicles from (Australia, Europe, Japan and United States<sup>4</sup>).

The following two proposed test procedures are similar to the test procedure used in the United Kingdom but modified to align with the 60% loaded test requirement used to date in New Zealand.

### Option 1

Use the same axle load that was required for the service brake test (a minimum of 60% of the rated axle load).

With both the left and right brake rollers running, progressively apply the park brake until a brake efficiency of 50% is registered. If a brake efficiency of 50% is achieved then the test could be stopped. If an efficiency of 50% cannot be achieved, then the maximum efficiency obtained at full park brake application would be recorded. The brake test should be stopped if there are any signs of severe brake judder or grab.

The rationale of testing the park brake to a minimum of 50% of the test weight is that if the maximum rear axle rating is at least 60% of the GVM then park brake efficiency will be at least 18% of the GVM. Equation 1 holds if the rear axle rating is a minimum of 60% of the GVM.

$$B_{eff} \times 0.6RAR \geq 0.18GVM$$

Equation 1

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<sup>3</sup> The tare weight of steer axles normally exceeds 60% of the rated steer axle load

<sup>4</sup> Vehicles imported from other jurisdictions will meet the standards of one of listed countries

Where:  $B_{eff}$  = Brake efficiency  
RAR = Rear axle rating  
GVM = Gross vehicle mass

The proposed test procedure has been derived to test the vehicles park brake to its GVM and to align with the axle load requirements of the current heavy vehicle brake testing protocol [4].

## Option 2

Use the same axle load that was required for the service brake test (a minimum of 60% of the rated axle load).

With both the left and right brake rollers running, progressively apply the park brake up to the minimum required brake force. The brake test should be stopped if there is impending brake lockup or there are any signs of severe brake judder or grab. The minimum required brake force would correspond to 18% of the tested vehicles GVM.

## Issues

For option 1, an efficiency of 50% may be recorded in the test but the vehicle will fail the 18% of GVM requirement if the test load is less than 60% of the maximum rated axle load. The test load was less than 60% in 9 out of the 24 vehicles tested (37.5%).

For both option 1, if the test load is too high, a test efficiency of 50% may not be achieved in the RBM test but the overall park brake efficiency could still be over 18%. Both proposed tests would verify the vehicles park brake performance against the GVM. This would give a high level of assurance in the functioning and performance of the park brake. This would require reprogramming of current RBM that calculate the park brake efficiency based on the combined test load.

## 5 REFERENCES

1. Latta, D.J., *Cardan Shaft Park Brake – Testing in Roller Brake Machines*. 2021, Transport and Mechanical Consulting Limited: Waiuku. p. 27.
2. Driver and Vehicle Standards Agency, *Heavy goods vehicle (HGV) inspection manual*. 2013, Driver and Vehicle Standards Agency: Nottingham, United Kingdom. p. 186.
3. New Zealand Transport Agency, *Land Transport Rule: Heavy Vehicle Brakes 2006*. 2013: Wellington, New Zealand.
4. New Zealand Transport Agency, *Heavy vehicle brake testing: CoF and entry certification brake test protocol and procedure*. 2015, New Zealand Transport Agency: Wellington. p. 47.

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## Appendix A Details of tested vehicles

Test No.	Registration No.	VIN	Make	Model	Year	Odometer	Front axle rating (kg)	Rear axle rating (kg)	GVM (kg)
1	Redacted - Out of scope		Hino	300	2015	253677	3100	6200	8500
2	Redacted - Out of scope		Mitsubishi Fuso	Canter	2014	252529	2570	4500	5995
3	Redacted - Out of scope		Mitsubishi	Fuso	1994	178980	5150	9500	14500
4	Redacted - Out of scope		Mitsubishi	Fuso	2011	329005	3000	5640	7500
5	Redacted - Out of scope		Hino	300	2016	117759	3100	6200	8500
6	Redacted - Out of scope		Mitsubishi	Fuso	2015	151000	3100	6000	7500
7	Redacted - Out of scope		Daihatsu	Delta	2003	209857	1800	2700	4100
8	Redacted - Out of scope		Hyundai	Mighty EX6	2021	33976	2760	4700	5995
9	Redacted - Out of scope		Mitsubishi	Fuso	1991	283352	3450	6000	8780
10	Redacted - Out of scope		Hyundai	Mighty EX9EL6	2021	2036	3100	6400	8500
11	Redacted - Out of scope		Isuzu	NPR 250	2003	349569	3100	4000	4490
12	Redacted - Out of scope		Toyota	Dyna	2013	126178	2060	3900	4955
13	Redacted - Out of scope		Fuso	Canter	2019	44234	3100	6000	5995
14	Redacted - Out of scope		Mazda	Titan	1998	324254	2200	2500	4000
15	Redacted - Out of scope		Isuzu	N Series	1998	540474	3100	6600	8500
16	Redacted - Out of scope		Mazda	Titan	1998	363602	2350	4200	5800
17	Redacted - Out of scope		Isuzu	Elf	2009	374211	2060	3900	4955
18	Redacted - Out of scope		Isuzu	Elf	2002	303944	2060	4360	4945
19	Redacted - Out of scope		Fuso	Canter	2021	10106	2570	4500	5995
20	Redacted - Out of scope		Hino	Dutro	2008	242102	2640	5000	6625
21	Redacted - Out of scope		Nissan	Atlas	2009	147185		3300	4400
22	Redacted - Out of scope		Hino	300	2018	18924	3100	6200	8500
23	Redacted - Out of scope		Fuso	Canter	2022	14	2570	4500	5995
24	Redacted - Out of scope		Nissan	Atlas	2013	56228	2300	4360	73.5%

Key:	Red text	Axle ratings derived from type capacity
	Green background	Tests conducted at VINZ Palmerston North – day 1
	Brown background	Tests conducted at VINZ Palmerston North – day 2
	Blue background	Tests conducted at VTNZ Seaview
	Pink background	Tests conducted at ITAS Te Rapa

## Appendix B RBM test results – park brake

Test No.	Park weight (kg)	Percentage of GVM	Brake force (kN)	Efficiency	No. clicks	Lever force	Efficiency @ test weight	Efficiency @ GVM	Stall test result	Notes
1	4080	65.8%	12.16	28%			NTW	14.6%	P	No axle 1 test, originally failed the stall test (1st gear)
2	2440	54.2%	14.45	65%	6	24	30.7%	24.6%	P	Vehicle organised by [Redacted - P] 1st park test 70% efficiency
3	4700	49.5%	29.41	55%	5	30-34	33.8%	20.7%	P	Lock up in rollers
4	3140	55.7%	27.24	61%	11-12	30-34	50.9%	37.0%	P	Lock up in rollers
5	3700	59.7%	19.24	53%	10		NTW	23.1%	P	After hours test, no printout
6	3620	60.3%	24.61	55%	11	48	40.0%	33.4%	P	After hours test, lock up in the rollers
7	840	31.1%	14.10	75%	6-7	21	46.4%	35.1%	P	Climbed out of rollers, low dynamic weight
8	2430	51.7%	10.67	47%	8	18	24.6%	18.1%	P	
9	3890	64.8%	9.47	25%	12	38	15.1%	11.0%	F	Shoes worn, cable worn
10	3800	59.4%	18.24	47%	6	18	28.1%	21.9%	P	
11	2590	64.8%	13.31	50%	8	22	27.9%	30.2%	P	
12	2220	56.9%	21.2	56%	11	43	55.8%	30.2%	P	Redacted - commercially sensitive
13	3740	62.3%	19.26	60%	8	49	36.0%	32.7%	P	
14	1000	40.0%	7.38	68%	13	16	29.8%	18.8%	P	Rail type park brake lever
15	3640	55.2%	11.9	32%	14	22	20.0%	14.3%	F	Did not lock at full park brake application
16	2280	54.3%	14.54	61%	8	30	35.5%	25.6%	P	
17	2560	65.6%	11.8	47%	7	17	27.9%	24.3%	P	
18	2340	53.7%	13.38	58%	9	23	30.3%	27.6%	P	
19	2660	59.1%	14.9	57%	11	21	34.8%	25.3%	P	
20	5340	106.8%	15.78	33%	9	23	32.0%	24.3%	P	
21	3080	93.3%	18.58	60%	7	18	44.9%	43.0%	P	
22	3720	60.0%	20.07	55%	9	21	NTW	24.1%	P	After hours test
23	2600	57.8%	14.03	55%			NTW	23.9%	P	After hours test
24	2910	66.7%	20.59	74%			35.4%	38.4%		

Key:	Color	Description
	Red text	Park brake efficiency less than 18% of GVM
	Green background	Tests conducted at VINZ Palmerston North – day 1
	Brown background	Tests conducted at VINZ Palmerston North – day 2
	Blue background	Tests conducted at VTNZ Seaview
	Pink background	Tests conducted at ITAS Te Rapa
	NTW	No test weight

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