TRANSPORT & MECHANICAL
Consulting LTD

Technical Report – N21030

Cardan Shaft Park Brake – Testing in Roller Brake Machines

Redacted - Privacy
Transport and Mechanical Consulting

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Prepared for:
Redacted - Privacy
Waka Kotahi New Zealand Transport Agency
Chews Lane
Wellington

Redacted - Privacy
Transport and Mechanical Consulting Ltd
71 Lewis Road, Waiuku, 2682
Redacted - Privacy
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1 INTRODUCTION

This report, on determining the feasibility of using roller brake machines to test vehicles fitted with transmission mounted park brakes, builds on earlier work which identified in-service performance deficiencies with this type of brake [1]. Transmission mounted park brakes, more commonly referred to as a cardan shaft park brake (CSB) are fitted to approximately 55,000 light commercial vehicles in New Zealand [1]. The Heavy Vehicle brake test protocol [2] prohibits cardan shaft park brakes from being tested in a roller brake machine, whereas wheel mounted parking brakes, typically fitted to heavy commercial vehicles must be tested in a roller brake machine as part of entry and in-service brake testing [2]. The prohibition on testing cardan shaft park brakes in roller brake machines is historic and in place because it is thought that the differential, driveline and or park brake mechanism may be damaged by testing in a roller brake machine.

For this work the cardan shaft park brakes of two trucks were tested, using a simulated slope (pull) test and a roller brake machine. One truck, which had a GVM of 8500 kg was representative of the majority of trucks fitted with CSB, while the second, older truck, with a significantly higher GVM was an extreme example of a vehicle fitted with a CSB. Details of the two trucks tested are given in Tables 1 and 2 below.

Table 1: Vehicle data – Vehicle A

Item	
Make:	Hino
Model:	300 XZU710R-HKFTTQ3
VIN:	Redacted - Out of scope
Registration Number:	Vehicle A
Axle configuration:	4x2
Year:	2018
Odometer:	12126 km
Tare weight:	3980 kg
Gross Vehicle Mass:	8500 kg
Gross Combination Mass:	12000 kg
Wheelbase:	3500 mm
Braking system:	Vacuum/hydraulic
Brake compliance:	ECE Regulation 13
Tyre size:	225/80 R 17.5
COF expiry:	04/08/2021
Test weight:	6440 kg
Gradeability at GVM:	60 %

Table 2: Vehicle data – Vehicle B

Item	
Make:	Hino
Model:	Dolphin
VIN:	Redacted - Out of scope
Registration Number:	Vehicle B
Axle configuration:	8x4
Year:	1988 (imported to NZ 1998)
Odometer:	833838 km
Tare weight:	9480 kg
Gross Vehicle Mass:	20500 kg
Gross Combination Mass:	- kg
Wheelbase:	6590 mm
Braking system:	Air/hydraulic
Brake compliance:	Unknown
Tyre size:	Axle 1: 9.00 R 20 Axles 2, 3 & 4: 9.5 R 17.5
COF expiry:	23/04/2021
Test weight:	19360 kg
Gradeability at GVM:	Unknown

2 CARDAN SHAFT PARK BRAKE TESTING

The cardan shaft park brakes on both trucks were tested with a simulated slope (pull) test and in a brake roller machine. The pull test was used to determine, if possible, the maximum performance of the cardan shaft parking brake and to compare this to the performance values obtained from tests in the brake roller machine.

2.1 Simulated slope (pull) tests

The pull tests were conducted on each test vehicle by connecting it to a tow vehicle via strops and a load cell. The force applied to the park brake lever was measured with a digital scale and this value and the number of ratchet clicks to achieve this force was recorded. The manufacturers standard operating force and the number of ratchet clicks to achieve this were used as a guide, these values are listed in Appendix B. Appendix C lists the specifications of the load cell and digital scale used in the testing of the two trucks. The procedure for determining the limit park brake performance was:

- In the forward direction, apply the park brake on the test truck to the manufacturers recommended maximum
- Apply pull force via tow vehicle until either, the drum on park brake starts to rotate or the rear wheels start to slide, at this point record pull force reading on the load cell
- Repeat test in the reverse direction

If the wheels skidded on the ground then the performance of the park brake was limited by the coefficient of friction between the tyres and the pavement and the vertical load on the axle. In this case the maximum limiting performance of the park brake is undetermined, but higher than the tested value.

2.2 Brake roller machine tests

After the initial pull tests each truck was tested in a roller brake machine, by either gradually applying the park with the roller brake machine running or with the brake roller machine started against a fully applied park brake. These two methods of testing CSB brakes had been identified as being used in other international jurisdictions, although review of the of the test procedure used in the United Kingdom only supports testing with the roller brake machined running [3]. For the first test the park brake was applied either up to the point of wheel lock or maximum park brake application if the wheels did not lock.

3 RESULTS

3.1 Pull tests

Tables 3 and 4 list the results from the pull tests, in the forwards and reverse direction for truck registration numbers Vehicle A and Vehicle B respectively. The park brake efficiency is listed as both a percentage of the test load and the GVM, in tests where the drum rotated the maximum park brake efficiency is the GVM value, whereas for tests where the wheels skidded the maximum park brake efficiency will be higher than GVM value. Test 4 on truck Vehicle A was conducted after the roller brake machined tests.

Test 4 on truck Vehicle B was stopped as the pull force was exceeding the rated capacity of the strops being used.

The CSB on both trucks were adjusted as they were found to be out of specification, on truck Vehicle B there was significant play in the park brake linkage mounted to the transmission.

Table 3: Pull tests – Vehicle A

Test No.	Direction	Lever clicks	Lever force (kg)	Pull force (kg)	Outcome[2]	Park brake efficiency (%)	
						Test Load	GVM
1	Forward	9	25	2700	WS	42	32
2	Reverse	9	25	1690	DR	26	20
3	Reverse	10	30	2700	DR	42	32
4	Forward	9	25	2700	WS & DR	42	32

[1] Park brake adjusted before tests as there was more than 9 ratchet clicks with a pull force of less than 25 kg
[2] WS – wheel skid, DR – drum rotated

Table 4: Pull tests – Vehicle B

Test No.	Direction	Lever clicks	Lever force (kg)	Pull force (kg)	Outcome	Park brake efficiency (%)	
						Test Load	GVM
1	Forward	8	25	1600	DR	8%	8%
2	Forward	10	40	2700	DR	14%	13%
3[1]	Forward	6	25	2700	DR	14%	13%
4	Forward	7	30	3100	TS[2]	16%	15%
5	Reverse	6	25	1800	DR	9%	9%
6	Reverse	7	30	2400	DR	12%	12%
7	Reverse	8	38	2700	DR	14%	13%

[1] Park brake adjusted before test 3
[2] TS – Test stopped, rated strength of strop exceeded

3.2 Brake roller machine tests

The park brake efficiency measured in the forwards and reverse directions in the roller brake machine for trucks Vehicle A and Vehicle B is listed in Table 5 and 6 respectively. For truck Vehicle A the maximum park brake efficiency would be higher than the listed GVM value as the application of the park brake was stopped when lockup of the drive axle was considered imminent. This was done to prevent the truck from moving backwards out of the brake rollers. In these cases a higher test load on the axle would have resulted in a higher park brake efficiency as the park brake could have been applied further. For truck Vehicle B the listed park brake efficiency was a maximum, as the tested axle did not approach lockup. For these tests, the number ratchet clicks the park brake lever was applied was between six and eight. The roller brake machine printouts for each test are included in Appendix A.

Table 5: Brake roller machine tests – Vehicle A

Test No.	Direction	Test type	Axle load (kg)	Brake force (kg)	Park brake efficiency (%)	
					Test load	GVM
1	Forward	GA[1]	3640	2249	35	26
2	Reverse	GA	3640	2508	39	30
3	Forward	SR[2]	3640	2359	37	28
4	Forward	SR	3640	2542	39	30

[1] GA – gradual application of park brake with brake rollers rotating

[2] SR – stalled roller, brake roller machine started with park brake fully applied

Table 6: Brake roller machine tests – Vehicle B

Test No.	Axle No.	Direction	Axle load (kg)	Brake force (kg)	Park brake efficiency (%)	
					Test load	GVM
1	3	Forward	5800	1654	17	16
2	4	Forward	5640	1502		
3	3	Reverse	5800	1861	18	17
4	4	Reverse	5640	1541		

3.3 Stall tests

Stall tests were conducted on truck Vehicle B after completion of the brake roller tests, when tested in second and third gears the truck passed the stall test. When tested in first gear, rotation of the park brake drum was detected at the point of engine stall – a possible failure.

4 DISCUSSION

Similar levels of park brake efficiency were recorded in the brake roller machine tests and the pull tests for both trucks. For truck Vehicle A the park brake efficiency based on the GVM ranged between 20% and 30% for both the pull and brake roller machine tests. If the first reverse test is excluded, then the range would be from 26% to 30%. In all cases the park brake efficiency was above the minimum of 18% required in the Heavy Vehicle Brake Rule (HVBR) for this type of vehicle [4]. These results would give a high level of confidence that the minimum park brake performance requirements had been met for this truck.

For truck Vehicle B after the park brake was adjusted, the park brake efficiency based on the GVM ranged between 13% and 17% for both the pull and brake roller tests. In all cases this was below the minimum required in the HVBR for this type of vehicle. A stall test conducted to the requirements of the Heavy Vehicle Test protocol would have passed this trucks park brake.

The maximum force applied to the park brake levers was 30 kg and 40 kg for trucks Vehicle A and Vehicle B respectively. This is less than the maximum stipulated in the international brake standards, that heavy vehicles imported into NZ have been required to meet since 1st July 2007. The braking system on truck Vehicle A was originally complied to the European brake standard UNECE Regulation 13, which stipulates that if a brake control is manual the maximum force applied to the control shall not exceed 60 daN (61 kg) [5]. The Australian and Japanese standards stipulate maximum application forces of 60 kg and 61 kg respectively [6].

5 SUMMARY

The feasibility of using a brake roller machine to test cardan shaft park brakes was shown with the testing of two trucks with different axle configurations and gross vehicle masses. No damage to the trucks driveline and park brake assemblies was detected.

There was good agreement in the measured park brake efficiencies between the brake roller machine tests and the simulated slope tests. Testing up to the park brakes limit performance was possible, giving a higher level of confidence in the actual park brake performance than the current stall test method. Further, the roller brake machine testing of the two trucks was able to detect a vehicle with a sub-standard park brake performance, which was not detected in a stall test.

6 RECOMMENDATIONS

A draft procedure for testing cardan shaft park brakes in roller brake machines should be developed and used to test a broader range of vehicle types fitted with cardan shaft park brakes. The purpose of the testing would be to give greater levels of confidence in the suitability of using roller brake machines to test cardan shaft park brakes and allow further refinement of the test procedure.

The manufacturers of heavy vehicles fitted with cardan shaft park brakes should be asked to supply written confirmation of their approval of the proposed cardan shaft park brake roller brake test procedure.

7 REFERENCES

1. Currie, A., *Report into Cardan Shaft Park Brakes - In-service Testing and Evaluation*. 2021, Waka Kotahi NZ Transport Agency: Wellinton. p. 34.
2. New Zeland Transport Agency, *Heavy vehicle brake testing: CoF and entry certification brake test protocol and procedure*. 2015, New Zealand Transport Agency: Wellington. p. 47.
3. Driver and Vehicle Standards Agency, *Heavy goods vehicle (HGV) inspection manual*. 2013, Driver and Vehicle Standards Agency: Nottingham, United Kingdom. p. 186.
4. New Zeland Transport Agency, *Land Transport Rule: Heavy Vehicle Brakes 2006*, N.Z.T. Agency, Editor. 2013, New Zealand Transport Agency: Wellington, New Zealand.
5. UNECE, *Uniform provisions concerning the approval of vehicles of categories M, N and O with regard to braking*, in *Regultion 13*, United Nations Economic Commission for Europe, Editor. 2014, United Nations Economic Commission for Europe,: Geneva. p. 281.
6. Australian Government, *Australian Design Rule 35/06 - Commercial Vehicle Brake Systems) 2018*, in *35/06*, Australian Government, Editor. 2018, Australian Government,: Canberra Australia,. p. 64.

Appendix A Roller Brake Machine test printouts

NZTA CoF B Brake Performance Test

RBT No : : SR004907
Site name : VTNZ Porirua

Test No. : 319001
Test finalised : 2/06/2021 6:14:10 p.m.
Mileage :
Reg No. Vehicle A

	Max BF (daN) Total	BF for Imbalance (daN) Left	Right	Imbalance (%) Max	Weight static (kg) Left	Right	Total	Dynamic efficiency (%)
Axle 1 Parking	2460				---	---	---	64

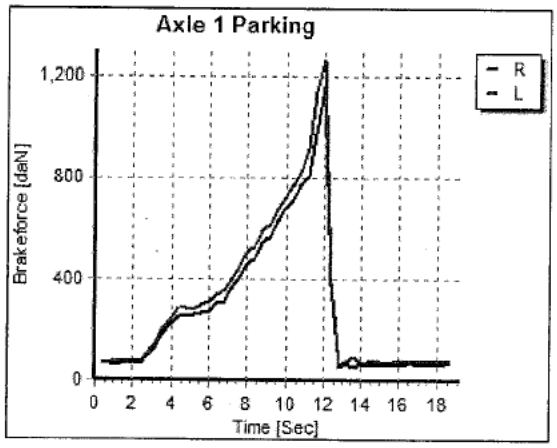
Total

Service brake

Brake force --- daN
Dynamic weight --- kg
Effeciency --- %

Parking brake

Brake force 2460 daN
Dynamic weight --- kg
Effeciency --- %



Test versions: BM FlexCheck 4.0.118 / Eprom: 9.94 /// Print versions: BM FlexCheck 4.0.118 www.bmtest.dk
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NZTA CoF B Brake Performance Test

RBT No : : SR004907
Site name : VTNZ Porirua

Test No. : 319029
Test finalised : 2/06/2021 6:22:59 p.m.
Mileage :
Reg No. Vehicle A

	Max BF (daN) Total	BF for Imbalance (daN) Left	Right	Imbalance (%) Max	Weight static (kg) Left	Right	Total	Dynamic efficiency (%)
Axle 1 Service	2164	400	440	9	1320	1480	2800	79
Axle 2 Service	2150	416	444	6	1840	1800	3640	63
Axle 2 Parking	2206				1840	1800	3640	67

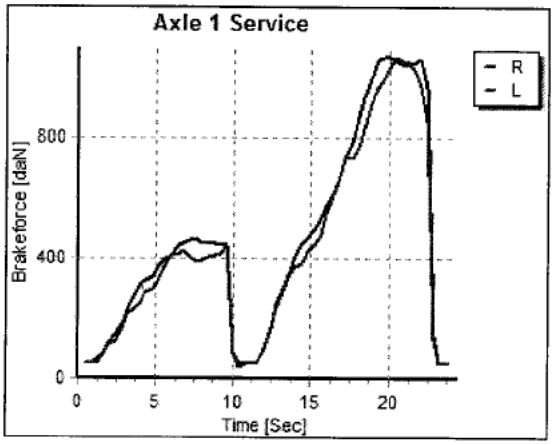
Total

Service brake

Brake force	4314 daN
Dynamic weight	6260 kg
Effeciency	70 %

Parking brake

Brake force	2206 daN
Dynamic weight	6260 kg
Effeciency	36 %



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NZTA CoF B Brake Performance Test

RBT No :	: SR004907	Test No.	: 319029
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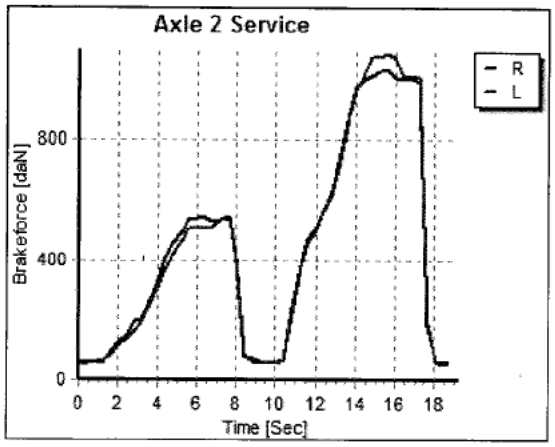
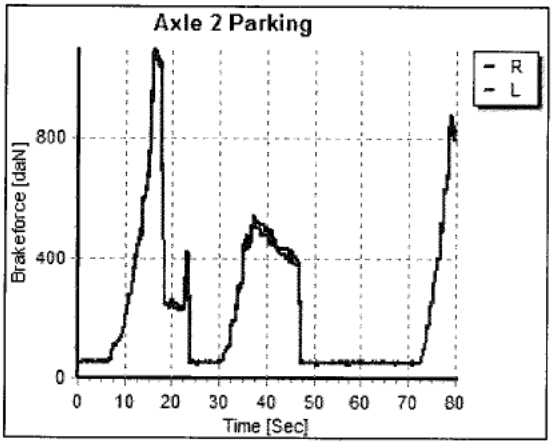
		Mileage	:
		Reg No.	Vehicle A





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NZTA CoF B Brake Performance Test

RBT No : : SR004907
Site name : VTNZ Porirua

Test No. : 319031
Test finalised : 2/06/2021 6:26:25 p.m.
Mileage
Reg No. Vehicle A

	Max BF (daN) Total	BF for Imbalance (daN) Left	Right	Imbalance (%) Max	Weight static (kg) Left	Right	Total	Dynamic efficiency (%)
Axle 1 Parking	2314 L				---	---	---	70

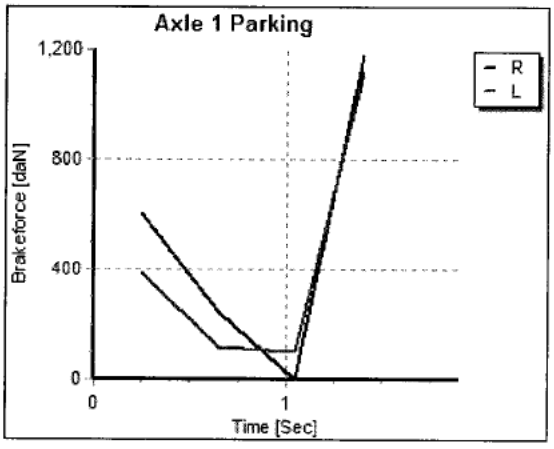
Total

Service brake

Brake force	--- daN
Dynamic weight	--- kg
Effeciency	--- %

Parking brake

Brake force	2314 daN
Dynamic weight	--- kg
Effeciency	--- %



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Site name : VTNZ Porirua

Test No. : 319033
Test finalised : 2/06/2021 6:28:18 p.m.
Mileage :
Reg No. Vehicle A

	Max BF (daN) Total	BF for Imbalance (daN) Left	Right	Imbalance (%) Max	Weight static (kg) Left	Right	Total	Dynamic efficiency (%)
Axle 1 Parking	2494 L				---	---	---	70

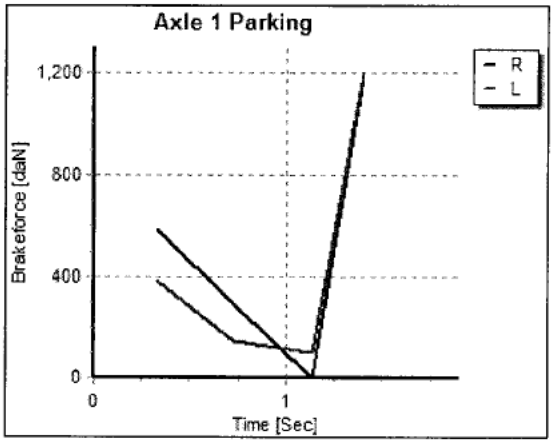
Total

Service brake

Brake force --- daN
Dynamic weight --- kg
Effeciency --- %

Parking brake

Brake force 2494 daN
Dynamic weight --- kg
Effeciency --- %



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NZTA CoF B Brake Performance Test

RBT No :	: SR004907	Test No.	: 319034
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		Mileage	:
		Reg No.	Vehicle B

	Max BF (daN)	BF for Imbalance (daN)		Imbalance (%)	Weight static (kg)			Dynamic efficiency (%)
	Total	Left	Right	Max	Left	Right	Total	
Axle 1 Parking	1826				---	---	---	32

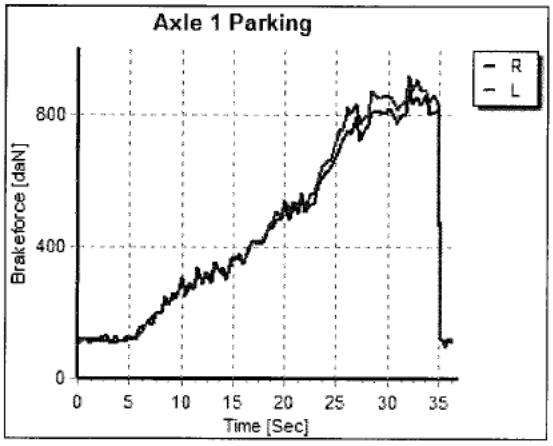
Total

Service brake

Brake force	--- daN
Dynamic weight	--- kg
Effeciency	--- %

Parking brake

Brake force	1826 daN
Dynamic weight	--- kg
Effeciency	--- %



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NZTA CoF B Brake Performance Test

RBT No : : SR004907
Site name : VTNZ Porirua

Test No. : 319035
Test finalised : 2/06/2021 7:32:01 p.m.
Mileage :
Reg No. Vehicle B

	Max BF (daN) Total	BF for Imbalance (daN) Left	Right	Imbalance (%) Max	Weight static (kg) Left	Right	Total	Dynamic efficiency (%)
Axle 1 Parking	1336				---	---	---	23

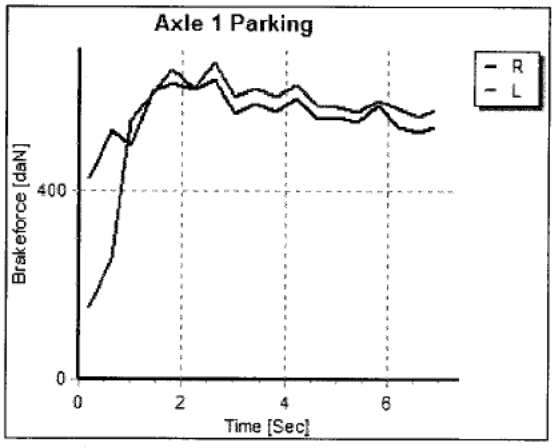
Total

Service brake

Brake force --- daN
Dynamic weight --- kg
Effeciency --- %

Parking brake

Brake force 1336 daN
Dynamic weight --- kg
Effeciency --- %



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NZTA CoF B Brake Performance Test

RBT No : : SR004907
Site name : VTNZ Porirua

Test No. : 319036
Test finalised : 2/06/2021 7:33:09 p.m.
Mileage :
Reg No. Vehicle B

	Max BF (daN) Total	BF for Imbalance (daN) Left	Right	Imbalance (%) Max	Weight static (kg) Left	Right	Total	Dynamic efficiency (%)
Axle 1 Parking	1512				---	---	---	26

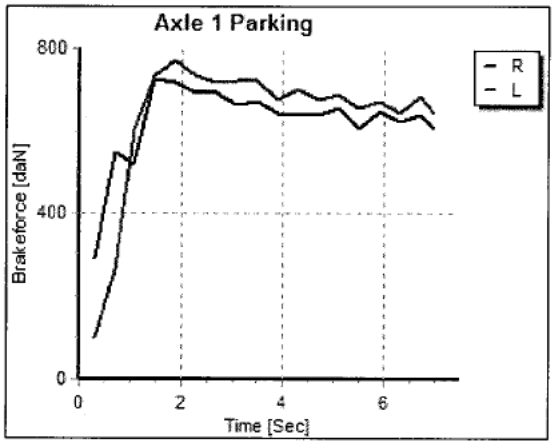
Total

Service brake

Brake force --- daN
Dynamic weight --- kg
Effeciency --- %

Parking brake

Brake force 1512 daN
Dynamic weight --- kg
Effeciency --- %



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NZTA CoF B Brake Performance Test

RBT No : : SR004907
Site name : VTNZ Porirua

Test No. : 319037
Test finalised : 2/06/2021 7:41:19 p.m.
Mileage .
Reg No. Vehicle B

	Max BF (daN) Total	BF for Imbalance (daN) Left	Right	Imbalance (%) Max	Weight static (kg) Left	Right	Total	Dynamic efficiency (%)
Axle 1 Service	3686	454	512	11	2280	2500	4780	82
Axle 2 Service	L 2604	820	546	33	1620	1520	3140	98
Axle 3 Service	3752	464	582	20	2620	3180	5800	65
Axle 3 Parking	1654				2620	3180	5800	27
Axle 4 Service	L 3938	956	660	30	2540	3100	5640	75
Axle 4 Parking	1502				2540	3100	5640	28

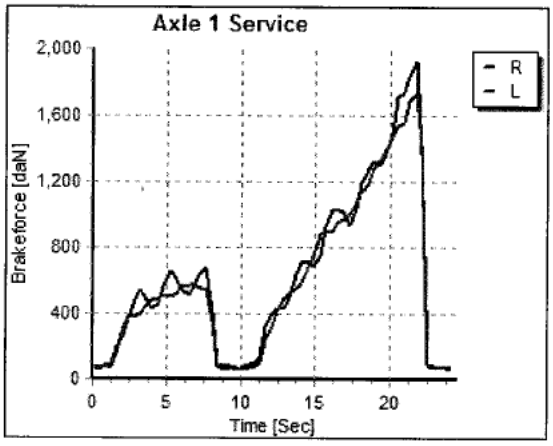
Total

Service brake

Brake force	13980 daN
Dynamic weight	18480 kg
Effeciency	77 %

Parking brake

Brake force	3156 daN
Dynamic weight	18480 kg
Effeciency	17 %



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NZTA CoF B Brake Performance Test

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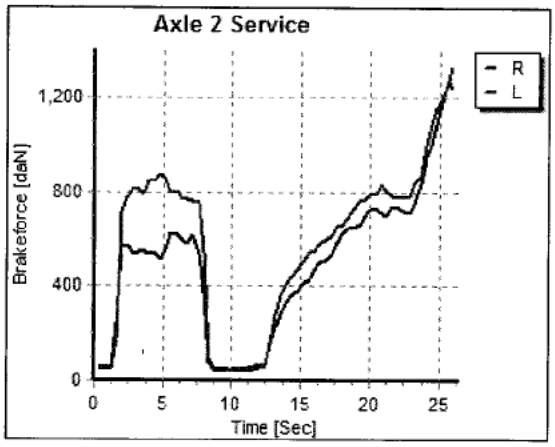

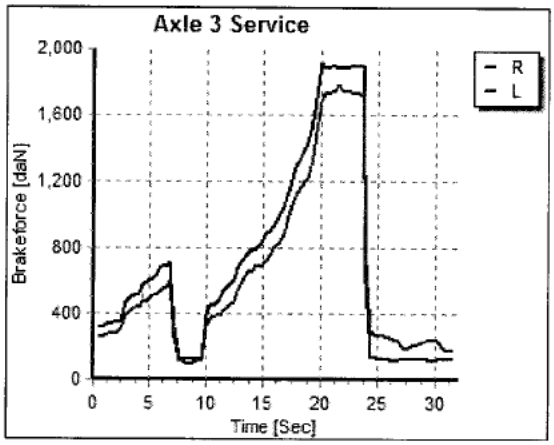

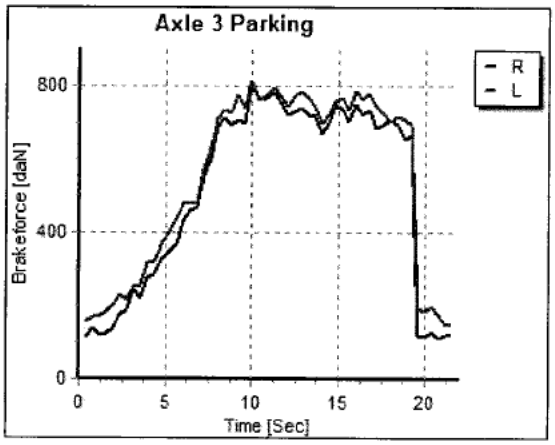

NZTA CoF B Brake Performance Test

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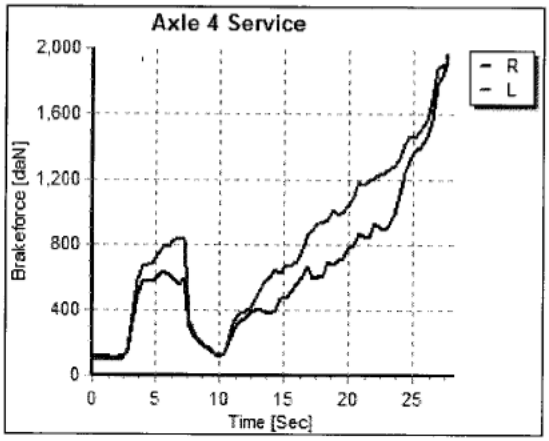
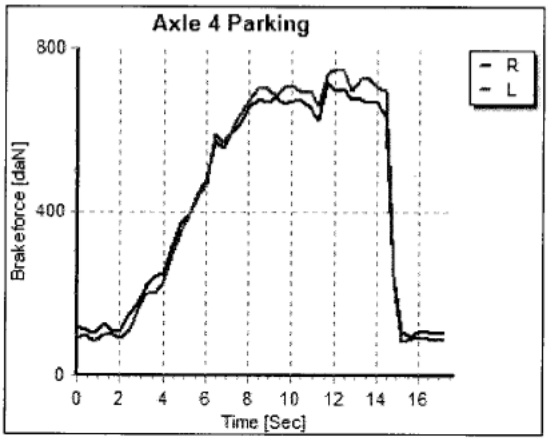
		Reg No.	Vehicle B





Test versions: BM FlexCheck 4.0.118 / Eprom: 9.94 /// Print versions: BM FlexCheck 4.0.118 www.bmtest.dk

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Appendix B Hino 300 Series Park Brake Adjustment

PARKING BRAKE

PARKING BRAKE

INSPECTION AND ADJUSTMENT

EN01E09ZZZ180402501001

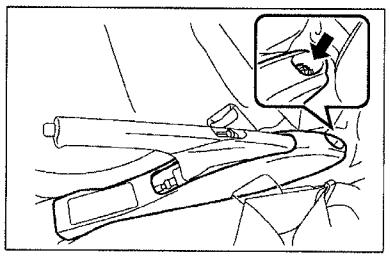
PARKING BRAKE ADJUSTMENT

1. **ADJUST THE PARKING BRAKE SHOE GAP.**
   Reference: BRAKE, PARKING BRAKE, PARKING BRAKE DRUM, OVERHAUL, ASSEMBLING THE PARKING BRAKE DRUM (PARKING DRUM INNER DIAMETER: 177.8 mm (7.000 in.)) (Page 9-331)
   Reference: BRAKE, PARKING BRAKE, PARKING BRAKE DRUM, OVERHAUL, ASSEMBLING THE PARKING BRAKE DRUM (PARKING DRUM INNER DIAMETER: 190 mm (7.480 in.)) (Page 9-340)
   Reference: BRAKE, PARKING BRAKE, PARKING BRAKE DRUM, OVERHAUL, ASSEMBLING THE PARKING BRAKE DRUM (PARKING DRUM INNER DIAMETER: 200 mm (7.874 in.)) (Page 9-349)
   Reference: BRAKE, PARKING BRAKE, PARKING BRAKE DRUM, OVERHAUL, ASSEMBLING THE PARKING BRAKE DRUM (PARKING DRUM INNER DIAMETER: 203.2 mm (8.000 in.)) (Page 9-361)

2. **INSPECT THE PARKING BRAKE RESERVE TRAVEL.**
   (1) Pull the parking brake lever hard once.
   (2) Release the parking brake lever.
   (3) Slowly release the parking brake lever and count the operating sound.

Standard value [Operating force 245 N {25 kgf, 55 lbf}]	**6-10 notches**

3. **REMOVE THE PARKING BRAKE HOLE COVER.**
   (1) Unfasten the screw and remove the parking brake hole cover.



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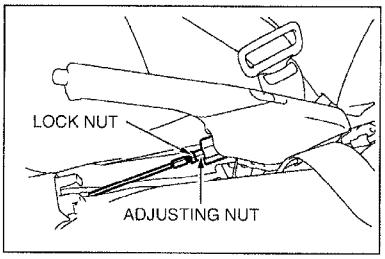

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4. ADJUST THE PARKING BRAKE LEVER RESERVE TRAVEL.

(1) Loosen the lock nut of the parking brake lever and turn the adjusting nut so that the reserve travel meets the standard value.

Standard value [Operating force 245 N {25 kgf, 55 lbf}]	**6-10 notches**

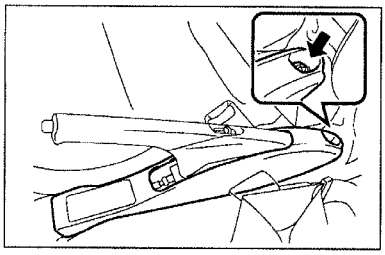
(2) Using a wrench (10 mm (0.394 in.)), tighten the lock nut.
Tightening Torque:
5.0 N·m {51 kgf·cm, 3.7 lbf·ft}

(3) Operate the parking brake lever three to four times to check the reserve travel.

Standard value [Operating force 245 N {25 kgf, 55 lbf}]	**6-10 notches**

(4) Make sure there is no dragging of the parking brake.
(5) When the parking brake lever is operated, inspect whether the parking brake light turns on.

STANDARD
The light must certainly turn on at the first notch after starting to pull the brake lever.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5. INSTALL THE PARKING BRAKE HOLE COVER.

(1) Install the parking brake hole cover with a screw.

Appendix C – Equipment Specifications

Load Cell

Make:	Dillon
Model:	EDjr-10T
Capacity:	10000 kg
Accuracy:	0.2% of capacity
Repeatability:	0.2% of capacity

Digital scale

Make:	Spigen
Model:	E500
Capacity:	50 kg
Accuracy:	
Repeatability:	