

APTA RP-BT-002 Transit Bus Foundation Brake Lining Classification

Review of
Inertia-dynamometer test procedure
and proposed Registration Program



Detroit, MI

August 2 &3, 2007





Agenda

- ❖ Attendees introduction
- ❖ AMECA introduction
- ❖ Lab tour and APTA RP-BT-002 witnessing
- ❖ Working lunch and presentation
 - Test procedure
 - Pass/fail criteria
 - Registration process
 - Audit process
- ❖ Continue APTA meeting and discussion



Test conditions

Table 1 - Brake configurations and test conditions

Description	Brake type	
	Brake size (dia x width in.)	14 ½ x 10
Designation	FMSI #4592 AD	FMSI #4728 D
Type	Meritor W brake	Meritor Cast Plus brake
Gross axle weight rating	26,000 lbs	26,000 lbs
Static loaded radius (SLR)	20.3 in	18.5 in
Air chamber	Type 30 standard stroke	Type 30 standard stroke
Slack adjuster length	7 in	6 ½ in
Drum weight	180 lbs nominal	165 lbs nominal
Surface finish	200 micro-inches maximum	200 micro-inches maximum
Test inertia	1,155 slug·ft ²	960 slug·ft ²



Test conditions on test report

Dynamometer Information

Rolling Radius:	20.3 inch	515.6 mm
Required Wheel Load:	13000 lb	5897 Kg
Actual Wheel Load:	13001 lb	5897 Kg
Gross Axle Weight:	26000 lb	11794 Kg
Required Inertia:	1156.9 slug-ft ²	1568.5 Kg-m ²
Actual Inertia:	1156.9 slug-ft ²	1568.6 Kg-m ²
Air Chamber:	MGM 30/30	
Slack Adjuster:	Haldex 7.0" Automatic	

Brake Information

Brake Type:	MERITOR "W" DRIVE
Brake Size:	14.5X10
Assy P/N:	WEBB 64115
Pri/Lead/Inner Lining:	formulation
Sec/Trail/Outer Lining:	formulation
Drum/Rotor Type:	CAST
Brake Orientation:	Left



Brake burnish

Brake burnish provides even contact surface and generates stable transfer layer in preparation for the performance test.

Burnish cycle makes 400 stops with controlled deceleration and initial brake temperature.

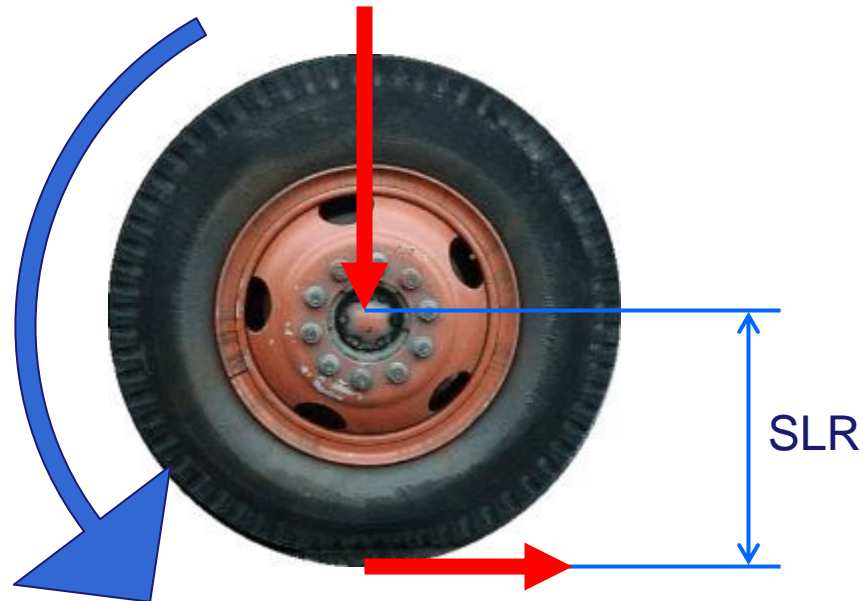
Link Test #:	Sample-1	Link Testing Laboratories, Inc. Brake Dynamometer Testing										Cust Ref:	NA
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Stop Num	Brake Speed mph	Rel. Speed mph	Stop Time sec	Avg Decel (time) ft/s ²	Min Torq. lb*ft	Avg Torq. (time) lb*ft	Max Torq. lb*ft	Min Press psi	Avg Press (time) psi	Max Press psi	Min Stroke Inch	Avg Stroke (time) Inch	Max Stroke Inch	Init Lead F	Final Lead F	Init Drum F	Final Drum F
Burnish																	
1	39.9	0.6	5.81	9.90	6912	7348	7809	33.8	63.1	77.5	1.611	1.775	1.849	350	359	357	499
10	39.9	0.6	5.79	9.94	6976	7420	7858	33.5	70.3	88.9	1.611	1.747	1.832	350	363	377	482
20	39.9	0.5	5.79	9.98	6994	7394	8015	34.4	69.6	81.5	1.611	1.736	1.791	351	363	376	481
180	39.9	0.5	5.76	10.03	6483	7339	7742	42.3	51.9	54.4	1.611	1.374	1.417	350	374	363	489
190	39.9	0.5	5.78	9.99	6586	7293	7607	53.1	54.1	60.0	1.611	1.372	1.441	350	374	363	490
200	39.9	0.6	5.78	9.96	6229	7339	7861	35.0	48.8	54.0	1.611	1.361	1.400	350	374	361	486
210	40.1	0.5	5.87	9.90	6696	7272	7495	64.7	70.3	79.7	1.611	1.727	1.829	500	540	556	656
220	40.1	0.5	5.79	10.03	6563	7292	7575	58.4	61.3	67.3	1.611	1.639	1.696	499	534	498	614
380	40.0	0.6	5.80	9.96	6447	7294	7583	51.8	55.6	58.7	1.611	1.381	1.449	500	543	496	591
390	40.0	0.6	5.80	9.96	6472	7303	7616	51.2	54.9	56.9	1.611	1.382	1.450	499	543	494	588
400	40.0	0.5	5.80	9.99	6618	7278	7630	49.7	53.7	63.8	1.611	1.385	1.491	500	543	496	588



Retardation ratio

$$\text{Wheel Load} = \frac{\text{GAWR}}{2} = \frac{26,000}{2} = 13,000 \text{ lb}$$



$$\text{Braking Force} = \text{Retardation Ratio} \times \frac{\text{GAWR}}{2} \text{ [lbs]}$$

$$\text{Brake Output Torque} = \text{Retardation Ratio} \times \frac{\text{GAWR}}{2} \times \frac{\text{SLR}}{12} \text{ [lb} \cdot \text{ft]}$$



Brake retardation on test report

Brake retardation tests measures the brake torque output (and equivalent deceleration level / retardation ratio) at increasing input brake pressures.

The APTA RP uses three pressure levels to characterize the friction material behavior.

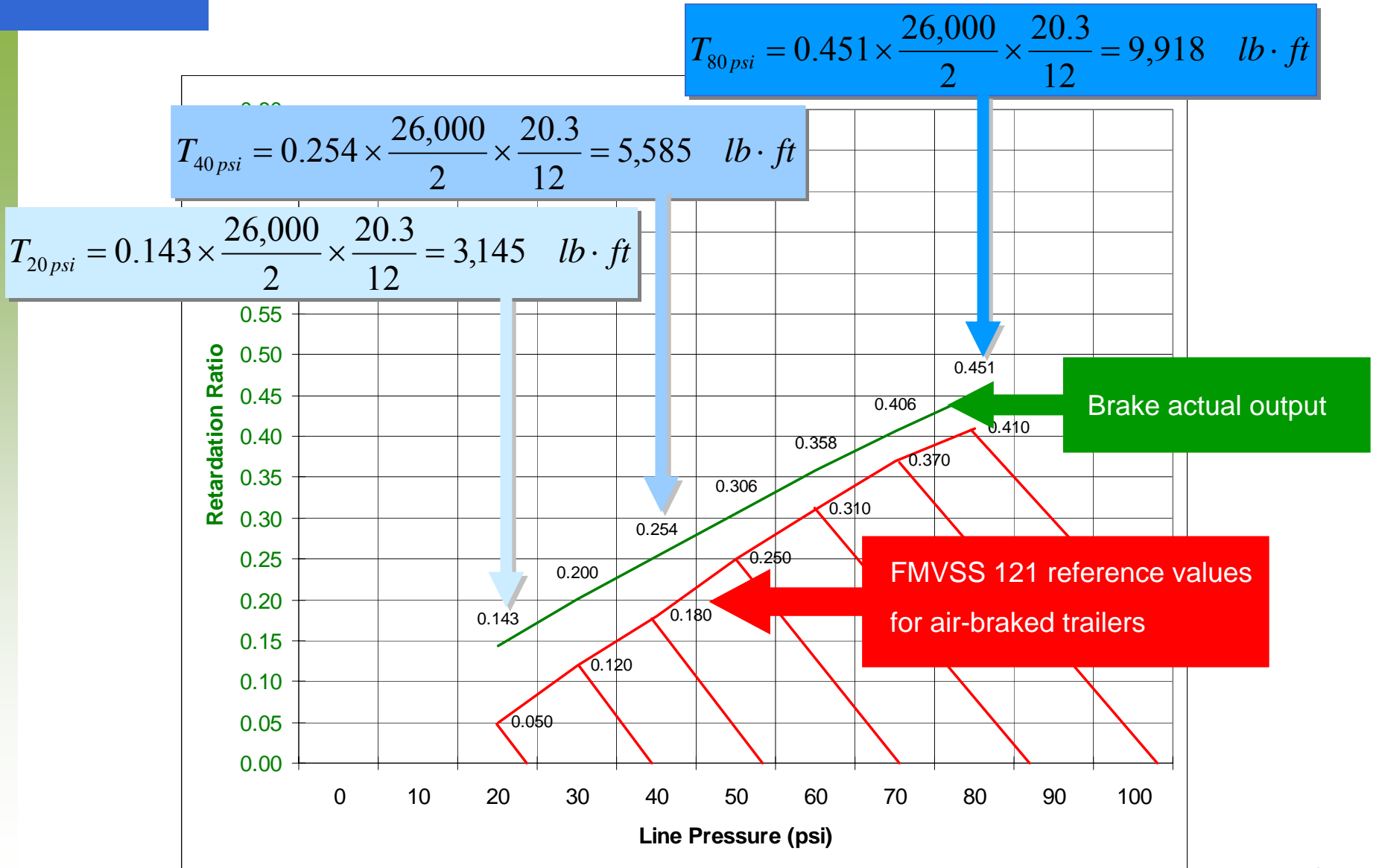
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Stop Num	Brake Speed mph	Rel. Speed mph	Stop Time sec	Avg Decel (time) ft/s ²	Min Torq. lb*ft	Avg Torq. (time) lb*ft	Max Torq. lb*ft	Avg Press (time) psi	Min Stroke inch	Avg Stroke (time) inch	Max Stroke inch	Min Req'd Retard Ratio	Ret Ratio Act	Ret Force Lb	Init Lead F	Final Lead F	Init Drum F	Final Drum F
Brake Retardation																		
1	49.9	0.5	16.2	4.47	2693	3139	3757	20.0	0.967	1.054	1.099	0.050	0.143	1855	170	262	181	279
2	49.9	0.5	11.7	6.19	3922	4399	5179	29.9	1.126	1.202	1.244	0.120	0.200	2601	169	231	174	266
3	49.9	0.6	9.3	7.81	5065	5587	6457	40.0	1.251	1.325	1.383	0.180	0.254	3303	169	222	172	275
4	49.9	0.5	7.7	9.36	6190	6739	7683	49.9	1.389	1.448	1.502	0.250	0.306	3984	170	222	171	290
5	49.9	0.6	6.7	10.81	7281	7869	8778	60.0	1.489	1.556	1.605	0.310	0.358	4651	169	226	169	313
6	49.9	0.5	5.9	12.21	8365	8939	9789	69.9	1.602	1.670	1.714	0.370	0.406	5284	170	225	169	330
7	50.0	0.5	5.4	13.46	9361	9912	10761	80.0	1.704	1.769	1.812	0.410	0.451	5859	171	225	169	346

APTA Torque ratings



Brake retardation graph





Brake power, hot stop, and recovery

Brake power, hot stop, and recovery tests determines the friction material performance during temperature build-up (brake power), and cool down (recovery).

The dynamometer control performs the different brake applications controlling the time between events.

Brake Power, Hot Stop and Recovery.

TABLE 7

Cycles	Initial Speed	Final Speed	Average Deceleration	Pressure	IBLT	Cycle Time
1	80.5 km/h (50 mph)	24.1 km/h (15 mph)	2.7 m/sec ² (9 ft/sec ²)	~	80 °C (176 °F)	~
9	80.5 km/h (50 mph)	24.1 km/h (15 mph)	2.7 m/sec ² (9 ft/sec ²)	~	~	72 sec
1	32.2 km/h (20 mph)	0 km/h (0 mph)	4.3 m/sec ² (14 ft/sec ²)	~	~	66 sec
1	48.3 km/h (30 mph)	0 km/h (0 mph)	3.7 m/sec ² (12 ft/sec ²)	~	~	122 sec
19	48.3 km/h (30 mph)	0 km/h (0 mph)	3.7 m/sec ² (12 ft/sec ²)	~	~	60 sec



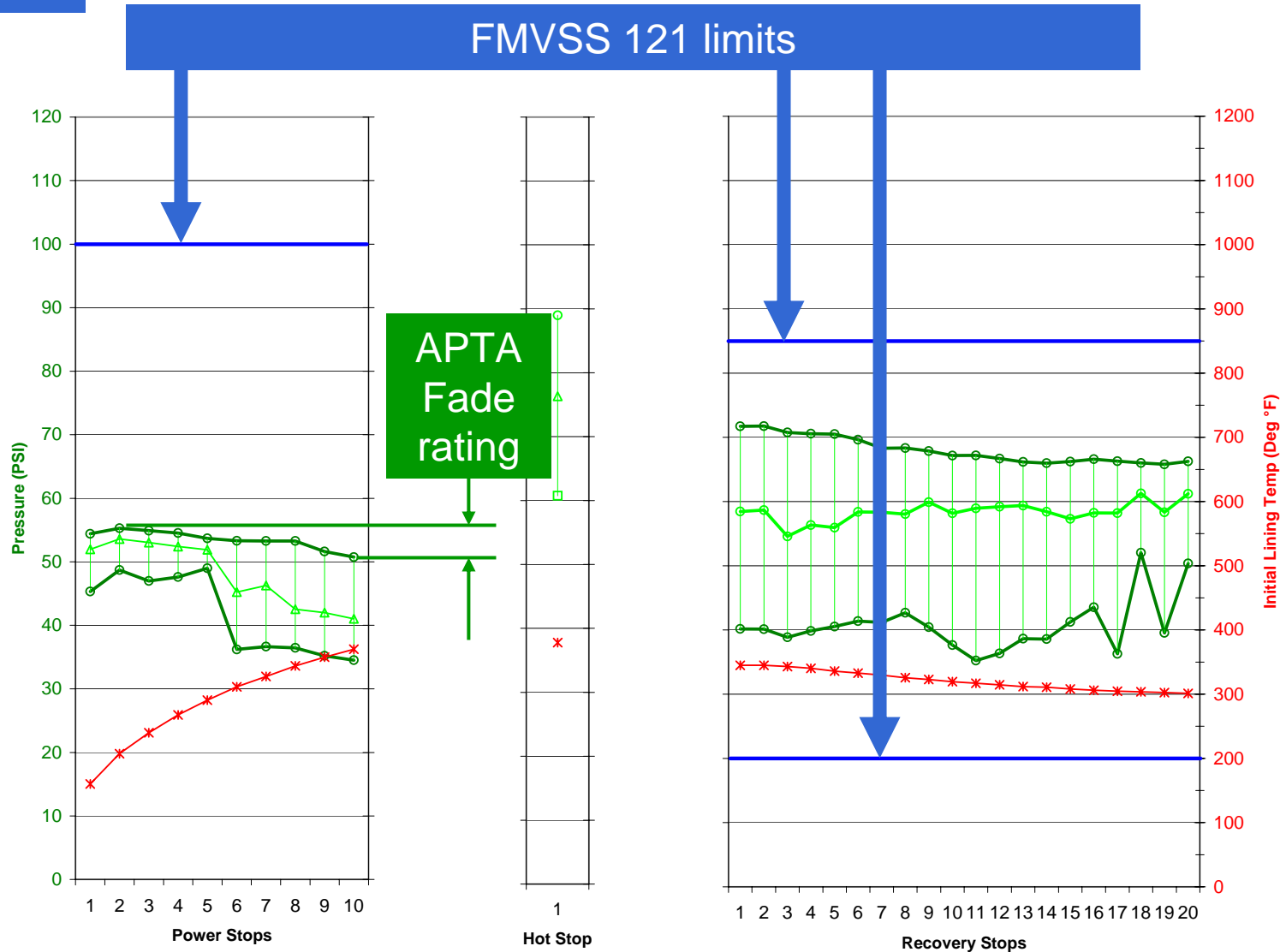
Brake power, hot stop, and recovery on test report

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Stop Num	Brake Speed mph	Rel. Speed mph	Stop Time sec	Avg Decel (time) ft/s ²	Min Torq. lb*ft	Avg Torq. (time) lb*ft	Max Torq. lb*ft	Min Press psi	Avg Press (time) psi	Max Press psi	Min Stroke Inch	Avg Stroke (time) Inch	Max Stroke Inch	Init Lead F	Final Lead F	Init Drum F	Final Drum F
Brake Power																	
1	49.9	15.1	5.63	9.07	6611	6895	7356	45.3	52.0	54.4	1.403	1.468	1.498	150	197	148	279
2	49.9	15.0	5.69	9.00	6680	6895	7254	48.7	53.6	55.3	1.480	1.529	1.570	198	242	201	319
3	50.0	15.1	5.67	9.03	6642	6899	7247	47.0	53.0	54.9	1.527	1.575	1.606	231	277	244	359
4	50.0	15.0	5.68	9.04	6628	6896	7241	47.6	52.4	54.5	1.567	1.616	1.645	259	302	279	397
5	50.0	15.0	5.70	9.02	6622	6890	7195	49.0	51.9	53.7	1.600	1.642	1.670	282	323	309	436
6	50.0	15.1	5.62	9.10	6408	6918	7535	36.2	45.2	53.3	1.623	1.654	1.699	303	343	336	469
7	50.0	15.1	5.60	9.14	6402	6915	7690	36.6	46.3	53.3	1.629	1.671	1.721	320	359	358	493
8	49.9	15.0	5.68	9.02	6388	6917	7496	36.5	42.5	53.3	1.614	1.671	1.706	336	374	377	512
9	50.0	15.0	5.72	8.98	6250	6904	7882	35.2	42.0	51.6	1.620	1.680	1.729	350	387	392	531
10	50.0	15.0	5.63	9.13	6274	6899	7937	34.5	41.0	50.7	1.623	1.687	1.733	362	399	406	547
Hot Stop																	
1	19.9	0.6	1.98	14.32	10125	11792	12622	60.7	76.3	89.0	1.986	2.020	2.058	378	382	422	454
Recovery																	
1	29.8	0.6	3.59	11.94	8099	9203	10392	40.2	58.5	71.7	1.690	1.782	1.853	345	360	361	430
2	29.8	0.5	3.57	12.07	8238	9260	10095	40.1	58.7	71.8	1.666	1.775	1.835	345	359	354	423
3	29.8	0.6	3.57	12.01	8143	9245	10662	38.9	54.6	70.7	1.654	1.751	1.853	343	358	349	415
4	29.8	0.5	3.57	12.06	8298	9297	10570	39.9	56.3	70.6	1.657	1.747	1.822	340	354	344	411
5	29.8	0.6	3.59	11.94	8052	9217	10604	40.5	55.9	70.5	1.637	1.730	1.817	336	352	339	404
15	29.8	0.5	3.55	12.12	8370	9271	9819	41.2	57.3	66.2	1.633	1.695	1.729	308	322	306	369
16	29.8	0.6	3.55	12.07	8576	9265	9738	43.6	58.2	66.6	1.637	1.695	1.729	306	320	304	367
17	29.8	0.5	3.54	12.16	8566	9306	9907	36.3	58.2	66.3	1.627	1.695	1.727	305	319	302	364
18	29.8	0.5	3.58	12.01	8454	9210	9611	52.0	61.3	66.0	1.667	1.699	1.719	304	317	300	361
19	29.8	0.5	3.56	12.09	8191	9248	10062	39.5	58.3	65.8	1.627	1.693	1.739	302	315	299	359
20	29.8	0.6	3.59	11.94	8325	9207	9628	50.3	61.2	66.2	1.661	1.700	1.722	301	314	298	359



Brake power, hot stop, and recovery graph





Summary pass/fail criteria Transit Buses

TABLE A1

Section	Application	Trailer minimum without antilock	Trailer minimum with antilock	Trailer maximum	Bus, Truck & Tractor Drive minimum without antilock	Bus, Truck & Tractor Drive minimum with antilock	Bus, Truck & Tractor Drive maximum	Bus, Truck & Tractor Front minimum	Tractor Front maximum	Bus & Truck Front maximum
Retardation	138 kPa (20 psi)	0.05 *	0.05 *	na	na	na	na	na	na	na
Retardation	207 kPa (30 psi)	0.12 *	0.12 *	na	na	na	na	na	na	na
Retardation	276 kPa (40 psi)	0.18 *	0.18 *	na	na	na	na	na	na	na
Retardation	345 kPa (50 psi)	0.25 *	0.25 *	na	na	na	na	na	na	na
Retardation	414 kPa (60 psi)	0.31 *	0.31 *	na	na	na	na	na	na	na
Retardation	483 kPa (70 psi)	0.37 *	0.37 *	na	na	na	na	na	na	na
Retardation	552 kPa (80 psi)	0.41 *	0.41 *	na	na	na	na	na	na	na
Power	1-10	na	na	690 kPa (100 psi)	na	na	690 kPa (100 psi)	na	690 kPa (100 psi)	690 kPa (100 psi)
Hot stop	1	na	na	na	na	na	na	na	na	na
Recovery	1-20	138 kPa (20 psi)	83 kPa (12 psi)	586 kPa (85 psi)	138 kPa (20 psi)	83 kPa (12 psi)	586 kPa (85 psi)	na	na	586 kPa (85 psi)

* Retardation Ratio per item 5.12



Conformance certification



AMERICAN PUBLIC TRANSPORTATION ASSOCIATION

Conformance Certification Report 07001

BT-RP-002-05 Transit Bus Foundation Brake Lining Conformance Certification

Customer: **Customer**
Address:

Brake: 14 ½ x 10
FMSI: **4592 AD**
GAWR: **26,000 lbs**
Material: **formulation**

SLR: **20.3 in**
Air chamber: **Type 30 Std**
Slack Adjuster: **7 in**

The tested material meets all APTA conformance criteria

APTA conformance criteria	Requirement	Units	Minimum	Maximum	Test #1	Test #2	Test #3	Average
			level	level				
Brake retardation ratio 20 psi	Reference only	-	0.050	-	0.143	0.154	0.176	0.158
Brake retardation ratio 30 psi	Reference only	-	0.120	-	0.200	0.223	0.239	0.221
Brake retardation ratio 40 psi	Reference only	-	0.180	-	0.254	0.293	0.291	0.279
Brake retardation ratio 50 psi	Reference only	-	0.250	-	0.306	0.330	0.342	0.326
Brake retardation ratio 60 psi	Reference only	-	0.310	-	0.358	0.378	0.388	0.374
Brake retardation ratio 70 psi	Reference only	-	0.370	-	0.406	0.424	0.429	0.420
Brake retardation ratio 80 psi	Reference only	-	0.410	-	0.451	0.464	0.465	0.460
Brake power maximum pressure	Below maximum	psi		100	55.3	48.9	46.7	50.3
Brake recovery maximum pressure	Below maximum	psi		85	71.8	66.1	55.2	64.4
Brake recovery minimum pressure	Above minimum	psi	12	-	35.2	41	31.9	36.0
Torque value at 20 psi	Reference only	lb-in	-	-	37,666	40,712	46,541	41,639
Torque value at 40 psi	Reference only	lb-in	-	-	67,049	77,316	76,894	73,753
Torque value at 80 psi	Reference only	lb-in	-	-	118,943	122,385	122,642	121,323
Fade rating	Reference only	psi	-	-	6	12.4	5.3	7.9



Conformance Certification date: 27-Apr-07
Valid until: 25-Apr-12

Approval: Kevin Woolford, Executive Director

This report expires automatically whenever formulation changes, customer does not keep a current quality system accreditation, or the audit test fails



Simplified Conformance Certification workflow

- ❖ Conduct three successful tests on an APTA brake configuration with approved hardware
- ❖ Send submission form to LINK
- ❖ LINK performs test review
- ❖ LINK conducts off-the-shelf audit test
- ❖ LINK submits to AMECA
- ❖ AMECA posts formulation and ratings on website



Definition of performance criteria

- ❖ Allowable test-to-test variation during initial registration process
 - Criteria
 - Reference values
- ❖ Allowable audit test variation versus initial registration testing

Q&A

