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POWER BRAKE
DIAMOND TECHNOLOGY SOLUTIONS

727-526-1333
www.powerbrake1.com

INSPECTION OF BUSES WITH TEST BRAKE BLOCK

Date of Inspection: August, 9 2016

Location: Palm Tran North County Maintenance Shop
3201 Electronics Way
West Palm Beach, FL 33407

Buses Inspected, Front or Rear, Installation Date, and Odometer Data:

UNIT	F/R	INSTALLATION COMPLETE	ODOMETER INSTALL	ODOMETER PRESENT	MILEAGE TO DATE
0715	F	9/19/2015	485,517	530,953	**45,436**
0802	F	10/9/2015	399,553	444,313	**44,760**
1207	R	10/7/2015	202,570	249,235	**46,665**
0710	R	10/18/2015	506,040	547,487	**41,447**

Purpose of Test

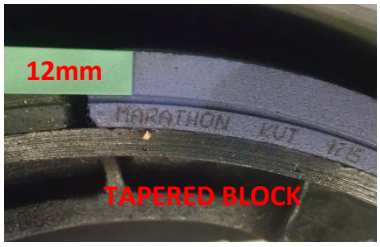
To compare performance and longevity of Palm Tran Gillig bus front and rear test brake block material, when used with Marathon friction on opposing axles. All buses are equipped with Power Brake Diamond Technology brake drums. After installation of new brakes and after periodic Preventative Maintenance, Vericom computer performance based brake tests (PBBT) were conducted to ensure bus stopping powers meet or exceeds Federal Motor Vehicle Safety Standards, and are consistent with typical Palm Tran performance. Visual inspections were done to evaluate lining wear. Measurements were taken on frictions to determine wear rates and draw reasonable conclusions about expected friction life.

While brake block *overall* thicknesses are known industry standard specifications, the available friction material for use is the material *above the end-of-life wear indicator line*. This is relevant because brake shoes are replaced when lining is worn to this indicator line. Therefore, as a baseline for comparison and to help estimate possible future life, brake block thicknesses above end-of-life wear indicator marks were taken for new front and rear frictions.

Front Block FMSI # 4715A

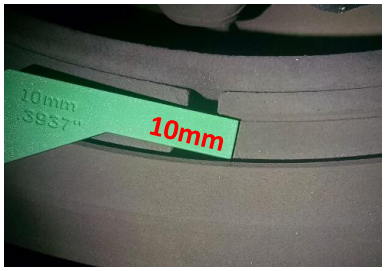
Overall thickness at shoe center, anchor .798", cam .842 (this is a tapered brake block design)

Thickness above wear indicator, approximately 12mm (.472")

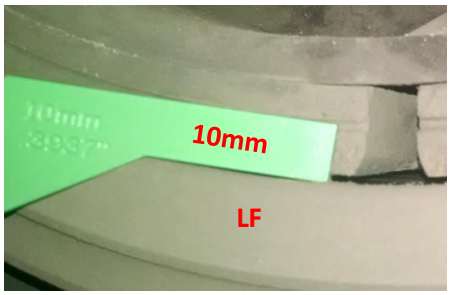


Rear Block FMSI # 4592A
Overall thickness at shoe center, anchor and cam .750”
(this is a parallel, non-tapered brake block design)
Thickness above wear indicator, approximately 8mm (.315”)

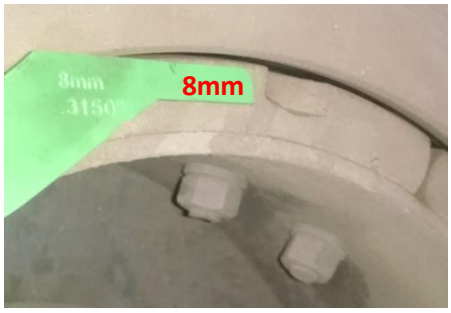
Bus 0715 (front)
Approximate lining thickness at shoe center:
RF 10mm (wear 2mm), LF 10mm (wear 2mm)
Overall thickness approx. 23/32”
Visible drum brake surface – normal
RF drum, no lip
LF drum, very slight lip



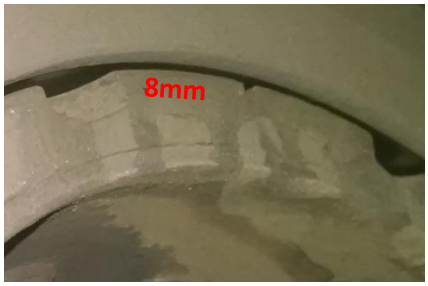
Bus 0802 (front)
Approximate lining thickness at shoe center:
RF 10mm (wear 2mm), LF 9mm (wear <3mm)
Overall thickness approx. RF 23/32”, LF 22/32”
Visible drum brake surface – normal
RF drum, no lip
LF drum, no lip



Bus 710 (rear)
Approximate lining thickness at shoe center:
RR 8mm, LR 8mm (no significant visible wear)
Overall thickness approx. 24/32”
Visible drum brake surface – normal, no lip



Bus 1207 (rear)
Approximate lining thickness at shoe center:
RR 8mm LR 8mm (no significant visible wear)
Overall thickness approx. 24/32”
Visible drum brake surface – normal, no lip but some minor scoring near open diameter of RR drum, nothing to be concerned about



Comments and Conclusions

All four of the buses inspected have been operating in service for about ten or eleven months, with service miles traveled at an average of approximately 45,000 miles. There have been no reported complaints or issues regarding performance or brake noise. Vericom PBBT reports all reflect excellent stopping power, well below federal regulations (FMVSS 121, FMCSA 393.52) of maximum 20mph stopping distance of 32 feet, and above APTA minimum recommended stopping power (decel, measured as g force). (See Appendix A for Vericom Transit Reports for each bus.)

It should be noted that in Palm Tran Gillig buses typical life of front brakes to rear brakes is two-to-one; meaning that front brakes last about twice as long as rear brakes. There is nothing in this report that would contradict this reality, even though front brake shoes exhibit more wear than the rears. Here is the reason for this assumption:

The design of the front 4715A lining is a tapered brake block that is thicker at the center than it is at the cam and anchor ends of the shoe. New tapered frictions are engineered to wear first at the thicker center apex of the shoe. Eventually, as the shoe wears out the "tapered" brake block wears toward that of a non-tapered block. Early in the service life of a tapered block wear rates are greater at the center contact area than later in the friction life cycle. Because of this design, percentage of shoe-to-drum contact area is less in the early stages and this contact area increases as the brakes wear.

The design of the rear 4592A lining is a straight, non-tapered brake block. Therefore, with a new brake drum this friction has a larger "footprint" of new shoe-to-drum percentage than its tapered counterpart. Wear rates are generally more consistent from the cam to the anchor end of the shoe.

While it is not possible to know if all of the system foundation brake and pneumatic factors will remain unchanged to precisely predict total brake life, it is reasonable to conclude that current observations are quite favorable to expect the front test brakes may last as many as 200,000 miles and rears could easily exceed 100,000 miles. This is based on the observations that the front brake shoes at 45,000 miles have 2 of the available 12 millimeters worn away, effectively $1/6^{th}$ of the usable friction. Multiplying 45K miles by 6 equals 270k miles. However, the other foundation components in the system (drums, bushings, pins, rollers, s-cams etc.) will also experience normal wear and tear and this will likely increase wear rates as the brakes age with time and mileage. The rear brake shoes do not show any significant wear at all, and the same principles apply. It would be premature, at the 45,000 mile threshold, to predict rear brake life in excess of 200,000 miles. Nonetheless, there is solid evidence to be optimistic about achieving unprecedented brake life using these friction materials, while employing the other known best practices regarding components, installation and maintenance procedures.

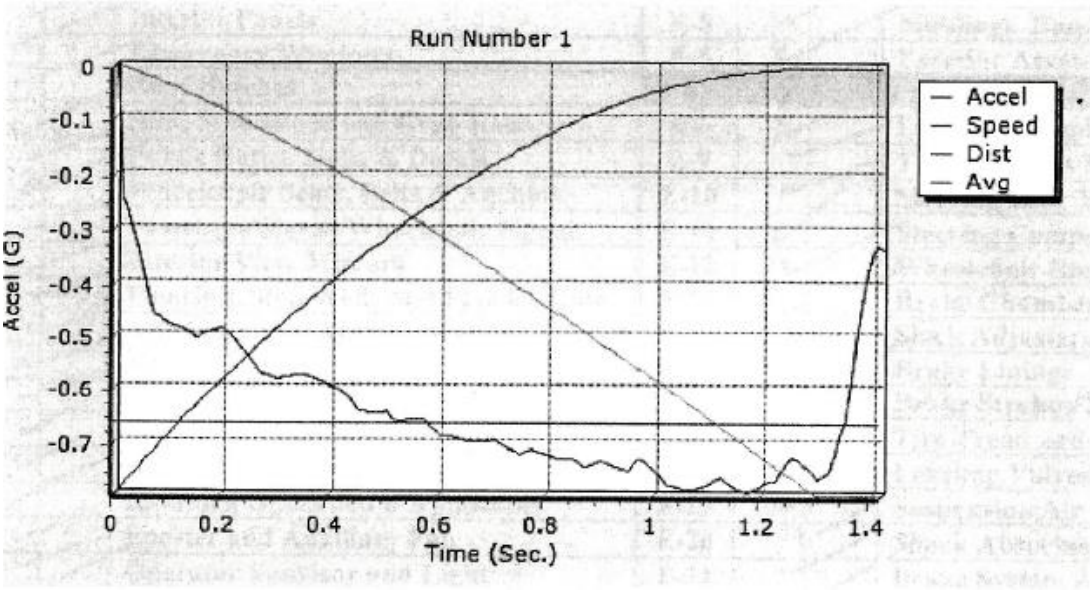
John R. Campo
Power Brake, LLC

APPENDIX A: Vericom Transit Reports

Bus 0715

Transit Report

VC4000 Run Information	
Run No	1
Date	6/17/2016 7:12:00 AM
Vehicle	715
Run Time	1.3
Speed	18.7 MPH
Distance	19.6 ft
Adjusted Distance	@(20 MPH) = 22.1 ft
Average	-0.657
Peak Accel	-0.796 at 1.170 sec
First Peak Accel	-0.719 at 0.740 sec
G Threshold	-0.200 G
G Summation	3D (XYZ)
Notes	

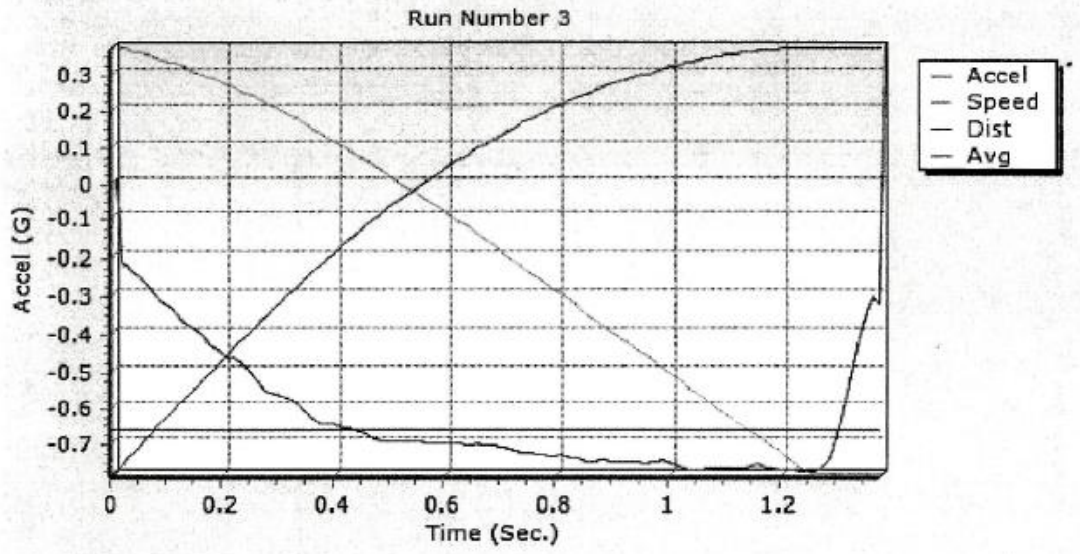


APPENDIX A: Vericom Transit Reports

Bus 0802

Transit Report

VC4000 Run Information	
Run No	3
Date	7/9/2016 6:54:00 AM
Vehicle	802
Run Time	1.25
Speed	17.9 MPH
Distance	18.4 ft
Adjusted Distance	@(20 MPH) = 22.4 ft
Average	-0.654
Peak Accel	-0.790 at 1.250 sec
First Peak Accel	-0.737 at 0.740 sec
G Threshold	-0.200 G
G Summation	3D (XYZ)
Notes	

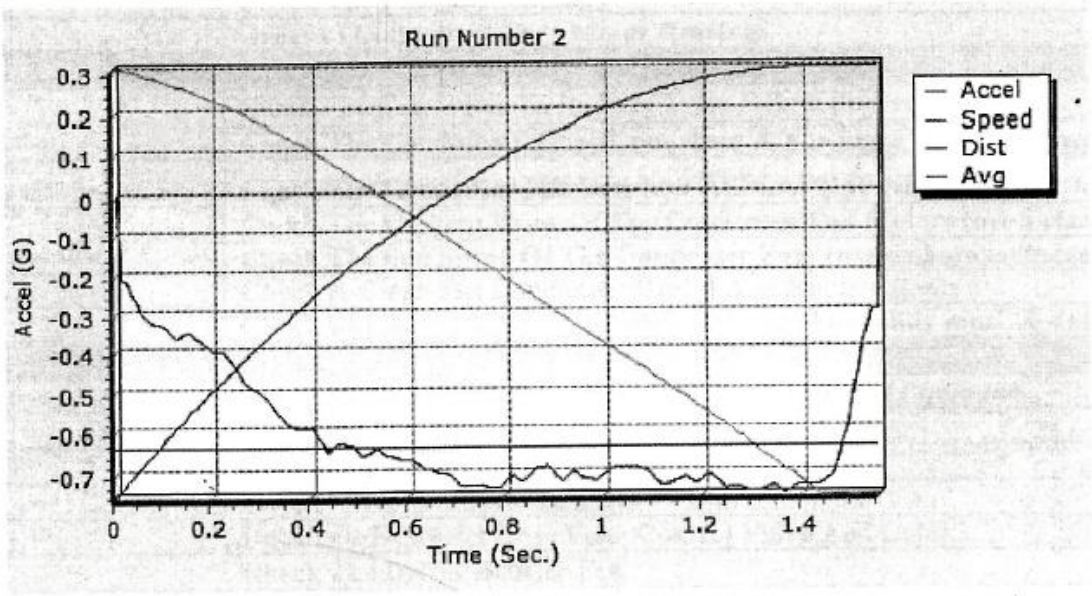


APPENDIX A: Vericom Transit Reports

Bus 0710

Transit Report

VC4000 Run Information	
Run No	2
Date	7/26/2016 2:55:00 PM
Vehicle	710
Run Time	1.44
Speed	19.9 MPH
Distance	23.3 ft
Adjusted Distance	@(20 MPH) = 23.6 ft
Average	-0.628
Peak Accel	-0.754 at 1.360 sec
First Peak Accel	-0.734 at 0.740 sec
G Threshold	-0.200 G
G Summation	3D (XYZ)
Notes	



APPENDIX A: Vericom Transit Reports

Bus 1207

Transit Report

VC4000 Run Information	
Run No	1
Date	7/24/2016 7:36:00 AM
Vehicle	1207
Run Time	1.42
Speed	18.5 MPH
Distance	20.2 ft
Adjusted Distance	@(20 MPH) = 23.5 ft
Average	-0.594
Peak Accel	-0.699 at 0.550 sec
First Peak Accel	-0.699 at 0.550 sec
G Threshold	-0.200 G
G Summation	3D (XYZ)
Notes