AFTERMARKET POLICE PURSUIT TESTING

GRATTAN RACEWAY

MICHIGAN STATE POLICE

LINK

AUGUST 2018

PREFACE

In August of 2018, the Michigan State Police (MSP) Precision Driving Unit partnered with Link Engineering to perform testing of aftermarket brake pads for police vehicles. Many agencies would like to have a less expensive brake pad option as part of their vehicle's maintenance program. The fleet manager's concern is how will the aftermarket parts performance compare to that of original equipment (OE). This testing procedure was developed to give the fleet manager comparative information from which to base that decision.

Link Engineering received submissions from several companies wishing to market their brake pads to the police industry. These brake pads were tested on a dynamometer at Link Engineering; using a testing protocol that simulated the braking effort and wear experienced at the Grattan Raceway during the annual Michigan State Police Vehicle Evaluation. Stop Tech, Brake Parts Inc. (BPI), and Fiat Chrysler Automobiles (FCA) Mopar submissions passed this testing with pads submitted for the Dodge Charger Pursuit and Ford Police Interceptor Utility.

The pads that passed the dynamometer testing were installed on the MSP patrol vehicles by Link Engineering. Link Engineering also installed OE pads on similar patrol vehicles. The patrol vehicles were instrumented to capture data during the testing.

The MSP vehicles were shipped to the Grattan Raceway where the vehicles were subjected to the same dynamics testing the MSP utilizes in its annual police vehicle evaluation. Prior to the dynamics testing, ten 60 - 0 mph full Antilock Brake System (ABS) activation best effort burnish stops were completed in rapid succession. A cooling period was performed between the burnish stops and dynamics testing.

During the dynamics testing, each vehicle was driven around the two-mile raceway a total of 32 timed laps. Four MSP test drivers drove each vehicle for eight laps around the raceway. The drivers were not informed which brake pad was on the vehicle so that any subjective opinion they may have about the vehicle/pad combination was unbiased towards any manufacturer. After the 32 timed laps were completed, two more best effort brake applications were made from 60 – 0 mph.

The ability of the pad to complete the last two stops after the dynamics testing at a deceleration rate of 25.79 ft/sec^2 or greater was considered a passing score.

After the testing was completed, the vehicles were shipped back to Link Engineering for post test analysis. The following pages summarize how each pad performed on the various vehicle platforms.

2016 Ford Police Interceptor Utility

- Brake Parts Inc. LLC
- StopTech

2017 Dodge Charger Pursuit AWD

- Brake Parts Inc. LLC
- FCA Mopar
- StopTech

Link Engineering Company
401 Southfield Road
Dearborn, Michigan 48120

Customer: **Brake Parts Inc. LLC**
Customer Contact(s):

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Website: https://www.brakepartsinc.com/products/brake-pads.html

On August 8th, 2018 Brake Parts Inc. participated in an aftermarket friction verification testing with Link Engineering and Michigan State Police. This event took place at Grattan Raceway in Belding Michigan. The tested vehicle (2016 Ford Police Interceptor Utility AWD) was built with the following hardware:

100580-2-1 Hardware	Front Axle	Rear Axle
Brake Pads[1]	SP1611APPH (Raybestos)	SP1612PPH (Raybestos)
Brake Pads[2]	17D1611AMHPVF1 (AC Delco)	17D1612MMHPVF1 (AC Delco)
Brake Rotors	680982P (Raybestos)	680983P (Raybestos)
Left Caliper	DG13-2011-EE1 (OE)	FG13-2K328-BA1 (OE)
Right Caliper	DG13-2010-EE1 (OE)	FG13-2K327-BA1 (OE)

[1]Raybestos hardware was tested on vehicle.
[2]AC Delco hardware was not tested on vehicle but both products share same edge code (JZ-FF)

Procedure:

This track testing was performed after the initial dyno screening. The dyno screening was done to assess the material's ability to withstand high performance testing on a single-corner brake dynamometer. The testing scenario was performed as follows:

1. Ten (10) burnish stops - 60mph to zero using best effort applies. These stops were ran in succession and there was no cooling time allotted.

2. Thirty-two (32) Lap High-Speed Vehicle Evaluation
   For this test, a single driver is utilized to complete eight laps around a 2 mile road course at Grattan Raceway in Belding, Michigan. There are an additional 2 laps that were performed - one (1) at the beginning as a reconnaissance lap and one (1) more at the end to cool down the brakes. After the last cool down lap the driver headed over to the fuel station to top off the fuel. After fueled, the driver then drove 50 yards over to allow for data transfer, tire pressure check/set, and lug nut check/set. The vehicles were then driven around to the front of the pits and parked for a heat soak while another block of cars ran.

After 32 timed laps are completed (and after the last cooling lap has been driven) we performed two (2) final stops from 60mph to zero using best effort applies. Test was completed after these last two (2) brake applies.

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401 Southfield Road
Dearborn, Michigan 48120

Instrumentation:

The vehicle was instrumented with the following: 3802 DAS, T/C Each Inpad at 3mm (0.120"), T/C Each Outpad at 3mm (0.120"), pedal force, deceleration module, low resolution GPS, ambient temperature, front and rear axle pressures, CAN speed, Q-term and digital Input.

Results:

The Brake Parts Inc brake pads successfully meet the Michigan State Police stopping distance requirement of being able to meet (2) back to back stops and achieve 0.80 g deceleration from 60 mph after the 32-lap handling evaluation.

	F: SP1611PPH R: SP1612PPH	
1. The braking system/components from this test meet the Michigan State Police purchasing standards which requires the completion of 32 pursuit laps and the ability to maintain a deceleration of 0.80g (25.79 ft/s^2) after those laps are complete.	**YES**	
	F: SP1611PPH R: SP1612PPH	OEM
2. Did test vehicle complete the 10 burnish stops, all 32 laps and an additional two (2) post-test best-effort brake applies?	**YES**	**YES**
	F: SP1611PPH R: SP1612PPH	OEM
3. How did the <u>average of the subjective ratings</u> compare to that of the original equipment (OE)? **Subjective ratings were taken after each 8 lap sequence by each performance driver.*	**8.0**	**8.5**
	F: SP1611PPH R: SP1612PPH	OEM
4a. How did the post test (best effort) stop # 1 (brake event 63 - section 4) compare to that of the original equipment vehicle <u>with respect to corrected stopping distance</u>? (Using SAE J299 Formula)	**60.9 m**	**63.9 m**
	F: SP1611PPH R: SP1612PPH	OEM
4b. How did the post test (best effort) stop # 2 (brake event 66 - section 4) compare to that of the original equipment vehicle <u>with respect to corrected stopping distance?</u> (Using SAE J299 Formula)	**63.5 m**	**59.2 m**
	F: SP1611PPH R: SP1612PPH	OEM
5a. How did the post test (best effort) stop # 1 (brake event 63 - section 4) compare to that of the original equipment vehicle <u>with respect to mean fully developed deceleration</u>?	**0.85 g**	**1.05 g**
	F: SP1611PPH R: SP1612PPH	OEM
5b. How did the post test (best effort) stop # 2 (brake event 66 - section 4) compare to that of the original equipment vehicle <u>with respect to mean fully developed deceleration</u>?	**0.81 g**	**0.91 g**

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Customer: **StopTech**

Customer Contact(s):

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ckirkland@centricparts.com

Website: http://www.stoptech.com/products/stoptech-brake-pads

On August 8th, 2018 StopTech participated in an aftermarket friction verification testing with Link Engineering and Michigan State Police. This event took place at Grattan Raceway in Belding Michigan. The tested vehicle (2016 Ford Police Interceptor Utility AWD) was built with the following hardware:

100632-1-1 Hardware	Front Axle	Rear Axle
Brake Pads	30716111 (StopTech)	30716120 (StopTech)
Brake Rotors	GG1Z-1125-A (OE)	DG1Z-2C026-A (OE)
Left Caliper	DG13-2011-EE1 (OE)	FG13-2K328-BA1 (OE)
Right Caliper	DG13-2010-EE1 (OE)	FG13-2K327-BA1 (OE)

Procedure:

This track testing was performed after the initial dyno screening. The dyno screening was done to assess the material's ability to withstand high performance testing on a single-corner brake dynamometer. The testing scenario was performed as follows:

1. Ten (10) burnish stops - 60mph to zero using best effort applies. These stops were ran in succession and there was no cooling time allotted.

2. Thirty-two (32) Lap High-Speed Vehicle Evaluation
   For this test, a single driver is utilized to complete eight laps around a 2 mile road course at Grattan Raceway in Belding, Michigan. There are an additional 2 laps that were performed - one (1) at the beginning as a reconnaissance lap and one (1) more at the end to cool down the brakes. After the last cool down lap the driver headed over to the fuel station to top off the fuel. After fueled, the driver then drove 50 yards over to allow for data transfer, tire pressure check/set, and lug nut check/set. The vehicles were then driven around to the front of the pits and parked for a heat soak while another block of cars ran.

After 32 timed laps are completed (and after the last cooling lap has been driven) we performed two (2) final stops from 60mph to zero using best effort applies. Test was completed after these last two (2) brake applies.

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401 Southfield Road
Dearborn, Michigan 48120

Instrumentation:

The vehicle was instrumented with the following: 3802 DAS, T/C Each Inpad at 3mm (0.120"), T/C Each Outpad at 3mm (0.120"), pedal force, deceleration module, low resolution GPS, ambient temperature, front and rear axle pressures, CAN speed, Q-term and digital Input.

Results:

The StopTech brake pads successfully meet the Michigan State Police stopping distance requirement of being able to meet (2) back to back stops and achieve 0.80 g deceleration from 60 mph after the 32-lap handling evaluation.

1. The braking system/components from this test meet the Michigan State Police purchasing standards which requires the completion of 32 pursuit laps and the ability to maintain a deceleration of 0.80g (25.79 ft/s^2) after those laps are complete.	F: 30716111 R: 30716120	
	YES	
	F: 30716111 R: 30716120	OEM
2. Did test vehicle complete the 10 burnish stops, all 32 laps and an additional two (2) post-test best-effort brake applies?	**YES**	**YES**
	F: 30716111 R: 30716120	OEM
3. How did the <u>average of the subjective ratings</u> compare to that of the original equipment (OEM)? **Subjective ratings were taken after each 8 lap sequence by each performance driver.*	**8.8**	**8.5**
	F: 30716111 R: 30716120	OEM
4a. How did the post test (best effort) stop # 1 (brake event 80 - section 4000) compare to that of the original equipment vehicle <u>with respect to corrected stopping distance</u>?	**65.8 m**	**63.9 m**
	F: 30716111 R: 30716120	OEM
4b. How did the post test (best effort) stop # 2 (brake event 82 - section 4000) compare to that of the original equipment vehicle <u>with respect to corrected stopping distance?</u>	**60.1 m**	**59.2 m**
	F: 30716111 R: 30716120	OEM
5a. How did the post test (best effort) stop # 1 (brake event 80 - section 4000) compare to that of the original equipment vehicle <u>with respect to mean fully developed deceleration</u>?	**0.92 g**	**1.05 g**
	F: 30716111 R: 30716120	OEM
5b. How did the post test (best effort) stop # 2 (brake event 82 - section 4000) compare to that of the original equipment vehicle <u>with respect to mean fully developed deceleration</u>?	**0.89 g**	**0.91 g**

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Customer: **Brake Parts Inc. LLC**

Customer Contact(s):

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Chip Hudson
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Website: https://www.brakepartsinc.com/products/brake-pads.html

On August 8th, 2018 Brake Parts Inc. participated in an aftermarket friction verification testing with Link Engineering and Michigan State Police. This event took place at Grattan Raceway in Belding Michigan. The tested vehicle (2017 Dodge Charger Pursuit AWD) was built with the following hardware:

100580-1-1 Hardware	Front Axle	Rear Axle
Brake Pads[1]	SP1767PPH (Raybestos)	SP1766PPH (Raybestos)
Brake Pads[2]	17D1767MHPV (AC Delco)	17D1766MHPV (AC Delco)
Brake Rotors	781774P (Raybestos)	780395P (Raybestos)
Left Caliper	68245095AA (OE)	68245291AA (OE)
Right Caliper	68245094AA (OE)	68245290AA (OE)

[1]Raybestos hardware was tested on vehicle.
[2]AC Delco hardware was not tested on vehicle but both products share same edge code (JZ-FF)

Procedure:

This track testing was performed after the initial dyno screening. The dyno screening was done to assess the material's ability to withstand high performance testing on a single-corner brake dynamometer. The testing scenario was performed as follows:

1. Ten (10) burnish stops - 60mph to zero using best effort applies. These stops were ran in succession and there was no cooling time allotted.

2. Thirty-two (32) Lap High-Speed Vehicle Evaluation
   For this test, a single driver is utilized to complete eight laps around a 2 mile road course at Grattan Raceway in Belding, Michigan. There are an additional 2 laps that were performed - one (1) at the beginning as a reconnaissance lap and one (1) more at the end to cool down the brakes. After the last cool down lap the driver headed over to the fuel station to top off the fuel. After fueled, the driver then drove 50 yards over to allow for data transfer, tire pressure check/set, and lug nut check/set. The vehicles were then driven around to the front of the pits and parked for a heat soak while another block of cars ran.

After 32 timed laps are completed (and after the last cooling lap has been driven) we performed two (2) final stops from 60mph to zero using best effort applies. Test was completed after these last two (2) brake applies.

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Instrumentation:

The vehicle was instrumented with the following: 3802 DAS, T/C Each Inpad at 3mm (0.120"), T/C Each Outpad at 3mm (0.120"), pedal force, deceleration module, low resolution GPS, ambient temperature, front and rear axle pressures, CAN speed, Q-term and digital Input.

Results:

The Brake Parts Inc brake pads successfully meet the Michigan State Police stopping distance requirement of being able to meet (2) back to back stops and achieve 0.80 g deceleration from 60 mph after the 32-lap handling evaluation.

	F: SP1767PPH R: SP1766PPH	
1. The braking system/components from this test meet the Michigan State Police purchasing standards which requires the completion of 32 pursuit laps and the ability to maintain a deceleration of 0.80g (25.79 ft/s^2) after those laps are complete.	**YES**	
	F: SP1767PPH R: SP1766PPH	OEM
2. Did test vehicle complete the 10 burnish stops, all 32 laps and an additional two (2) post-test best-effort brake applies?	**YES**	**YES**
	F: SP1767PPH R: SP1766PPH	OEM
3. How did the <u>average of the subjective ratings</u> compare to that of the original equipment (OEM)? **Subjective ratings were taken after each 8 lap sequence by each performance driver.*	**9.5**	**8.6**
	F: SP1767PPH R: SP1766PPH	OEM
4a. How did the post test (best effort) stop # 1 (brake event 114 - section 4) compare to that of the original equipment vehicle <u>with respect to corrected stopping distance</u>? (Using SAE J299 Formula)	**69.1 m**	**62.7 m**
	F: SP1767PPH R: SP1766PPH	OEM
4b. How did the post test (best effort) stop # 2 (brake event 117 - section 4) compare to that of the original equipment vehicle <u>with respect to corrected stopping distance?</u> (Using SAE J299 Formula)	**57.8 m**	**56.9 m**
	F: SP1767PPH R: SP1766PPH	OEM
5a. How did the post test (best effort) stop # 1 (brake event 114 - section 4) compare to that of the original equipment vehicle <u>with respect to mean fully developed deceleration</u>?	**0.95 g**	**1.21 g**
	F: SP1767PPH R: SP1766PPH	OEM
5b. How did the post test (best effort) stop # 2 (brake event 117 - section 4) compare to that of the original equipment vehicle <u>with respect to mean fully developed deceleration</u>?	**0.95 g**	**1.00 g**

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Customer: **FCA Mopar**

Customer Contact(s):

Karolina Kala
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Auburn Hills, MI. 48321
Phone: 586-497-1060

Website: https://store.mopar.com/2017-dodge-charger-pursuit-gas_5.7_v_8-transmission_automatic_5-brakes-parts/

On August 8th, 2018 FCA Mopar participated in an aftermarket friction verification testing with Link Engineering and Michigan State Police. This event took place at Grattan Raceway in Belding Michigan. The tested vehicle (2017 Dodge Charger Pursuit AWD) was built with the following hardware:

100605-1-1 Hardware	Front Axle	Rear Axle
Brake Pads	FMSI 8998 / D1767 (FCA Mopar)	6824511AB (FCA Mopar)
Brake Rotors	68184337AB09 (OE)	04779438AG001 (OE)
Left Caliper	68245095AA (OE)	68245291AA (OE)
Right Caliper	68245094AA (OE)	68245290AA (OE)

Procedure:

This track testing was performed after the initial dyno screening. The dyno screening was done to assess the material's ability to withstand high performance testing on a single-corner brake dynamometer. The testing scenario was performed as follows:

1. Ten (10) burnish stops - 60mph to zero using best effort applies. These stops were ran in succession and there was no cooling time allotted.

2. Thirty-two (32) Lap High-Speed Vehicle Evaluation
   For this test, a single driver is utilized to complete eight laps around a 2 mile road course at Grattan Raceway in Belding, Michigan. There are an additional 2 laps that were performed - one (1) at the beginning as a reconnaissance lap and one (1) more at the end to cool down the brakes. After the last cool down lap the driver headed over to the fuel station to top off the fuel. After fueled, the driver then drove 50 yards over to allow for data transfer, tire pressure check/set, and lug nut check/set. The vehicles were then driven around to the front of the pits and parked for a heat soak while another block of cars ran.

After 32 timed laps are completed (and after the last cooling lap has been driven) we performed two (2) final stops from 60mph to zero using best effort applies. Test was completed after these last two (2) brake applies.

Link Engineering Company
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Instrumentation:

The vehicle was instrumented with the following: 3802 DAS, T/C Each Inpad at 3mm (0.120"), T/C Each Outpad at 3mm (0.120"), pedal force, deceleration module, low resolution GPS, ambient temperature, front and rear axle pressures, CAN speed, Q-term and digital Input.

Results:

The FCA Mopar brake pads successfully meet the Michigan State Police stopping distance requirement of being able to meet (2) back to back stops and achieve 0.80 g deceleration from 60 mph after the 32-lap handling evaluation.

	F: FMSI 8998 / D1767 R: 6824511AB	
1. The braking system/components from this test meet the Michigan State Police purchasing standards which requires the completion of 32 pursuit laps and the ability to maintain a deceleration of 0.80g (25.79 ft/s^2) after those laps are complete.	**YES**	
	F: FMSI 8998 / D1767 R: 6824511AB	OEM
2. Did test vehicle complete the 10 burnish stops, all 32 laps and an additional two (2) post-test best-effort brake applies?	**YES**	**YES**
	F: FMSI 8998 / D1767 R: 6824511AB	OEM
3. How did the <u>average of the subjective ratings</u> compare to that of the original equipment (OEM)? **Subjective ratings were taken after each 8 lap sequence by each performance driver.*	**9.3**	**8.6**
	F: FMSI 8998 / D1767 R: 6824511AB	OEM
4a. How did the post test (best effort) stop # 1 (brake event 99 - section 4000) compare to that of the original equipment vehicle <u>with respect to corrected stopping distance</u>? (Using SAE J299 Formula)	**51.9 m**	**62.7 m**
	F: FMSI 8998 / D1767 R: 6824511AB	OEM
4b. How did the post test (best effort) stop # 2 (brake event 101 - section 4000) compare to that of the original equipment vehicle <u>with respect to corrected stopping distance?</u> (Using SAE J299 Formula)	**50.2 m**	**56.9 m**
	F: FMSI 8998 / D1767 R: 6824511AB	OEM
5a. How did the post test (best effort) stop # 1 (brake event 99 - section 4000) compare to that of the original equipment vehicle <u>with respect to mean fully developed deceleration</u>?	**0.98 g**	**1.21 g**
	F: FMSI 8998 / D1767 R: 6824511AB	OEM
5b. How did the post test (best effort) stop # 2 (brake event 101 - section 4000) compare to that of the original equipment vehicle <u>with respect to mean fully developed deceleration</u>?	**0.97 g**	**1.00 g**

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401 Southfield Road
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Customer: **StopTech**

Customer Contact(s):

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Website: http://www.stoptech.com/products/stoptech-brake-pads

On August 8th, 2018 Stop Tech participated in an aftermarket friction verification testing with Link Engineering and Michigan State Police. This event took place at Grattan Raceway in Belding Michigan. The tested vehicle (2017 Dodge Charger Pursuit AWD) was built with the following hardware:

100632-2-1 Hardware	Front Axle	Rear Axle
Friction	30717670 (StopTech)	30717660 (StopTech)
Rotor	68184337AB09 (OE)	04779438AG001 (OE)
Left Caliper	68245095AA (OE)	68245291AA (OE)
Right Caliper	68245094AA (OE)	68245290AA (OE)

Procedure:

This track testing was performed after the initial dyno screening. The dyno screening was done to assess the material's ability to withstand high performance testing on a single-corner brake dynamometer. The testing scenario was performed as follows:

1. Ten (10) burnish stops - 60mph to zero using best effort applies. These stops were ran in succession and there was no cooling time allotted.

2. Thirty-two (32) Lap High-Speed Vehicle Evaluation
   For this test, a single driver is utilized to complete eight laps around a 2 mile road course at Grattan Raceway in Belding, Michigan. There are an additional 2 laps that were performed - one (1) at the beginning as a reconnaissance lap and one (1) more at the end to cool down the brakes. After the last cool down lap the driver headed over to the fuel station to top off the fuel. After fueled, the driver then drove 50 yards over to allow for data transfer, tire pressure check/set, and lug nut check/set. The vehicles were then driven around to the front of the pits and parked for a heat soak while another block of cars ran.

After 32 timed laps are completed (and after the last cooling lap has been driven) we performed two (2) final stops from 60mph to zero using best effort applies. Test was completed after these last two (2) brake applies.

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401 Southfield Road
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Instrumentation:

The vehicle was instrumented with the following: 3802 DAS, T/C Each Inpad at 3mm (0.120"), T/C Each Outpad at 3mm (0.120"), pedal force, deceleration module, low resolution GPS, ambient temperature, front and rear axle pressures, CAN speed, Q-term and digital Input.

Results:

The StopTech brake pads successfully meet the Michigan State Police stopping distance requirement of being able to meet (2) back to back stops and achieve 0.80 g deceleration from 60 mph after the 32-lap handling evaluation.

	F: 30717670 R: 30717660	
1. The braking system/components from this test meet the Michigan State Police purchasing standards which requires the completion of 32 pursuit laps and the ability to maintain a deceleration of 0.80g (25.79 ft/s^2) after those laps are complete.	**YES**	
	F: 30717670 R: 30717660	OEM
2. Did test vehicle complete the 10 burnish stops, all 32 laps and an additional two (2) post-test best-effort brake applies?	**YES**	**YES**
	F: 30717670 R: 30717660	OEM
3. How did the <u>average of the subjective ratings</u> compare to that of the original equipment (OEM)? **Subjective ratings were taken after each 8 lap sequence by each performance driver.*	**9.3**	**8.6**
	F: 30717670 R: 30717660	OEM
4a. How did the post test (best effort) stop # 1 (brake event 79 - section 4) compare to that of the original equipment vehicle <u>with respect to corrected stopping distance</u>? (Using SAE J299 Formula)	**53.9 m**	**62.7 m**
	F: 30717670 R: 30717660	OEM
4b. How did the post test (best effort) stop # 2 (brake event 81 - section 4) compare to that of the original equipment vehicle <u>with respect to corrected stopping distance?</u> (Using SAE J299 Formula)	**50.0 m**	**56.9 m**
	F: 30717670 R: 30717660	OEM
5a. How did the post test (best effort) stop # 1 (brake event 79 - section 4) compare to that of the original equipment vehicle <u>with respect to mean fully developed deceleration</u>?	**1.08 g**	**1.21 g**
	F: 30717670 R: 30717660	OEM
5b. How did the post test (best effort) stop # 2 (brake event 81 - section 4) compare to that of the original equipment vehicle <u>with respect to mean fully developed deceleration</u>?	**0.97 g**	**1.00 g**