

<b>CUSTOMER</b>	Department of the Environment and Heritage	<b>PROJECT</b>	GOV5 - 26
<b>TITLE</b>	<b>Comparison of Vehicle Drivability Toyota Corolla – GOV5-12</b>		

**AIM**

- To evaluate the general startability, idle and acceleration performance of the vehicle using premium unleaded petrol and E5.
- To evaluate the vehicles fully warmed up driveability on premium unleaded petrol and E5.
- To provide a comparative measure between the use of premium unleaded petrol and E5.

**EQUIPMENT**

- N/A

**PROCEDURE**

- The vehicle was refuelled with the test fuel and a short drive performed to allow the new fuel to fully replace the old in the carburettor.
- The vehicle driveability assessment was commenced when the vehicle had soaked to the ambient air temperature (approximately 25°C).
- The vehicle driveability assessment was performed, for differing driving conditions, to evaluate the vehicles startability, idle, acceleration, driveability and performance. These conditions are laid out on the Vehicle Appraisal Form (Form #8838).
- The vehicle driveability assessments were performed twice on each fuel type by different drivers. These subjective ratings were then compared to ensure the assessments were mutually agreeable.

## RESULTS

Average Driveability Ratings.	PULP	PULPE5	Max. Delta ( $\Delta$ )
Cold Start	7.0	6.8	-0.3
Warmed-up Start	5.3	6.3	1.0
Overall Restart	5.8	6.5	0.8
Idle Stability	6.6	6.8	0.2
Idle Roughness	6.4	6.8	0.3
Launchability, Part Load	7.0	7.0	0.0
Launchability, WOT	6.5	7.0	0.5
Acceleration Feel, Part Load	7.0	7.0	0.0
Acceleration Feel, WOT	6.5	7.0	0.5
Passing feel, Part Load	7.0	7.0	0.0
Passing feel, WOT	7.0	7.0	0.0
Gradeability	6.5	7.0	0.5
Low speed shunt/chuggle	6.5	7.0	0.5
Tip-in, Low gear	7.0	7.0	0.0
Tip-in, High gear	7.0	7.0	0.0
Tip-out, Low gear	7.0	7.0	0.0
Tip-out, High gear	7.0	7.0	0.0
Part Load, Steady State	6.5	7.0	0.5
Part Load, Accel (LTI, crowd)	7.0	7.0	0.0
Fuel Cut-off and re-intro shock	7.0	7.0	0.0
Full Load ,Torque Delivery	7.0	7.0	0.0
Knocking	7.0	7.0	0.0
Average	<b>6.7</b>	<b>6.9</b>	<b>0.2</b>
Minimum	5.3	6.3	-0.3
Maximum	7.0	7.0	1.0

**Table 1 – Driveability Assessment Summary and Comparison**

*The values in the table above are the rounded average results of two vehicle driveability evaluations. Max Delta (largest reduction in rating of any fuel compared to PULP result) also rounded to one decimal place.*

## CONCLUSIONS/DISCUSSION

- 1) Overall, driveability and performance were very similar when comparing the use of premium petrol and E5 fuels.
  - a) Apparent differences in warmed up start and restart are thought to be due to test variability.
- 2) The subjective ratings, as assessed by two drivers, provided acceptable agreement.
- 3) An average driver is unlikely to notice any difference between petrol and E5.

**ATTACHMENTS**

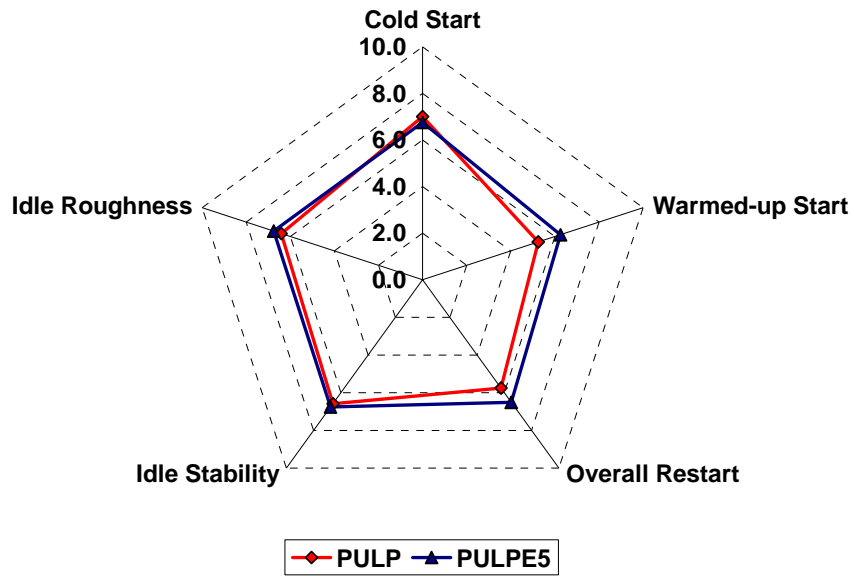
1. Test summary of start, idle, performance and driveability ratings
2. Vehicle Appraisal Results #1 PULP
3. Vehicle Appraisal Results #2 PULP
4. Vehicle Appraisal Results #1 E5
5. Vehicle Appraisal Results #2 E5


**Attachment 1**

**Test summary of start, idle performance and driveability ratings**

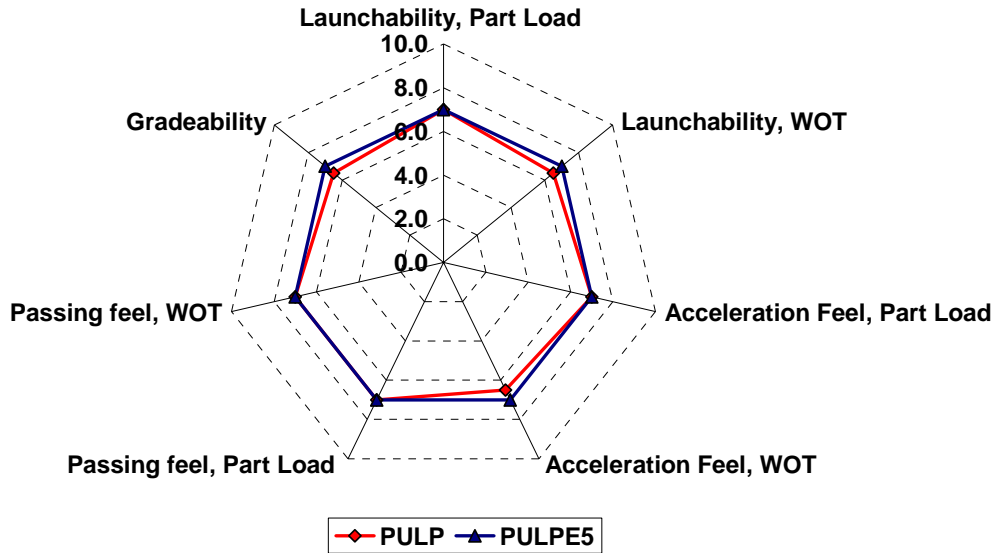
Each point on these charts is an average of two tests.

**Startability and Idle Quality**



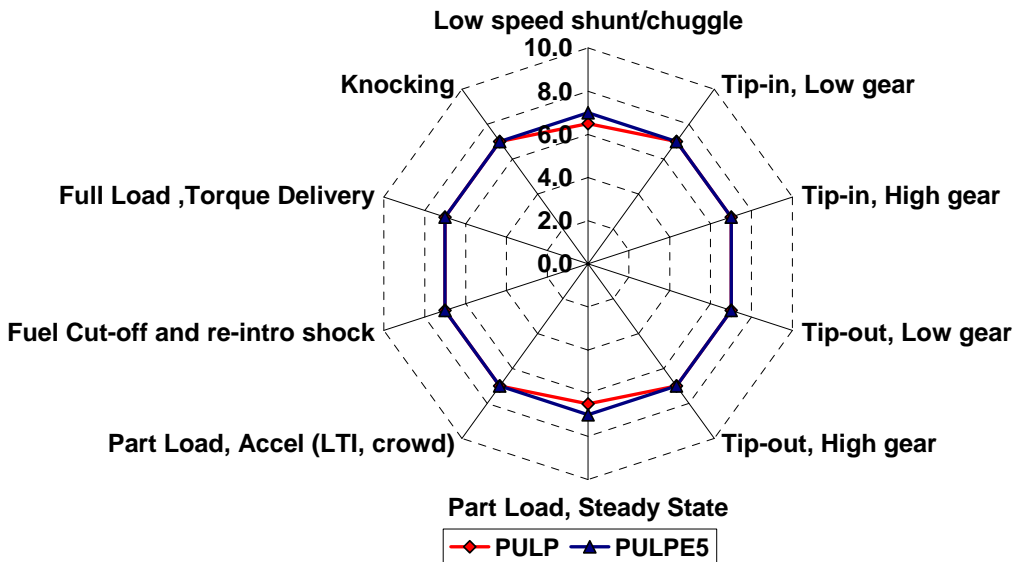
**Figure 1 - Start and Idle Quality**

**Vehicle Performance**



**Figure 2 - Vehicle Performance Comparison**

**Warmed-up Driveability**



**Figure 3. – Warmed – up Driveability Comparison**

## Attachment 2 Vehicle Appraisal Results #1 PULP

### Vehicle Appraisal Form Fuel (1, driver A)

Vehicle name	GOV5-12 Toyota	Test date	18/09/2006
Mileage (km)	197268	Test time	11h00
Ambient temperature (deg C)	18.7	Test road	Balcatta area
Barometric pressure (kPa)	101.7	Engine	Standard
Test driver	AKM	Fuel	PULP
Co-driver	DFN	Oil	SAE 10W40

1. Startability		Rating	Remarks	
Cold start	Starting Time	7		
	Flare to idle	7		
	Restartability	7		
Warmed up start	Starting Time	6		
	Flare to idle	5		
	Restartability	5		
2. Idle Quality		Rating		Remarks
RPM stability	No load	6.5		
	part load	6		
	Full load	6		
Idle roughness	No load	6.5		
	part load	6		
	Full load	5		
3. Performance		Rating	Remarks	
Launch feel	Part throttle	7		
	WOT	6		
Accel feel	Part throttle	7		
	WOT	6		
Passing feel	Part throttle	7		
	WOT	7		
Gradeability		6		
Long hill climbing ability		6		
4. Acceleration Pedal Feel		Rating		Remarks
Effort	Start			
	End			
Linearity				
Stroke				
5. Clutch Pedal Feel		Rating		Remarks
Effort	Start			
	End			
Stroke				
Linkage noise				
6. Driveability		Rating	Run-on feel	
Low speed driveability(<50 Kph)		5	<b>Subjective rating</b> 1. Very bad 2. Bad 3. Very poor misfire feel 5. Mediocre 6. Agreeable (just acceptable) 7. Satisfactory 8. Good 9. Very good 10. Excellent	
Low speed shunt/chuggle		7		
Tip-in (1st and 2nd gear)	("n/a" if auto)	7		
Tip-out (1st and 2nd gear)		7		
Tip-in (3rd,4th and 5th gear)		7		
Tip-out (3rd, 4th and 5th gear)		7		
Part-throttle steady-state		6		
Part-throttle acceleration	inlc throttle crowding	7		
Fuel cut-off	Engine brake feel	7		
	Harshness at refuelling	7		
WOT torque delivery/strength		7		
WOT noise/harshness		7		
WOT knocking		7		
Gear change 1st to 2nd		7		
Gear change 2nd to 3rd		7		
P/N to D Transition	("N/a" if m/t)	n/a		

## Attachment 3 Vehicle Appraisal Results #2 PULP

### Vehicle Appraisal Form (fuel 1, driver B)

Vehicle name	GOV5-12 Toyota	Test date	19/09/2006
Mileage (km)	197283	Test time	19h00
Ambient temperature (deg C)	17	Test road	Balcatta area
Barometric pressure (kPa)	102.4	Engine	Standard
Test driver	AT1	Fuel	PULP
Co-driver	DFN	Oil	SAE 10W40

1. Startability		Rating	Remarks
Cold start	Starting Time	7	
	Flare to idle	7	
	Restartability	6	
Warmed up start	Starting Time	5	
	Flare to idle	5	
	Restartability	5	
2. Idle Quality		Rating	Remarks
RPM stability	No load	7	
	part load	7	
	Full load	7	
Idle roughness	No load	7	
	part load	7	
	Full load	7	
3. Performance		Rating	Remarks
Launch feel	Part throttle	7	
	WOT	7	
Accel feel	Part throttle	7	
	WOT	7	
Passing feel	Part throttle	7	
	WOT	7	
Gradeability		7	
Long hill climbing ability		7	
4. Acceleration Pedal Feel		Rating	Remarks
Effort	Start		
	End		
Linearity			
Stroke			
5. Clutch Pedal Feel		Rating	Remarks
Effort	Start		
	End		
Stroke			
Linkage noise			
6. Driveability		Rating	<b>Subjective rating</b>  1. Very bad 2. Bad 3. Very poor 4. Poor 5. Mediocre 6. Agreeable (just acceptable) 7. Satisfactory 8. Good 9. Very good 10. Excellent
Low speed driveability(<50 Kph)		7	
Low speed shunt/chuggle		7	
Tip-in (1st and 2nd gear)	("n/a" if auto)	7	
Tip-out (1st and 2nd gear)		7	
Tip-in (3rd,4th and 5th gear)		7	
Tip-out (3rd, 4th and 5th gear)		7	
Part-throttle steady-state		7	
Part-throttle acceleration	inlc throttle crowding	7	
	Engine brake feel	7	
Fuel cut-off	Harshness at refuelling	7	
	WOT torque delivery/strength	7	
WOT noise/harshness		7	
WOT knocking		7	
Gear change 1st to 2nd		7	
Gear change 2nd to 3rd		7	
P/N to D Transition	("N/a" if m/t)	n/a	

## Attachment 4 Vehicle Appraisal Results #1 PULPE5

### Vehicle Appraisal Form (Fuel 2, driver A)

Vehicle name	GOV5-12 Toyota	Test date	29/09/2006
Mileage (km)	197378	Test time	10:00
Ambient temperature (deg C)	19	Test road	Balcatta area
Barometric pressure (kPa)	102.4	Engine	Standard
Test driver	AKM	Fuel	PULPE5
Co-driver	DFN	Oil	SAE 10W40

1. Startability		Rating	Remarks
Cold start	Starting Time	7	High idle
	Flare to idle	6	
	Restartability	7	
Warmed up start	Starting Time	7	
	Flare to idle	7	
	Restartability	7	
2. Idle Quality		Rating	Remarks
RPM stability	No load	6.5	
	part load	6.5	
	Full load	6.5	
Idle roughness	No load	6.5	
	part load	6.5	
	Full load	6.5	
3. Performance		Rating	Remarks
Launch feel	Part throttle	7	
	WOT	7	
Accel feel	Part throttle	7	
	WOT	7	
Passing feel	Part throttle	7	
	WOT	7	
Gradeability		7	
Long hill climbing ability		7	
4. Acceleration Pedal Feel		Rating	Remarks
Effort	Start		
	End		
Linearity			
Stroke			
5. Clutch Pedal Feel		Rating	Remarks
Effort	Start		
	End		
Stroke			
Linkage noise			
6. Driveability		Rating	<b>Subjective rating</b>  1. Very bad 2. Bad 3. Very poor 4. Poor 5. Mediocre 6. Agreeable (just acceptable) 7. Satisfactory 8. Good 9. Very good 10. Excellent
Low speed driveability(<50 Kph)		7	
Low speed shunt/chuggle		7	
Tip-in (1st and 2nd gear)	("n/a" if auto)	7	
Tip-out (1st and 2nd gear)		7	
Tip-in (3rd,4th and 5th gear)		7	
Tip-out (3rd, 4th and 5th gear)		7	
Part-throttle steady-state		7	
Part-throttle acceleration	incl throttle crowding	7	
	Engine brake feel	7	
Fuel cut-off	Harshness at refuelling	7	
	WOT torque delivery/strength	7	
WOT noise/harshness		7	
WOT knocking		7	
Gear change 1st to 2nd		7	
Gear change 2nd to 3rd		7	
P/N to D Transition	("N/a" if m/t)		

## Attachment 5 Vehicle Appraisal Results #2 PULPE5

### Vehicle Appraisal Form (Fuel 2, driver B)

Vehicle name	GOV5-12 Toyota	Test date	28/09/2006
Mileage (km)	197394	Test time	15h00
Ambient temperature (deg C)	24	Test road	Balcatta area
Barometric pressure (kPa)	102	Engine	Std
Test driver	AT1	Fuel	PULPE5
Co-driver	DFN	Oil	SAE 10W40

1. Startability		Rating	Remarks	
Cold start	Starting Time	7		
	Flare to idle	7		
	Restartability	7		
Warmed up start	Starting Time	5		Closed throttle. May be better with... ...cracked open throttle long crank
	Flare to idle	6		
	Restartability	5		
2. Idle Quality		Rating	Remarks	
RPM stability	No load	7		
	part load	7		
	Full load	7		
Idle roughness	No load	7		
	part load	7		
	Full load	7		
3. Performance		Rating	Remarks	
Launch feel	Part throttle	7		
	WOT	7		
Accel feel	Part throttle	7		
	WOT	7		
Passing feel	Part throttle	7		
	WOT	7		
Gradeability		7		
Long hill climbing ability		7		
4. Acceleration Pedal Feel		Rating	Remarks	
Effort	Start			
	End			
Linearity				
Stroke				
5. Clutch Pedal Feel		Rating	Remarks	
Effort	Start			
	End			
Stroke				
Linkage noise				
6. Driveability		Rating	<b>Subjective rating</b>  1. Very bad 2. Bad 3. Very poor 4. Poor 5. Mediocre 6. Agreeable (just acceptable) 7. Satisfactory 8. Good 9. Very good 10. Excellent	
Low speed driveability(<50 Kph)		7		
Low speed shunt/chuggle		7		
Tip-in (1st and 2nd gear)	("n/a" if auto)	7		
Tip-out (1st and 2nd gear)		7		
Tip-in (3rd,4th and 5th gear)		7		
Tip-out (3rd, 4th and 5th gear)		7		
Part-throttle steady-state		7		
Part-throttle acceleration		7		
Fuel cut-off	Engine brake feel	7		
	Harshness at refuelling	7		
WOT torque delivery/strength		7		
WOT noise/harshness		7		
WOT knocking		7		
Gear change 1st to 2nd		7		
Gear change 2nd to 3rd		7		
P/N to D Transition	("N/a" if m/t)			

<b>CUSTOMER</b>	Department of the Environment and Heritage	<b>PROJECT</b>	GOV5 - 26
<b>TITLE</b>	<b>Hot Start and Driveability Evaluation Toyota Corolla – GOV5-12</b>		

## AIM

- To evaluate the hot startability, extended idle and no-load acceleration performance of the vehicle using premium unleaded petrol and E5.
- To evaluate hot driveability of the vehicle on premium unleaded petrol and E5.
- To provide a comparative measure between the use of premium unleaded petrol and E5.

## EQUIPMENT

- Hot vehicle chamber
- Data logger – Virtual Bench with National Instruments DAQ Card 1200
- Thermocouple readouts

## PROCEDURE

- The vehicle was fuelled with the test fuel.
- The vehicle was driven on the test road until a minimum oil temperature of 120°C was reached.
- The vehicle was driven into the hot chamber, which was set to an ambient temperature of 40°C, with a track temperature of 60-65°C and a solar radiation load of 1100W/m<sup>2</sup>.
- The battery voltage and starter current were logged for each initial engine start. The oil, coolant and ambient temperatures were recorded. Handheld, battery powered digital readouts were used to indicate the temperatures.
- The vehicle went through the steps outlined in the “Hot Start and Driveability Evaluation” schedule to evaluate startability, extended idle roughness/stability and hot driveability. This included a hot start and idle assessment within the hot chamber, an extended idle within the hot chamber, and the hot driveability evaluation performed on the real road.
- The above procedure was performed twice on each fuel type by different drivers. These subjective ratings were then compared to ensure the assessments were mutually agreeable.

## RESULTS

Average Ratings.	Fuel:	PULP	PULPE5	Max. Delta ( $\Delta$ )
Start Time - 10min Soak (seconds)		1.0	2.4	<del>1.4</del>
Restart Time - 30min Soak (seconds)		1.1	1.2	<del>0.1</del>
Restart Time - Ext. Idle/20min Soak (seconds)		1.4	1.7	<del>0.3</del>
Hot Startability (10min. Soak)		6.8	5.3	-1.5
Hot Idle Quality (10min. Soak)		7.0	7.0	0.0
Hot Restartability (30min. Soak)		6.8	6.3	-0.5
Hot Idle Quality (30min. Soak)		7.0	7.0	0.0
Hot Idle Quality (40min. Idle)		7.0	6.8	-0.3
Hot Startability (Ext. Idle/20min. Soak)		6.5	5.8	-0.8
Hot Idle Quality (Ext. Idle/20min. Soak)		7.0	7.0	0.0
Hot Acceleration - Idle Racing Mode		7.0	6.5	-0.5
Restart and idle after drive rating		6.6	6.4	-0.2
Hot Soak & Drive Idle Quality		6.9	6.6	-0.3
Part Throttle Acceleration		6.6	6.8	0.2
WOT acceleration		7.0	7.0	0.0
50km/h Steady State		6.3	6.9	0.6
70km/h Steady State		7.0	7.0	0.0
<b>Average all.</b>		<b>6.8</b>	<b>6.6</b>	<b>-0.2</b>
<b>Minimum</b>		<b>6.3</b>	<b>5.3</b>	<b>-1.5</b>
<b>Maximum</b>		<b>7.0</b>	<b>7.0</b>	<b>0.6</b>

**Table 1 Hot Start and Driveability Assessment Summary and Comparison**

The values in the table above are the rounded average results of two vehicle hot start and driveability evaluations. Max Delta (largest reduction in rating of any fuel compared to PULP result) also rounded to one decimal place.

## CONCLUSIONS/DISCUSSION

- 1) A degradation of hot ratings occurred with E5 when compared to PULP, which may be expected from ethanol's higher volatility at these temperatures. One feature of this may be noticed by an average driver. In detail:
  - a) After the 10 min soak E5 required a longer cranking time than PULP. This may be noticed by an average driver with the use of E5.
  - b) A similar deterioration after extended idle is unlikely to be noticed.
- 2) The objective start times recorded agree with the subjective ratings given by the drivers.
- 3) The subjective ratings, as assessed by two drivers, provided acceptable agreement.

**ATTACHMENTS**

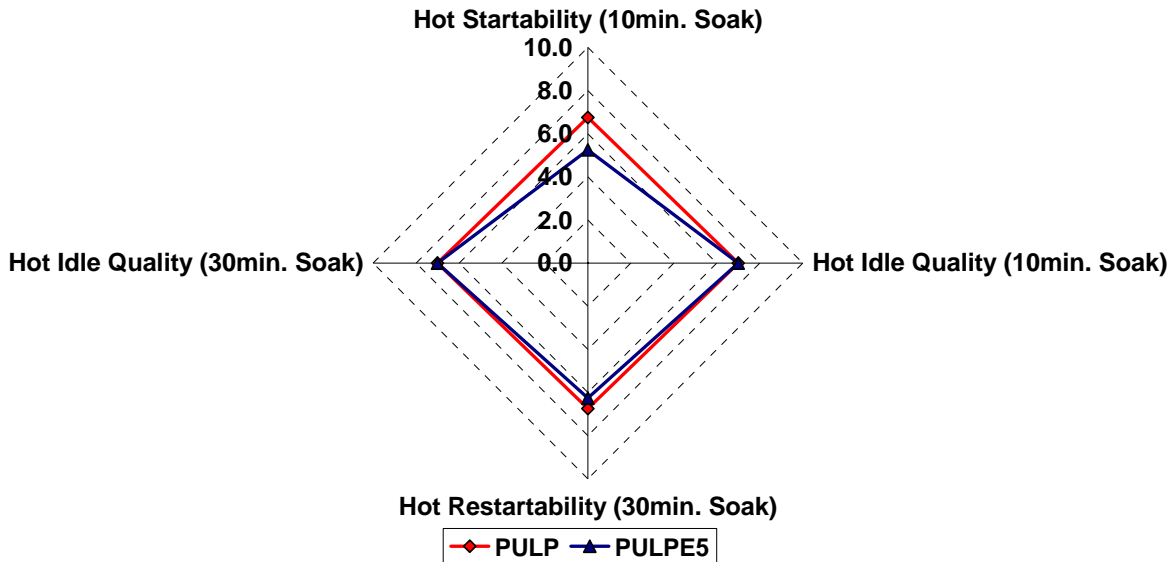
1. Test summary of the hot start, extended idle and hot driveability
2. Hot start and driveability evaluation results #1 PULP
3. Hot start and driveability evaluation results #2 PULP
4. Hot start and driveability evaluation results #1 E5
5. Hot start and driveability evaluation results #2 E5


**Attachment 1**

**Test summary of hot start, extended idle and hot driveability**

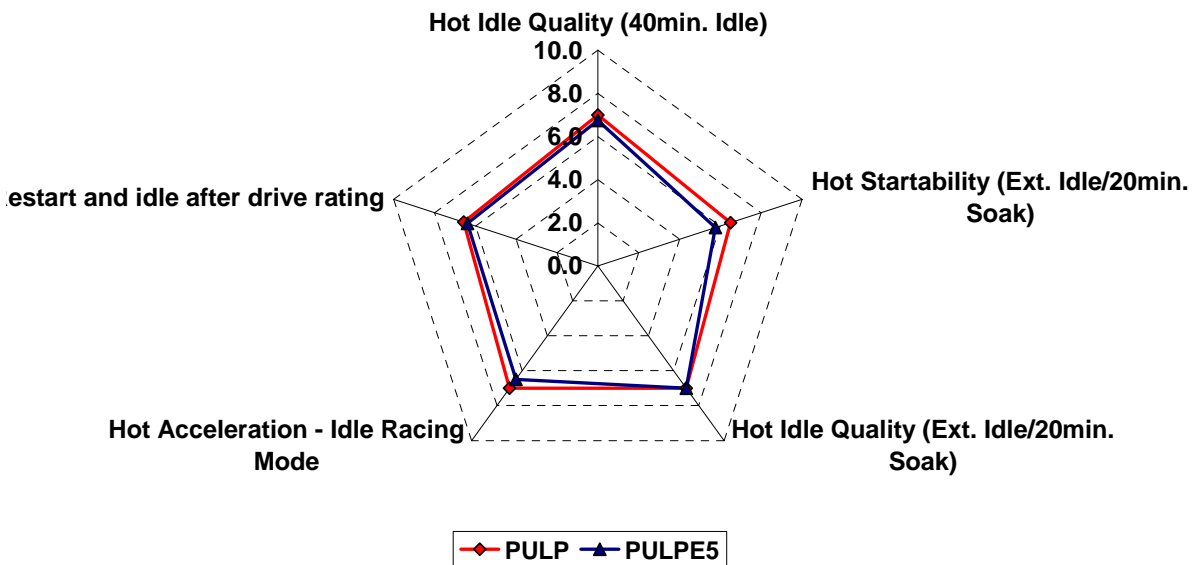
Each point on these charts is an average of two tests.

**Hot Startability and Idle Quality after Hot Soak**



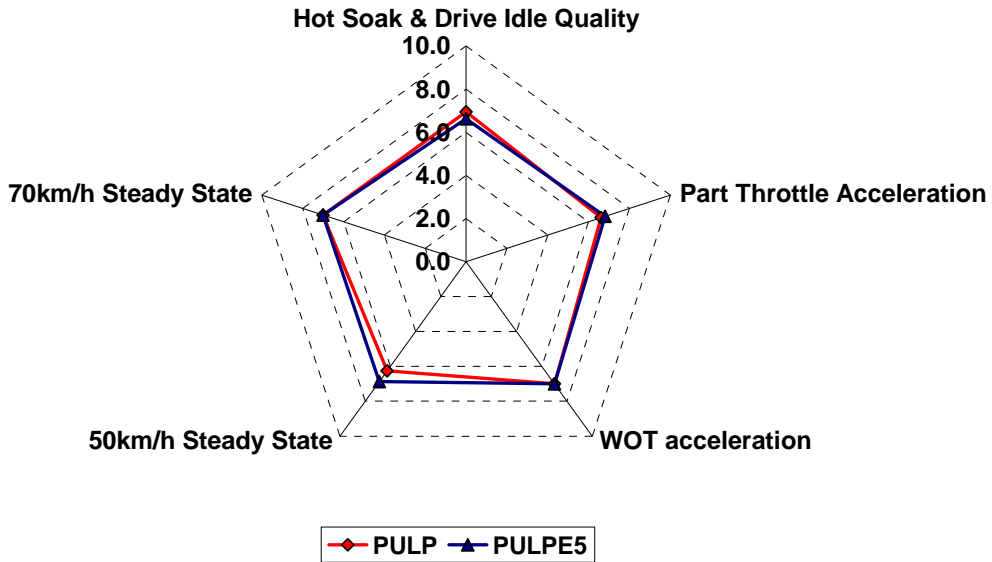
**Figure 1 – Hot Start and Idle after Soak**

**Hot Extended Idle Test and 20min. Hot Soak**



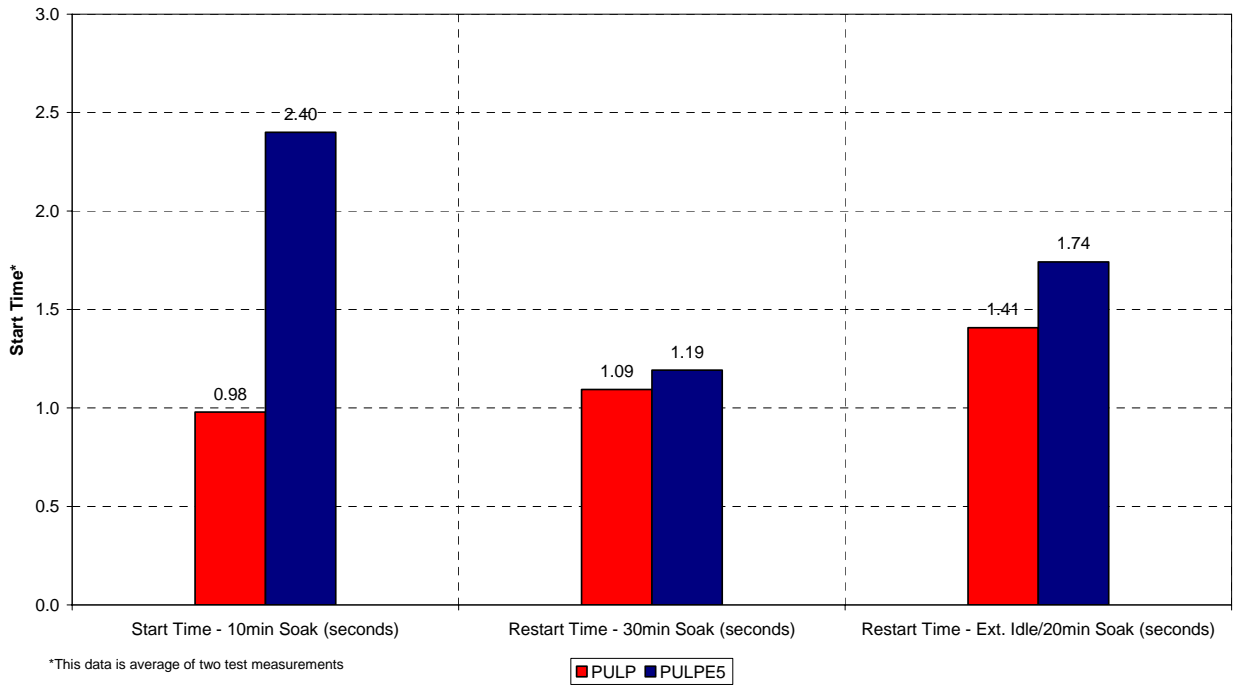
**Figure 2 – Hot Start and Idle after extended idles and soaks**

**Hot Driveability Test**



**Figure 3 – Hot Driveability Comparison**

**Hot Start Times**



\*This data is average of two test measurements

**Figure 3 – Hot Start Times**

## Attachment 2 Hot start and driveability evaluation results #1 PULP

### Hot Start and Driveability Evaluation, 1a

Vehicle Number	GOV5-12	Registration	DU 417
Vehicle name	Toyota Corolla	Test date	21/09/2006
Vehicle colour	Blue	Test time	9:00-11:30 drive
Mileage (km)	197300		
Ambient temperature (deg C)	19.3	Engine	1.6L, In line, 4cyl
Barometric pressure (kPa)	101.3	Fuel	PULP
Test driver	AT1/dfn	Oil	SAE 10W40
		SOAK Temp	40degC (Set point)

#### 1. Vehicle preparation

Drain tank fuel and refill to 60% (or 28L) of tank volume  
 Move the vehicle to the test road (Mitchell freeway)  
 Warm-up the vehicle until oil temperature reaches a min.120 deg C  
 Return vehicle to hot chamber  
 Note that engine oil temperature must be min. 120 deg C before hot soak

Ambient Temperature: 40°C  
 Track Temperature: 60-65°C  
 Solar Radiation: 1100W/m<sup>2</sup>

#### 2. Hot soak

Hot startability rating	
No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more	
Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	

Rating	Ambient (°C)	Coolant (°C)	oil (°C)
Soak 10 minutes			
Ignition on	40	62	75
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.544	0.5	
Evaluate startability	7		
Evaluate idle roughness for 10 sec.	7		
Ignition-off and soak 30 minutes			
Ignition-on	37	48	54
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.89	1	
Evaluate re-startability	7		
Evaluate idle roughness for 10 sec.	7		

Data file names: C:\logs\gov05veh\_12\_HTST1

Data file names: C:\logs\gov05veh\_12\_HTST2

#### 3. Vehicle preparation

Move the vehicle to the test road (Mitchell freeway)  
 Warm-up the vehicle until oil temperature reaches a min.120 deg C  
 Return vehicle to hot chamber (note: do not turn-off the engine)

#### 4. Hot extended idle

Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	

Rating	Ambient (°C)	Coolant (°C)	oil (°C)
Extended idle for 40 minutes, in gear and A/C on (Blower medium, External air mode)			
Record data, 0 minute	7	40	84
Record data, 10 minute	7	37	90
Record data, 20 minute	7	40	103
Record data, 30 minute	7	40	114
Record data, 40 minute	7	41	114
Ignition-off and soak 20 minutes			
Ignition on	40	77	85
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.405	1.5	
Evaluate startability	6.5		
Evaluate idle roughness	7		

Data file names: C:\logs\gov05veh\_12\_HTST3

### Hot Start and Driveability Evaluation

Hot acceleration	
Hot acceleration rating	
Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more	

Shift to P/N or disengage clutch (NIG)  
 Idle racing mode to 3000rpm  
 Evaluate acceleration

7
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Hot soak and drive	
Hot acceleration rating	
Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more	
Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	
Hot startability rating	
No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more	

Rating  
 Move the car to the test road with A/C on (Blower medium and external air mode )

Idle 10 seconds	7
1/2 throttle to 50km/hr	5
50km/hr cruise	5
Stop and idle 10 seconds	7
WOT to 70km/hr	7
70km/hr cruise	7
Stop and idle 10 seconds	7
1/4 throttle to 50km/hr	7
50km/hr cruise	7
3/4 throttle to 70km/hr	7
70km/hr cruise	7
Stop and idle 10 seconds	7
Interrupted acceleration	7
1/2 throttle to 70km/hr	7
70km/hr cruise	7
Stop and idle 20 seconds	7
Steering lock to lock	7 n/a
Idle in P/N	7 n/a
Ignition off	
Restart	5

Driveability Ratings:  
 Idle during drive 7  
 Start after various soak times 6.4  
 Average accel rating 6.6  
 Average Steady speed rating 6.6

## Attachment 3 Hot start and driveability evaluation results #2 PULP

### Hot Start and Driveability Evaluation, 1b

Vehicle Number	GOV5-12	Registration	DU 417
Vehicle name	Toyota Corolla	Test date	21/09/2006
Vehicle colour	Blue	Test time	11:30-14:00 drive
Mileage (km)	197306		
Ambient temperature (deg C)	16.2	Engine	1.6L, In line, 4cyl
Barometric pressure (kPa)	101.4	Fuel	PULP
Test driver	AKM/vjm	Oil	SAE 10W40
		SOAK Temp	40degC (Set point)

#### 1. Vehicle preparation

Drain tank fuel and refill to 60% (or 28L) of tank volume  
 Move the vehicle to the test road (Mitchell freeway)  
 Warm-up the vehicle until oil temperature reaches a min.120 deg C  
 Return vehicle to hot chamber  
 Note that engine oil temperature must be min. 120 deg C before hot soak

Ambient Temperature: 40°C  
 Track Temperature: 60-65°C  
 Solar Radiation: 1100W/m<sup>2</sup>

#### 2. Hot soak

Hot startability rating	
No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more	
Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	

Rating	Ambient (°C)	Coolant (°C)	oil (°C)
Soak 10 minutes			
Ignition on	40	65	79
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.414		
Evaluate startability	6.5		
Evaluate idle roughness for 10 sec.	7		
Ignition-off and soak 30 minutes			
Ignition-on	40	55	63
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.298		
Evaluate re-startability	6.5		
Evaluate idle roughness for 10 sec.	7		

Data file names: C:\logs\gov05veh\_12\_HTST4  
 C:\logs\gov05veh\_12\_HTST5

#### 3. Vehicle preparation

Move the vehicle to the test road (Mitchell freeway)  
 Warm-up the vehicle until oil temperature reaches a min.120 deg C  
 Return vehicle to hot chamber (note: do not turn-off the engine)

#### 4. Hot extended idle

Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	

Rating	Ambient (°C)	Coolant (°C)	oil (°C)
Extended idle for 40 minutes, in gear and A/C on (Blower medium, External air mode)			
Record data, 0 minute	7	39	76
Record data, 10 minute	7	41	83
Record data, 20 minute	7	42	111
Record data, 30 minute	7	42	108
Record data, 40 minute	7		117
Ignition-off and soak 20 minutes			
Ignition on	40	85	91
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.41		
Evaluate startability	6.5		
Evaluate idle roughness	7		

Shut off early due oil light illumination.  
 Data file names: C:\logs\gov05veh\_12\_HTST6

### Hot Start and Driveability Evaluation

Hot acceleration	
Hot acceleration rating	
Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more	

Shift to P/N or disengage clutch (NIG)  
 Idle racing mode to 3000rpm  
 Evaluate acceleration

7
---

Hot soak and drive	
Hot acceleration rating	
Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more	
Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	
Hot startability rating	
No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more	

Rating		
Move the car to the test road with A/C on (Blower medium and external air mode)		
Idle 10 seconds	7	
1/2 throttle to 50km/hr	5	
50km/hr cruise	7	
Stop and idle 10 seconds	7	
WOT to 70km/hr	7	
70km/hr cruise	7	
Stop and idle 10 seconds	7	
1/4 throttle to 50km/hr	7	
50km/hr cruise	6	Misfire feeling
3/4 throttle to 70km/hr	7	
70km/hr cruise	7	
Stop and idle 10 seconds	6.5	
Interrupted acceleration	7	
1/2 throttle to 70km/hr	7	
70km/hr cruise	7	
Stop and idle 20 seconds	6.5	
Steering lock to lock	6.5	n/a
Idle in P/N	6.5	n/a
Ignition off		
Restart	7	

Driveability Ratings:  
 Idle during drive 6.71428571  
 Start after various soak times 6.6  
 Average accel rating 6.6  
 Average Steady speed rating 6.8  
 7 with cracked throttle, 5.5 without

## Attachment 4 Hot start and driveability evaluation results #1 E5

### Hot Start and Driveability Evaluation, 2a

Vehicle Number	GOV5-12	Registration	DU 417
Vehicle name	Toyota Corolla	Test date	3/10/2006
Vehicle colour	Blue	Test time	10:00-12:30 drive
Mileage (km)	197453		
Ambient temperature (deg C)	19.9	Engine	1.6L, In line, 4cyl
Barometric pressure (kPa)	101	Fuel	PULPE5
Test driver	AKM	Oil	SAE 10W40
		SOAK Temp	40degC (Set point)

#### 1. Vehicle preparation

Drain tank fuel and refill to 60% (or 28L) of tank volume  
 Move the vehicle to the test road (Mitchell freeway)  
 Warm-up the vehicle until oil temperature reaches a min.120 deg C  
 Return vehicle to hot chamber  
 Note that engine oil temperature must be min. 120 deg C before hot soak

Ambient Temperature: 40°C  
 Track Temperature: 60-65°C  
 Solar Radiation: 1100W/m<sup>2</sup>

#### 2. Hot soak

Hot startability rating	
No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more	
Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	

Rating	Ambient (°C)	Coolant (°C)	oil (°C)
Soak 10 minutes			
Ignition on	39	58	74
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	2.59		
Evaluate startability	5.5		
Evaluate idle roughness for 10 sec.	7		
Ignition-off and soak 30 minutes			
Ignition-on	40	48	56
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.274		
Evaluate re-startability	6		
Evaluate idle roughness for 10 sec.	7		

Data file names: C:\logs\gov05veh\_12\_HTST7  
 C:\logs\gov05veh\_12\_HTST8

#### 3. Vehicle preparation

Move the vehicle to the test road (Mitchell freeway)  
 Warm-up the vehicle until oil temperature reaches a min.120 deg C  
 Return vehicle to hot chamber (note: do not turn-off the engine)

#### 4. Hot extended idle

Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	

Rating	Ambient (°C)	Coolant (°C)	oil (°C)
Extended idle for 40 minutes, in gear and A/C on (Blower medium, External air mode)			
Record data, 0 minute	7	39	79
Record data, 10 minute	7	37	75
Record data, 20 minute	7	38	88
Record data, 30 minute	7	38	91
Record data, 40 minute	7	37	91
Ignition-off and soak 20 minutes			
Ignition on	38	63	69
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.739		
Evaluate startability	5.5		
Evaluate idle roughness	7		

Data file names: C:\logs\gov05veh\_12\_HTST9

### Hot Start and Driveability Evaluation

Hot acceleration	
Hot acceleration rating	
Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more	

Shift to P/N or disengage clutch (NIG)  
 Idle racing mode to 3000rpm  
 Evaluate acceleration

6
---

Hot soak and drive	
Hot acceleration rating	
Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more	
Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	
Hot startability rating	
No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more	

Rating	
Move the car to the test road with A/C on (Blower medium and external air mode)	
Idle 10 seconds	6.5
1/2 throttle to 50km/hr	7
50km/hr cruise	6.5
Stop and idle 10 seconds	6
WOT to 70km/hr	7
70km/hr cruise	7
Stop and idle 10 seconds	6
1/4 throttle to 50km/hr	7
50km/hr cruise	7
3/4 throttle to 70km/hr	6.5
70km/hr cruise	7
Stop and idle 10 seconds	6.5
Interrupted acceleration	6.5
1/2 throttle to 70km/hr	7
70km/hr cruise	7
Stop and idle 20 seconds	6
Steering lock to lock	6
Idle in P/N	6
Ignition off	
Restart	6

uneven feeling  
 uneven feeling

**Driveability Ratings:**  
 Idle during drive 6.1  
 Start after various soak times 5.8  
 Average accel rating 6.9  
 Average Steady speed rating 6.9

## Attachment 5 Hot start and driveability evaluation results #2 E5

### Hot Start and Driveability Evaluation, 2b

Vehicle Number	GOV5-12	Registration	DU 417
Vehicle name	Toyota Corolla	Test date	3/10/2006
Vehicle colour	Blue	Test time	13:00-15:00 drive
Mileage (km)	197460		
Ambient temperature (deg C)	18	Engine	1.6L, In line, 4cyl
Barometric pressure (kPa)	101.2	Fuel	PULPE5
Test driver	AT1/dfn	Oil	SAE 10W40
		SOAK Temp	40degC (Set point)

#### 1. Vehicle preparation

Drain tank fuel and refill to 60% (or 28L) of tank volume  
 Move the vehicle to the test road (Mitchell freeway)  
 Warm-up the vehicle until oil temperature reaches a min.120 deg C  
 Return vehicle to hot chamber  
 Note that engine oil temperature must be min. 120 deg C before hot soak

Ambient Temperature: 40°C  
 Track Temperature: 60-65°C  
 Solar Radiation: 1100W/m<sup>2</sup>

#### 2. Hot soak

Hot startability rating	
No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more	
Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	

Rating	Ambient (°C)	Coolant (°C)	oil (°C)
Soak 10 minutes			
Ignition on	38	60	68
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	2.209		
Evaluate startability	5		
Evaluate idle roughness for 10 sec.	7		
Ignition-off and soak 30 minutes			
Ignition-on	41	50	57
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.111		
Evaluate re-startability	6.5		
Evaluate idle roughness for 10 sec.	7		

Data file names: C:\logs\gov05veh\_12\_HTST10  
 C:\logs\gov05veh\_12\_HTST11

#### 3. Vehicle preparation

Move the vehicle to the test road (Mitchell freeway)  
 Warm-up the vehicle until oil temperature reaches a min.120 deg C  
 Return vehicle to hot chamber (note: do not turn-off the engine)

#### 4. Hot extended idle

Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	

Rating	Ambient	Coolant	Intake
Extended idle for 40 minutes, in gear and A/C on (Blower medium, External air mode)			
Record data, 0 minute	7	40	82
Record data, 10 minute	7	42	98
Record data, 20 minute	6.5	42	106
Record data, 30 minute	6.5	41	108
Record data, 40 minute	6.5	42	110
Record data, 40 minute			118
Ignition-off and soak 20 minutes			
Ignition on	40	80	90
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.745		
Evaluate startability	6		
Evaluate idle roughness	7		

Data file names: C:\logs\gov05veh\_12\_HTST12

### Hot Start and Driveability Evaluation

Hot acceleration	
Hot acceleration rating	
Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more	

Shift to P/N or disengage clutch (NIG)  
 Idle racing mode to 3000rpm  
 Evaluate acceleration

7
---

Hot soak and drive	
Hot acceleration rating	
Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more	
Hot idle quality rating	
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more	
Hot startability rating	
No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more	

Rating	
Move the car to the test road with A/C on (Blower medium and external air mode )	
Idle 10 seconds	7
1/2 throttle to 50km/hr	7
50km/hr cruise	7
Stop and idle 10 seconds	7
WOT to 70km/hr	7
70km/hr cruise	7
Stop and idle 10 seconds	7
1/4 throttle to 50km/hr	6
50km/hr cruise	7
3/4 throttle to 70km/hr	7
70km/hr cruise	7
Stop and idle 10 seconds	7
Interrupted acceleration	7
1/2 throttle to 70km/hr	7
70km/hr cruise	7
Stop and idle 20 seconds	7
Steering lock to lock	7
Idle in P/N	7
Ignition off	7
Restart	6

some irregularity noted, but not sufficient to rate down, considering vehicle type/age

some unevenness noted

longish crank

Driveability Ratings:  
 Idle during drive 7  
 Start after various soak times 5.9  
 Average accel rating 6.8  
 Average Steady speed rating 7

<b>CUSTOMER</b>	Department of the Environment and Heritage	<b>PROJECT</b>	GOV5 - 26
<b>TITLE</b>	<b>Cold Start and Warm-up Evaluation Toyota Corolla – GOV5-12</b>		

## AIM

- To evaluate the cold startability, idle and no-load acceleration performance of the vehicle using premium petrol and E5.
- To evaluate the warm-up driveability on premium petrol and E5.
- To provide a comparative measure between the use of premium petrol and E5.

## EQUIPMENT

- Cold vehicle chamber
- Stopwatch/data logger
- Thermocouple readouts

## PROCEDURE

- The vehicle was fuelled with the test fuel and a short drive performed to allow the new fuel to fully replace the old in the carburettor.
- The vehicle was placed in the cold environment chamber and cooled until it had stabilised at the setpoint temp of -10 deg C (+/- 1deg C)
- The oil, coolant and inlet air temperatures were logged. Handheld, battery powered digital readouts were used to indicate the temperatures.
- The vehicle went through the steps outlined in the “Cold Start and Warm up Evaluation” schedule to evaluate startability, idle roughness/stability and warm up driveability. This included a cold start assessment within the cold chamber, and the warm up driveability evaluation performed on the road immediately after cold start and idle testing.
- The above procedure was performed twice on each fuel type by different drivers. These subjective ratings were then compared to ensure the assessments were mutually agreeable.

## RESULTS

Average Ratings.	Fuel:	PULP	PULPE5	Max. Delta ( $\Delta$ )
Start Time (seconds)		1.1	1.7	<del>0.6</del>
Restart Time (seconds)		0.8	1.0	<del>0.2</del>
Cold Startability		7.0	7.0	0.0
Cold Restartability		7.0	7.0	0.0
Cold Idle Roughness/Stability No Load		6.4	6.5	0.1
Cold Idle Roughness/Stability Electrical load		6.0	6.0	0.0
Cold Idle Roughness/Stability Elec+P/S load		6.0	6.0	0.0
Cold Acceleration Idle racing mode		5.1	5.9	0.8
Warm-up idle Roughness/Stability		4.3	6.6	2.3
Warmed up idle and restart		6.6	6.3	-0.3
Part Throttle Acceleration		6.5	7.0	0.5
Interrupted accel		7.0	7.0	0.0
WOT acceleration		7.0	7.0	0.0
50km/h steady state		6.8	6.8	0.0
60/70km/h steady state		6.5	6.8	0.3
<b>Average</b>		<b>6.3</b>	<b>6.6</b>	<b>0.3</b>
<b>Minimum</b>		<b>4.3</b>	<b>5.9</b>	<b>-0.3</b>
<b>Maximum</b>		<b>7.0</b>	<b>7.0</b>	<b>2.3</b>

**Table 1 – Cold Start and Warm-up Assessment Summary and Comparison**

The values in the table above (except where indicated) are the rounded average results of two cold start and warm up driveability evaluations. Max Delta (largest reduction in rating of any fuel compared to PULP result) also rounded to one decimal place.

## CONCLUSIONS/DISCUSSION

1. Overall, driveability and performance appeared to be better with E5 than PULP. One feature of this would probably be noticed by an average driver. In detail:
  - a. One PULP test had significantly poorer driveability/idles than the other. However, since the better PULP test was still worse than either E5 test, it is assumed that this test was significant.
  - b. E5 showed significantly better idle quality than PULP (PULP displayed stalls/near stalls at idle during warm-up; E5 displayed none). This improvement would probably be noticed by an average user.
  - c. Idle racing mode also showed a slight improvement in response and reduced smoke with E5, but this is unlikely to be noticed by an average driver.
2. Although the objective start times recorded show differences, even the slowest start was subjectively rated as a seven. This shows the difference in start times is unlikely to be noticed by an average user.
3. Apart from one PULP test as discussed above, the subjective ratings, as assessed by two drivers, provided acceptable agreement.

**ATTACHMENTS**

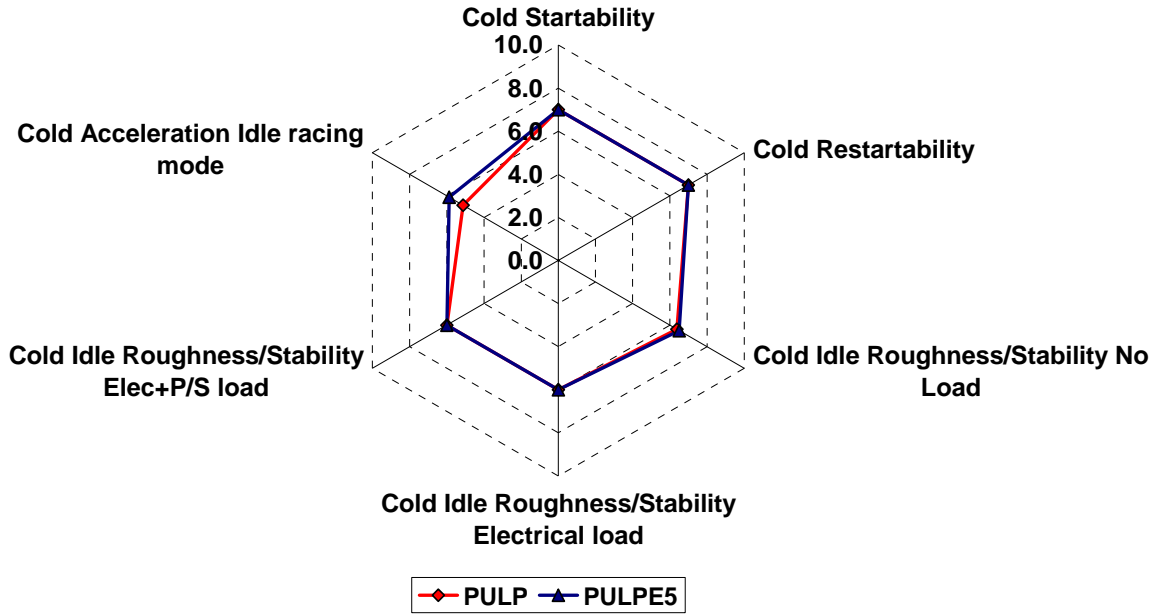
1. Test summary of the cold start, idle and warm-up driveability
2. Cold start and warm up evaluation results #1 PULP
3. Cold start and warm up evaluation results #2 PULP
4. Cold start and warm up evaluation results #1 E5
5. Cold start and warm up evaluation results #2 E5


**Attachment 1**

**Test summary of cold start, idle and warm-up driveability**

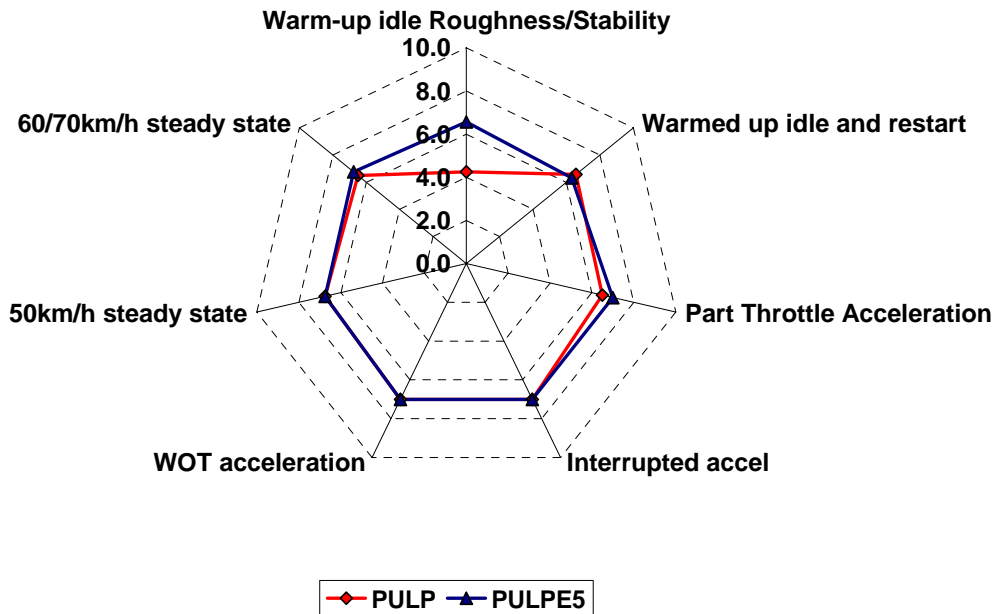
Each point on these charts is an average of two tests.

**Cold Starting and Idle**

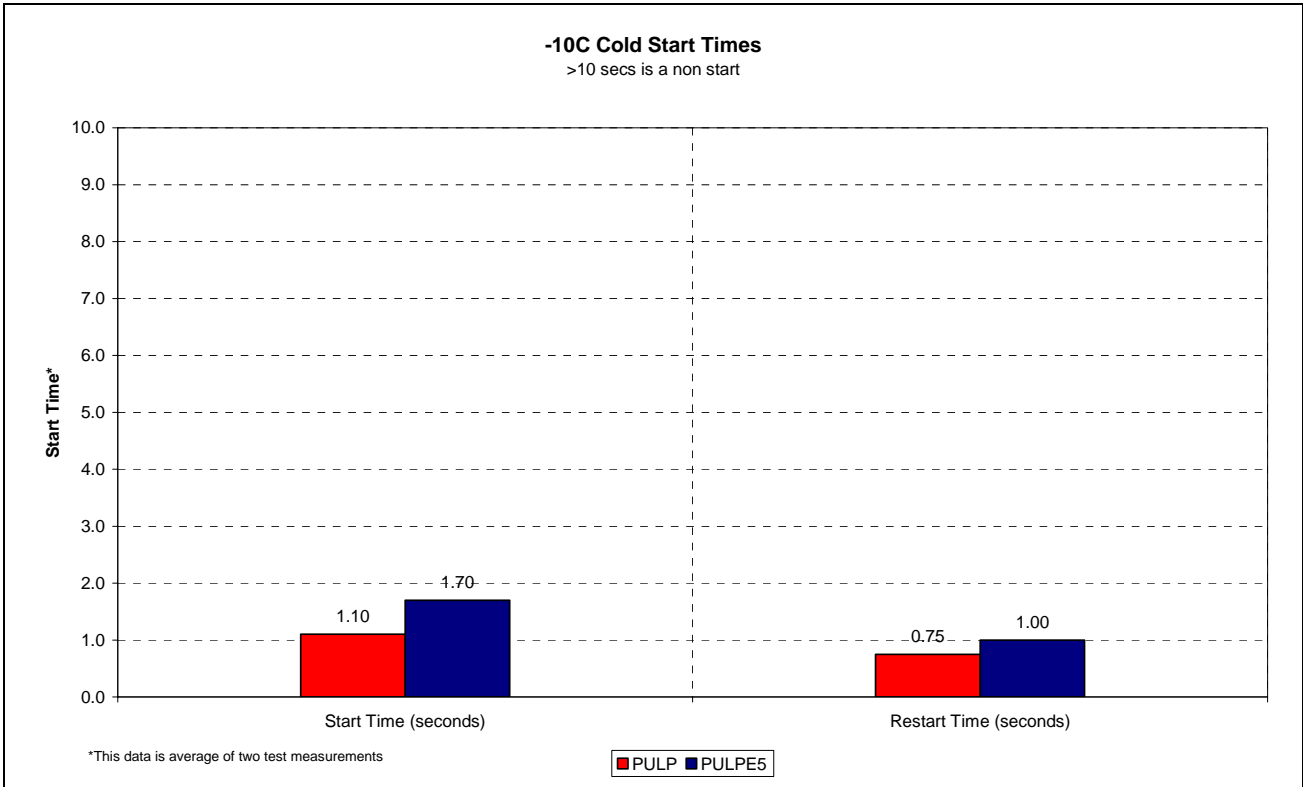


**Figure 1 – Cold Start and Idle Quality**

**Warm-up Driveability after Cold Start**



**Figure 2 – Driveability during Warm-up**



## Attachment 2 Cold start and warm up evaluation results #1 PULP

### Cold Start and Warm-up Evaluation, Test no 1a

Vehicle Number	GOV5-12	Registration	DU 417
Vehicle name	Toyota Corolla	Test date	27/09/2006
Vehicle colour	Blue	Test time	07:00
Mileage (km)	197360		
Ambient temperature (deg C)	11	Engine	1.6L, In line, 4cyl
Barometric pressure (kPa)	102	Fuel	PULP
Test driver	AKM	Oil	SAE 10W40
		SOAK Temp	-10degC (Set point)

<b>1. Cold start</b>	<b>Cold startability rating</b>		
	No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more		

Rating	Oil (°C)	Coolant(°C)	Intake (°C)
	-12	-12	-11.1

Ignition on  
Crank after fuel pump relay is off. No start if crank time is > 10 seconds

Crank time	0.7
Evaluate startability	7

Ignition -off within 5 seconds

Ignition-on

Crank after fuel pump relay is off. No start if crank time is > 10 seconds

Crank time	0.7
Evaluate re-startability	7

Data file: C:\logs\gov05\12\_CSTa

<b>2. Cold idle</b>	<b>Cold idle quality rating</b>		
	Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more		

Evaluate idle roughness (10 seconds)	6
--------------------------------------	---

Shift to D/R or clutch engaged

Evaluate idle roughness (10 seconds)	5.5
--------------------------------------	-----

Turn on the headlights, blower (max position) and defroster

Evaluate idle roughness (10 seconds)	5
--------------------------------------	---

Turn power steering to the right end

Evaluate idle roughness (10 seconds)	5
--------------------------------------	---

Turn power steering to the left end

Evaluate idle roughness (10 seconds)	5
--------------------------------------	---

Re-align steering

Turn off headlights, blower and defroster

<b>3. Cold acceleration</b>	<b>Cold acceleration rating</b>		
	Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more		

Shift in P/N or disengage clutch (NIG)

Idle racing mode to 3000rpm

Evaluate acceleration	5.5	slight hesitation
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Black smoke present?

	4	Dark: 1, Grey:5, Normal: 7
--	---	----------------------------

<b>4. Warm-up drive</b>	<b>Cold acceleration rating</b>		
	Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more		

<b>Cold idle quality rating</b>		
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more		

<b>Cold startability rating</b>		
No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more		

Move the car to the test road

Idle 10 seconds	5	lumpy
-----------------	---	-------

1/2 throttle to 50km/hr	6	uneven
-------------------------	---	--------

### Cold Start and Warm-up Evaluation

<b>4. Warm-up drive</b>	<b>Cold acceleration rating</b>		
	Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more		

<b>Cold idle quality rating</b>		
Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more		

<b>Cold startability rating</b>		
No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more		

50km/hr cruise	7	
----------------	---	--

Stop and idle 10 seconds	5	
--------------------------	---	--

WOT to 70km/hr	7	
----------------	---	--

70km/hr cruise	5	misfire feeling
----------------	---	-----------------

Stop and idle 10 seconds	1	stall. Excessive choke
--------------------------	---	------------------------

1/4 throttle to 50km/hr	6	misfire feeling
-------------------------	---	-----------------

50km/hr cruise	6	uneven
----------------	---	--------

3/4 throttle to 70km/hr	6	uneven
-------------------------	---	--------

70km/hr cruise	6	uneven
----------------	---	--------

Stop and idle 10 seconds	3	near-stall
--------------------------	---	------------

Interrupted acceleration	7	
--------------------------	---	--

1/2 throttle to 70km/hr	7	
-------------------------	---	--

70km/hr cruise	7	
----------------	---	--

Stop and idle 20 seconds	6.5	
--------------------------	-----	--

Steering lock to lock	6.5	n/a
-----------------------	-----	-----

Idle in P/N	6.5	n/a
-------------	-----	-----

Ignition off		
--------------	--	--

Restart	6	Long crank w/o throttle
---------	---	-------------------------

start with open throttle acceptable and rated as 6.

## Attachment 3 Cold start and warm up evaluation results #2 PULP

### Cold Start and Warm-up Evaluation, Test no 1b

Vehicle Number	GOV5-12	Registration	DU 417
Vehicle name	Toyota Corolla	Test date	27/09/2006
Vehicle colour	Blue	Test time	14h45
Mileage (km)	197371		
Ambient temperature (deg C)	20	Engine	1.6L, In line, 4cyl
Barometric pressure (kPa)	102	Fuel	PULP
Test driver	AT1	Oil	SAE 10W40
		SOAK Temp	-10degC (Set point)

<b>1. Cold start</b>	<b>Cold startability rating</b>
	No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more

Rating	Oil (°C)	Coolant(°C)	Intake (°C)
	-9	-8	-10.3

Ignition on  
Crank after fuel pump relay is off. No start if crank time is > 10 seconds

Crank time	1.5
Evaluate startability	7

Ignition -off within 5 seconds  
Ignition-on  
Crank after fuel pump relay is off. No start if crank time is > 10 seconds

Crank time	0.8
Evaluate re-startability	7

Data file: C:..logs\gov05\12\_CSTb

<b>2. Cold idle</b>	<b>Cold idle quality rating</b>
	Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more

Evaluate idle roughness (10 seconds)	7
Shift to D/R or clutch engaged	7
Evaluate idle roughness (10 seconds)	7
Turn on the headlights, blower (max position) and defroster	7
Evaluate idle roughness (10 seconds)	7
Turn power steering to the right end	7
Evaluate idle roughness (10 seconds)	7
Turn power steering to the left end	7
Evaluate idle roughness (10 seconds)	7
Re-align steering	7
Turn off headlights, blower and defroster	7

<b>3. Cold acceleration</b>	<b>Cold acceleration rating</b>
	Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more

Shift in P/N or disengage clutch (NIG)  
Idle racing mode to 3000rpm

Evaluate acceleration	7
Black smoke present?	4

Dark: 1, Grey:5, Normal: 7

<b>4. Warm-up drive</b>	<b>Cold acceleration rating</b>
	Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more
	<b>Cold idle quality rating</b>
	Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more
	<b>Cold startability rating</b>
	No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more

Move the car to the test road

Idle 10 seconds	5
1/2 throttle to 50km/hr	6

lack of response

### Cold Start and Warm-up Evaluation

<b>4. Warm-up drive</b>	<b>Cold acceleration rating</b>
	Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more
	<b>Cold idle quality rating</b>
	Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more
	<b>Cold startability rating</b>
	No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more

50km/hr cruise	7	
Stop and idle 10 seconds	3	near stall
WOT to 70km/hr	7	
70km/hr cruise	7	
Stop and idle 10 seconds	5	
1/4 throttle to 50km/hr	7	
50km/hr cruise	7	
3/4 throttle to 70km/hr	7	
70km/hr cruise	7	
Stop and idle 10 seconds	7	
Interrupted acceleration	7	
1/2 throttle to 70km/hr	7	
70km/hr cruise	7	
Stop and idle 20 seconds	7	
Steering lock to lock	7	n/a
Idle in P/N	7	n/a
Ignition off	7	
Restart	6	

## Attachment 4 Cold start and warm up evaluation results #1 E5

### Cold Start and Warm-up Evaluation, Test no 2a

Vehicle Number	GOV5-12	Registration	DU 417
Vehicle name	Toyota Corolla	Test date	5/10/2006
Vehicle colour	Blue	Test time	13:00
Mileage (km)	197468		
Ambient temperature (deg C)	25.3	Engine	1.6L In line, 4cyl
Barometric pressure (kPa)	102.3	Fuel	PULPE5
Test driver	AT1	Oil	SAE 10W40
		SOAK Temp	-10degC (Set point)

<b>1. Cold start</b>	<b>Cold startability rating</b>
	No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more

	Rating		Oil (°C)	Coolant(°C)	Intake (°C)
Ignition on			-10.2	-11	-11

Crank after fuel pump relay is off. No start if crank time is > 10 seconds	1.7	
Evaluate startability	7	
Ignition -off within 5 seconds		
Ignition-on		
Crank after fuel pump relay is off. No start if crank time is > 10 seconds	1.2	
Crank time	7	
Evaluate re-startability		

Data file: C:..logsgov05\veh\_ 12\_CST2a

<b>2. Cold idle</b>	<b>Cold idle quality rating</b>
	Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more

Evaluate idle roughness (10 seconds)	6	lumpy
Shift to D/R or clutch engaged	6	
Evaluate idle roughness (10 seconds)	6	
Turn on the headlights, blower (max position) and defroster		
Evaluate idle roughness (10 seconds)	6	
Turn power steering to the right end		
Evaluate idle roughness (10 seconds)	6	
Turn power steering to the left end		
Evaluate idle roughness (10 seconds)	6	
Re-align steering		
Turn off headlights, blower and defroster		

<b>3. Cold acceleration</b>	<b>Cold acceleration rating</b>
	Engine stall: 1, Backfires: 2, Hesitation:3 , Surge:4, Rough: 5, Normal: 7 more

Shift in P/N or disengage clutch (NIG)		
Idle racing mode to 3000rpm		
Evaluate acceleration	7	
Black smoke present?	5	Dark: 1, Grey:5, Normal: 7

<b>4. Warm-up drive</b>	<b>Cold acceleration rating</b>
	Engine stall: 1, Backfires: 2, Hesitation:3 , Surge:4, Rough: 5, Normal: 7 more
	<b>Cold idle quality rating</b>
	Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more
	<b>Cold startability rating</b>
	No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more

Move the car to the test road		
Idle 10 seconds	6	
1/2 throttle to 50km/hr	7	

### Cold Start and Warm-up Evaluation

<b>4. Warm-up drive</b>	<b>Cold acceleration rating</b>
	Engine stall: 1, Backfires: 2, Hesitation:3 , Surge:4, Rough: 5, Normal: 7 more
	<b>Cold idle quality rating</b>
	Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more
	<b>Cold startability rating</b>
	No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more

50km/hr cruise	7	
Stop and idle 10 seconds	6	
WOT to 70km/hr	7	
70km/hr cruise	7	
Stop and idle 10 seconds	7	
1/4 throttle to 50km/hr	7	
50km/hr cruise	7	
3/4 throttle to 70km/hr	7	
70km/hr cruise	7	
Stop and idle 10 seconds	7	
Interrupted acceleration	7	
1/2 throttle to 70km/hr	7	
70km/hr cruise	7	
Stop and idle 20 seconds	7	
Steering lock to lock	7	n/a
Idle in P/N	7	n/a
Ignition off		
Restart	5	long crank w/o throttle.

## Attachment 5 Cold start and warm up evaluation results #2 E5

### Cold Start and Warm-up Evaluation, Test no 2b

Vehicle Number	GOV5-12	Registration	DU 417
Vehicle name	Toyota Corolla	Test date	6/10/2006
Vehicle colour	Blue	Test time	10:00
Mileage (km)	197473		
Ambient temperature (deg C)	22.2	Engine	1.6L In line, 4cyl
Barometric pressure (kPa)	102	Fuel	PULPE5
Test driver	AKM/dfn	Oil	SAE 10W40
		SOAK Temp	-10degC (Set point)

#### 1. Cold start

##### Cold startability rating

No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more

Rating

Oil (°C)	Coolant(°C)	Intake (°C)
-9.6	-10.7	-11

Ignition on Crank after fuel pump relay is off. No start if crank time is > 10 seconds	
Crank time	1.7
Evaluate startability	7
Ignition -off within 5 seconds	
Ignition-on Crank after fuel pump relay is off. No start if crank time is > 10 seconds	
Crank time	0.8
Evaluate re-startability	7

Data file: C:\logs\gov05\veh\_ 12\_CST2b

#### 2. Cold idle

##### Cold idle quality rating

Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more

Evaluate idle roughness (10 seconds)	7
Shift to D/R or clutch engaged	
Evaluate idle roughness (10 seconds)	7
Turn on the headlights, blower (max position) and defroster	
Evaluate idle roughness (10 seconds)	6
Turn power steering to the right end	
Evaluate idle roughness (10 seconds)	6
Turn power steering to the left end	
Evaluate idle roughness (10 seconds)	6
Re-align steering	
Turn off headlights, blower and defroster	

#### 3. Cold acceleration

##### Cold acceleration rating

Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more

Shift in P/N or disengage clutch (NIG)	
Idle racing mode to 3000rpm	
Evaluate acceleration	6.5
Black smoke present?	5

Dark: 1, Grey:5, Normal: 7

#### 4. Warm-up drive

##### Cold acceleration rating

Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more

##### Cold idle quality rating

Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more

##### Cold startability rating

No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more

Move the car to the test road	
Idle 10 seconds	6
1/2 throttle to 50km/hr	7

### Cold Start and Warm-up Evaluation

#### 4. Warm-up drive

##### Cold acceleration rating

Engine stall: 1, Backfires: 2, Hesitation:3, Surge:4, Rough: 5, Normal: 7 more

##### Cold idle quality rating

Engine stall: 1, Surge: 3, Rough: 5, Normal: 7 more

##### Cold startability rating

No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more

50km/hr cruise	6	
Stop and idle 10 seconds	7	lumpy
WOT to 70km/hr	7	
70km/hr cruise	6.5	uneven
Stop and idle 10 seconds	7	
1/4 throttle to 50km/hr	7	
50km/hr cruise	7	
3/4 throttle to 70km/hr	7	
70km/hr cruise	7	
Stop and idle 10 seconds	6.5	occasional stumble
Interrupted acceleration	7	
1/2 throttle to 70km/hr	7	
70km/hr cruise	6	
Stop and idle 20 seconds	6.5	
Steering lock to lock	6.5	n/a
Idle in P/N	6.5	n/a
Ignition off		
Restart	5	long crank with throttle closed.

<b>CUSTOMER</b>	Department of the Environment and Heritage	<b>PROJECT</b>	GOV005
<b>TITLE</b>	<b>WOT Performance Test Toyota Corolla – GOV5-12</b>		

## AIM

- To evaluate the WOT acceleration performance of a vehicle.
- To compare Petrol and E5 for WOT acceleration performance.

## EQUIPMENT

- MACD – Mileage Accumulation Chassis Dynamometer
- Data logger – Virtual Bench with National Instruments DAQCard 1200.

## PROCEDURE

This procedure evaluated the wide-open throttle (WOT) performance of a power train installed in a vehicle. It was based on the SAE standard, J1491. An ambient air temperature below 32°C was required before proceeding with testing. The same procedure described below was used for Petrol and E5 fuels.

### Preparation

- The roadload was equivalent to the mileage accumulation roadload, based on the ADR79 “book value”.
- The MACD was warmed and calibrated, and the coast-down data recorded (with vehicle off the dynamometer).
- The fan speed was set to be equivalent to the road speed.
- Vehicle tyre pressures were checked to be as per vehicle specification, and all vehicles electrical accessories were set to the ‘OFF’ position.
- The vehicle was driven for a minimum of 32km at an average speed of 88km/h.

### WOT Accelerations from a Standing Start

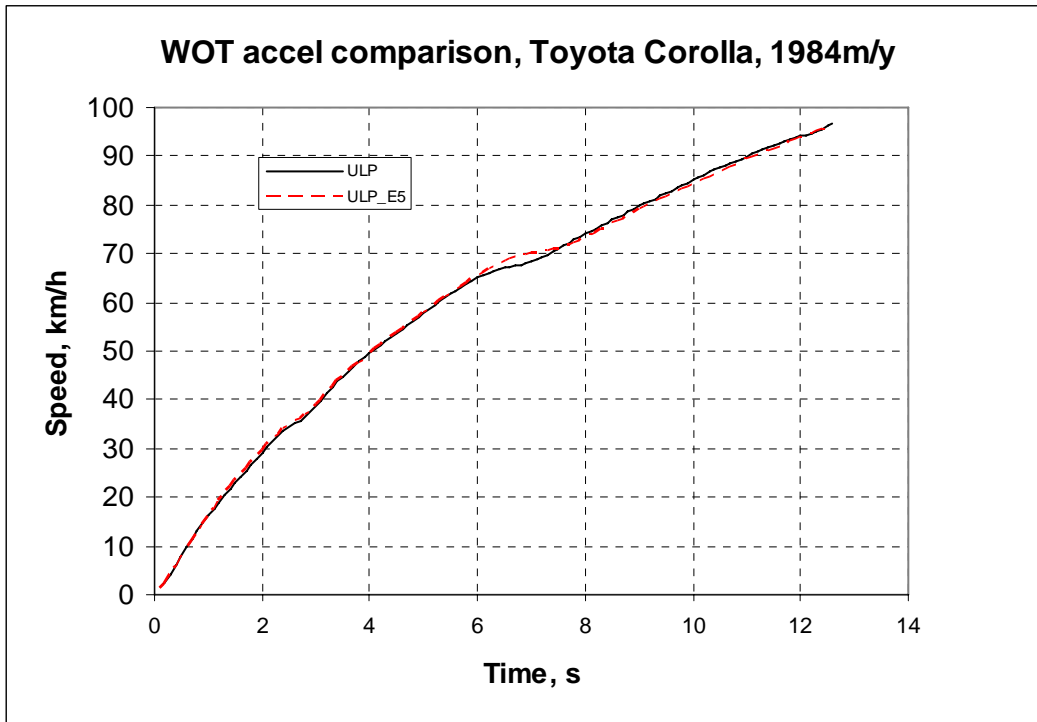
- The test was conducted in “drive” for automatic transmissions and gear shifts occurred at redline engine speed for manual transmissions.
- Three (3) WOT accelerations were performed from a standing start to a speed of no less than 100km/h, and covering no less than 402m.
- Each test followed the previous one with minimum delay, began from a standing start and driven to achieve maximum performance with minimum wheel spin.
- The vehicle speed, exhaust temperatures and AFR were logged. The presence, or absence, of audible engine knock and also general engine/vehicle performance was noted.

### WOT Accelerations from 64 km/h

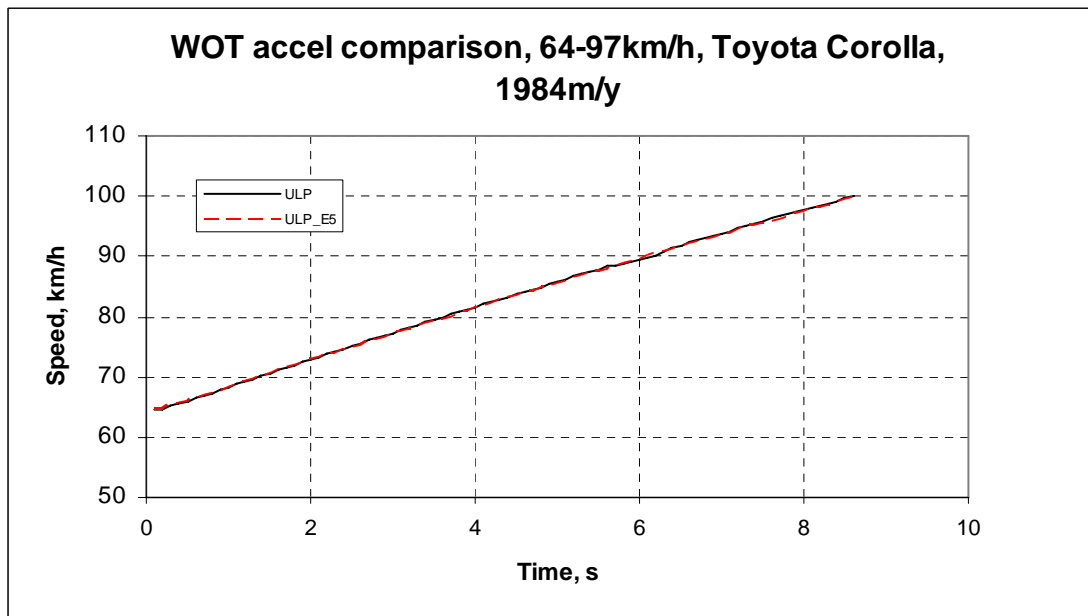
- From a stabilized speed of 64km/h ( $\pm 0.8$  km/h) the vehicle was accelerated at wide-open throttle to 97km/h.
- Separate tests for manual transmissions were run in top gear, and top gear less one, and not downshifted during the acceleration. Automatic transmissions were allowed to downshift as determined by the vehicle transmission controller.
- The vehicle speed, exhaust temperatures and AFR were logged. The presence, or absence, of audible engine knock and also general engine/vehicle performance was noted.

**RESULTS**

The WOT test procedure produced repeatable results with minimal variability. Figures 1 and 2 below represent the average petrol and E5 WOT acceleration test data.



**Figure 1 – Standing Start WOT Acceleration Comparison Between Petrol and E5**

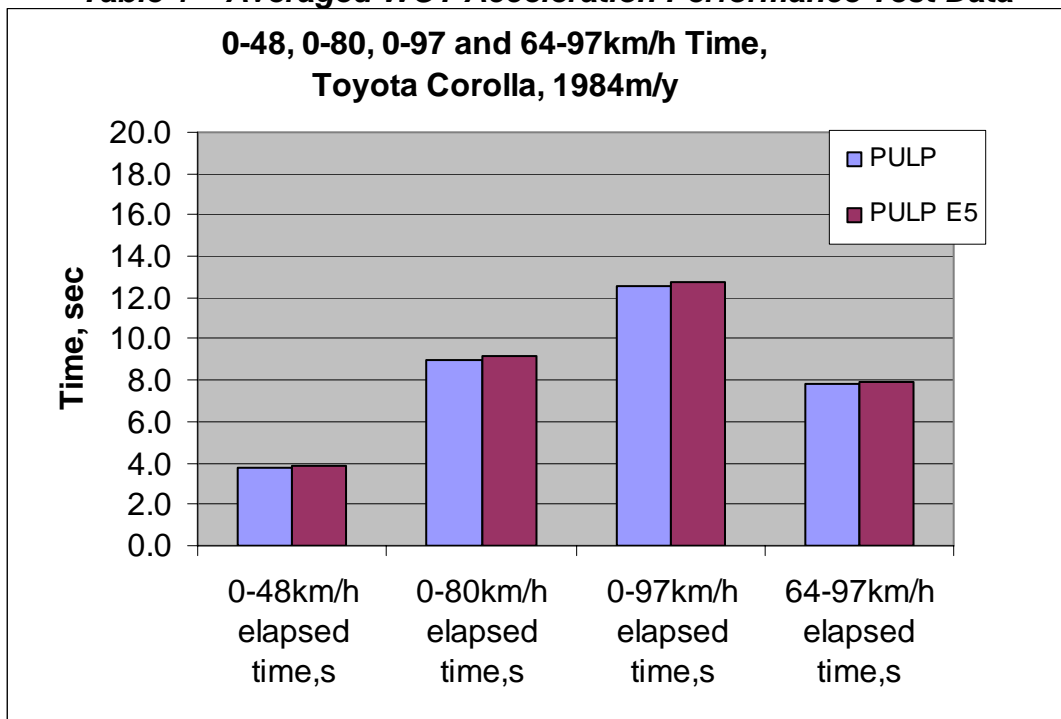


**Figure 2 – 64 to 97 km/h WOT Acceleration Comparison Between Petrol and E5**

Results:	PULP	PULP E5	% Improvement over Petrol. E5
0-48km/h elapsed time,s	3.73	3.83	-3%
0-80km/h elapsed time,s	9.00	9.13	-1%
0-97km/h elapsed time,s	12.60	12.77	-1%
64-97km/h elapsed time,s	7.83	7.97	-2%
0-5s distance covered, m	46.17	46.2	0%
0-5s terminal speed, km/h	57.97	57.8	0%
0-400m elapsed time	18.97	19.0	0%
0-400m terminal speed, km/h	116.92	116.2	-0.6%
Uego Average	0.88	0.92	4.2%
Exhaust temp max.	699	719.5	2.9%

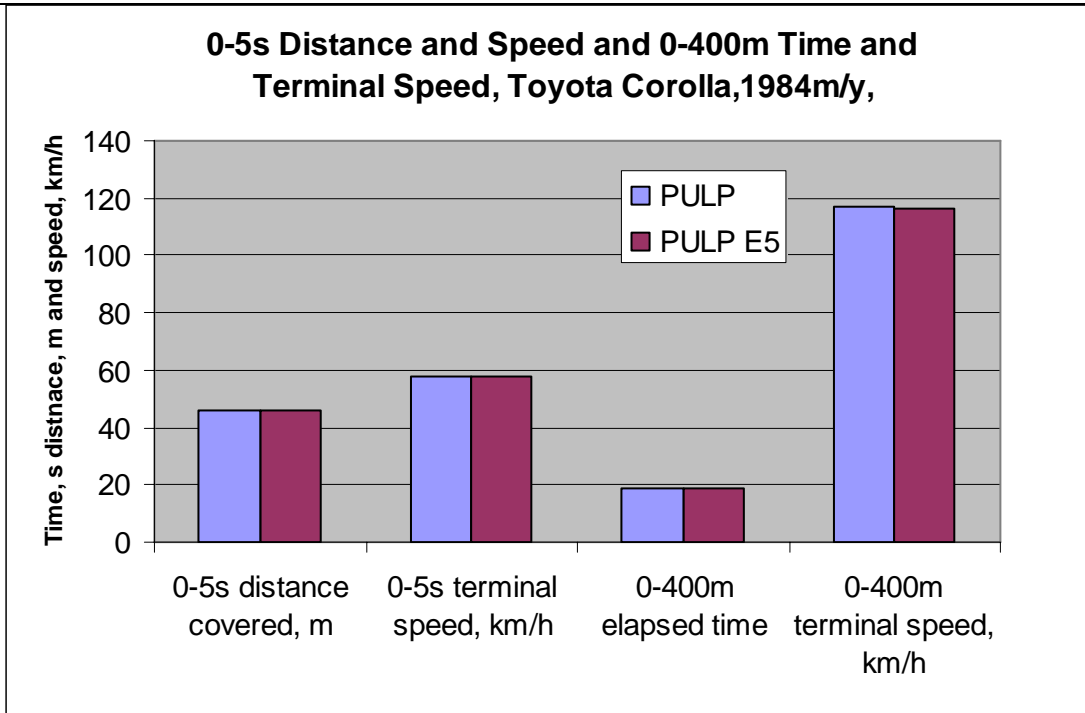
The values shown are average values, calculated from the three acceleration runs on each fuel.

**Table 1 – Averaged WOT Acceleration Performance Test Data**



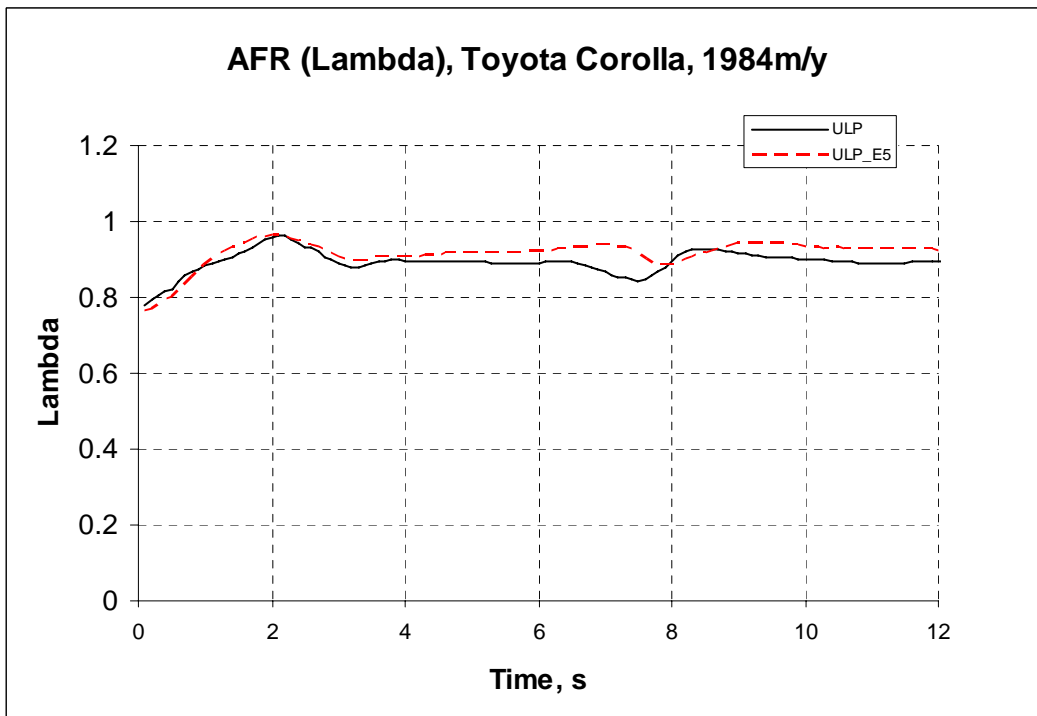
**Figure 3 – Elapsed Times for WOT Accelerations**

Overall the WOT acceleration test data indicates a small worsening in the acceleration times for E5 over Petrol. For 0~97km/h test, E5 showed a 1~3% increase in the times to reach the 48, 80 and 97km/h terminal speeds. Similarly, for accelerations from 64~97km/h km/h, the acceleration times were worsened by 2% for E5 over Petrol.



**Figure 4 – 0 to 5s and 0 to 402m WOT Acceleration Performance Comparison**

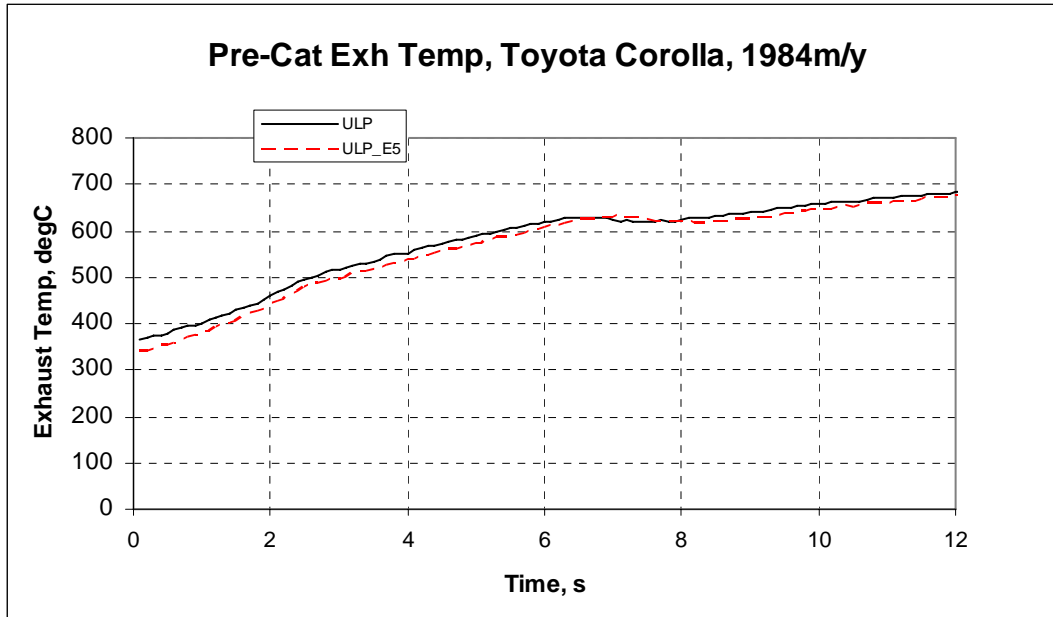
The 0~400m elapsed times were similar for Petrol and E5, but the terminal speed was reduced by 0.6% for E5. Launch, as measured by the 0~5s distance was similar for the E5 fuel and Petrol. The terminal speed after 5s was similar for the E5 fuel.



**Figure 5 – Standing Start WOT Acceleration AFR Comparison**

Figure 5 shows that on average the engine was running 4% leaner for E5 compared to

Petrol. This is consistent with a vehicle which does not apply learning to the AFR, although it is somewhat higher than the expected enleanment for E5 fuel.



**Figure 6 – Standing Start WOT Acceleration Exhaust Temperatures**

The peak pre-catalyst exhaust gas temperature recorded at the end of each run was 3% higher (20degC) for the E5 fuel than the Petrol figure. (The peak temperature is a better indicator of the exhaust temperature than the average over the test, as it is less affected by the entry temperature, which is variable, than the average value). In view of the low temperatures recorded, this should not lead to a problem.

**CONCLUSIONS/DISCUSSION**

The WOT acceleration results on the Toyota Corolla indicate there is a slight reduction in performance with the use of E5 fuel. However the magnitude is such that change due to the use of E5 on the WOT performance would not be noticeable.

The enleanment noted is not likely to cause any detrimental effect on the vehicle. The actual exhaust temperatures measured were low and increase in exhaust temperature noted is unlikely to be significant.

**ATTACHMENT**

1. MACD WOT Acceleration Performance Vehicle Data Sheet for petrol.
2. MACD WOT Acceleration Performance Vehicle Data Sheet for E5.
3. MACD WOT Acceleration Comparison over all fuels tested.


## Attachment 1 MACD WOT Acceleration Performance Vehicle Data Sheet For Petrol.

<u>Vehicle:</u> Make <u>Toyota</u> Model <u>Corolla</u> Year <u>1984</u>		Test Date <u>6/11/2006</u>			
Odometer <u>197482</u> km		Car No <u>12</u>			
<u>Test Location</u> <u>MACD no 1</u>		Driver <u>R Brooks</u>			
Start of test date <u>6/11/2006</u>		Time strt <u>14:30</u>			
End of test date <u>6/11/2006</u>		Time end <u>16:00</u>			
Transmission, type <u>5m/t</u>		Automatic shift mode <u>Manual</u>			
Fuel Type <u>PULP</u>					
<u>Remarks</u> <u>Some knock (moderate) in 4th gear in bothe 0-97 and 64-97 acceleration tests.</u>					
<u>Ambient conditions for test:</u>					
Temperature	<u>30</u> °C	Barometric Pressure <u>100.9</u>			
Wind Velocity	<u>roller speed</u> km/h	Direction <u>Head-on</u>			
		Relative Humidity <u>34</u> %			
		Peak wind velocity <u>Road speed</u>			
<u>Results:</u>	Test1	Test2	Test3	Average	Variability (Max-mean)/mean
0-48km/h elapsed time,s	<u>3.7</u>	<u>3.8</u>	<u>3.7</u>	<u>3.73</u>	<u>1.79</u> %
0-80km/h elapsed time,s	<u>8.9</u>	<u>9.1</u>	<u>9</u>	<u>9.00</u>	<u>1.11</u> %
0-97km/h elapsed time,s	<u>12.6</u>	<u>12.6</u>	<u>12.6</u>	<u>12.60</u>	<u>0.00</u> %
64-97km/h elapsed time,s	<u>7.9</u>	<u>7.8</u>	<u>7.8</u>	<u>7.83</u>	<u>0.85</u> %
0-5s distance covered, m	<u>46.9</u>	<u>45.4</u>	<u>46.3</u>	<u>46.2</u>	<u>1.53</u> %
0-5s terminal speed, km/h	<u>58.2</u>	<u>57.4</u>	<u>58.3</u>	<u>58.0</u>	<u>0.60</u> %
0-400m elapsed time	<u>18.9</u>	<u>19</u>	<u>19</u>	<u>19.0</u>	<u>0.18</u> %
0-400m terminal speed, km/h	<u>117.2</u>	<u>115.8</u>	<u>117.8</u>	<u>116.9</u>	<u>0.75</u> %
Uego Average	<u>0.88</u>	<u>0.90</u>	<u>0.89</u>	<u>0.89</u>	<u>1.13</u> %
Exhaust temp max.	<u>700.9</u>	<u>705.2</u>	<u>696.6</u>	<u>698.9</u>	<u>0.89</u> %
File reference: P:\Projects\Government\GOV005\Test Data\GOV5-12 - Toyota Corolla\MACD_WOT\VEH12_WOT01a_M01.xls\Report					

## Attachment 2 MACD WOT Acceleration Performance Vehicle Data Sheet for E5.

<u>Vehicle:</u> Make <u>Toyota</u>		Model <u>Corolla</u>	Year <u>1984</u>	Test Date <u>6/11/2006</u>	
Odometer <u>197540</u> km				Car No <u>12</u>	
<u>Test Location</u> <u>MACD no 1</u>		Driver <u>R Brooks</u>			
Start of test date <u>6/11/2006</u>		Time strt <u>16:30</u>			
End of test date <u>6/11/2006</u>		Time end <u>17:00</u>			
Transmission, type <u>5m/t</u>		Automatic shift mode <u>Manual</u>			
<u>Fuel Type</u> <u>PULP</u>					
<u>Remarks</u> <u>No knock in 0-97km/h test, some moderate knock in 64-97km/h test.</u>					
<u>Ambient conditions for test:</u>					
Temperature	<u>30</u> °C	Barometric Pressure	<u>100.8</u>	Relative Humidity	<u>38</u> %
Wind Velocity	<u>roller speed</u> km/h	Direction	<u>Head-on</u>	Peak wind velocity	<u>Road speed</u>
<u>Results:</u>	Test1	Test2	Test3	Average	Variability (Max-mean)/mean
0-48km/h elapsed time,s	<u>3.9</u>	<u>3.7</u>	<u>3.9</u>	<u>3.83</u>	<u>1.74</u> %
0-80km/h elapsed time,s	<u>8.9</u>	<u>8.7</u>	<u>9.8</u>	<u>9.13</u>	<u>7.30</u> %
0-97km/h elapsed time,s	<u>12.8</u>	<u>12.2</u>	<u>13.3</u>	<u>12.77</u>	<u>4.18</u> %
64-97km/h elapsed time,s	<u>8.1</u>	<u>7.9</u>	<u>7.9</u>	<u>7.97</u>	<u>1.67</u> %
0-5s distance covered, m	<u>45.9</u>	<u>46.9</u>	<u>45.9</u>	<u>46.2</u>	<u>1.48</u> %
0-5s terminal speed, km/h	<u>57.5</u>	<u>58.5</u>	<u>57.3</u>	<u>57.8</u>	<u>1.29</u> %
0-400m elapsed time	<u>18.9</u>	<u>18.8</u>	<u>19.3</u>	<u>19.0</u>	<u>1.58</u> %
0-400m terminal speed, km/h	<u>116.9</u>	<u>117.2</u>	<u>114.5</u>	<u>116.2</u>	<u>0.89</u> %
Uego Average	<u>0.91</u>	<u>0.91</u>	<u>0.93</u>	<u>0.92</u>	<u>1.81</u> %
Exhaust temp max.	<u>685.9</u>	<u>737.3</u>	<u>710.5</u>	<u>719.5</u>	<u>2.48</u> %
<u>File reference:</u> P:\Projects\Government\GOV005\Test Data\GOV5-12 - Toyota Corolla\MACD_WOT\VEH12_WOT02a_M01.xls\Report					

### Attachment 3

## MACD WOT Acceleration Performance Vehicle Data Sheet Averaged data and variance for all fuels.

<b>Vehicle:</b> Make	Toyota	Model	Corolla	Year	1984	Base fuel test date	6/11/2006
Odometer	197482 km					Car No	12
End Ods	197540 km						
<b>Test Location</b>	MACD no 1			Driver	R Brooks		
Start of test date	6/11/2006			Time strt	various		
End of test date	6/11/2006			Time end	various		
Transmission, type	5m/t			Automatic shift mode	Manual		
<b>Fuel Type (base)</b>	PULP						
<b>Remarks</b>							
<b>Ambient conditions for test:</b>							
Temperature	30-30 °C	Barometric Pressure	100.8-100.9	Relative Humidity	34-38 %		
Wind Velocity	roller speed km/h	Direction	Head-on	Peak wind velocity	Road speed		
<b>Results:</b>	<b>PULP</b>	<b>PULP E5</b>	<b>% Improvement over Petrol. E5</b>				
0-48km/h elapsed time,s	3.73	3.83	-3%				
0-80km/h elapsed time,s	9.00	9.13	-1%				
0-97km/h elapsed time,s	12.60	12.77	-1%				
64-97km/h elapsed time,s	7.83	7.97	-2%				
0-5s distance covered, m	46.17	46.2	0%				
0-5s terminal speed, km/h	57.97	57.8	0%				
0-400m elapsed time	18.97	19.0	0%				
0-400m terminal speed, km/h	116.92	116.2	-0.6%				
Uego Average	0.88	0.92	4.2%				
Exhaust temp max.	699	719.5	2.9%				
<b>File reference:</b>	P:\Projects\Government\GOV005\Test Data\GOV5-12 - Toyota Corolla\MACD_WOT\VEH12_WOT_comp_M01_twofuels.xls\Report						

<b>CUSTOMER</b>	Department of Environment and Heritage	<b>PROJECT</b>	GOV005
<b>TITLE</b>	2000hr Materials Compatibility Testing of Fuel System Components for a "Pre 1986" Toyota Corolla GOV5-12		

## AIM

To identify the impacts of 5% ethanol gasoline fuel blend on the fuel system components of a "pre 1986" Toyota Corolla.

## EQUIPMENT

- Environmental test cell utilised as a soak room operating at 55°C.
- Adjacent test cell at 23°C for test part monitoring and fuel disposal and replenishment.
- Wide mouth polyethylene test bottles
- 2 test fuel types
  - S.PULP (summer grade PULP)
  - S.PULP.E5 containing 5% ethanol and 0.25% corrosive water
- Fuel system components as outlined in the attached data.
- Digital camera
- Shore hardness tester
- Micrometer
- Gravimetric scales

## PROCEDURE

- A selection of fuel system components was made based on them having contact with fuel and potentially influencing the integrity and function of the fuel system. These components were characterised accordingly and their features recorded. A photographic record of the components was also taken.
- All components were labelled with part numbers according to the appropriate SAE standard. A listing of the components tested is shown in Table 1.
- Parts tested were from a MY1984 Toyota Corolla and unless otherwise noted were genuine OEM parts or OEM recommended alternatives.
- Components were immersed in S.PULP and in the S.PULP/ethanol/corrosive water mix. Immersion was according to the appropriate SAE standard. Parts were placed in the test bottles and listed on test sheets, on which all components in that bottle were listed. One sheet was kept per part and results were recorded on these test sheets as the test progressed
- Each test bottle was also marked with the immersed components part number ensuring adequate quality control. The test bottles were sealed and placed into the soak room at 55°C. Tests were run on groups of bottles for each set of vehicle components. The start time and inspection times for each group of bottles were recorded in a log book to track the exposure time.
- Final test duration target was 2000hrs of soak time.
  - At regular times the fluid level in the sample containers was inspected and

replenished if necessary.

- At interim times, the samples were removed from the bottles for progress inspection. At each of these times the test fuels were replaced with fresh fuel prior to recommencing the soak.
- At completion of the 2000hrs, the samples were inspected as per the interim points, but were also “dried” in accordance with the SAE standard and given a final inspection.
- In addition to weighing, dimensioning and hardness testing (as appropriate), component inspection included recording of the visual differences (such as distortion, enlargement, colour change or loss of shape) between the initial appearance by photograph and comparison between the fuel types was made. For the metal engine components, evidence of corrosion, discoloration or tarnishing was recorded.

## **RESULTS**

The GOV5-12 test parts completed 2035 hours of fluid exposure with interim progress inspections and recordings made at 504 hrs and at 1026 hours. The fluid effects noted were:

- swelling and softening of elastomers when wet;
- shrinkage and hardening of elastomers when dried; and
- corrosion of some metallic components.

Numeric results are shown in Table 2 through Table 4. Results showing the relative change (%) are shown graphically in Figure 1 through Figure 7.

### **2000hr “Wet” Results for Elastomeric Components**

Figure 1 shows the weight gain of components when wet. Of particular note was the weight gain of:

- Hose (part #2)
- Carburettor float (part #4a)
- Carburettor gasket (part # 4b)
- O-ring (part #4h)
- Fuel filter (part # 6)
- Fuel pump diaphragm (part # 7b)
- Check valve (part #8)

For these parts the weight gain when wet was generally greater for E5 than for S.PULP. This indicates greater absorption of fuel by rubber, elastomer or plastic parts when exposed to ethanol blend.

Figure 2 shows the change in a key dimension (thickness or diameter) of the part after exposure to fuel. Of note was the swelling of:

- Carburettor gasket (part # 4b)
- O-ring (part #4h)

For these parts the swelling was greater for E5 than for S.PULP. This indicates greater absorption of fluid by the rubber or elastomer parts when exposed to ethanol blend.

Figure 3 shows the hardness (where measured) for parts after exposure to fuel. Of note was the reduced hardness of:

- Hose (part #2)

For this parts the softening was greater for E5 than for S.PULP.

### **2000hr “Dry” Results for Elastomeric Components**

Figure 4 shows the weight change of components when dried at the completion of the test. Of particular note was the weight loss of:

- Hoses (part # 1, 2)
- Carburettor gasket (part # 4b)
- O-ring (part #4h)
- Fuel pump diaphragm (part # 7b)

For these parts the weight loss was generally greater for E5 than for S.PULP. The loss of weight compared to the initial weight of the component indicates that material has been dissolved by the fuel, changing the material composition. This indicates greater change in the material composition after exposure to ethanol blends.

Figure 5 shows the change in a key dimension (where measured) of the part when dried after exposure to fuel. Typically outside diameter was measured for hoses, thickness for flat material and section diameter for O-rings. Of note was the greater shrinkage of:

- O-ring (part #4h)

This part showed greater reduction in section when dried after exposure to E5 than after exposure to S.PULP.

Also noted was the retained expansion of the carburettor gasket (part # 4b) which remained very swollen after drying.

Figure 6 shows the hardness (where measured) for parts when dried after exposure to fuel. One fuel hose (part #2) showed a greater increase in hardness when dried after exposure to E5 than after exposure to S.PULP.

### **Metal components at 2000 hrs**

- Tarnished brass float valve seat (part # 4d), see Figure 8.
- Tarnished brass float valve needle (part # 4e)
- Tarnished sealing washer (part # 4f), see Figure 9.
- Corroded cut edges of fuel pump housing (part # 7a), see Figure 10. This corrosion is not considered to be a problem as none was observed on the undisturbed surfaces.

### **General Observations**

- Discoloured filter housing (part # 6), see Figure 11

- Filter loose in filter housing (part #6)

## CONCLUSIONS/DISCUSSION

Examination of the selected parts after exposure to S.PULP and E5 fuel blend showed:

- Increased weight gain of elastomer components due to increased absorption of fuel for ethanol blend.
- Increased swelling of elastomer components due to exposure to ethanol blends
- Softening of elastomer components due to exposure to ethanol blends.
- Greater weight loss by some elastomer components when dried after exposure to ethanol blends
- Increased hardness of some elastomer components when dried after exposure to ethanol blends
- Corrosion of some metal components when exposed to ethanol blends

The swelling and softening of the fuel hoses creates a risk of failure of the joints. The swelling and softening of O-rings, seals and gaskets causes a risk of damage or incorrect fitment of the seal during assembly of joints leading to fuel leakage. The swelling of plastic components is likely to have caused the loosening of the filter in the filter housing. The loss of filtration in the fuel system makes the jets and valves in the fuel system vulnerable to contamination by foreign material. Materials experiencing significant changes due to contact with E5 are considered unacceptable. Metal components which corroded during this accelerated test are considered incompatible with the test fluid. Discolouration of the plastic fuel filter housing may indicate material compatibility.

Some of the elastomer and polymer components tested would not normally be exposed to fuel immersion on their external surface whilst in-service, however identification of a difference in compatibility between S.PULP and ethanol blend results highlights potential for a change in performance should fuel exposure occur.

## ATTACHMENTS

The materials compatibility result sheets.


Table 1 – Components Tested

Pre 86 Vehicle		
GOV5-12 Toyota Corolla		
Part	Description	Material
1	Hose, tank supply	rubber
2	Hose - fuel return	rubber
3	Throttle - carburettor	brass/steel
4a	Float - carburettor	plastic
4b	Gasket - carburettor	composite
4c	Plunger -carburettor	various
4d	Seat - float valve	brass
4e	Needle - float valve	brass/steel
4f	Washer - sealing	copper
4g	Washer - sealing	aluminium
4h	O-ring	rubber
5	Insulator - carburettor	plastic
6	Fuel filter housing	plastic
7a	Housing - fuel pump	steel
7b	Diaphragm - fuel pump	rubber
8	Check valve assy	plastic

Table 2 – Measurements at beginning of test

Pre 86 Vehicle			Pre Test measurements					
GOV5-12 Toyota Corolla			S.PULP			S.PULP.E5		
Part	Description	Material	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)
1	Hose, tank supply	rubber	26.578	5.1	76	25.597	4.9	76
2	Hose - fuel return	rubber	7.689	3	70	7.429	3	70
3	Throttle - carburettor	brass/steel	164.14			171.62		
4a	Float - carburettor	plastic	3.4			3.362		
4b	Gasket - carburettor	composite	2.151	0.76		2.157	0.57	
4c	Plunger -carburettor	various	3.348	6		3.343	6	
4d	Seat - float valve	brass	12.798	6.07		12.876	6.12	
4e	Needle - float valve	brass/steel	1.011	16.8		1.016	16.67	
4f	Washer - sealing	copper	0.159	0.69		0.156	0.67	
4g	Washer - sealing	aluminium	0.127	0.6		0.123	0.6	
4h	O-ring	rubber	0.221	2.01		0.216	2.02	
5	Insulator - carburettor	plastic	21.781	9.36		19.639	9.35	
6	Fuel filter housing	plastic	35.792	7.78		33.466	6.88	
7a	Housing - fuel pump	steel	15.112			16.497		
7b	Diaphragm - fuel pump	rubber	3.069	1.28	78	2.881	1.28	78
8	Check valve assy	plastic	5.729	51.2		5.769	51.2	

Table 3 – Measurements at completion of test, wet.

Pre 86 Vehicle			2000 hr measurements (wet)					
GOV5-12 Toyota Corolla			S.PULP			S.PULP.E5		
Part	Description	Material	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)
1	Hose, tank supply	rubber	23.785	4.9	76	23.691	4.8	74
2	Hose - fuel return	rubber	9.187	4	57	9.204	3.7	47
3	Throttle - carburettor	brass/steel	164.18			171.8		
4a	Float - carburettor	plastic	3.564			3.787		
4b	Gasket - carburettor	composite	3.55	0.88		3.9	1	
4c	Plunger - carburettor	various	3.433	6.06		3.49	6.09	
4d	Seat - float valve	brass	12.78	6.07		12.891	6.11	
4e	Needle - float valve	brass/steel	1.04	16.95		1.032	16.8	
4f	Washer - sealing	copper	0.152	0.69		0.161	0.72	
4g	Washer - sealing	aluminium	0.127	0.6		0.129	0.61	
4h	O-ring	rubber	0.258	2.1		0.278	2.27	
5	Insulator - carburettor	plastic	21.685	9.35		19.598	9.36	
6	Fuel filter housing	plastic	46.451	7.78		44.371	6.98	
7a	Housing - fuel pump	steel	15.19			16.558		
7b	Diaphragm - fuel pump	rubber	3.332	1.36	72	3.354		74
8	Check valve assy	plastic	6.533	51.62		6.777	51.81	

Table 4 – Measurements at completion of test, dry.

Pre 86 Vehicle			Post test measurements (dry)					
GOV5-12 Toyota Corolla			S.PULP			S.PULP.E5		
Part	Description	Material	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)
1	Hose, tank supply	rubber	20.993	4.7	96	19.972	4.5	90
2	Hose - fuel return	rubber	6.628	3	87	6.228	3	92
3	Throttle - carburettor	brass/steel	164.07			171.55		
4a	Float - carburettor	plastic	3.378			3.466		
4b	Gasket - carburettor	composite	2.016	0.8		2.046	0.85	
4c	Plunger - carburettor	various	3.373	6.02		3.382	6.03	
4d	Seat - float valve	brass	12.777	6.07		12.862	6.11	
4e	Needle - float valve	brass/steel	1.012	16.9		1.016	16.9	
4f	Washer - sealing	copper	0.16	0.69		0.159	0.73	
4g	Washer - sealing	aluminium	0.127	0.6		0.126	0.61	
4h	O-ring	rubber	0.197	1.93		0.188	1.92	
5	Insulator - carburettor	plastic	21.566	9.35		19.487	9.35	
6	Fuel filter housing	plastic	41.236	7.75		37.673	6.97	
7a	Housing - fuel pump	steel	15.088			16.482		
7b	Diaphragm - fuel pump	rubber	2.576	1.16	85	2.397		83
8	Check valve assy	plastic	5.831	51.54		5.846	51.48	

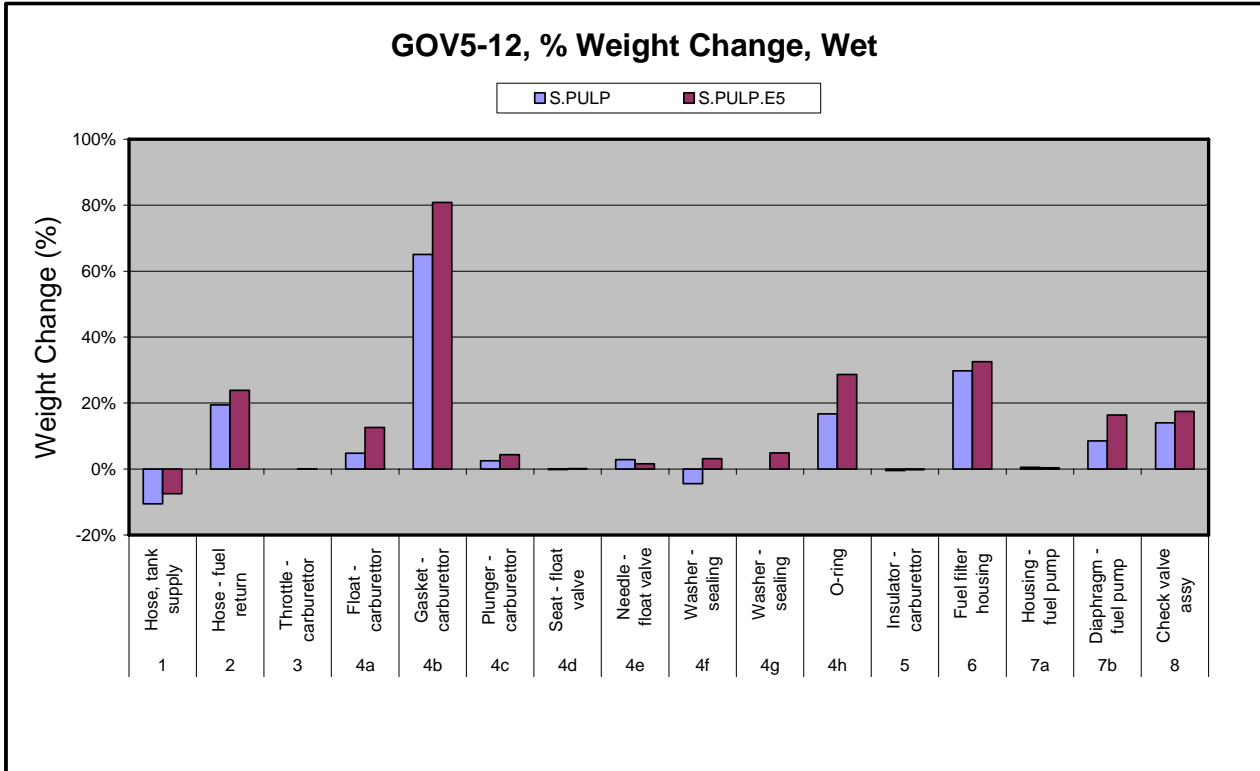


Figure 1 – Component weight change at test completion, wet.

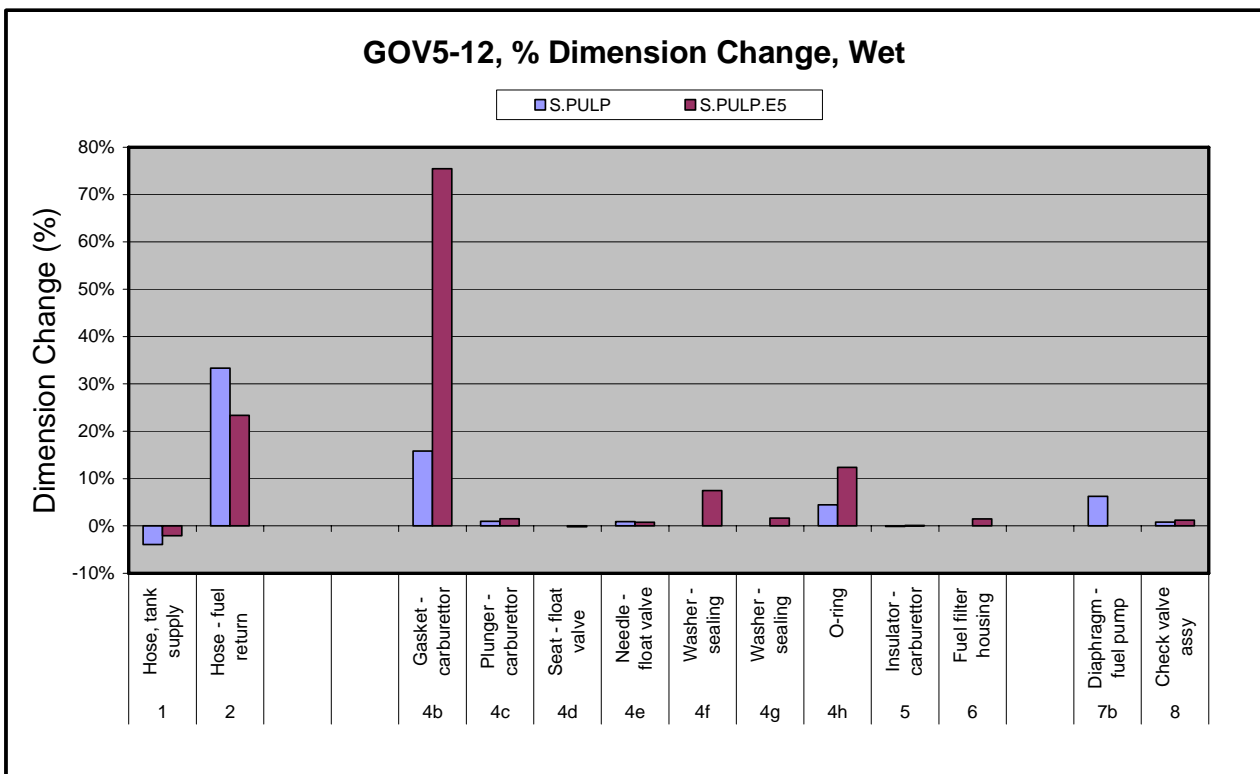


Figure 2 – Component thickness change at test completion, wet

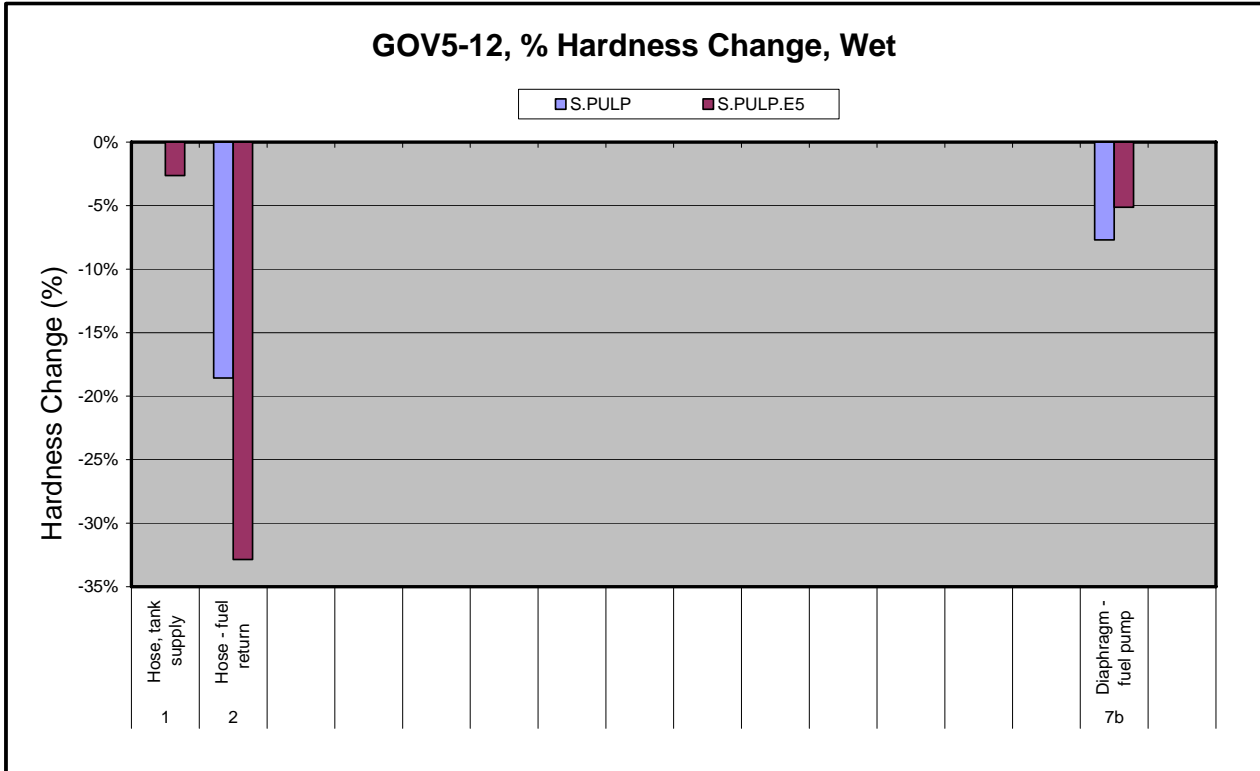


Figure 3 – Component hardness change at test completion, wet

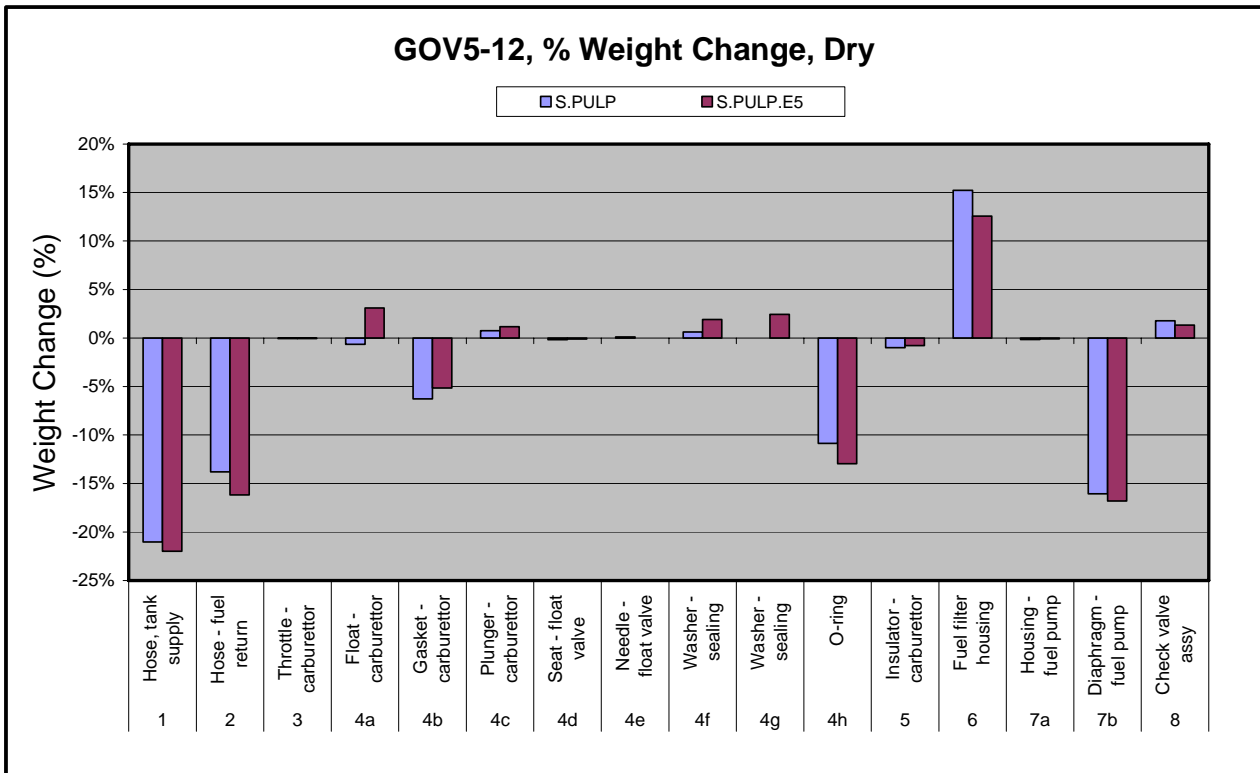


Figure 4 – Component weight change at test completion, dry

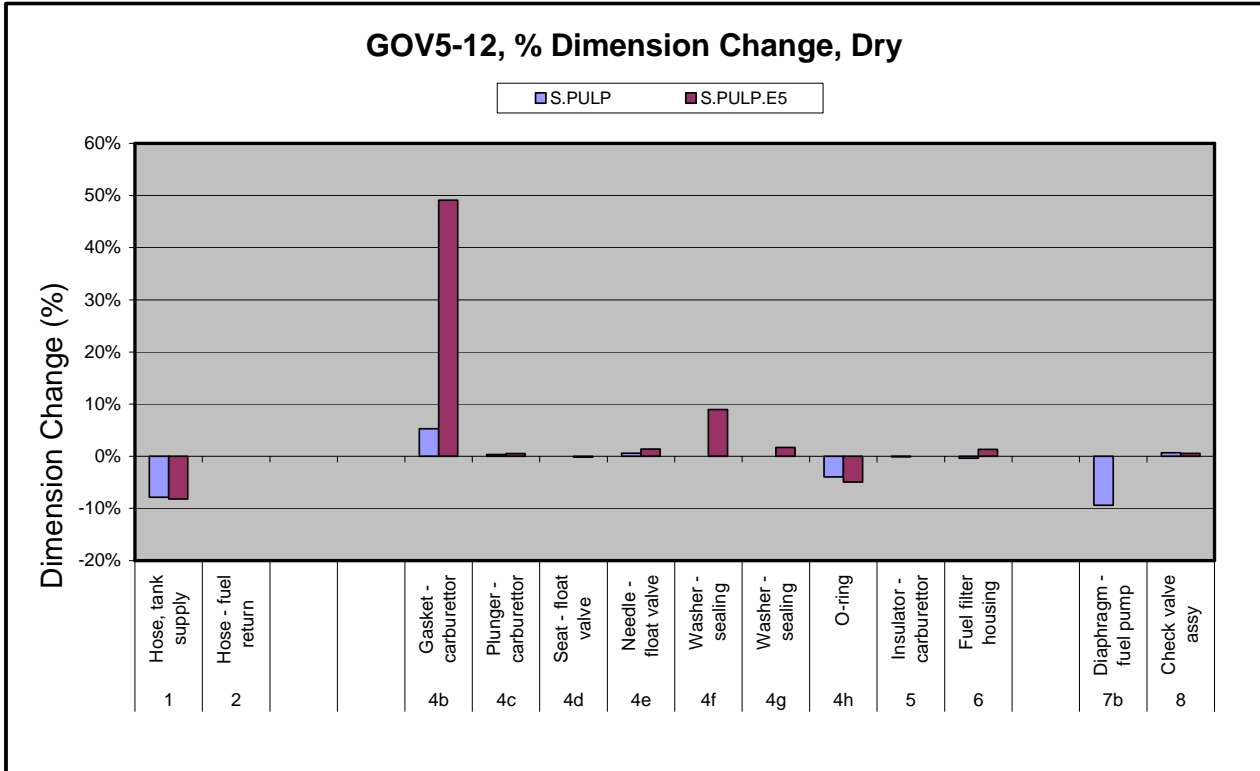


Figure 5 – Component thickness change at test completion, dry

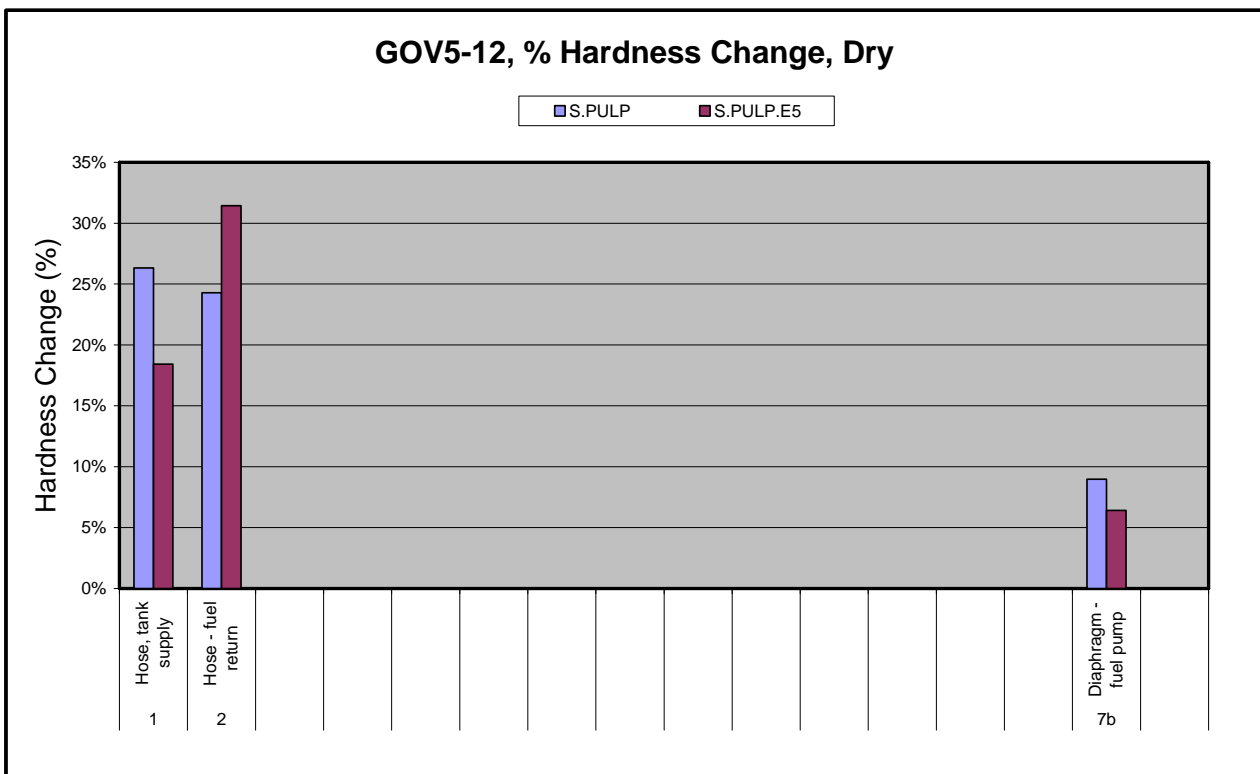


Figure 6 – Component hardness change at test completion, dry

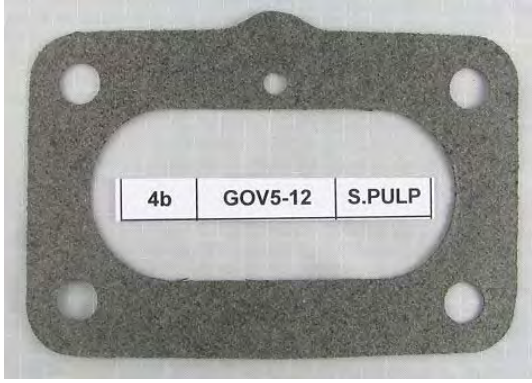
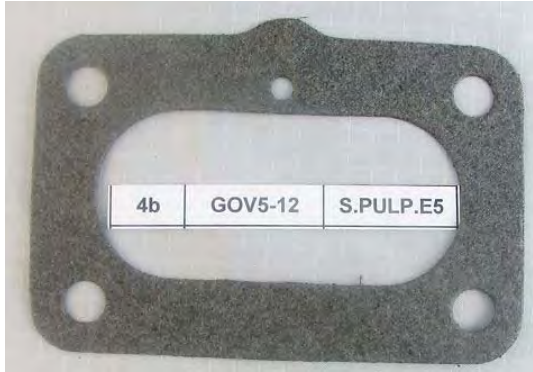
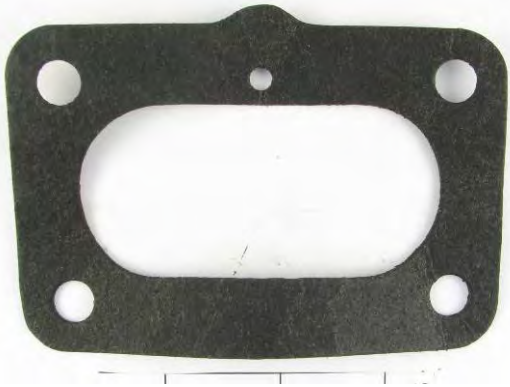
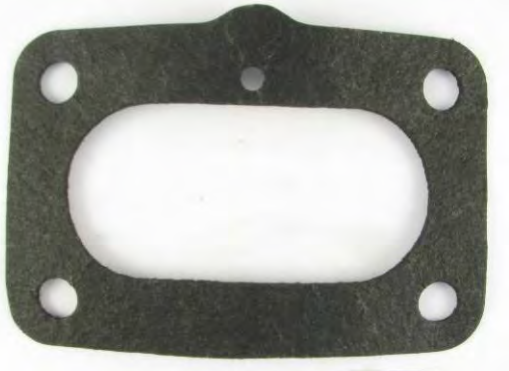
	S.PULP	S.PULP.E5
Pre Test		
Post Test (wet)		

Figure 7 –Part # 4b, Carburettor gasket





	S.PULP	S.PULP.E5
Pre Test		
Post Test (wet)		

Figure 8 Part # 4d, Float valve seat





	S.PULP	S.PULP.E5
Pre Test	 A circular, copper-colored metal ring (sealing washer) is shown against a light blue textured background. The ring appears clean and uniform in color.	 A circular, copper-colored metal ring (sealing washer) is shown against a dark background. The ring appears clean and uniform in color.
Post Test (wet)	 A circular, copper-colored metal ring (sealing washer) is shown against a white background. The ring shows some dark spots and a slightly darker, more aged appearance compared to the pre-test state.	 A circular, copper-colored metal ring (sealing washer) is shown against a white background. The ring shows significant darkening and discoloration, particularly around the edges, indicating corrosion or staining.

Figure 9 Part # 4f, Sealing washer

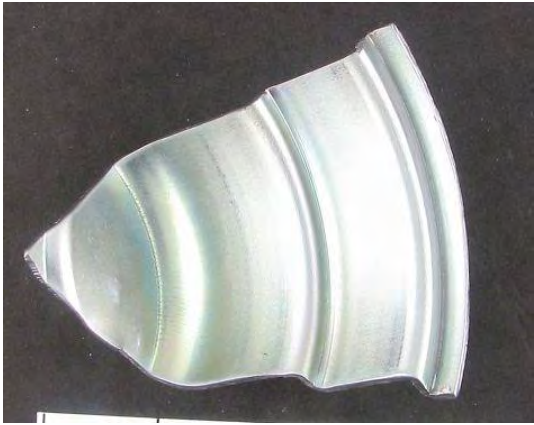
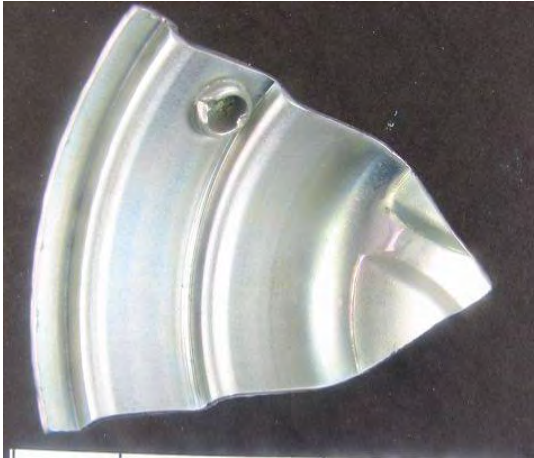
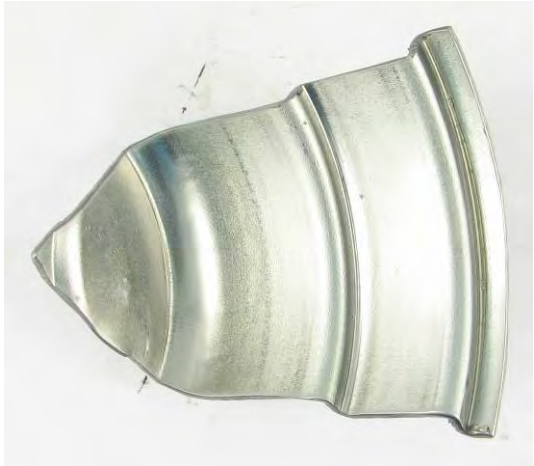

	S.PULP	S.PULP.E5
Pre Test		
Post Test (wet)		

Figure 10 Part # 7a, Fuel pump housing




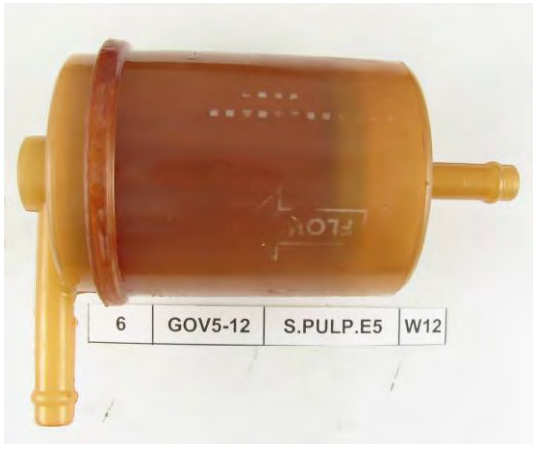
	S.PULP	S.PULP.E5
Pre Test	 <p>6 GOV5-12 S.PULP</p>	
Post Test (wet)		 <p>6 GOV5-12 S.PULP.E5 W12</p>

Figure 11 Part # 6, Fuel Filter