

CUSTOMER	Department of the Environment and Heritage	PROJECT	GOV5 - 26
TITLE	Comparison of Vehicle Drivability Toyota Landcruiser – GOV5-14		

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 (Δ)
Cold Start	6.8	6.8	0.0
Warmed-up Start	6.5	7.0	0.5
Overall Restart	6.8	6.8	0.0
Idle Stability	6.5	6.0	-0.5
Idle Roughness	6.5	6.0	-0.5
Launchability, Part Load	7.0	7.0	0.0
Launchability, WOT	7.0	7.0	0.0
Acceleration Feel, Part Load	7.0	7.0	0.0
Acceleration Feel, WOT	7.0	7.0	0.0
Passing feel, Part Load	7.0	6.5	-0.5
Passing feel, WOT	7.0	7.0	0.0
Gradeability	7.5	7.0	-0.5
Low speed shunt/chuggle	7.0	7.0	0.0
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	7.0	7.0	0.0
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	6.9	6.9	-0.1
Minimum	6.5	6.0	-0.5
Maximum	7.5	7.0	0.5

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 PULP and E5 fuels.
- 2) The subjective ratings, as assessed by two drivers, provided acceptable agreement.
- 3) An average driver is unlikely to notice any difference between PULP 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

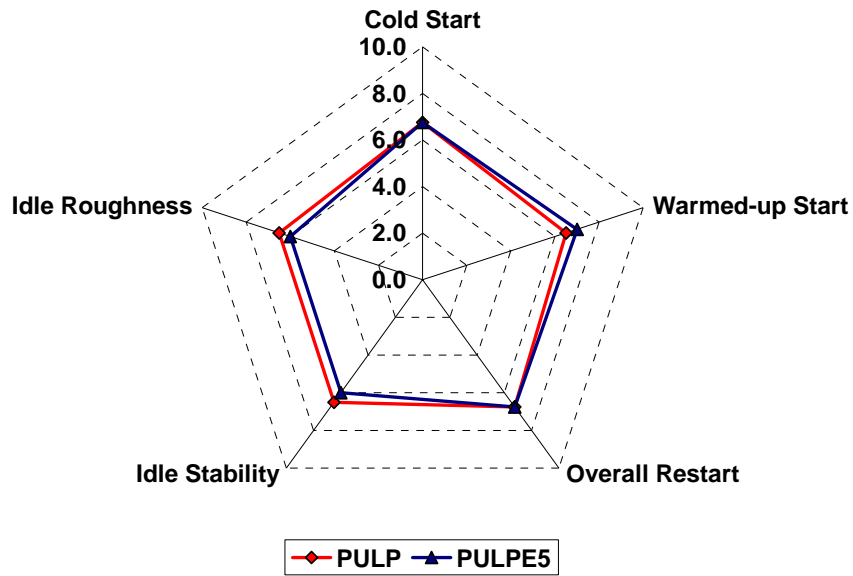


Figure 1 - Start and Idle Quality

Vehicle Performance

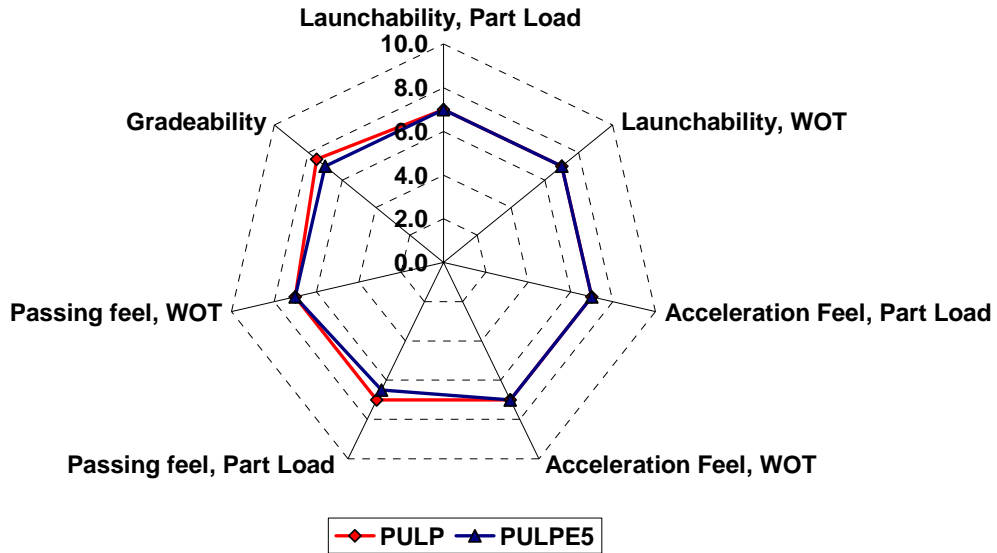


Figure 2 - Vehicle Performance Comparison

Warmed-up Driveability

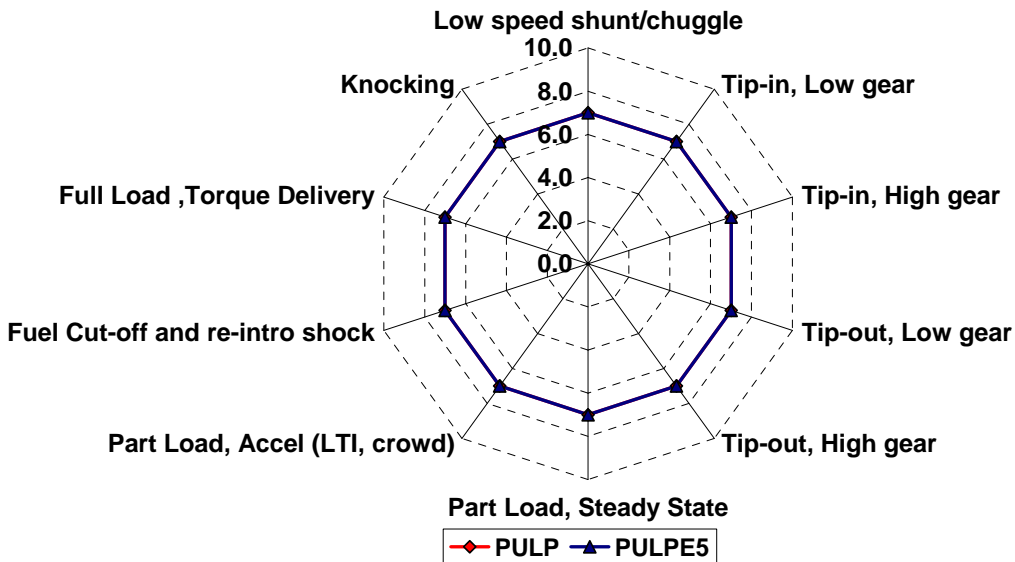


Figure 3. – Warmed – up Driveability Comparison

Attachment 2 Vehicle Appraisal Results #1 PULP

Vehicle Appraisal Form Fuel (1, driver A)

Vehicle name	GOV5-14 Toyota	Test date	22/08/2006
Mileage (km)	358106	Test time	11h00
Ambient temperature (deg C)	16.3	Test road	Balcatta area
Barometric pressure (kPa)	100.8	Engine	I6, Pushrod, Carburettor
Test driver	HS1	Fuel	PULP
Co-driver	AKM	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	7		
	Restartability	7		
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	Subjective rating 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		
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	GOV5-14 Toyota	Test date	23/08/2006
Mileage (km)	358144	Test time	9:50
Ambient temperature (deg C)	17	Test road	Balcatta area
Barometric pressure (kPa)	102.1	Engine	I6, Pushrod, Carburettor
Test driver	AKM	Fuel	PULP
Co-driver	DFN	Oil	SAE 10W40

1. Startability		Rating	Remarks	
Cold start	Starting Time	7		
	Flare to idle	6		
	Restartability	6		
Warmed up start	Starting Time	7		
	Flare to idle	6		
	Restartability	7		
2. Idle Quality		Rating		Remarks
RPM stability	No load	6		
	part load	6		
	Full load	6		
Idle roughness	No load	6		
	part load	6		
	Full load	6		
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		8		
Long hill climbing ability		8		
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	Subjective rating 1. Very bad 2. Bad 3. Very poor 4. Poor 5. Mediocre 6. Agreeable (just acceptable) 7. Satisfactory 8. Good 9. Very good Possible trace knock heard.. - Ascribed to mechanical noise	
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		
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)	7		

Attachment 4 Vehicle Appraisal Results #1 PULPE5

Vehicle Appraisal Form (Fuel 2, driver A)

Vehicle name	GOV5-14 Toyota	Test date	29/08/2006
Mileage (km)	358265	Test time	10:15
Ambient temperature (deg C)	23.6	Test road	Balcatta area
Barometric pressure (kPa)	101.7	Engine	I6, Pushrod, Carburettor
Test driver	AKM	Fuel	PULPE5
Co-driver	DFN	Oil	SAE 10W40

1. Startability		Rating	Remarks
Cold start	Starting Time	7	Choke two clicks open
	Flare to idle	6	
	Restartability	7	
Warmed up start	Starting Time	7	OK with cracked open throttle
	Flare to idle	7	
	Restartability	7	
2. Idle Quality		Rating	Remarks
RPM stability	No load	6	
	part load	6	
	Full load	6	
Idle roughness	No load	6	
	part load	6	
	Full load	6	
3. Performance		Rating	Remarks
Launch feel	Part throttle	7	
	WOT	7	
Accel feel	Part throttle	7	
	WOT	7	
Passing feel	Part throttle	6	
	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	Subjective rating 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	
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 5 Vehicle Appraisal Results #2 PULPE5

Vehicle Appraisal Form (Fuel 2, driver B)

Vehicle name	GOV5-14 Toyota	Test date	30/08/2006
Mileage (km)	358280	Test time	10h00
Ambient temperature (deg C)	21	Test road	Balcatta area
Barometric pressure (kPa)	101.5	Engine	I6, Pushrod, Carburettor
Test driver	HS1	Fuel	PULPE5
Co-driver	DFN	Oil	SAE 10W40

1. Startability		Rating	Remarks	
Cold start	Starting Time	7	OK after throttle pump	
	Flare to idle	7		
	Restartability	7		
Warmed up start	Starting Time	7		Variable, depending on throttle
	Flare to idle	7		
	Restartability	6		
2. Idle Quality		Rating	Remarks	
RPM stability	No load	6		
	part load	6		
	Full load	6		
Idle roughness	No load	6		
	part load	6		
	Full load	6		
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	Subjective rating 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)	n/a		

CUSTOMER	Department of the Environment and Heritage	PROJECT	GOV5 - 26
TITLE	Hot Start and Driveability Evaluation Toyota Landcruiser – GOV5-14		

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/m².
- 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 (Δ)
Start Time - 10min Soak (seconds)		0.8	1.0	
Restart Time - 30min Soak (seconds)		0.8	0.7	
Restart Time - Ext. Idle/20min Soak (seconds)		0.8	1.1	
Hot Startability (10min. Soak)		7.0	6.0	-1.0
Hot Idle Quality (10min. Soak)		6.0	5.5	-0.5
Hot Restartability (30min. Soak)		7.0	7.0	0.0
Hot Idle Quality (30min. Soak)		6.0	5.9	-0.2
Hot Idle Quality (40min. Idle)		5.8	5.8	0.0
Hot Startability (Ext. Idle/20min. Soak)		6.8	6.3	-0.5
Hot Idle Quality (Ext. Idle/20min. Soak)		6.0	5.8	-0.3
Hot Acceleration - Idle Racing Mode		7.0	7.0	0.0
Restart and idle after drive rating		5.9	6.1	0.3
Hot Soak & Drive Idle Quality		6.1	5.8	-0.3
Part Throttle Acceleration		6.9	6.9	0.0
WOT acceleration		7.5	7.0	-0.5
50km/h Steady State		7.0	7.0	0.0
70km/h Steady State		7.0	6.8	-0.2
Average all.		6.6	6.3	-0.2
Minimum		5.8	5.5	-1.0
Maximum		7.5	7.0	0.3

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 gave a poorer start than PULP. This may be noticed by an average driver with introduction of E5.
 - b) Hot idle qualities and startability after extended idles/soaks are slightly reduced with E5 but this is unlikely to be noticed by an average driver.
- 2) With the exception of one start on E5 after 10 min soak; 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 except where mentioned previously.
- 4) With the exception of start and idle; an average driver is unlikely to notice any difference between petrol and E5.

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

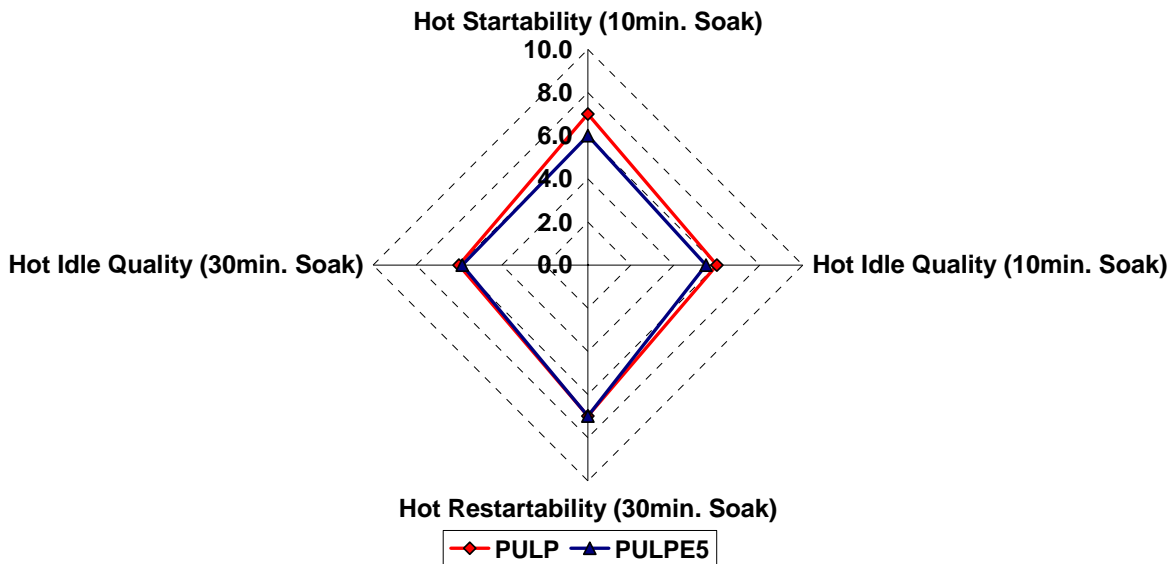


Figure 1 – Hot Start and Idle after Soak

Hot Extended Idle Test and 20min. Hot Soak

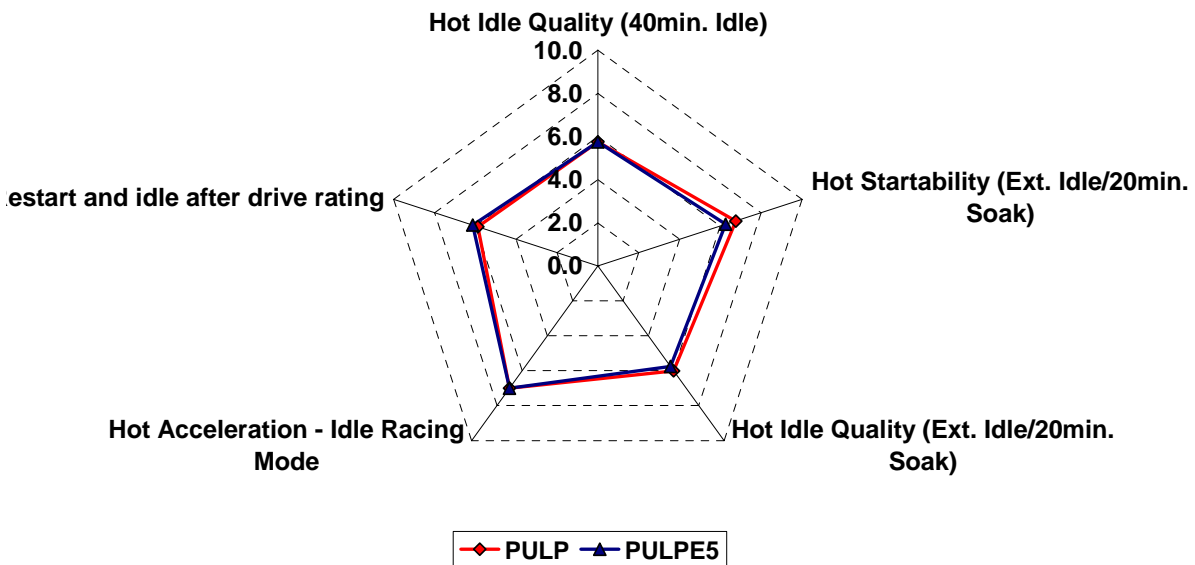


Figure 2 – Hot Start and Idle after extended idles and soaks

Hot Driveability Test

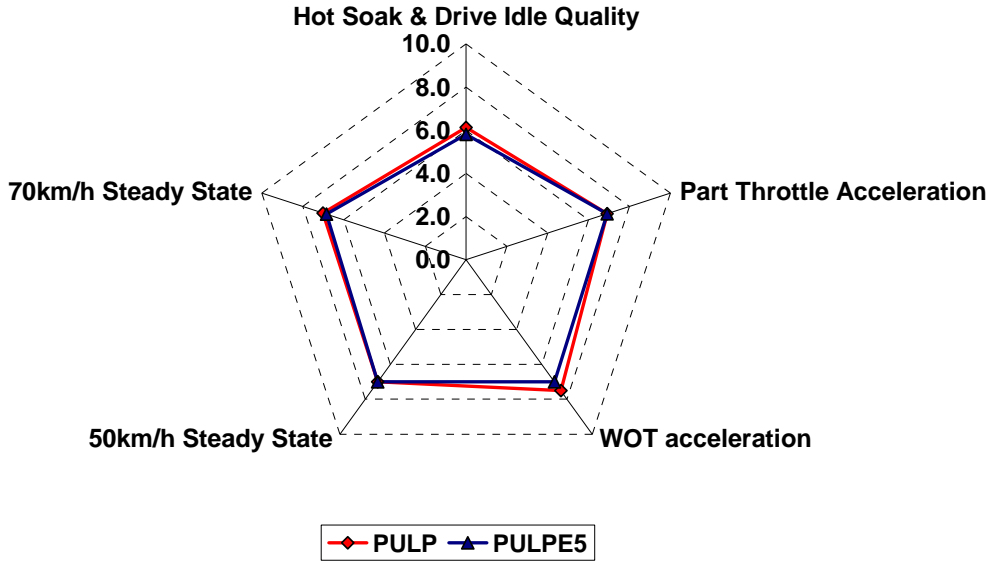


Figure 3 – Hot Driveability Comparison

Hot Start Times

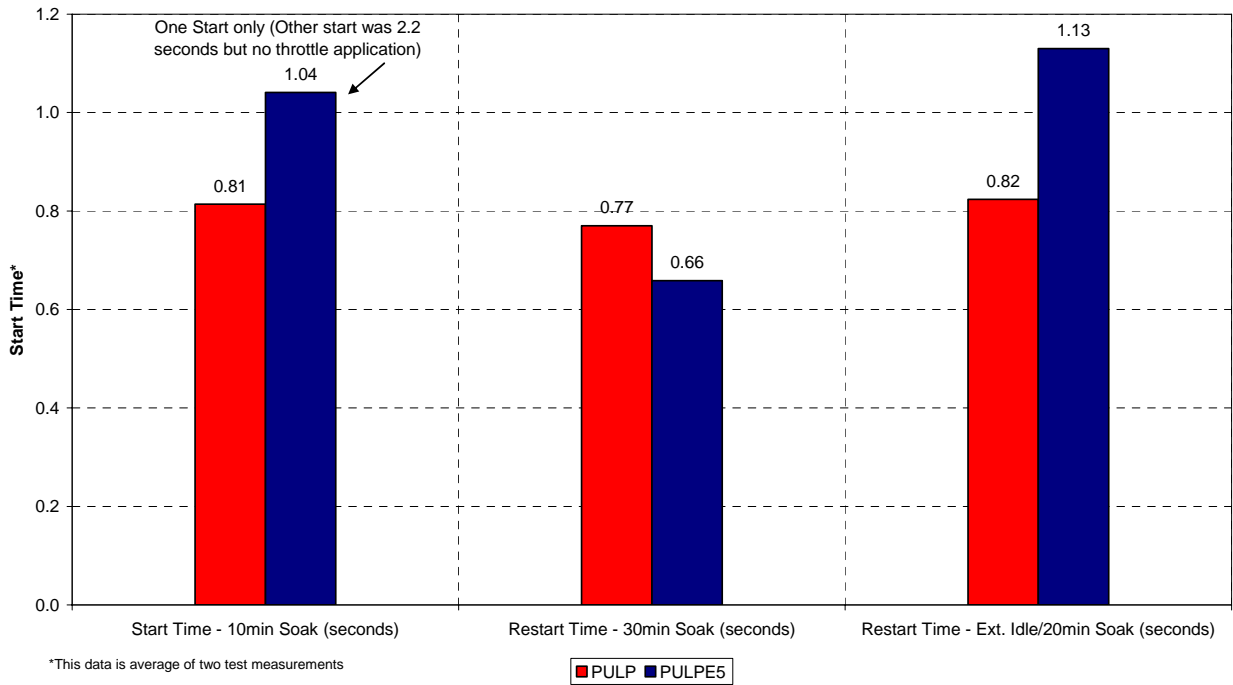


Figure 3 – Hot Start Times

Attachment 2 Hot start and driveability evaluation results #1 PULP

Hot Start and Driveability Evaluation, 1a

Vehicle Number	GOV5-14	Registration	DA 037
Vehicle name	Toyota Landcruiser	Test date	24/08/2006
Vehicle colour	Silver-green	Test time	12h30-15h30
Mileage (km)	358226		
Ambient temperature (deg C)	21.9	Engine	4L In line, 6cyl
Barometric pressure (kPa)	102	Fuel	PULP
Test driver	AKM/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/m²

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	79	82
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.865	0.8	
Evaluate startability	7		
Evaluate idle roughness for 10 sec.	6		
Ignition-off and soak 30 minutes			
Ignition-on	40	63	76
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.941	1	
Evaluate re-startability	7		
Evaluate idle roughness for 10 sec.	6		

Data file names: C:\logs\gov05veh_14_HTST1

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	6	44	95
Record data, 10 minute	6	44	93
Record data, 20 minute	6	43	92
Record data, 30 minute	6	42	92
Record data, 40 minute	5.5	45	91
Ignition-off and soak 20 minutes			
Ignition on	42	72	80
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.134	1	
Evaluate startability	6.5		
Evaluate idle roughness	6		

Data file names: C:\logs\gov05veh_14_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

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
1/2 throttle to 50km/hr	7
50km/hr cruise	7
Stop and idle 10 seconds	6
WOT to 70km/hr	8
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	7
70km/hr cruise	7
Stop and idle 10 seconds	6
Interrupted acceleration	7
1/2 throttle to 70km/hr	6
70km/hr cruise	7
Stop and idle 20 seconds	6
Steering lock to lock	6
Idle in P/N	6
Ignition off	6
Restart	5

Driveability Ratings:
 Idle during drive 6
 Start after various soak times 6.4
 Average accel rating 7
 Average Steady speed rating 7

Attachment 3 Hot start and driveability evaluation results #2 PULP

Hot Start and Driveability Evaluation, 1b

Vehicle Number	GOV5-14	Registration	DA 037
Vehicle name	Toyota Landcruiser	Test date	25/08/2006
Vehicle colour	Silver-green	Test time	09:30-11h30 drive
Mileage (km)	358242		
Ambient temperature (deg C)	18.3	Engine	4L In line, 6cyl
Barometric pressure (kPa)	101.9	Fuel	PULP
Test driver	DFN/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/m²

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	42	85	108
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.763	0.8	
Evaluate startability	7		
Evaluate idle roughness for 10 sec.	6		
Ignition-off and soak 30 minutes			
Ignition-on	40	68	78
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.599	0.8	
Evaluate re-startability	7		
Evaluate idle roughness for 10 sec.	6		

Data file names: C:\logs\gov05veh_14_HTST4
 C:\logs\gov05veh_14_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	6	40	94
Record data, 10 minute	6	40	88
Record data, 20 minute	6	39	85
Record data, 30 minute	6	38	82
Record data, 40 minute	6	38	81
Ignition-off and soak 20 minutes			
Ignition on	38	72	78
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.513	0.5	
Evaluate startability	7		
Evaluate idle roughness	6		

Data file names: C:\logs\gov05veh_14_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	6
1/2 throttle to 50km/hr	7
50km/hr cruise	7
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	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	6.5
Steering lock to lock	6
Idle in P/N	6.5
Ignition off	
Restart	5
long crank	

Driveability Ratings:

Idle during drive	6.3
Start after various soak times	6.5
Average accel rating	7
Average Steady speed rating	7

Attachment 4 Hot start and driveability evaluation results #1 E5

Hot Start and Driveability Evaluation, 2a

Vehicle Number	GOV5-14	Registration	DA 037
Vehicle name	Toyota Landcruiser	Test date	31/08/2006
Vehicle colour	Silver-green	Test time	13:15
Mileage (km)	358320		
Ambient temperature (deg C)	17.8	Engine	4L In line, 6cyl
Barometric pressure (kPa)	101.5	Fuel	PULPE5
Test driver	HS1	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/m²

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	79	80
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	2.208	2.0 Due no throttle application?	
Evaluate startability	6	Data file names: C:\logsgov05veh_ 14_HTST7	
Evaluate idle roughness for 10 sec.	5.5		
Ignition-off and soak 30 minutes			
Ignition-on	40	69	80
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.625	0.8. Slight throttle application.	
Evaluate re-startability	7		
Evaluate idle roughness for 10 sec.	6		
		Data file names: C:\logsgov05veh_ 14_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	6	42	90
Record data, 10 minute	6	40	87
Record data, 20 minute	5.8	39	84
Record data, 30 minute	5.8	39	81
Record data, 40 minute	5.8	39	80
Ignition-off and soak 20 minutes			
Ignition on	42	75	81
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.39	1.5	
Evaluate startability	5.5	Data file names: C:\logsgov05veh_ 14_HTST9	
Evaluate idle roughness	5.8		

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	Driveability Ratings:
Move the car to the test road with A/C on (Blower medium and external air mode)	
Idle 10 seconds	6
1/2 throttle to 50km/hr	7
50km/hr cruise	7
Stop and idle 10 seconds	5
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	7
70km/hr cruise	7
Stop and idle 10 seconds	6
Interrupted acceleration	7
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	6
Restart	5.5
Variable with throttle opening	Average accell rating 7
	Average Steady speed rating 7
	Idle during drive 5.9
	Start after various soak times 6

Attachment 5 Hot start and driveability evaluation results #2 E5

Hot Start and Driveability Evaluation, 2b

Vehicle Number	GOV5-14	Registration	DA 037
Vehicle name	Toyota Landcruiser	Test date	31/08/2006
Vehicle colour	Silver-green	Test time	08:45 drive.
Mileage (km)	358327		
Ambient temperature (deg C)	12.2	Engine	4L In line, 6cyl
Barometric pressure (kPa)	102.1	Fuel	PULPE5
Test driver	AKM/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/m²

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	42	80	97
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.041	1.8 with slight throttle opening	
Evaluate startability	6	Data file names: C:\logsgov05veh_ 14_HTST10	
Evaluate idle roughness for 10 sec.	5.5		
Ignition-off and soak 30 minutes			
Ignition-on	41	66	78
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.692	1	
Evaluate re-startability	7		
Evaluate idle roughness for 10 sec.	5.7		
		Data file names: C:\logsgov05veh_ 14_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	5.5	41	82
Record data, 10 minute	6	43	90
Record data, 20 minute	5.7	43	91
Record data, 30 minute	5.5	43	91
Record data, 40 minute	5.7	43	92
Ignition-off and soak 20 minutes			
Ignition on	41	81	86
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.87	1	
Evaluate startability	7	Data file names: C:\logsgov05veh_ 14_HTST12	
Evaluate idle roughness	5.7		

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	

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

Rating	
Idle 10 seconds	5.5
1/2 throttle to 50km/hr	6
50km/hr cruise	7
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	7
70km/hr cruise	7
Stop and idle 10 seconds	6
Interrupted acceleration	7
1/2 throttle to 70km/hr	7
70km/hr cruise	6
Stop and idle 20 seconds	5.5
Steering lock to lock	7
Idle in P/N	6
Ignition off	7
Restart	7

Driveability Ratings:
 Idle during drive 6
 Start after various soak times 6.8
 Average accell rating 6.8
 Average Steady speed rating 6.8

CUSTOMER	Department of the Environment and Heritage	PROJECT	GOV5 - 26
TITLE	Cold Start and Warm-up Evaluation Toyota Landcruiser – GOV5-14		

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 (Δ)
Start Time (seconds)		2.7	2.9	0.2
Restart Time (seconds)		1.4	1.7	0.3
Cold Startability		4.5	4.5	0.0
Cold Restartability		7.0	6.0	-1.0
Cold Idle Roughness/Stability No Load		6.5	6.0	-0.5
Cold Idle Roughness/Stability Electrical load		6.5	6.0	-0.5
Cold Idle Roughness/Stability Elec+P/S load		6.5	6.0	-0.5
Cold Acceleration Idle racing mode		5.5	4.8	-0.8
Warm-up idle Roughness/Stability		7.0	6.4	-0.6
Warmed up idle and restart		6.5	6.0	-0.5
Part Throttle Acceleration		5.4	6.5	1.1
Interrupted accel		7.0	7.0	0.0
WOT acceleration		6.5	7.0	0.5
50km/h steady state		7.0	7.0	0.0
60/70km/h steady state		7.0	7.0	0.0
Average		6.4	6.2	-0.2
Minimum		4.5	4.5	-1.0
Maximum		7.0	7.0	1.1

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. Although restart and idle appeared to be worse with E5 than PULP, E5 caused improvement to part throttle acceleration. In detail:
 - a. Part throttle driveability was poor with PULP, especially at lighter loads and the coldest temperatures. E5 gave a significant improvement. This may in part be due to the drivers becoming more used to the vehicles choke requirements (this vehicle had a manual choke, PULP was tested first), but an improvement may still be noticed by an average driver.
 - b. The difference in restart between the fuels was not repeated, and unlikely to be noticed by an average driver.
 - c. Reduction in idle quality and idle racing performance with E5 fuel is unlikely to be noticed by an average driver.
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 reasonable agreement except where mentioned previously.

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

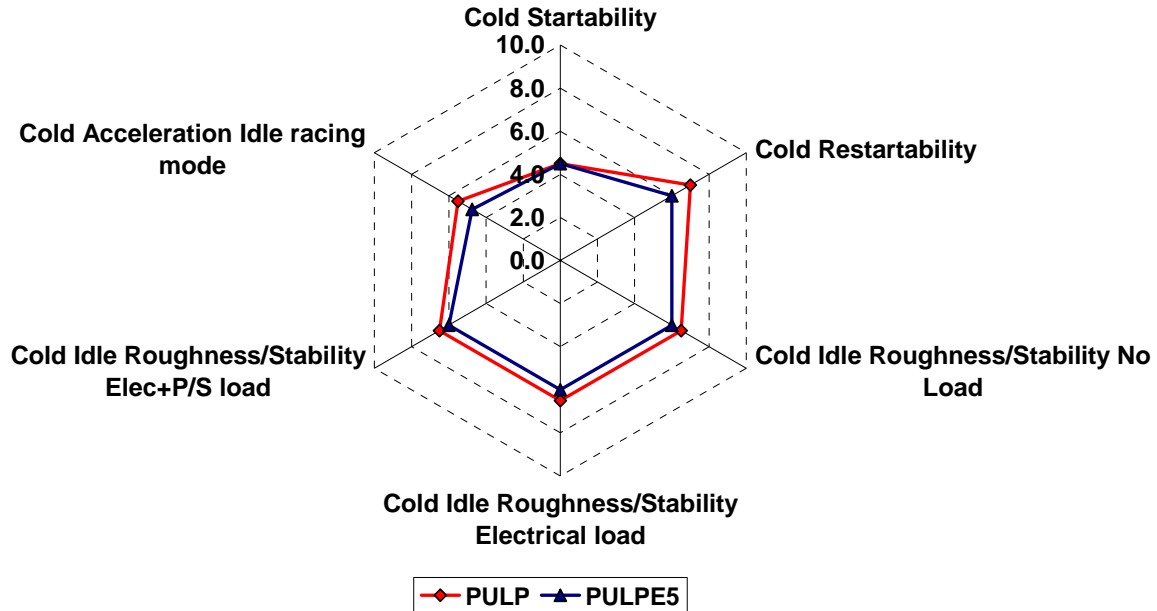


Figure 1 – Cold Start and Idle Quality

Warm-up Driveability after Cold Start

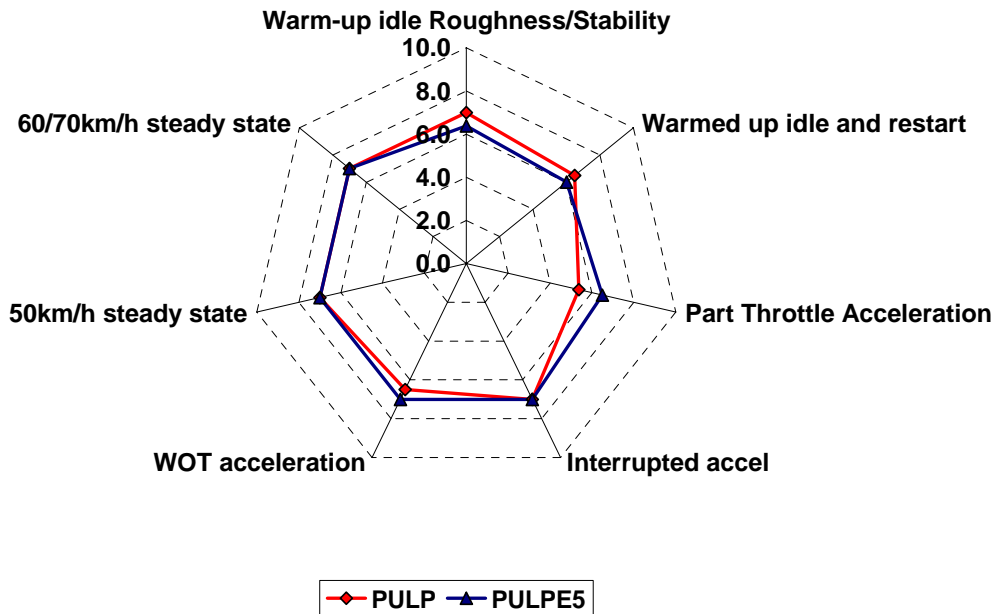
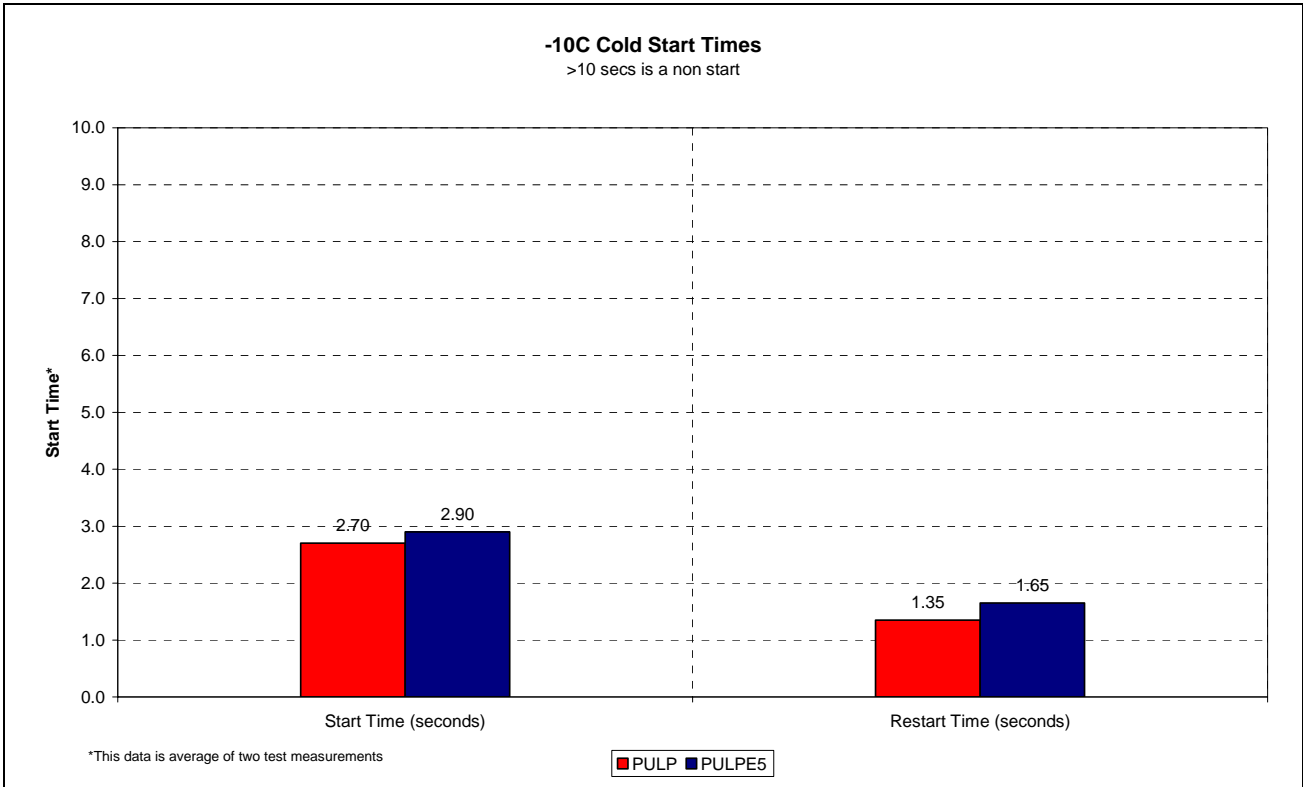


Figure 2 – Driveability during Warm-up



Attachment 2

Cold start and warm up evaluation results #1 PULP

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

Vehicle Number	GOV5-14	Registration	DA 037
Vehicle name	Toyota Landcruiser	Test date	28/08/2006
Vehicle colour	Silver-green	Test time	09h00
Mileage (km)	358251		
Ambient temperature (deg C)	19.2	Engine	4L, In line, 6cyl
Barometric pressure (kPa)	102.3	Fuel	PULP
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)
		-11	-10	-10.5

Ignition on
 Crank after fuel pump relay is off. No start if crank time is > 10 seconds
 Crank time With choke, 3 clicks
 Evaluate startability Long crank.
 Ignition -off within 5 seconds (Stall after start. Rated 5 without stall.)
 Ignition-on
 Crank after fuel pump relay is off. No start if crank time is > 10 seconds
 Crank time
 Evaluate re-startability

Data file: C:\logs\gov05\04_CST1a

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

Evaluate idle roughness (10 seconds)
 Shift to D/R or clutch engaged
 Evaluate idle roughness (10 seconds)
 Turn on the headlights, blower (max position) and defroster
 Evaluate idle roughness (10 seconds)
 Turn power steering to the right end
 Evaluate idle roughness (10 seconds)
 Turn power steering to the left end
 Evaluate idle roughness (10 seconds)
 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
 Black smoke present? 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
 1/2 throttle to 50km/hr hesitation, sag

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	<input style="width: 50px;" type="text" value="7"/>
Stop and idle 10 seconds	<input style="width: 50px;" type="text" value="7"/>
WOT to 70km/hr	<input style="width: 50px;" type="text" value="7"/>
70km/hr cruise	<input style="width: 50px;" type="text" value="7"/>
Stop and idle 10 seconds	<input style="width: 50px;" type="text" value="7"/>
1/4 throttle to 50km/hr	<input style="width: 50px;" type="text" value="7"/>
50km/hr cruise	<input style="width: 50px;" type="text" value="7"/>
3/4 throttle to 70km/hr	<input style="width: 50px;" type="text" value="7"/>
70km/hr cruise	<input style="width: 50px;" type="text" value="7"/>
Stop and idle 10 seconds	<input style="width: 50px;" type="text" value="7"/>
Interrupted acceleration	<input style="width: 50px;" type="text" value="7"/>
1/2 throttle to 70km/hr	<input style="width: 50px;" type="text" value="7"/>
70km/hr cruise	<input style="width: 50px;" type="text" value="7"/>
Stop and idle 20 seconds	<input style="width: 50px;" type="text" value="7"/>
Steering lock to lock	<input style="width: 50px;" type="text" value="7"/>
Idle in P/N	<input style="width: 50px;" type="text" value="7"/>
Ignition off	<input style="width: 50px;" type="text" value="7"/>
Restart	<input style="width: 50px;" type="text" value="7"/>

OK with choke, two clicks
 Variable according to technique.

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

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

Vehicle Number	GOV5-14	Registration	DA 037
Vehicle name	Toyota Landcruiser	Test date	28/08/2006
Vehicle colour	Silver-green	Test time	15h00
Mileage (km)	358258		
Ambient temperature (deg C)	23.4	Engine	4L, In line, 6cyl
Barometric pressure (kPa)	101.9	Fuel	PULP
Test driver	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	-11	-11

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

Crank time

Evaluate startability

Ignition -off within 5 seconds
Ignition-on

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

Crank time

Evaluate re-startability

Data file: C:..logs\gov05\04_CST1b

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

Evaluate idle roughness (10 seconds)

Shift to D/R or clutch engaged

Evaluate idle roughness (10 seconds)

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

Evaluate idle roughness (10 seconds)

Turn power steering to the right end

Evaluate idle roughness (10 seconds)

Turn power steering to the left end

Evaluate idle roughness (10 seconds)

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

Black smoke present?

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

1/2 throttle to 50km/hr

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

Stop and idle 10 seconds

WOT to 70km/hr

70km/hr cruise

Stop and idle 10 seconds

1/4 throttle to 50km/hr

50km/hr cruise

3/4 throttle to 70km/hr

70km/hr cruise

Stop and idle 10 seconds

Interrupted acceleration

1/2 throttle to 70km/hr

70km/hr cruise

Stop and idle 20 seconds

Steering lock to lock

Idle in P/N

Ignition off

Restart

long crank. Variable with throttle position

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

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

Vehicle Number	GOV5-14	Registration	DA 037
Vehicle name	Toyota Landcruiser	Test date	6/09/2006
Vehicle colour	Silver-green	Test time	07h40
Mileage (km)	358385		
Ambient temperature (deg C)	9.8	Engine	4L, In line, 6cyl
Barometric pressure (kPa)	103.1	Fuel	PULPE5
Test driver	AKM	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)
-10	-10	-10.2

Ignition on

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

Crank time

2

Evaluate startability

6

Ignition -off within 5 seconds

Ignition-on

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

Crank time

1.3

Evaluate re-startability

7

Data file: C:..logs\gov05\veh_ 14_CST2a

2. Cold idle

Cold idle quality rating

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

Evaluate idle roughness (10 seconds)

6

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

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

7

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

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

7

3/4 throttle to 70km/hr

6

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

6

Steering lock to lock

5

Idle in P/N

6

Ignition off

Restart

7

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

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

Vehicle Number	GOV5-14	Registration	DA 037
Vehicle name	Toyota Landcruiser	Test date	06.09.06
Vehicle colour	Silver-green	Test time	15h10
Mileage (km)	358395		
Ambient temperature (deg C)	18.1	Engine	4L, In line, 6cyl
Barometric pressure (kPa)	102.6	Fuel	PULPE5
Test driver	HS1	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)
-10.5	-10	-11

Ignition on

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

Crank time

3.8

with jump start, possible flooding

Evaluate startability

3

3 clicks on choke, cracked throttle.

Ignition -off within 5 seconds

Ignition-on

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

Crank time

2

Evaluate re-startability

5

Data file: C:..logsgov05\veh_ 14_CST2b

2. Cold idle

Cold idle quality rating

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

Evaluate idle roughness (10 seconds)

6

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

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

Black smoke present?

1

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

6

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

7

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

6

50km/hr cruise

7

3/4 throttle to 70km/hr

6

70km/hr cruise

7

Stop and idle 10 seconds

6

Interrupted acceleration

7

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

two clicks on choke.

CUSTOMER	Department of the Environment and Heritage	PROJECT	GOV005
TITLE	WOT Performance Test Toyota Landcruiser – GOV5-14		

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 (± 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.

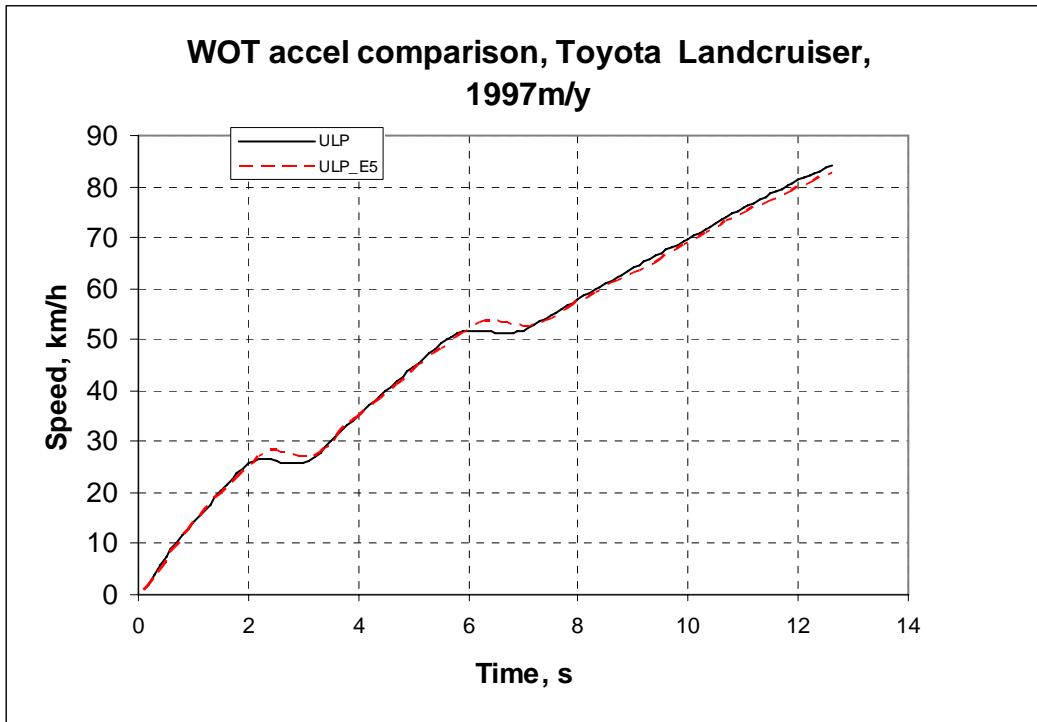


Figure 1 – Standing Start WOT Acceleration Comparison Between Petrol and E5

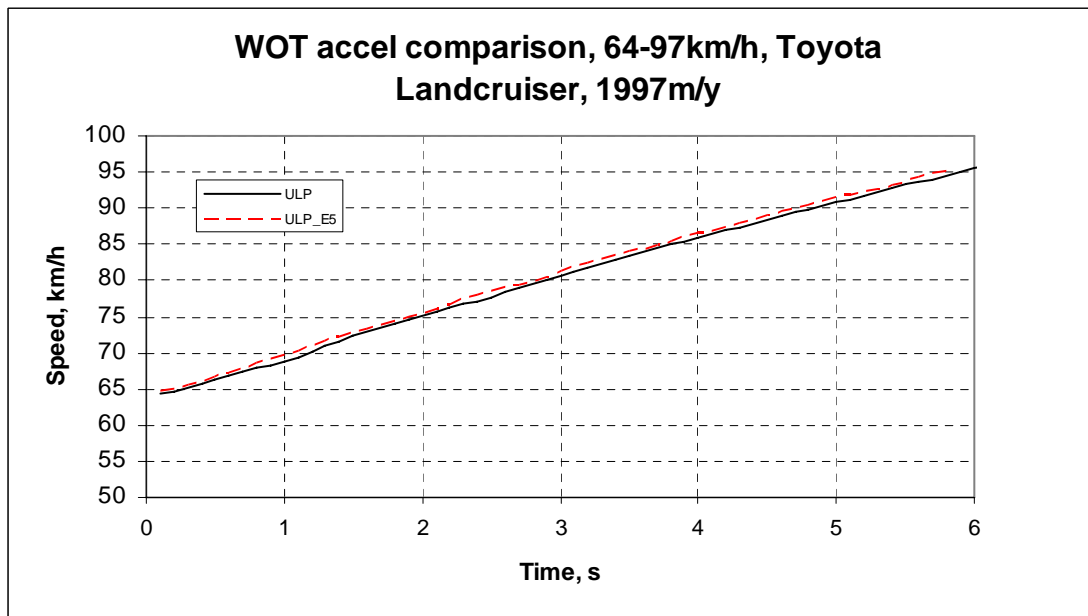


Figure 2 – 64 to 97 km/h WOT Acceleration Comparison Between Petrol and E5

Results:	ULP	ULP E5	% Improvement over Petrol. E5
0-48km/h elapsed time,s	5.30	5.40	-2%
0-80km/h elapsed time,s	11.70	12.07	-3%
0-97km/h elapsed time,s	16.60	16.97	-2%
64-97km/h elapsed time,s	6.37	6.10	4%
0-5s distance covered, m	34.91	34.7	-1%
0-5s terminal speed, km/h	44.74	44.1	-2%
0-400m elapsed time	21.10	21.2	0%
0-400m terminal speed, km/h	110.82	110.2	-1%
Uego Average	0.89	0.91	2%
Exhaust temp max.	732	761.2	4%

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

Table 1 – Averaged WOT Acceleration Performance Test Data

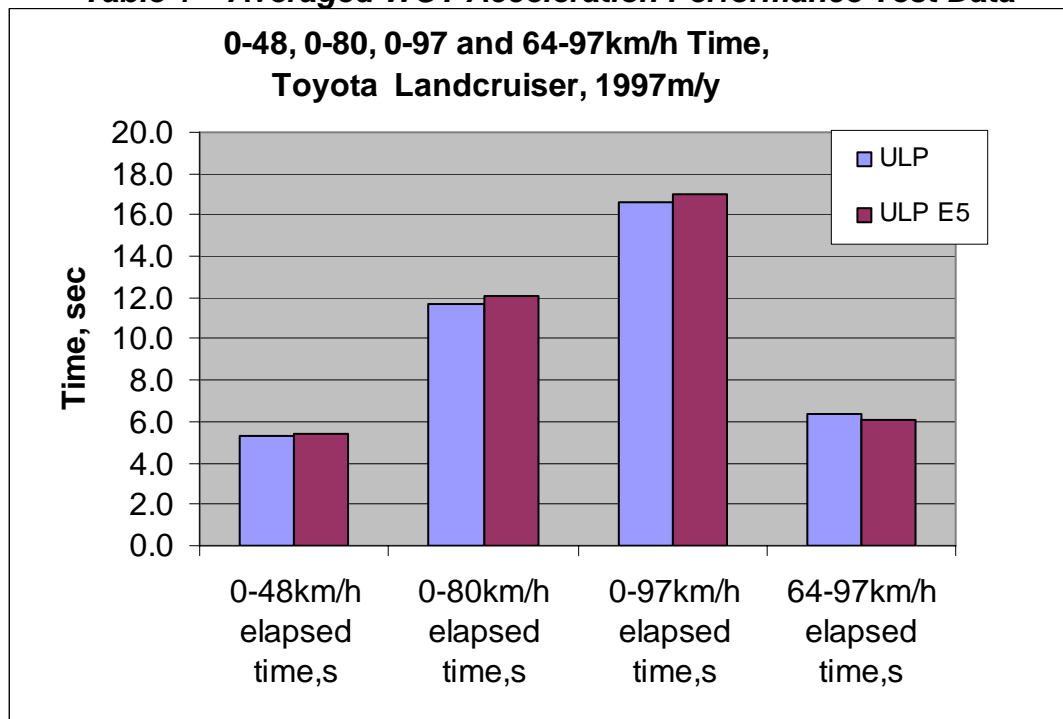


Figure 3 – Elapsed Times for WOT Accelerations

Overall the WOT acceleration test data indicates a small worsening in the acceleration times for E5 over Petrol. For standing start accelerations E5 showed a 2~3% increase in the times to reach all three terminal speeds. Conversely, for accelerations from 64~97km/h km/h acceleration times improved by 4% for E5 over Petrol.

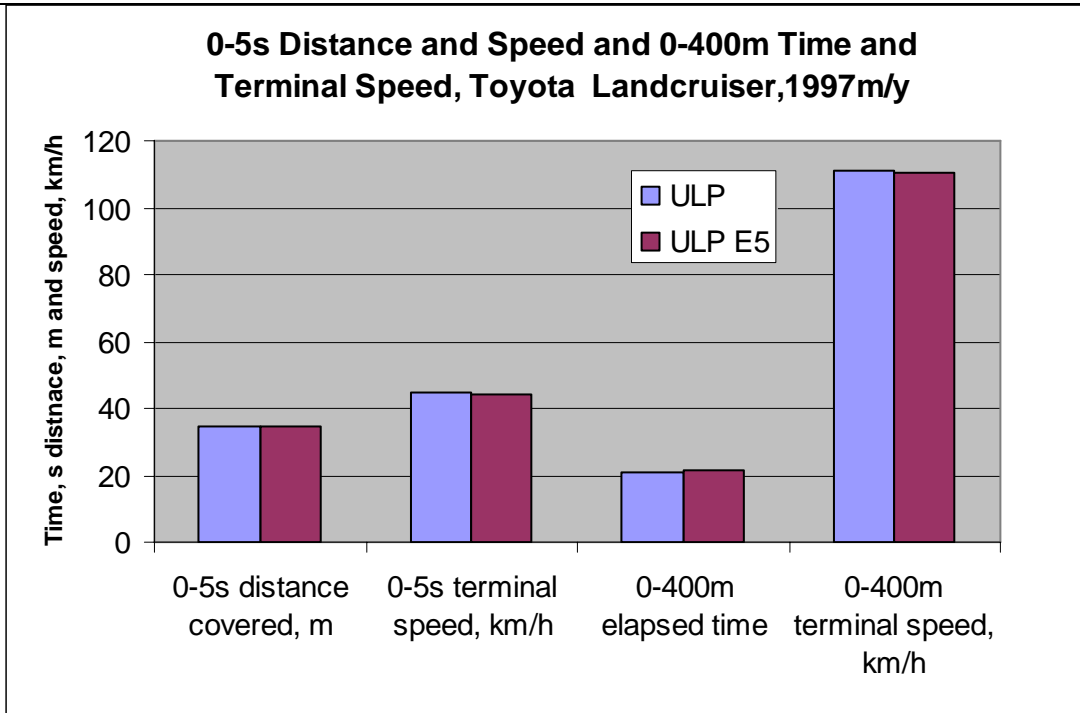


Figure 4 – 0 to 5s and 0 to 402m WOT Acceleration Performance Comparison

The 0~400m elapsed times were similar for Petrol and E5, but the terminal speed was reduced by 1% for E5. Launch, as measured by the 0~5s distance was poorer for the E5 fuel by 1% compared to Petrol. The terminal speed after 5s was 2% worse for E5 than Petrol.

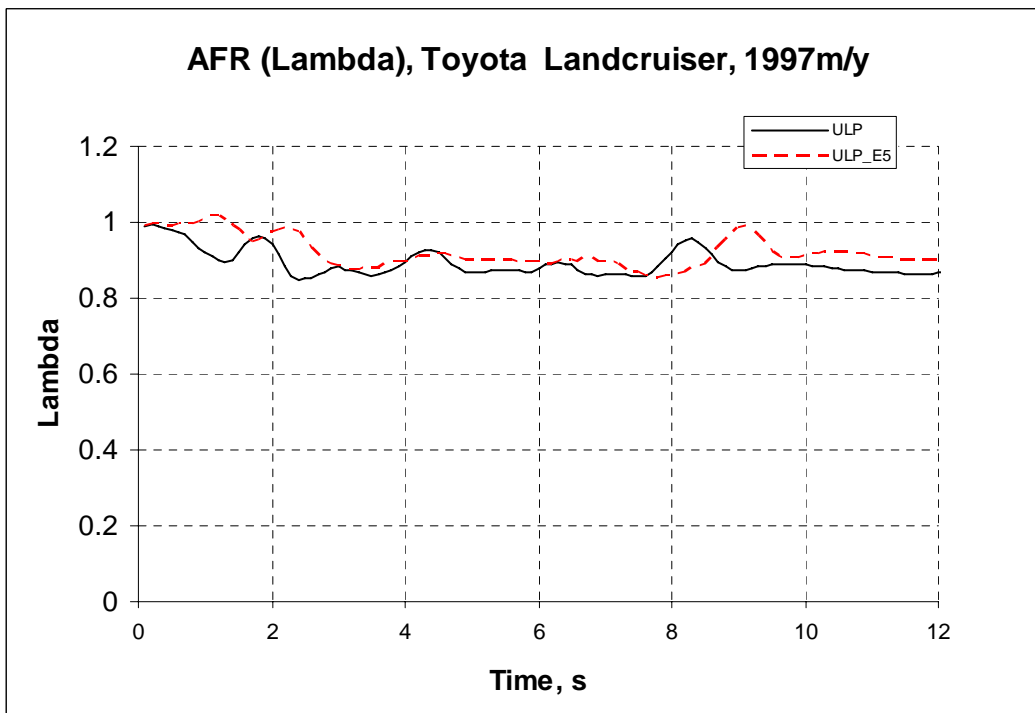


Figure 5 – Standing Start WOT Acceleration AFR Comparison

Figure 5 shows the Air Fuel Ratio (Lambda value) during the acceleration runs to 97km/h. On average, the engine was running 2% leaner for E5 compared to Petrol. This is consistent with a vehicle which does not apply learning to the AFR, and is close to the expected enleanment for E5 fuel.

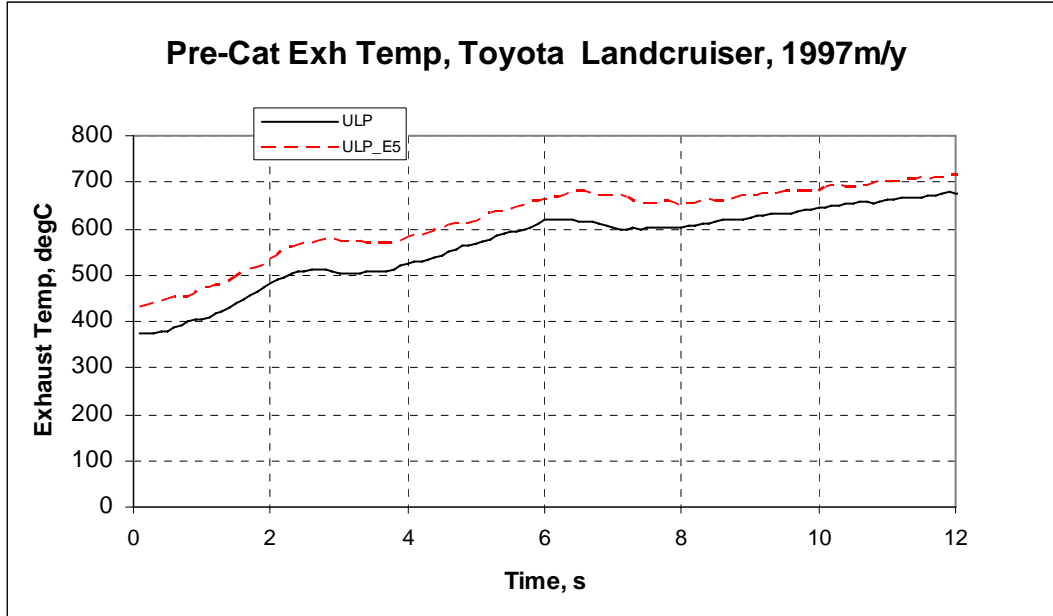


Figure 6 – Standing Start WOT Acceleration Exhaust Temperatures

The peak pre-catalyst exhaust gas temperature recorded at the end of each run was 4% higher (29degC) 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).

CONCLUSIONS/DISCUSSION

The WOT acceleration results on the Toyota Landcruiser 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, but the increase in exhaust temperature was higher than expected. However, the actual exhaust temperatures measured were low and the effect 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>		<u>Model</u> <u>Landcruiser</u>	<u>Year</u> <u>1997</u>	<u>Test Date</u> <u>8/09/2006</u>	
Odometer <u>358444</u> km				<u>Car No</u> <u>14</u>	
<u>Test Location</u> <u>MACD no 1</u>		<u>Driver</u> <u>R Brooks</u>			
<u>Start of test date</u> <u>8/09/2006</u>		<u>Time strt</u> <u>11:30</u>			
<u>End of test date</u> <u>8/09/2006</u>		<u>Time end</u> <u>13:30</u>			
<u>Transmission, type</u> <u>5m/t</u>		<u>Automatic shift mode</u> <u>N/a</u>			
<u>Fuel Type</u> <u>PULP</u>					
<u>Remarks</u> <u>repeat of test 1.</u>					
<u>Ambient conditions for test:</u>					
<u>Temperature</u>	<u>16</u> °C	<u>Barometric Pressure</u>	<u>101.98</u> kPa	<u>Relative Humidity</u>	
<u>Wind Velocity</u>	<u>roller speed</u> km/h	<u>Direction</u>	<u>Head-on</u>	<u>66</u>	
				<u>Peak wind velocity</u>	
				<u>n/a</u>	
<u>Results:</u>	<u>Test1</u>	<u>Test2</u>	<u>Test3</u>	<u>Average</u>	<u>Variability</u> (Max-mean)/mean
0-48km/h elapsed time,s	<u>5.5</u>	<u>5.2</u>	<u>5.2</u>	<u>5.30</u>	<u>3.77</u> %
0-80km/h elapsed time,s	<u>11.9</u>	<u>11.6</u>	<u>11.6</u>	<u>11.70</u>	<u>1.71</u> %
0-97km/h elapsed time,s	<u>16.9</u>	<u>16.5</u>	<u>16.4</u>	<u>16.60</u>	<u>1.81</u> %
64-97km/h elapsed time,s	<u>6.6</u>	<u>6.2</u>	<u>6.3</u>	<u>6.37</u>	<u>3.66</u> %
0-5s distance covered, m	<u>33.4</u>	<u>35.8</u>	<u>35.6</u>	<u>34.9</u>	<u>2.62</u> %
0-5s terminal speed, km/h	<u>42.6</u>	<u>46.1</u>	<u>45.5</u>	<u>44.7</u>	<u>3.09</u> %
0-400m elapsed time	<u>21.3</u>	<u>21</u>	<u>21</u>	<u>21.1</u>	<u>0.95</u> %
0-400m terminal speed, km/h	<u>110.6</u>	<u>110.8</u>	<u>111.1</u>	<u>110.8</u>	<u>0.26</u> %
Uego Average	<u>0.89</u>	<u>0.89</u>	<u>0.89</u>	<u>0.89</u>	<u>0.11</u> %
Exhaust temp max.	<u>698.2</u>	<u>750.2</u>	<u>732.8</u>	<u>712.4</u>	<u>5.30</u> %
<u>File reference:</u> P:\Projects\Government\GOV005\Test Data\GOV5-14 - Toyota Landcruiser\WOT_MACD-Testing\[VEH14_WOT1a_M1.xls]Report					

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

<u>Vehicle:</u> Make <u>Toyota</u>		<u>Model</u> <u>Landcruiser</u>	<u>Year</u> <u>1997</u>	<u>Test Date</u> <u>7/09/2006</u>	
Odometer <u>358400</u> km				<u>Car No</u> <u>14</u>	
<u>Test Location</u> <u>MACD no 1</u>		<u>Driver</u> <u>R Brooks</u>			
<u>Start of test date</u> <u>7/09/2006</u>		<u>Time strt</u> <u>11:00</u>			
<u>End of test date</u> <u>7/09/2006</u>		<u>Time end</u> <u>13:00</u>			
<u>Transmission, type</u> <u>5m/t</u>		<u>Automatic shift mode</u> <u>N/a</u>			
<u>Fuel Type</u> <u>ULP E5</u>					
<u>Remarks</u> <u>UEGO data from Test 2</u>					
<u>Ambient conditions for test:</u>					
<u>Temperature</u>	<u>16</u> °C	<u>Barometric Pressure</u>	<u>102.5</u> kPa	<u>Relative Humidity</u> <u>55</u>	
<u>Wind Velocity</u>	<u>roller speed</u> km/h	<u>Direction</u>	<u>Head-on</u>	<u>Peak wind velocity</u> <u>n/a</u>	
<u>Results:</u>	<u>Test1</u>	<u>Test2</u>	<u>Test3</u>	<u>Average</u>	<u>Variability (Max-mean)/mean</u>
0-48km/h elapsed time,s	<u>5.5</u>	<u>5.2</u>	<u>5.5</u>	<u>5.40</u>	<u>1.85</u> %
0-80km/h elapsed time,s	<u>12.3</u>	<u>11.7</u>	<u>12.2</u>	<u>12.07</u>	<u>1.93</u> %
0-97km/h elapsed time,s	<u>16.9</u>	<u>16.9</u>	<u>17.1</u>	<u>16.97</u>	<u>0.79</u> %
64-97km/h elapsed time,s	<u>6.2</u>	<u>6.1</u>	<u>6</u>	<u>6.10</u>	<u>1.64</u> %
0-5s distance covered, m	<u>34.3</u>	<u>35.7</u>	<u>33.9</u>	<u>34.7</u>	<u>3.04</u> %
0-5s terminal speed, km/h	<u>43.9</u>	<u>44.7</u>	<u>43.5</u>	<u>44.1</u>	<u>1.55</u> %
0-400m elapsed time	<u>21.3</u>	<u>21</u>	<u>21.3</u>	<u>21.2</u>	<u>0.47</u> %
0-400m terminal speed, km/h	<u>110.8</u>	<u>110.3</u>	<u>109.4</u>	<u>110.2</u>	<u>0.55</u> %
Uego Average	<u>0.90</u>	<u>0.91</u>	<u>0.91</u>	<u>0.91</u>	<u>0.60</u> %
Exhaust temp max.	<u>752.8</u>	<u>761.2</u>	<u>768.0</u>	<u>754.3</u>	<u>1.82</u> %
<u>File reference:</u> P:\Projects\Government\GOV005\Test Data\GOV5-14 - Toyota Landcruiser\WOT_MACD-Testing\[VEH14_WOT2a_M1.xls]Report					

Attachment 3

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

<u>Vehicle:</u> Make <u>Toyota</u> Model <u>Landcruiser</u> Year <u>1997</u>		Base fuel test date <u>8/09/2006</u>	
Odometer <u>115972</u> km		Car No <u>14</u>	
End Ods <u>190713</u> km			
<u>Test Location</u> <u>MACD no 1</u>	Driver <u>R Brooks</u>		
Start of test date <u>7/09/2006</u>	Time strt <u>various</u>		
End of test date <u>8/09/2006</u>	Time end <u>various</u>		
Transmission, type <u>5m/t</u>	Automatic shift mode <u>N/a</u>		
<u>Fuel Type</u> (base) <u>ULP</u>			
<u>Remarks</u>			
<u>Ambient conditions for test:</u>			
Temperature <u>16-16</u> °C	Barometric Pressure <u>101.9-102.5</u>	Relative Humidity <u>55-66</u> %	
Wind Velocity <u>roller speed</u> km/h	Direction <u>Head-on</u>	Peak wind velocity <u>Road speed</u>	
<u>Results:</u>	<u>ULP</u>	<u>ULP E5</u>	
		<u>% Improvement over Petrol. E5</u>	
0-48km/h elapsed time,s	<u>5.30</u>	<u>5.40</u>	<u>-2%</u>
0-80km/h elapsed time,s	<u>11.70</u>	<u>12.07</u>	<u>-3%</u>
0-97km/h elapsed time,s	<u>16.60</u>	<u>16.97</u>	<u>-2%</u>
64-97km/h elapsed time,s	<u>6.37</u>	<u>6.10</u>	<u>4%</u>
0-5s distance covered, m	<u>34.91</u>	<u>34.7</u>	<u>-1%</u>
0-5s terminal speed, km/h	<u>44.74</u>	<u>44.1</u>	<u>-2%</u>
0-400m elapsed time	<u>21.10</u>	<u>21.2</u>	<u>0%</u>
0-400m terminal speed, km/h	<u>110.82</u>	<u>110.2</u>	<u>-1%</u>
Uego Average	<u>0.89</u>	<u>0.91</u>	<u>2%</u>
Exhaust temp max.	<u>732</u>	<u>761.2</u>	<u>4%</u>
File reference: P:\Projects\Government\GOV005\Test Data\GOV5-14 - Toyota Landcruiser\WOT_MACD-Testing\VEH14_WOT_comp.xls\Report			

CUSTOMER	Department of Environment and Heritage	PROJECT	GOV005
TITLE	2000hr Materials Compatibility Testing of Fuel System Components for a "Pre 1986" Toyota Landcruiser GOV5-14		

AIM

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

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 MY1985 Toyota Landcruiser 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 GOV5-14 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:

- Hoses (part # 1, 2)
- Carburettor float (part # 3b)
- Carburettor gasket (part # 4a)
- Fuel filter (part # 5)
- Fuel pump diaphragm (part # 6b)

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 # 4a)
- Fuel filter (part # 5)
- Fuel pump diaphragm (part # 6b)
- Fuel pump housing (part # 6c)

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:

- Hoses (part # 1, 2)

For these 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:

- Hose (part # 2)
- Carburettor gasket (part # 4a)

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.

Also noted was the increased weight of:

- Carburettor float (part # 3b)
- Fuel filter (part # 5)

The increased weight of these parts showing retention of mass despite the drying process.

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 swelling of:

- Hose (part # 1)
- Carburettor gasket (part # 4a)
- Fuel filter (part # 5)

These parts showed ongoing swelling in section when dried after exposure to E5 than after exposure to S.PULP.

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

- Tarnishing of brass float valve seat (part # 4c), see Figure 7

General Observations

- Discoloured filter housing (part # 6), see Figure 9
- Sticky fuel pump diaphragm (part # 6b)
- Discoloured fuel pump inner housing (part # 6c) see Figure 10

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
- Retained weight increase by some elastomers when dried after exposure to ethanol blend.
- Increased hardness of some elastomer components when dried after exposure to ethanol blends
- Corrosion of some metal components when exposed to ethanol blends
- Discolouration of some plastics when exposed to ethanol blend.

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 may cause 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. The weight increase of the carburettor float will reduce it's buoyancy which may lead to flooding of the carburettor.

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		
GOV5-14 Toyota Landcruiser		
Part	Description	Material
1	Hose, tank supply	rubber
2	Hose - fuel return	rubber
3a	Throttle - carburettor	brass/steel
3b	Float - carburettor GOV5-19 # 4	plastic
4a	Gasket - carburettor bowl cover	composite
4b	Plunger -carburettor	various
4c	Seat - float valve	brass
4d	Needle - float valve	brass/steel
4e	Washer - sealing	copper
4f	Washer - sealing	aluminium
5	Fuel filter housing	plastic
6a	Housing - fuel pump	steel
6b	Diaphragm - fuel pump	rubber
6c	Inner housing - fuel pump	plastic

Table 2 – Measurements at beginning of test

Pre 86 Vehicle			Pre Test measurements					
GOV5-14 Toyota Landcruiser			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	6.244	53.72	60	6.439	55.2	66
2	Hose - fuel return	rubber	7.108	48.78	70	7.604	52.06	70
3a	Throttle - carburettor	brass/steel	275.55			353.62		
3b	Float - carburettor GOV5-19 # 4	plastic	7.868	51.35		7.907	51.32	
4a	Gasket - carburettor bowl cover	composite	1.07	0.77		0.875	0.74	
4b	Plunger -carburettor	various	18.421	6.01		18.57	6.02	
4c	Seat - float valve	brass	12.022	24.82		12	6.12	
4d	Needle - float valve	brass/steel	1.019	16.5		1.022	16.5	
4e	Washer - sealing	copper	0.165	0.59		0.164	0.6	
4f	Washer - sealing	aluminium	0.059	0.78		0.06	0.8	
5	Fuel filter housing	plastic	50.138	7.98		49.44	8.04	
6a	Housing - fuel pump	steel	14.247			13.247		
6b	Diaphragm - fuel pump	rubber	4.698	1.6	80	4.641	1.6	80
6c	Inner housing - fuel pump	plastic	8.15	1.7		10.54	1.7	

Table 3 – Measurements at completion of test, wet.

Part	Description	Material	2000 hr measurements (wet)					
			S.PULP			S.PULP.E5		
			Weight (g)	Thickness/Dia (mm)	Hardness (Shore)	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)
1	Hose, tank supply	rubber	6.828	53.5	60	7.886	58.5	48
2	Hose - fuel return	rubber	8.508	48.8	56	9.503	53	47
3a	Throttle - carburettor	brass/steel	275.85			353.84		
3b	Float - carburettor GOV5-19 # 4	plastic	7.866	51.43		8.258	51.52	
4a	Gasket - carburettor bowl cover	composite	1.811	0.84		1.643	0.95	
4b	Plunger -carburettor	various	18.587	6.01		18.795	6.02	
4c	Seat - float valve	brass	12.057	24.85		12.021	6.12	
4d	Needle - float valve	brass/steel	1.036	16.8		1.054	16.9	
4e	Washer - sealing	copper	0.165	0.59		0.161	0.6	
4f	Washer - sealing	aluminium	0.058	0.77		0.062	0.79	
5	Fuel filter housing	plastic	58.204	7.98		62.71	8.28	
6a	Housing - fuel pump	steel	14.313			13.267		
6b	Diaphragm - fuel pump	rubber	5.053	1.77	80	5.324	1.93	
6c	Inner housing - fuel pump	plastic	8.061	1.7		10.909	1.77	

Table 4 – Measurements at completion of test, dry.

Part	Description	Material	Post test measurements (dry)					
			S.PULP			S.PULP.E5		
			Weight (g)	Thickness/Dia (mm)	Hardness (Shore)	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)
1	Hose, tank supply	rubber	5.585	52.65	70	5.742	54.6	70
2	Hose - fuel return	rubber	6.129	47.3	86	6.388	49.8	93
3a	Throttle - carburettor	brass/steel	275.47			353.49		
3b	Float - carburettor GOV5-19 # 4	plastic	7.814	51.43		8.062	51.55	
4a	Gasket - carburettor bowl cover	composite	1.007	0.81		0.791	0.87	
4b	Plunger -carburettor	various	18.405	6.01		18.563	6.02	
4c	Seat - float valve	brass	12.019	24.85		11.996	6.12	
4d	Needle - float valve	brass/steel	1.018	16.75		1.021	16.8	
4e	Washer - sealing	copper	0.163	0.59		0.162	0.6	
4f	Washer - sealing	aluminium	0.061	0.77		0.061	0.79	
5	Fuel filter housing	plastic	50.141	7.98		51.615	8.12	
6a	Housing - fuel pump	steel	14.241			13.238		
6b	Diaphragm - fuel pump	rubber	3.855	1.53	85	3.787	1.53	83
6c	Inner housing - fuel pump	plastic	7.956	1.7		10.638	1.74	

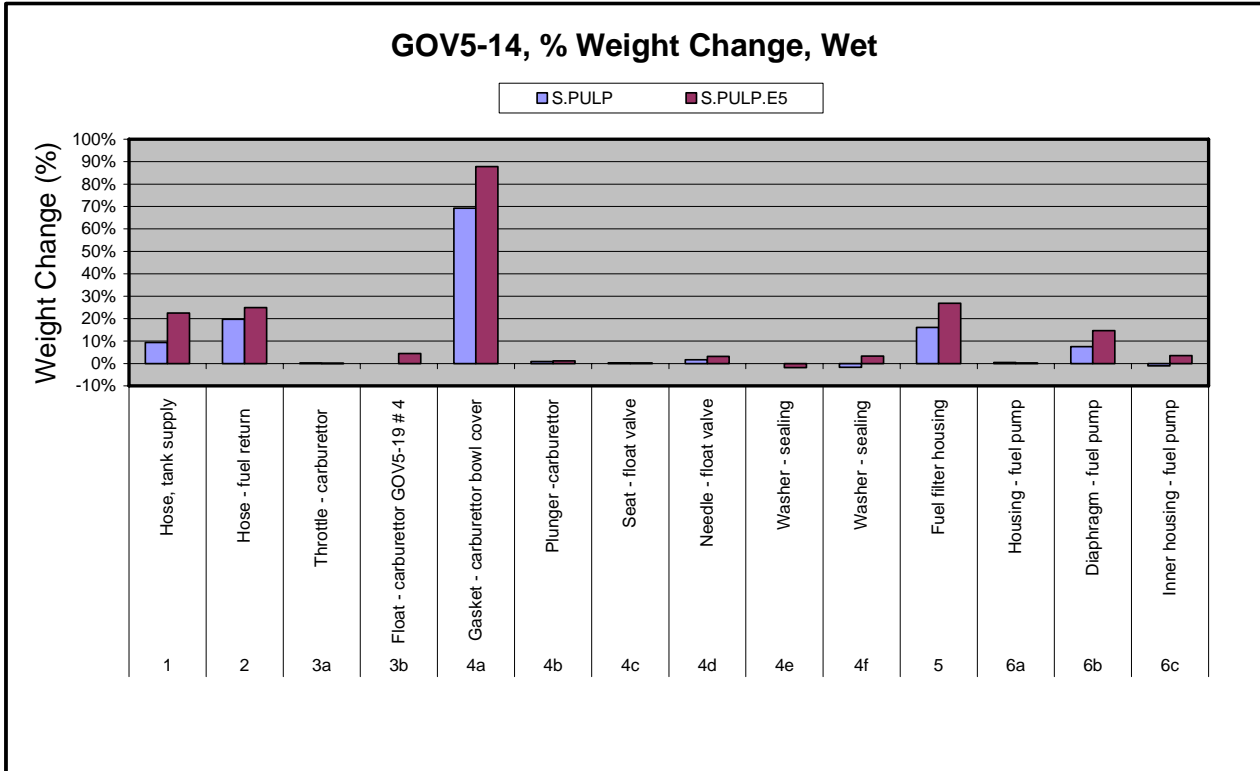


Figure 1 – Component weight change at test completion, wet.

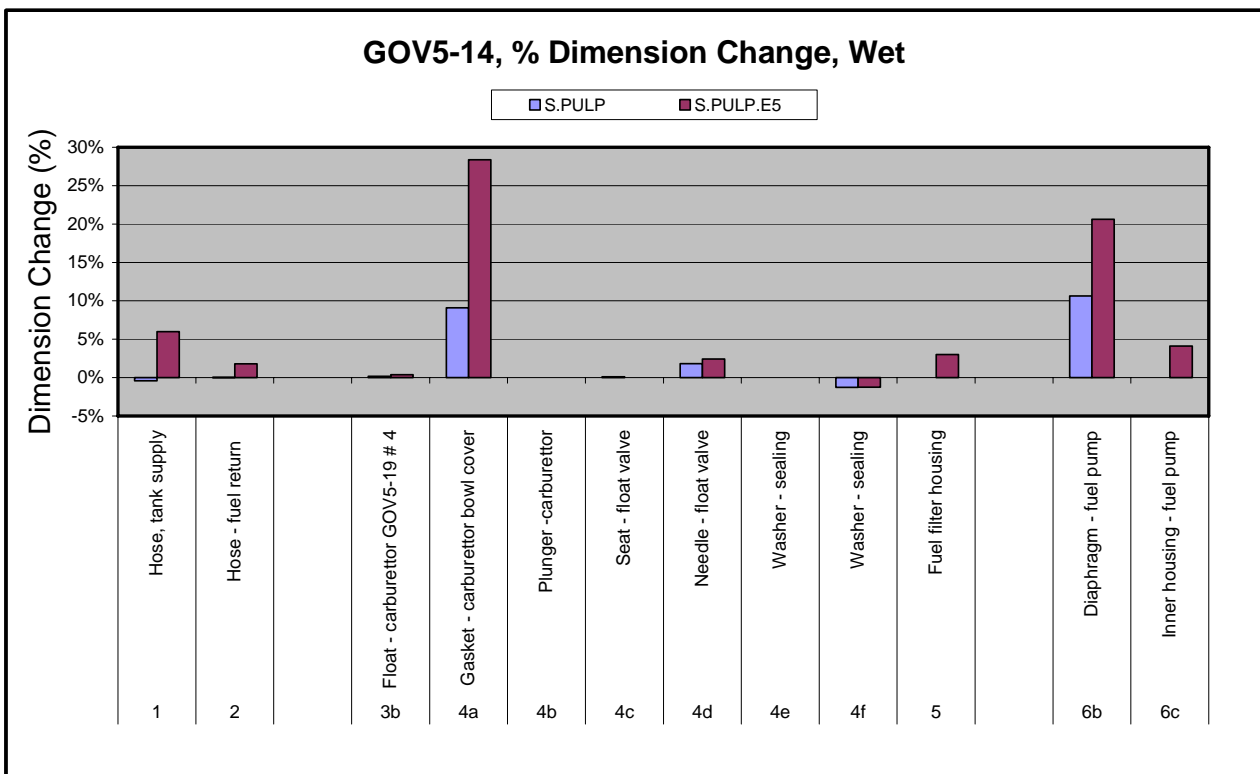


Figure 2 – Component thickness change at test completion, wet

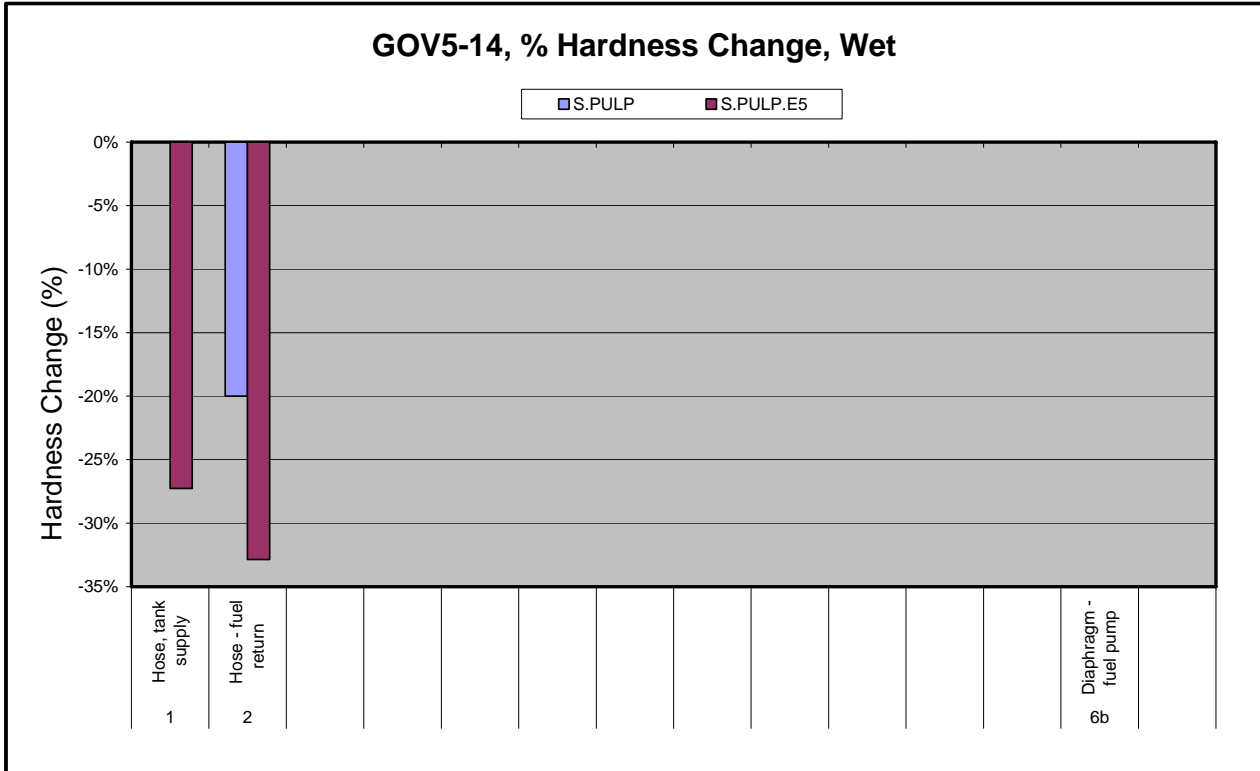


Figure 3 – Component hardness change at test completion, wet

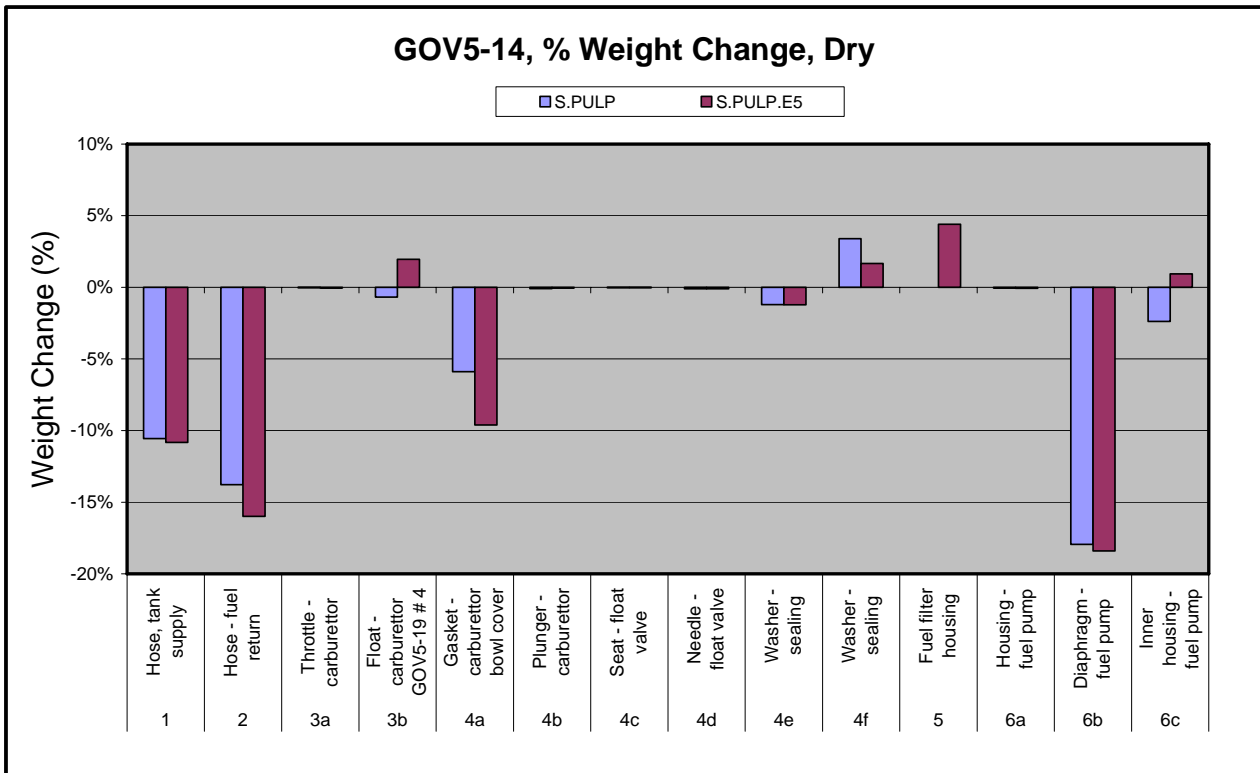


Figure 4 – Component weight change at test completion, dry

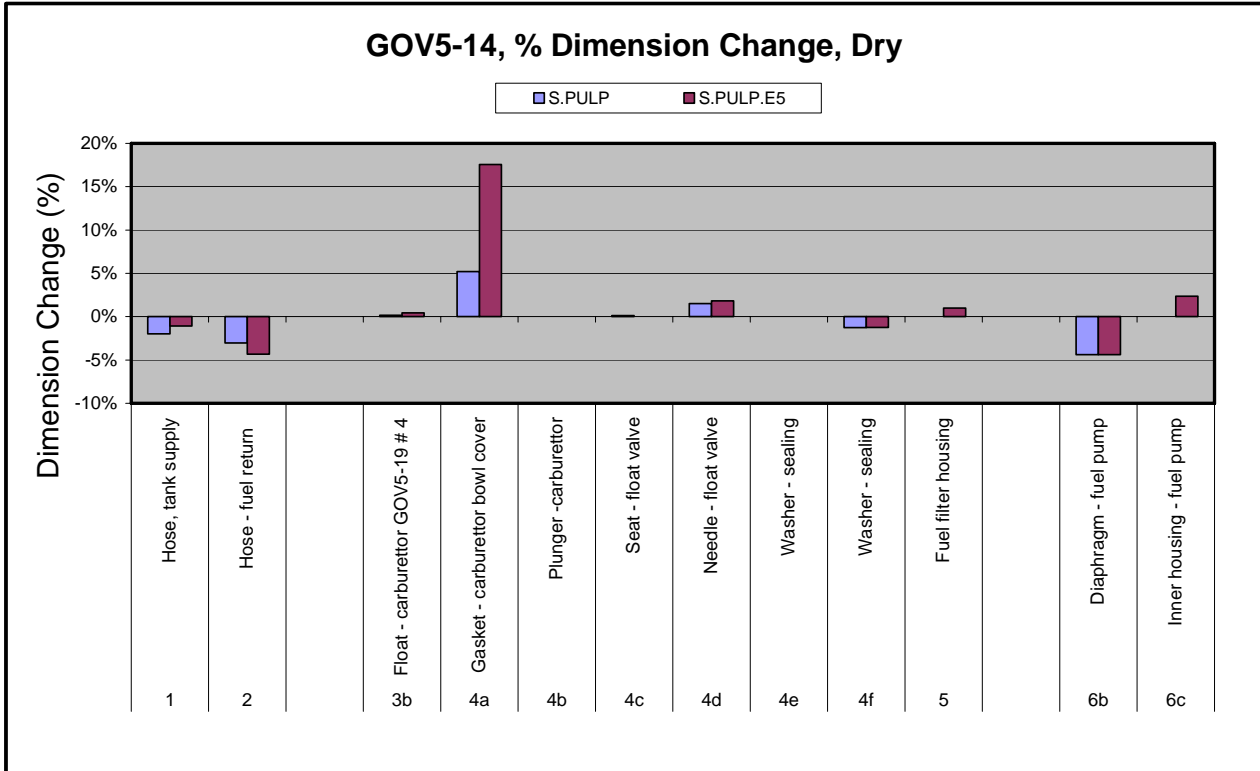


Figure 5 – Component thickness change at test completion, dry

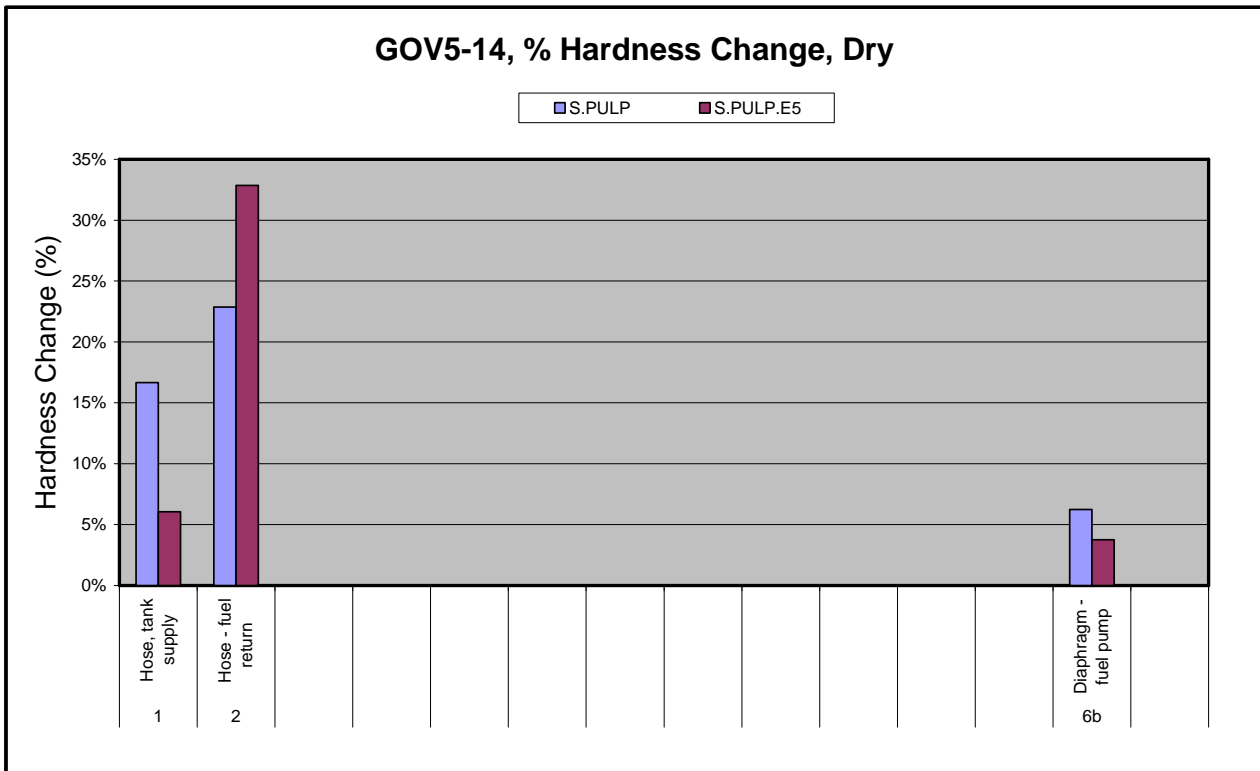


Figure 6 – Component hardness change at test completion, dry




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

Figure 7 –Part # 4c, Seat – float valve





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

Figure 8 Part # 4e, Washer, Sealing





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

Figure 9 Part # 5, Fuel Filter


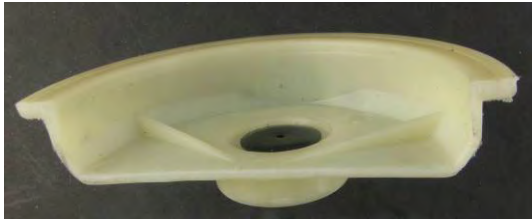


	S.PULP	S.PULP.E5
Pre Test		
Post Test (wet)		

Figure 10 Part # 6c, Inner housing, fuel pump