

CUSTOMER	Department of the Environment and Heritage	PROJECT	GOV5 - 26
TITLE	Comparison of Vehicle Drivability Ford Falcon – GOV5-10		

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	7.0	7.0	0.0
Warmed-up Start	6.5	6.8	0.3
Overall Restart	6.5	6.8	0.3
Idle Stability	6.3	6.1	-0.3
Idle Roughness	6.3	6.1	-0.3
Launchability, Part Load	7.0	7.0	0.0
Launchability, WOT	7.0	6.8	-0.3
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	7.0	0.0
Passing feel, WOT	7.0	7.0	0.0
Gradeability	7.0	7.5	0.5
Low speed shunt/chuggle	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
P/N to D transition	7.0	7.0	0.0
Average	6.9	6.9	0.0
Minimum	6.3	6.1	-0.3
Maximum	7.0	7.5	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 petrol 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 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

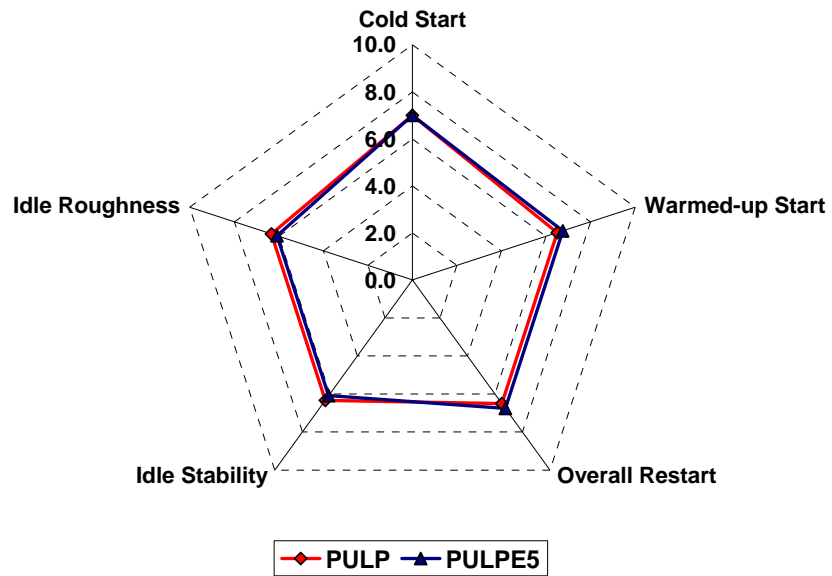


Figure 1 - Start and Idle Quality

Vehicle Performance

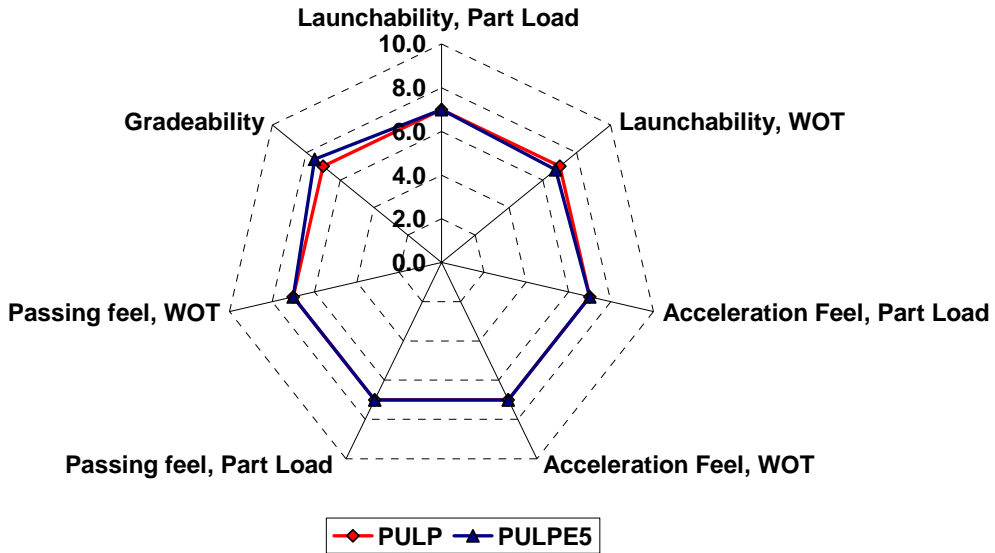


Figure 2 - Vehicle Performance Comparison

Warmed-up Driveability

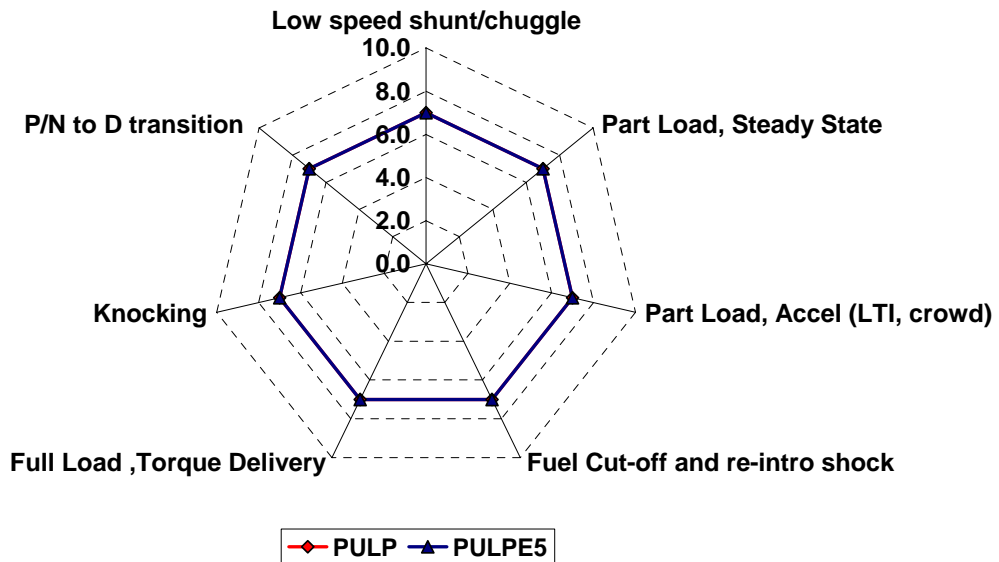


Figure 3. – Warmed – up Driveability Comparison

Attachment 2 Vehicle Appraisal Results #1 PULP

Vehicle Appraisal Form Fuel (1, driver A)

Vehicle name	GOV5-10 Ford	Test date	6/10/2006
Mileage (km)	179586	Test time	8:00
Ambient temperature (deg C)	16	Test road	Balcatta area
Barometric pressure (kPa)	102.1	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	7		
	Flare to idle	7		
	Restartability	7		
2. Idle Quality		Rating		Remarks
RPM stability	No load	5		
	part load	6		
	Full load	6		
Idle roughness	No load	5		
	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	n/a		
	End	n/a		
Stroke		n/a		
Linkage noise		n/a		
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)			
Tip-out (1st and 2nd gear)				
Tip-in (3rd,4th and 5th gear)				
Tip-out (3rd, 4th and 5th gear)				
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)	7		

**Attachment 3
Vehicle Appraisal Results #2 PULP**

Vehicle Appraisal Form (fuel 1, driver B)

Vehicle name	GOV5-10 Ford	Test date	6/10/2006
Mileage (km)	179589	Test time	14h00
Ambient temperature (deg C)	21.7	Test road	Balcatta area
Barometric pressure (kPa)	101.9	Engine	Standard
Test driver	AT1	Fuel	PULP
Co-driver	DFN	Oil	SAE 10W40

1. Startability		Rating	Remarks
Cold start	Starting Time	7	long crank
	Flare to idle	7	
	Restartability	7	
Warmed up start	Starting Time	5	
	Flare to idle	7	
	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	n/a	
	End	n/a	
Stroke		n/a	
Linkage noise		n/a	
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)	na	
Tip-out (1st and 2nd gear)		na	
Tip-in (3rd,4th and 5th gear)		na	
Tip-out (3rd, 4th and 5th gear)		na	
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)	7	

Attachment 4 Vehicle Appraisal Results #1 PULPE5

Vehicle Appraisal Form (Fuel 2, driver A)

Vehicle name	GOV5-10 Ford	Test date	13/10/2006
Mileage (km)	179586	Test time	9:00
Ambient temperature (deg C)	14.8	Test road	Balcatta area
Barometric pressure (kPa)	102.5	Engine	Standard
Test driver	AKM	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	7	
	Flare to idle	7	
	Restartability	7	
2. Idle Quality		Rating	Remarks
RPM stability	No load	5	
	part load	5.5	
	Full load	5	
Idle roughness	No load	5	
	part load	5.5	
	Full load	5	
3. Performance		Rating	Remarks
Launch feel	Part throttle	7	Slight hesitation on one occasion
	WOT	6.5	
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	n/a	
	End	n/a	
Stroke		n/a	
Linkage noise		n/a	
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)		
Tip-out (1st and 2nd gear)			
Tip-in (3rd,4th and 5th gear)			
Tip-out (3rd, 4th and 5th gear)			
Part-throttle steady-state		7	
Part-throttle acceleration	inc 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)	7	

Attachment 5 Vehicle Appraisal Results #2 PULPE5

Vehicle Appraisal Form (Fuel 2, driver B)

Vehicle name	GOV5-10 Ford	Test date	16/10/2006
Mileage (km)	179589	Test time	8:00
Ambient temperature (deg C)	21.7	Test road	Balcatta area
Barometric pressure (kPa)	101.9	Engine	Standard
Test driver	AT1	Fuel	PULPE5
Co-driver	DFN	Oil	SAE 10W40

1. Startability		Rating	Remarks
Cold start	Starting Time	7	slightly long crank
	Flare to idle	7	
	Restartability	7	
Warmed up start	Starting Time	6	
	Flare to idle	7	
	Restartability	6	
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	not sparkling, but presuem typical.
	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	n/a	
	End	n/a	
Stroke		n/a	
Linkage noise		n/a	
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)	na	
Tip-out (1st and 2nd gear)		na	
Tip-in (3rd,4th and 5th gear)		na	
Tip-out (3rd, 4th and 5th gear)		na	
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)	7	

CUSTOMER	Department of the Environment and Heritage	PROJECT	GOV5 - 26
TITLE	Hot Start and Driveability Evaluation Ford Falcon – GOV5-10		

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)	1.2	1.3	
Restart Time - 30min Soak (seconds)	0.6	0.8	
Restart Time - Ext. Idle/20min Soak (seconds)	1.1	0.8	
Hot Startability (10min. Soak)	7.0	6.8	-0.3
Hot Idle Quality (10min. Soak)	6.8	6.5	-0.3
Hot Restartability (30min. Soak)	7.0	7.0	0.0
Hot Idle Quality (30min. Soak)	7.0	6.5	-0.5
Hot Idle Quality (40min. Idle)	7.0	6.3	-0.8
Hot Startability (Ext. Idle/20min. Soak)	7.0	7.0	0.0
Hot Idle Quality (Ext. Idle/20min. Soak)	7.0	6.0	-1.0
Hot Acceleration - Idle Racing Mode	7.0	6.5	-0.5
Restart and idle after drive rating	6.8	6.5	-0.3
Hot Soak & Drive Idle Quality	6.5	6.7	0.2
Part Throttle Acceleration	7.0	7.0	0.0
WOT acceleration	7.0	7.0	0.0
50km/h Steady State	7.0	7.0	0.0
70km/h Steady State	7.0	7.0	0.0
Average all.	6.9	6.7	-0.2
Minimum	6.5	6.0	-1.0
Maximum	7.0	7.0	0.2

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) Overall, start and idle were slightly poorer with E5 than PULP fuel, which may be expected from ethanol's higher volatility at these temperatures. One feature of this may be noticed by an average user. In detail:
 - a) Hot idle quality after the extended idle and 20 minute soak was slightly worse with E5 fuel. This may be noticed by an average driver.
 - b) Lesser deteriorations in start and idle quality at other points in the test with E5 are 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 acceptable agreement.
- 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

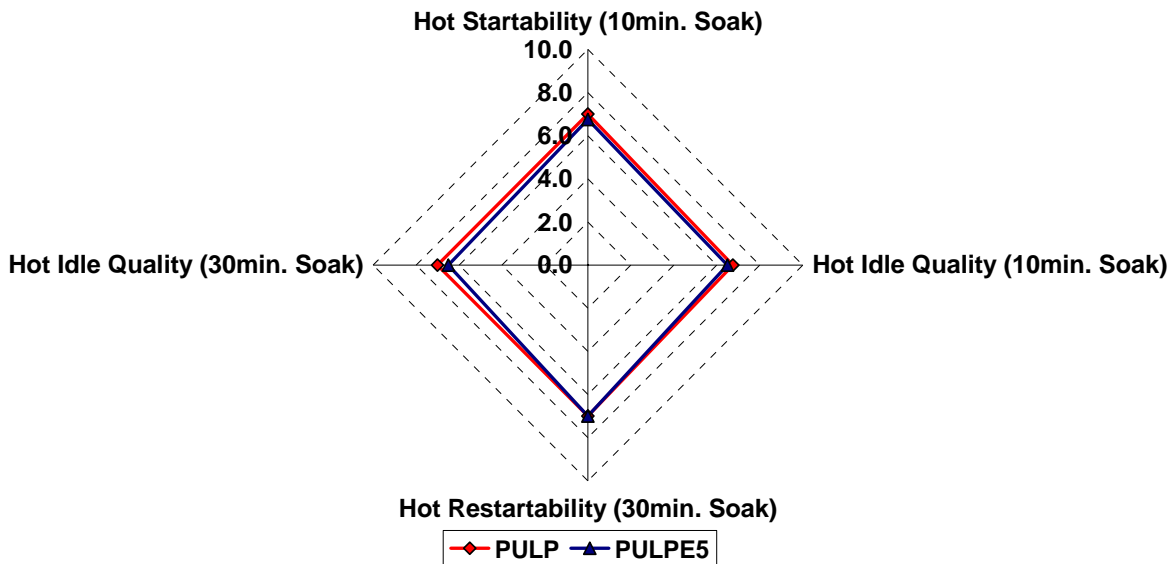


Figure 1 – Hot Start and Idle after Soak

Hot Extended Idle Test and 20min. Hot Soak

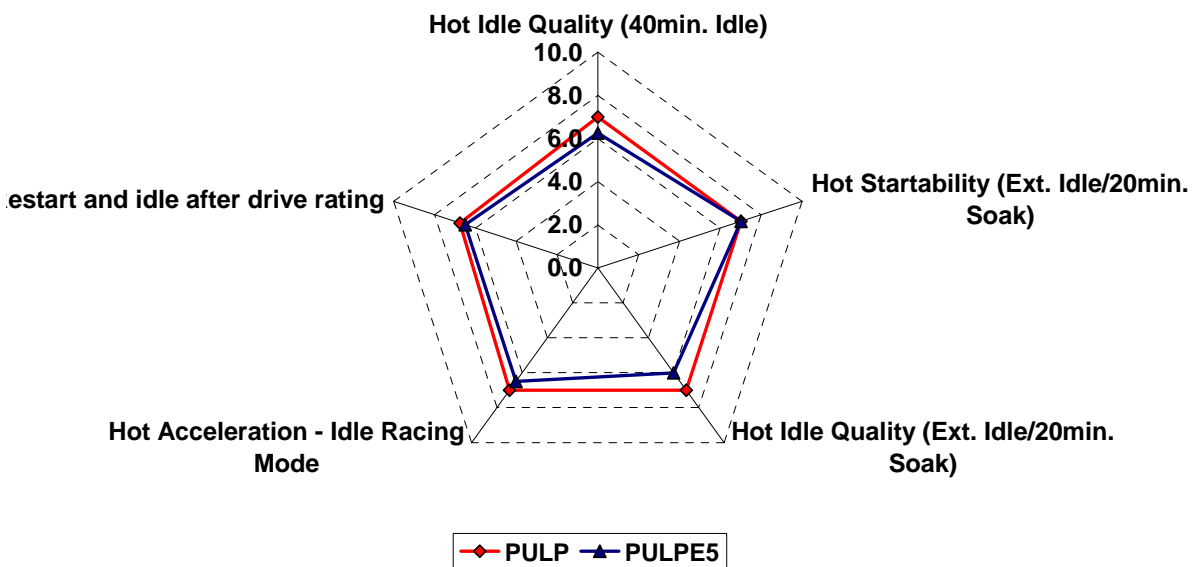


Figure 2 – Hot Start and Idle after extended idles and soaks

Hot Driveability Test

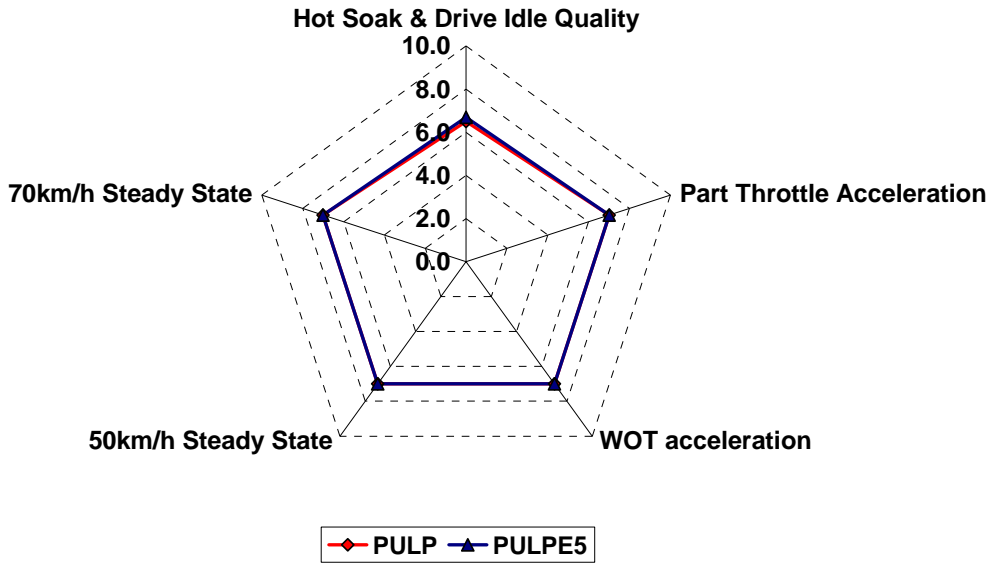


Figure 3 – Hot Driveability Comparison

Hot Start Times

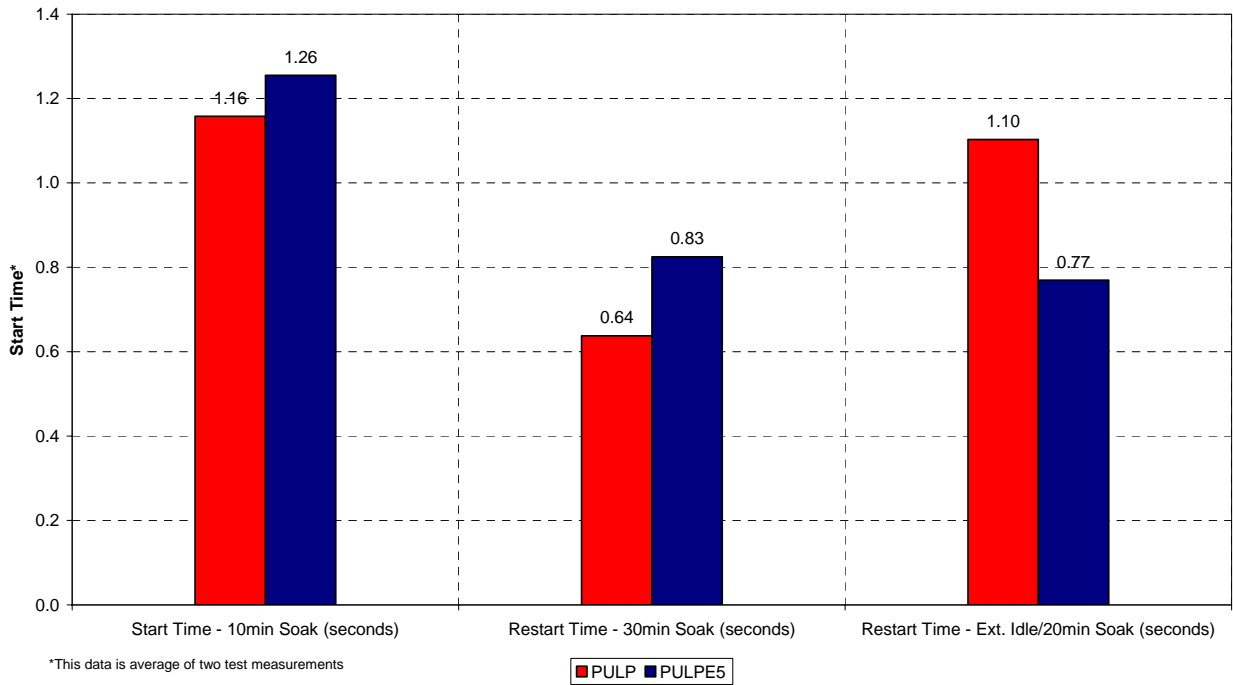


Figure 3 – Hot Start Times

Attachment 2 Hot start and driveability evaluation results #1 PULP

Hot Start and Driveability Evaluation, 1a

Vehicle Number	GOV5-10	Registration	6NZ 005
Vehicle name	Ford Falcon	Test date	10/10/2006
Vehicle colour	Gold, faded	Test time	11:00-13:30 drive
Mileage (km)	179586		
Ambient temperature (deg C)	23.1	Engine	4.1L, In line, 6cyl
Barometric pressure (kPa)	101.3	Fuel	PULP
Test driver	AT1	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	41	93	95
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.633		
Evaluate startability	7		
Evaluate idle roughness for 10 sec.	7		
Ignition-off and soak 30 minutes			
Ignition-on	41	81	72
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.567		
Evaluate re-startability	7		
Evaluate idle roughness for 10 sec.	7		

Data file names: C:\logs\gov05veh_10_HTST1

Data file names: C:\logs\gov05veh_10_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	42	97
Record data, 10 minute	7	42	105
Record data, 20 minute	7	42	106
Record data, 30 minute	7	42	108
Record data, 40 minute	7	42	109
Record data, 40 minute			111
Record data, 40 minute			113
Ignition-off and soak 20 minutes			
Ignition on	40	106	88
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.756		
Evaluate startability	7		
Evaluate idle roughness	7		

Data file names: C:\logs\gov05veh_10_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	

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

Rating	
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	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
Idle in P/N	7
Ignition off	7
Restart	7

Driveability Ratings:
 Idle during drive 7
 Start after various soak times 7
 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	GOV5-10	Registration	6NZ 005
Vehicle name	Ford Falcon	Test date	11/10/2006
Vehicle colour	Gold, faded	Test time	8:00-11:00 Drive
Mileage (km)	179 586		
Ambient temperature (deg C)	13	Engine	4.1L, In line, 6cyl
Barometric pressure (kPa)	101.2	Fuel	PULP
Test driver	HS1/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	39	93	82
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.683	1.5	
Evaluate startability	7		
Evaluate idle roughness for 10 sec.	6.5		
Ignition-off and soak 30 minutes			
Ignition-on	39	75	64
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.708	1	
Evaluate re-startability	7		
Evaluate idle roughness for 10 sec.	7		

Data file names: C:\logsgov05veh_ 10_HTST4

Data file names: C:\logsgov05veh_ 10_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	89
Record data, 10 minute	7	41	84
Record data, 20 minute	7	38	82
Record data, 30 minute	7	39	91
Record data, 40 minute	7	39	93
Ignition-off and soak 20 minutes			
Ignition on	41	95	80
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.45	1.5	
Evaluate startability	7		
Evaluate idle roughness	7		

Data file names: C:\logsgov05veh_ 10_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	

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

Rating	
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	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	7
Idle in P/N	6
Ignition off	7
Restart	7

Driveability Ratings:
 Idle during drive 6.1
 Start after various soak times 7.0
 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	GOV5-10	Registration	6NZ 005
Vehicle name	Ford Falcon	Test date	16/10/2006
Vehicle colour	Gold, faded	Test time	09:00
Mileage (km)	179586		
Ambient temperature (deg C)	16	Engine	4.1L, In line, 6cyl
Barometric pressure (kPa)	102	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/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	97	87
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.654	2	
Evaluate startability	6.5	Data file names: C:\logsgov05veh_ 10_HTST7	
Evaluate idle roughness for 10 sec.	7		
Ignition-off and soak 30 minutes			
Ignition-on	41	80	68
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.851	1.5	
Evaluate re-startability	7		
Evaluate idle roughness for 10 sec.	7	Data file names: C:\logsgov05veh_ 10_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	Coolant	oil
Extended idle for 40 minutes, in gear and A/C on (Blower medium, External air mode)			
Record data, 0 minute	6	42	92
Record data, 10 minute	6	41	103
Record data, 20 minute	6	42	104
Record data, 30 minute	6	42	105
Record data, 40 minute	6	42	105
Ignition-off and soak 20 minutes			
Ignition on	41	105	89
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.703	1	
Evaluate startability	7	Data file names: C:\logsgov05veh_ 10_HTST9	
Evaluate idle roughness	5.5		

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
6
7
7
6.5
7
7
6.5
7
7
6.5
7
7
6.5
7
7
6.5
7
6
5.5
7

Driveability Ratings:

Idle during drive	6.2
Start after various soak times	6.9
Average accel rating	7
Average Steady speed rating	7

Attachment 5 Hot start and driveability evaluation results #2 E5

Hot Start and Driveability Evaluation, 2b

Vehicle Number	GOV5-10	Registration	6NZ 005
Vehicle name	Ford Falcon	Test date	16/10/2006
Vehicle colour	Gold, faded	Test time	12:20
Mileage (km)	179586		
Ambient temperature (deg C)	16	Engine	4.1L, In line, 6cyl
Barometric pressure (kPa)	102	Fuel	PULPE5
Test driver	AT1	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	40	101	91
Ignition on			
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.856	1	
Evaluate startability	7	Data file names: C:\logsgov05veh_ 10_HTST10	
Evaluate idle roughness for 10 sec.	6		
Ignition-off and soak 30 minutes			
Ignition-on	41	82	71
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.799	1.2	
Evaluate re-startability	7	Data file names: C:\logsgov05veh_ 10_HTST11	
Evaluate idle roughness for 10 sec.	6		

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	6.5	42	94
Record data, 10 minute	6.5	42	99
Record data, 20 minute	6.5	41	104
Record data, 30 minute	6.5	39	98
Record data, 40 minute	6.5	39	95
Ignition-off and soak 20 minutes			
Ignition on	41	99	82
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.836	1	
Evaluate startability	7	Data file names: C:\logsgov05veh_ 10_HTST12	
Evaluate idle roughness	6.5		

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	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	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
Idle in P/N	7
Ignition off	7
Restart	6

Driveability Ratings:
 Idle during drive 7.0
 Start after various soak times 6.8
 Average accel rating 7
 Average Steady speed rating 7

CUSTOMER	Department of the Environment and Heritage	PROJECT	GOV5 - 26
TITLE	Cold Start and Warm-up Evaluation Ford Falcon – GOV5-10		

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)		2.6*	1.6	2.6
Restart Time (seconds)		1.4	1.4	1.4
Cold Startability		3.0*	7.0	4.0
Cold Restartability		7.0	7.0	0.0
Cold Idle Roughness/Stability No Load		3.8	3.8	0.0
Cold Idle Roughness/Stability Electrical load		3.5	4.0	0.5
Cold Idle Roughness/Stability Elec+P/S load		3.0	4.3	1.3
Cold Acceleration Idle racing mode		2.8	5.0	2.3
Warm-up idle Roughness/Stability		5.4	5.1	-0.3
Warmed up idle and restart		6.3	6.6	0.3
Part Throttle Acceleration		6.3	6.3	0.1
Interrupted accel		7.0	7.0	0.0
WOT acceleration		6.0	5.5	-0.5
50km/h steady state		6.5	6.3	-0.3
60/70km/h steady state		6.8	6.8	0.1
Average		5.3	5.7	0.6
Minimum		2.8	3.8	-0.5
Maximum		7.0	7.0	4.0

* Data from one start only

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. The Falcon's start, idle and driveability were poor at these temperatures. Overall, E5 gave better ratings than PULP. In detail:
 - a. On one cold start with PULP the battery failed, therefore this data has been excluded from the analysis. However, E5 still started noticeably better than PULP, an average driver would probably notice this.
 - b. The vehicle idled badly on PULP, the opinion of the testers was that it was running too rich. As could be expected, ethanol improved the initial idle quality, especially under load. It did not however completely cure stalling at idle when the engine was very cold. This improvement with E5 may be noticed by an average user.
 - c. The significance of a slightly better idle racing response with E5 is confirmed by better smoke ratings. An average user probably would notice the difference.
2. There were no differences during the warm-up drive that and average user is likely to notice.
3. The objective start times recorded agree with the subjective ratings given by the drivers.
4. 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

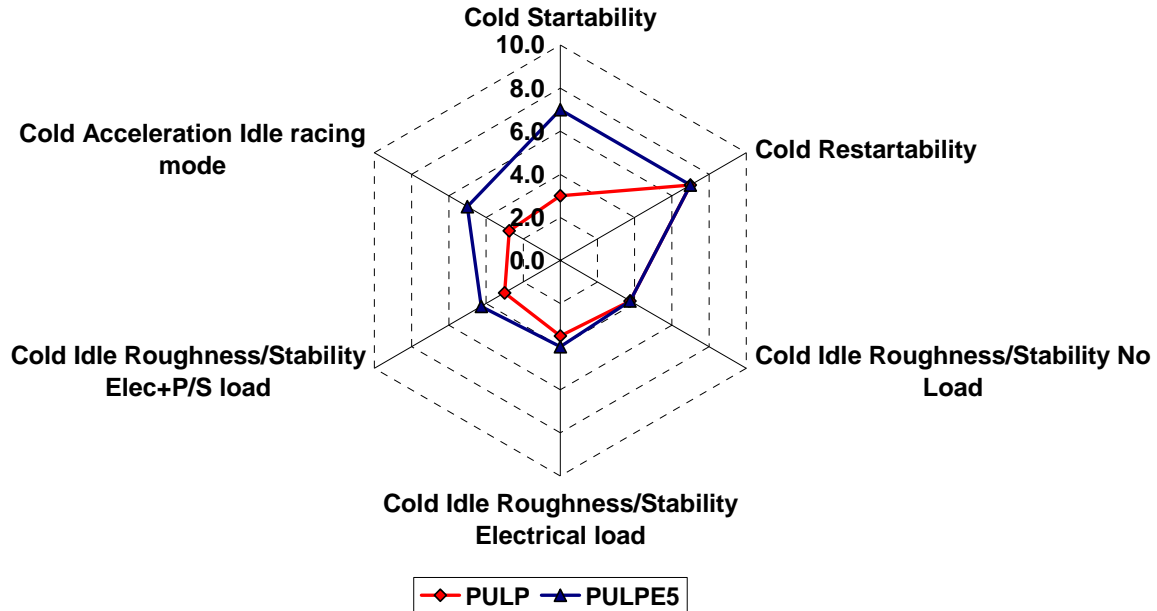


Figure 1 – Cold Start and Idle Quality

Warm-up Driveability after Cold Start

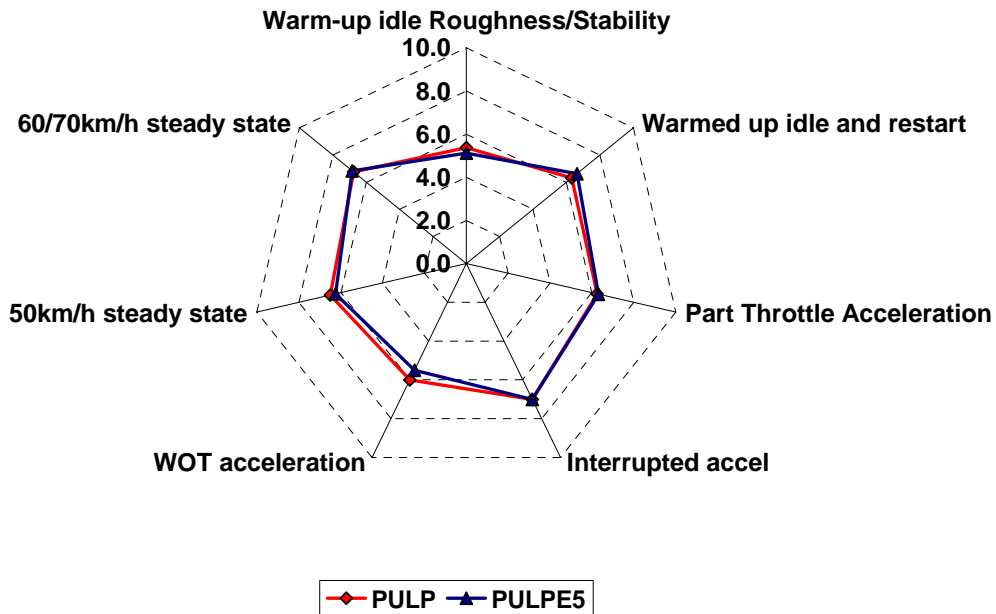
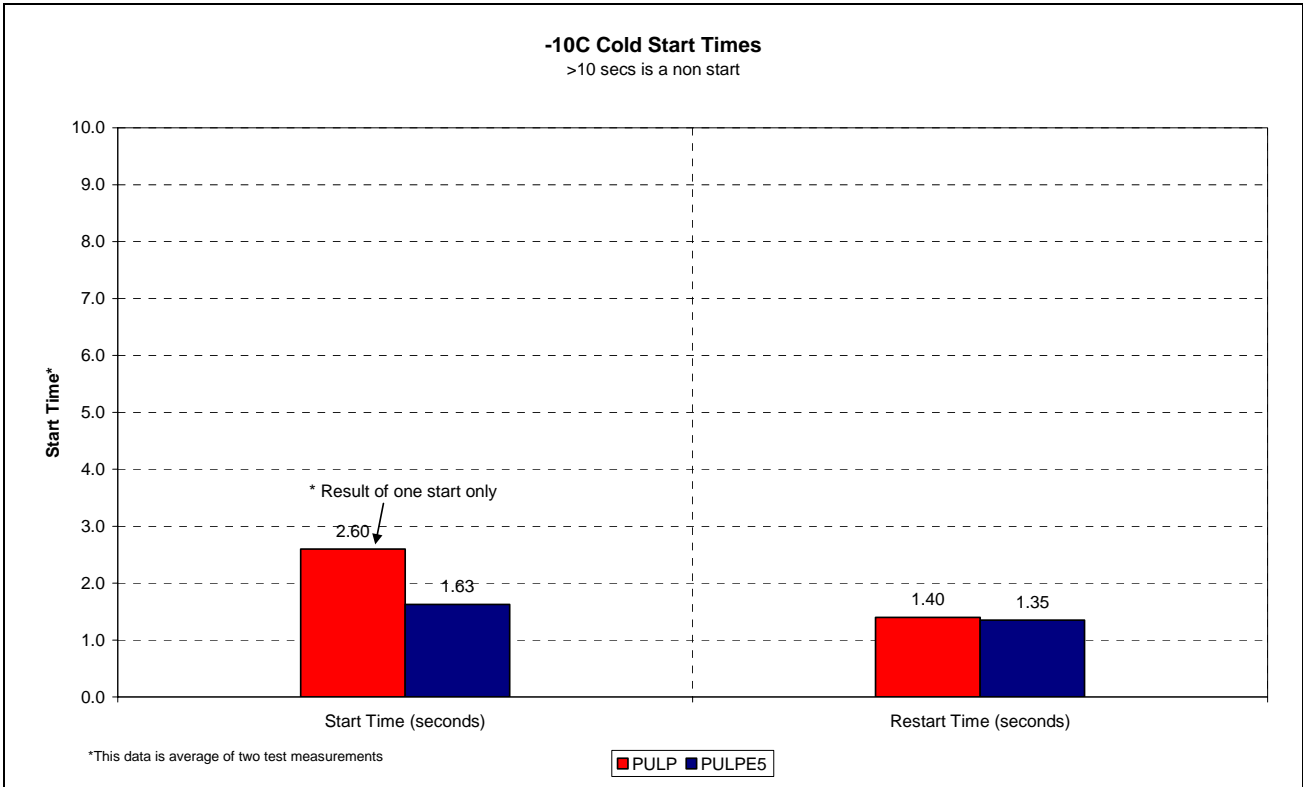


Figure 2 – Driveability during Warm-up



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

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

Vehicle Number	GOV5-10	Registration	6NZ 005
Vehicle name	Ford Falcon	Test date	26/10/2006
Vehicle colour	Gold, faded	Test time	10:45
Mileage (km)	179583		RH, 43%
Ambient temperature (deg C)	24.7	Engine	4.1L, In line, 6cyl
Barometric pressure (kPa)	101.8	Fuel	PULP
Test driver	AT1	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)
	-10.9	-10.5	-10.3

Ignition on		} Flat Batt: Carry over result from next test
Crank after fuel pump relay is off. No start if crank time is > 10 seconds		
Crank time	4.4	
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	
Evaluate re-startability	7	

Data file: C:..logs\gov05\10_CSTa

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

Evaluate idle roughness (10 seconds)	4	
Shift to D/R or clutch engaged		
Evaluate idle roughness (10 seconds)	3	
Turn on the headlights, blower (max position) and defroster		
Evaluate idle roughness (10 seconds)	3	
Turn power steering to the right end		
Evaluate idle roughness (10 seconds)	1	Stall
Turn power steering to the left end		
Evaluate idle roughness (10 seconds)	3	After restart
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	3	stumble throughout rev range
Black smoke present?	3	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	3	
1/2 throttle to 50km/hr	3	hesitation

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	5	
Stop and idle 10 seconds	6	
WOT to 70km/hr	5	hesitation on tip in
70km/hr cruise	6	
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	7	
Steering lock to lock	6	
Idle in P/N	7	
Ignition off		
Restart	6	

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

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

Vehicle Number	GOV5-10	Registration	6NZ 005
Vehicle name	Ford Falcon	Test date	30/10/2006
Vehicle colour	Gold, faded	Test time	10H00
Mileage (km)	179583		
Ambient temperature (deg C)	20.5	Engine	4.1L, In line, 6cyl
Barometric pressure (kPa)	101.7	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)
	-10.5	-10.4	-10.7

Ignition on
Crank after fuel pump relay is off. No start if crank time is > 10 seconds
Crank time Start and immediate stall
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\10_CSTb**

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

Evaluate idle roughness (10 seconds) Over-rich and very lumpy
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 Misfire on run-up.
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 Some misfire feeling

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 Possible misfire?
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

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

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

Vehicle Number	GOV5-10	Registration	6NZ 005
Vehicle name	Ford Falcon	Test date	18/10/2006
Vehicle colour	Gold, faded	Test time	08:00
Mileage (km)	179586		
Ambient temperature (deg C)	17.7	Engine	4.1L, In line, 6cyl
Barometric pressure (kPa)	102.3	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)
-8.5	-10.5	-10.5

Ignition on

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

Crank time

1.75

retested start only with charged battery.

Evaluate startability

7

Stall after start. Idle too rich

Ignition -off within 5 seconds

Ignition-on

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

Crank time

1.7

Evaluate re-startability

7

Data file: C:..logslgov05\veh_ 10_CST2a

2. Cold idle

Cold idle quality rating

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

Evaluate idle roughness (10 seconds)

4

very low and lumpy

Shift to D/R or clutch engaged

4

Evaluate idle roughness (10 seconds)

4

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

Evaluate idle roughness (10 seconds)

4

Turn power steering to the right end

4

Evaluate idle roughness (10 seconds)

4

Turn power steering to the left end

4

Evaluate idle roughness (10 seconds)

4

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

5

very slow idle

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

1

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

6

Stop and idle 10 seconds

5.5

WOT to 70km/hr

5

70km/hr cruise

6

Stop and idle 10 seconds

6

1/4 throttle to 50km/hr

5.5

lack of performance, light surge noted

50km/hr cruise

7

3/4 throttle to 70km/hr

7

70km/hr cruise

7

Stop and idle 10 seconds

5.5

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

7

Restart

7

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

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

Vehicle Number	GOV5-10	Registration	6NZ 005
Vehicle name	Ford Falcon	Test date	18/10/2006
Vehicle colour	Gold, faded	Test time	15:00
Mileage (km)	179586		
Ambient temperature (deg C)	22	Engine	4.1L, In line, 6cyl
Barometric pressure (kPa)	102.2	Fuel	PULPE5
Test driver	AT1	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	-9	-10.5

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

1

Evaluate re-startability

7

Data file: C:..logslgov05\veh_ 10_CST2b

2. Cold idle

Cold idle quality rating

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

Evaluate idle roughness (10 seconds)

3

Rough and hunting

Shift to D/R or clutch engaged

4

Evaluate idle roughness (10 seconds)

4

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

Evaluate idle roughness (10 seconds)

4

Turn power steering to the right end

Evaluate idle roughness (10 seconds)

4

Turn power steering to the left end

Evaluate idle roughness (10 seconds)

5

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

3

rough

Black smoke present?

7

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

3

hesitation

1/2 throttle to 50km/hr

4

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

5

Stop and idle 10 seconds

6

WOT to 70km/hr

6

hesitation

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

Idle in P/N

7

Ignition off

Restart

7

CUSTOMER	Department of the Environment and Heritage	PROJECT	GOV005
TITLE	WOT Performance Test Ford Falcon – GOV5-10		

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.

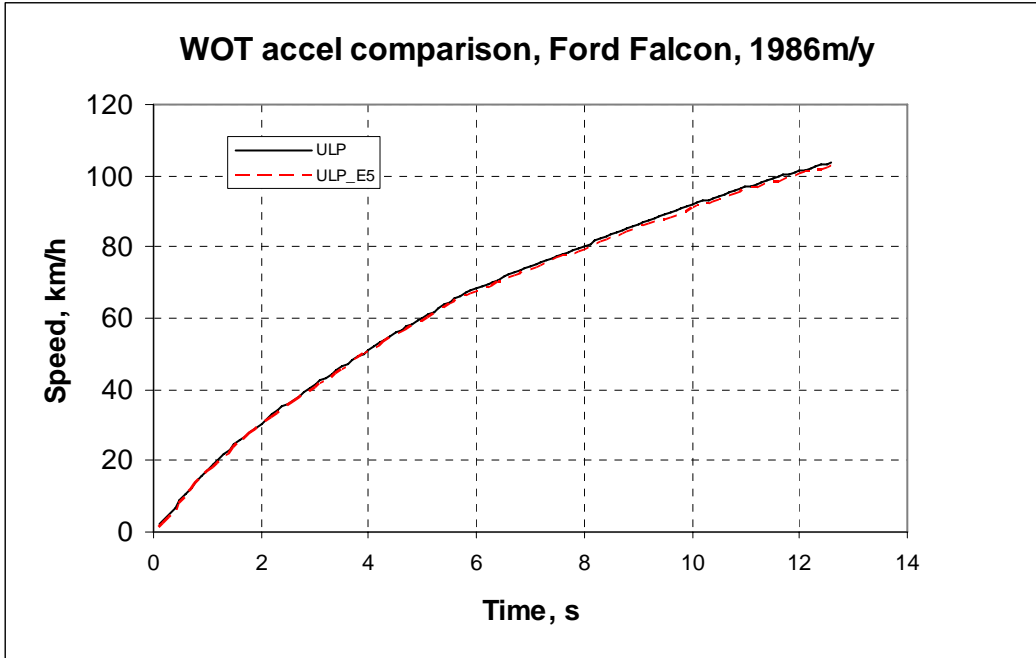


Figure 1 – Standing Start WOT Acceleration Comparison Between Petrol and E5

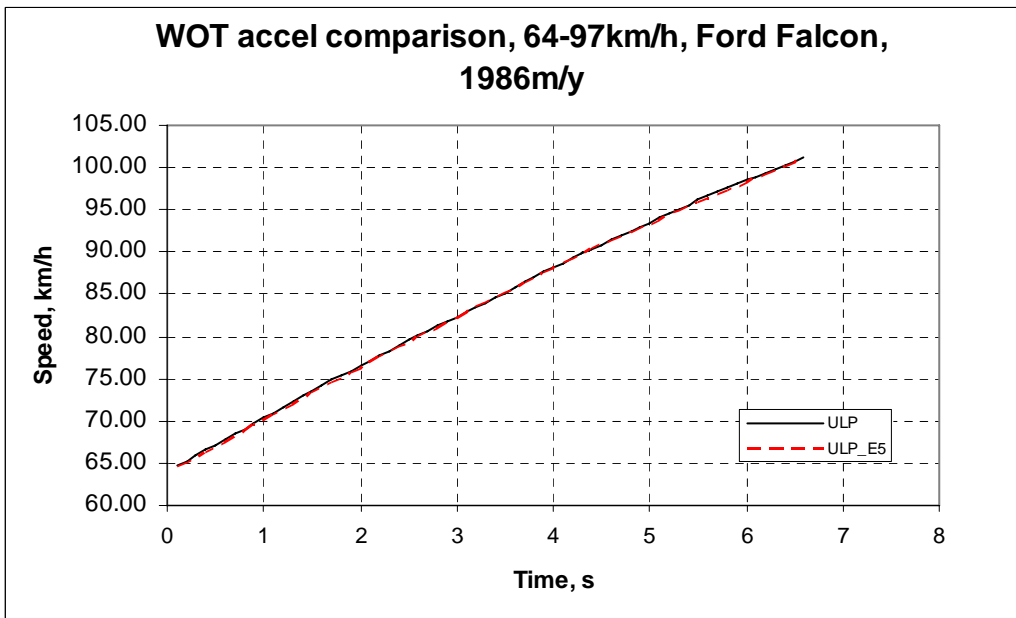


Figure 2 – 64 to 97 km/h WOT Acceleration Comparison Between Petrol and E5

Results:	ULP	ULP E5	% Improvement over Petrol. E5
0-48km/h elapsed time,s	3.63	3.67	-1%
0-80km/h elapsed time,s	7.93	8.10	-2%
0-97km/h elapsed time,s	10.93	11.23	-3%
64-97km/h elapsed time,s	5.70	5.80	-2%
0-5s distance covered, m	48.39	47.3	-2%
0-5s terminal speed, km/h	60.13	59.1	-2%
0-400m elapsed time	18.13	18.3	-1%
0-400m terminal speed, km/h	121.97	121.2	-1%
Uego Average	0.82	0.83	2%
Exhaust temp max.	772	801.6	4%

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

Table 1 – Averaged WOT Acceleration Performance Test Data

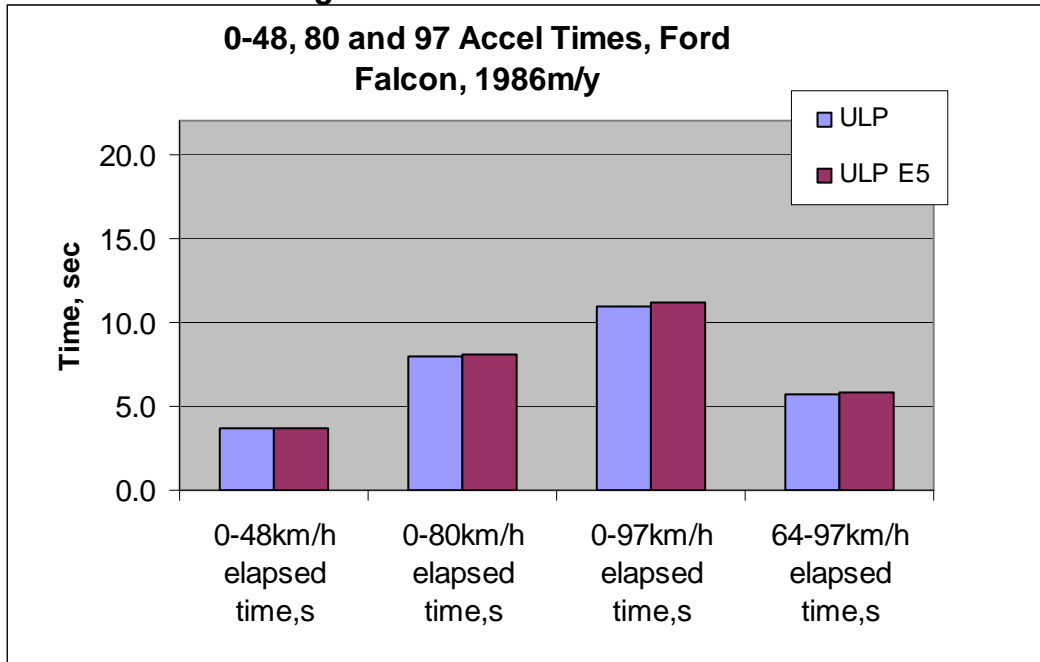


Figure 3 – Elapsed Times for WOT Accelerations

Overall the WOT acceleration test data indicates little difference in the acceleration times for E5 and petrol. For the 0~97km/h acceleration tests, E5 appears slightly slower than petrol, with an increase of 1~3% in the times to reach all three terminal speeds. For accelerations from 64~97km/h km/h a similar trend is shown with E5 providing a slightly slower acceleration time than petrol, the difference being 2%.

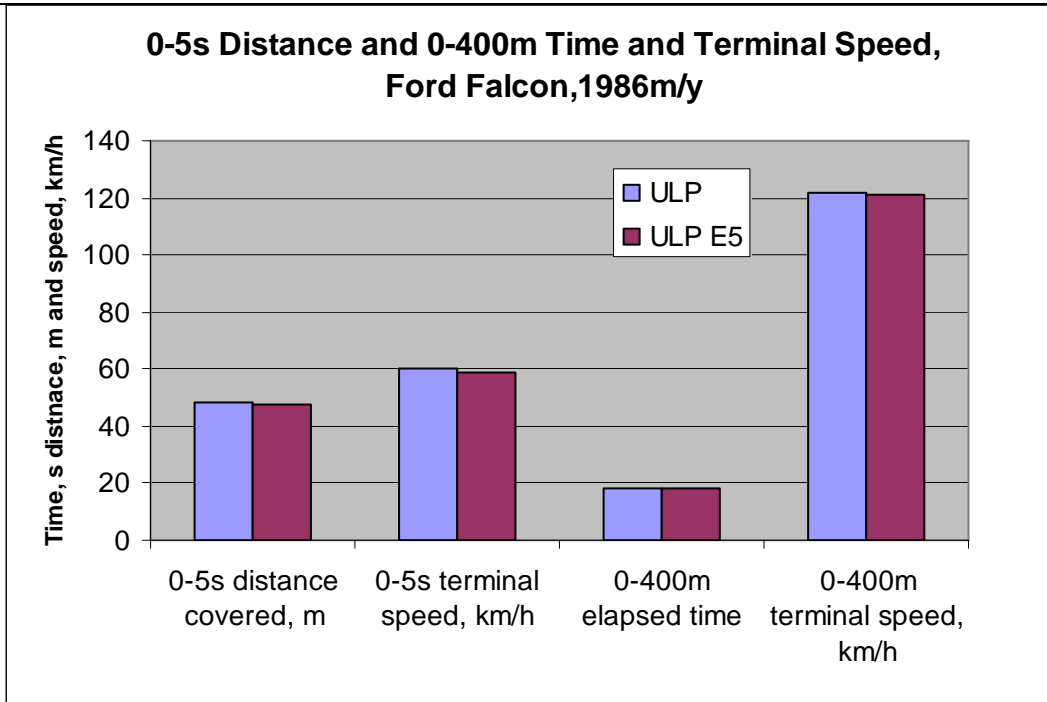


Figure 4 – 0 to 5s and 0 to 402m WOT Acceleration Performance Comparison

The standing start WOT acceleration test data also indicates that there is a slight reduction in performance between petrol and E5. The 0~300m elapsed times were increased by 1% and the terminal speed reduced by 1% for E5. Launch, as measured by the 0~5s distance was slightly poorer for the E5 fuel by 2% compared to petrol.

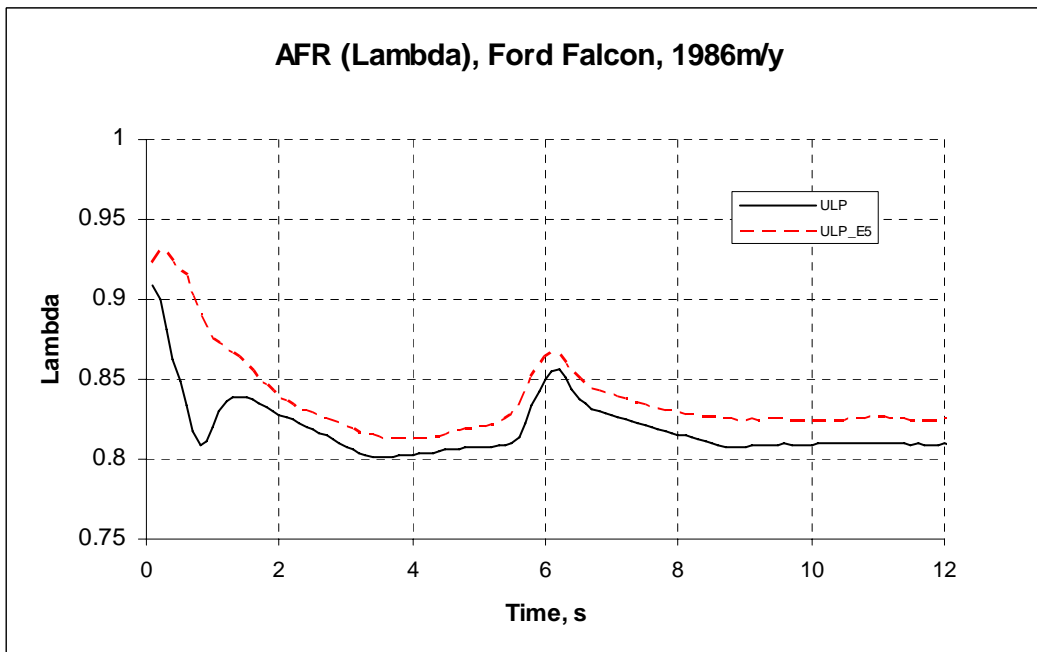


Figure 5 – Standing Start WOT Acceleration AFR Comparison

Figure 5 shows that on average the engine was running 2% leaner for E5 compared to petrol. This is consistent with a vehicle, being a carburetor vehicle, which does not apply

learning to the WOT AFR.

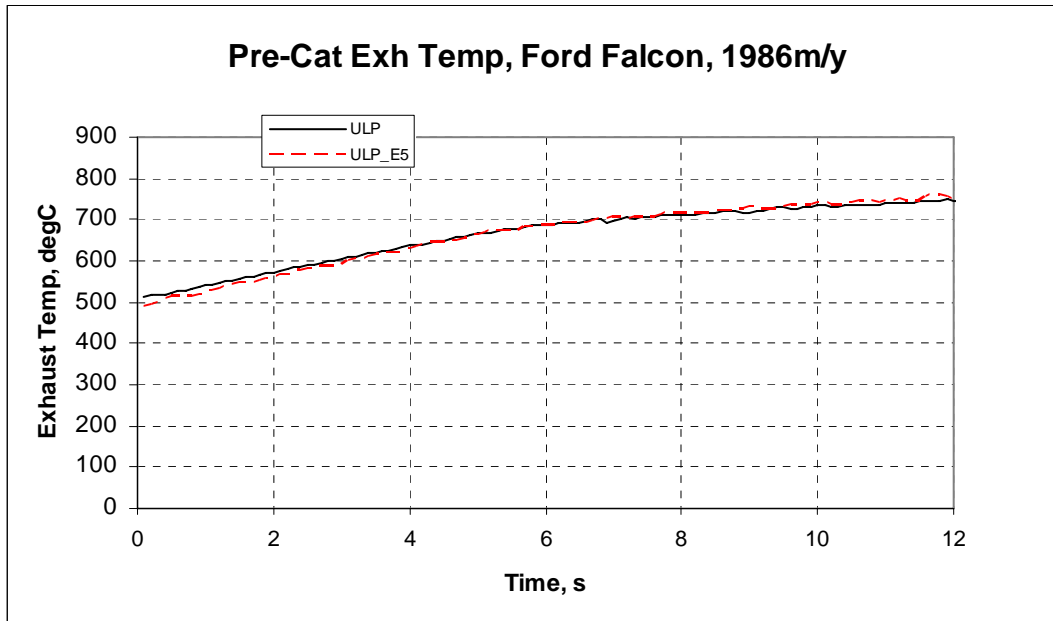


Figure 6 – Standing Start WOT Acceleration Exhaust Temperatures

The peak pre-catalyst exhaust gas temperature recorded at the end of each run was 4% higher (30degC) 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 Ford Falcon indicate there is a slight loss of performance with the use of E5 fuel. However the magnitude is such that the detrimental effect caused by the use of E5 on the WOT performance would not be noticeable. The enleanment and increase in exhaust temperature noted are unlikely to cause any detrimental effect on the vehicle.

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>Ford</u> Model <u>Falcon</u> Year <u>1986</u>		Test Date <u>9/10/2006</u>			
Odometer <u>190713</u> km		Car No <u>10</u>			
<u>Test Location</u> <u>MACD no 1</u>		Driver <u>R Brooks</u>			
Start of test date <u>9/10/2006</u>		Time strt <u>15:00</u>			
End of test date <u>9/10/2006</u>		Time end <u>17:00</u>			
Transmission, type <u>3 a/t</u>		Automatic shift mode <u>Auto</u>			
<u>Fuel Type</u> <u>PULP</u>					
<u>Remarks</u>					
<u>Ambient conditions for test:</u>					
Temperature	<u>28</u> °C	Barometric Pressure	<u>101.7</u>	Relative Humidity	<u>50</u> %
Wind Velocity	<u>roller speed</u> km/h	Direction	<u>Head-on</u>	Peak wind velocity	<u>n/a</u>
<u>Results:</u>					
	Test1	Test2	Test3	Average	Variability (Max-mean)/mean
0-48km/h elapsed time,s	<u>3.7</u>	<u>3.6</u>	<u>3.6</u>	<u>3.63</u>	<u>1.83</u> %
0-80km/h elapsed time,s	<u>8</u>	<u>7.9</u>	<u>7.9</u>	<u>7.93</u>	<u>0.84</u> %
0-97km/h elapsed time,s	<u>11</u>	<u>10.9</u>	<u>10.9</u>	<u>10.93</u>	<u>0.61</u> %
64-97km/h elapsed time,s	<u>5.7</u>	<u>5.7</u>	<u>5.7</u>	<u>5.70</u>	<u>0.00</u> %
0-5s distance covered, m	<u>48.2</u>	<u>48.8</u>	<u>48.1</u>	<u>48.4</u>	<u>0.91</u> %
0-5s terminal speed, km/h	<u>59.9</u>	<u>60.2</u>	<u>60.4</u>	<u>60.1</u>	<u>0.40</u> %
0-400m elapsed time	<u>18.2</u>	<u>18.1</u>	<u>18.1</u>	<u>18.1</u>	<u>0.37</u> %
0-400m terminal speed, km/h	<u>121.7</u>	<u>122.3</u>	<u>121.9</u>	<u>122.0</u>	<u>0.29</u> %
Uego Average (Lambda)	<u>0.82</u>	<u>0.82</u>	<u>0.82</u>	<u>0.82</u>	<u>0.52</u> %
Exhaust temp max.	<u>756.6</u>	<u>770.5</u>	<u>779.1</u>	<u>772.2</u>	<u>0.89</u> %
File reference: P:\Projects\Government\GOV005\Test Data\GOV5-10 - Ford Falcon\WOT Tests\[VEH10_WOT01_M01.xls]Report					

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

<u>Vehicle:</u> Make <u>Ford</u>		Model <u>Falcon</u>	Year <u>1986</u>	Test Date <u>12/10/2006</u>	
Odometer <u>190713</u> km				Car No <u>10</u>	
<u>Test Location</u> <u>MACD no 1</u>		Driver <u>R Brooks</u>			
Start of test date <u>12/10/2006</u>		Time strt <u>15:00</u>			
End of test date <u>12/10/2006</u>		Time end <u>17:00</u>			
Transmission, type <u>3 a/t</u>		Automatic shift mode <u>Manual</u>			
<u>Fuel Type</u> <u>PULP</u>					
<u>Remarks</u>					
<u>Ambient conditions for test:</u>					
Temperature	<u>22</u> °C	Barometric Pressure	<u>102</u>	Relative Humidity	<u>50</u> %
Wind Velocity	<u>roller speed</u> km/h	Direction	<u>Head-on</u>	Peak wind velocity	<u>n/a</u>
<u>Results:</u>	Test1	Test2	Test3	Average	Variability (Max-mean)/mean
0-48km/h elapsed time,s	<u>3.8</u>	<u>3.6</u>	<u>3.6</u>	<u>3.67</u>	<u>3.64</u> %
0-80km/h elapsed time,s	<u>8.4</u>	<u>8</u>	<u>7.9</u>	<u>8.10</u>	<u>3.70</u> %
0-97km/h elapsed time,s	<u>11.6</u>	<u>11</u>	<u>11.1</u>	<u>11.23</u>	<u>3.26</u> %
64-97km/h elapsed time,s	<u>5.9</u>	<u>5.7</u>	<u>5.8</u>	<u>5.80</u>	<u>1.72</u> %
0-5s distance covered, m	<u>45.3</u>	<u>48.1</u>	<u>48.5</u>	<u>47.3</u>	<u>2.49</u> %
0-5s terminal speed, km/h	<u>57.8</u>	<u>59.5</u>	<u>59.8</u>	<u>59.1</u>	<u>1.29</u> %
0-400m elapsed time	<u>18.5</u>	<u>18.2</u>	<u>18.2</u>	<u>18.3</u>	<u>1.09</u> %
0-400m terminal speed, km/h	<u>120.3</u>	<u>121.4</u>	<u>121.8</u>	<u>121.2</u>	<u>0.55</u> %
Uego Average Lambda	<u>0.84</u>	<u>0.83</u>	<u>0.83</u>	<u>0.83</u>	<u>0.90</u> %
Exhaust temp max.	<u>762.0</u>	<u>793.1</u>	<u>832.7</u>	<u>801.6</u>	<u>3.88</u> %
File reference: P:\Projects\Government\GOV005\Test Data\GOV5-10 - Ford Falcon\WOT Tests\[VEH10_WOT02_M01.xls]Report					

Attachment 3

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

<u>Vehicle:</u> Make <u>Ford</u> Model <u>Falcon</u> Year <u>1986</u>		Base fuel test date <u>9/10/2006</u>	
Odometer <u>115972</u> km		Car No <u>10</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>17/07/2006</u>		Time strt <u>various</u>	
End of test date <u>12/10/2006</u>		Time end <u>various</u>	
Transmission, type <u>3 a/t</u>		Automatic shift mode <u>Auto</u>	
<u>Fuel Type</u> (base) <u>ULP</u>			
<u>Remarks</u> _____			
<u>Ambient conditions for test:</u>			
Temperature	<u>14-28</u> °C	Barometric Pressure	<u>102.5-102.5</u>
Wind Velocity	<u>roller speed</u> km/h	Direction	<u>Head-on</u>
		Relative Humidity	<u>50-60</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>3.63</u>	<u>3.67</u>	<u>-1%</u>
0-80km/h elapsed time,s	<u>7.93</u>	<u>8.10</u>	<u>-2%</u>
0-97km/h elapsed time,s	<u>10.93</u>	<u>11.23</u>	<u>-3%</u>
64-97km/h elapsed time,s	<u>5.70</u>	<u>5.80</u>	<u>-2%</u>
0-5s distance covered, m	<u>48.39</u>	<u>47.3</u>	<u>-2%</u>
0-5s terminal speed, km/h	<u>60.13</u>	<u>59.1</u>	<u>-2%</u>
0-400m elapsed time	<u>18.13</u>	<u>18.3</u>	<u>-1%</u>
0-400m terminal speed, km/h	<u>121.97</u>	<u>121.2</u>	<u>-1%</u>
Uego Average	<u>0.82</u>	<u>0.83</u>	<u>2%</u>
Exhaust temp max.	<u>772</u>	<u>801.6</u>	<u>4%</u>
File reference: P:\Projects\Government\GOV005\Test Data\GOV5-10 - Ford Falcon\WOT Tests\[VEH10_WOT_comp_M01.xls]Report			

CUSTOMER	Department of Environment and Heritage	PROJECT	GOV005
TITLE	2000hr Materials Compatibility Testing of Fuel System Components for a "Pre 1986" Ford Falcon GOV5-10		

AIM

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

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 XE/XF Ford Falcon 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 GOV5-10 test parts completed 2035 hours of fluid exposure with interim progress inspections and recordings made at 504 hrs and at 1028 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 8.

2000hr “Wet” Results for Elastomeric Components

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

- Seal, fuel tank sender unit (part #1)
- Carburettor gasket (part # 2a)
- Fuel filter (part # 4)
- Seal, fuel pump cap (part # 5c)
- Fuel pump diaphragm (part # 5d)

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:

- Seal, fuel tank sender unit (part #1)
- Carburettor gasket (part # 2a)
- Seal, fuel pump cap (part # 5c)
- Fuel pump diaphragm (part # 5d)

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:

- Seal, fuel pump cap (part # 5c)
- Fuel pump diaphragm (part # 5d)

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:

- Seal, fuel tank sender unit (part #1)
- Seal, fuel pump cap (part # 5c)
- Fuel pump diaphragm (part # 5d)

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 shrinkage of the:

- Seal, fuel tank sender unit (part #1)
- Seal, fuel pump cap (part # 5c)

These showed slightly greater shrinkage 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. The hardness changes noted for these parts after drying were not considered to be of concern.

Metal components at 2000 hrs

- Throttle (part #3) corroded on shaft. Some resistance to rotation. See. Figure 7
- Brass components tarnished (part #'s 2c, 2d.) See Figure 8

General Observations

- Filter housing (part # 6) discoloured. See Figure 9

CONCLUSIONS/DISCUSSION

Examination of the selected parts of the Pre-1986 Ford Falcon 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 elastomer components when dried after exposure to ethanol blends
- Greater shrinkage 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 seals and gaskets causes a risk of damage or incorrect fitment of the seal during assembly of joints leading to fuel leakage. 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.

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		
GOV5-10 Ford Falcon		
Part	Description	Material
1	Seal, tank sender	rubber
2a	Gasket, carburettor	gasket
2b	Plunger, carburettor	rubber , plastic
2c	Seat, carburettor float valve	brass
2d	Needle, carburettor float valve	brass
2e	Washer, sealing	brass
2f	Washer, sealing	aluminium
3	Throttle	aluminium & brass
4	Fuel Filter	Plastic casing
5a	Housing, fuel pump	Aluminium
5b	Cap, fuel pump	Aluminium
5c	Seal, Cap, fuel pump	Rubber
5d	Diaphragm	Reinforced rubber

Note: Parts # 2a – 2f were from a Fuelmiser SB-655 carburettor overhaul kit and the fuel filter part # 4 was a Ryco Z14 as recommended by the Ford dealer.

Table 2 – Measurements at beginning of test

Pre 86 Vehicle			Pre Test measurements					
GOV5-10 Ford Falcon			S.PULP			S.PULP.E5		
Part	Description	Material	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)
1	Seal, tank sender	rubber	9.479	12.89		9.38	12.83	
2a	Gasket, carburettor	gasket	1.405	0.75		1.393	0.76	
2b	Plunger, carburettor	rubber , plastic	2.368	4		2.364	4.01	
2c	Seat, carburettor float valve	brass	13.402	7.87		13.26	7.87	
2d	Needle, carburettor float valve	brass	2.023	17.18		2.026	17.3	
2e	Washer, sealing	brass	0.214	0.54		0.214	0.66	
2f	Washer, sealing	aluminium	0.168	0.79		0.165	0.78	
3	Throttle	aluminium & brass	160.39			165.91		
4	Fuel Filter	Plastic casing	38.211	9.48		38.342	9.48	
5a	Housing, fuel pump	Aluminium	107.905			123.44		
5b	Cap, fuel pump	Aluminium	16.672			14.92		
5c	Seal, Cap, fuel pump	Rubber	2.181	0.96	84	2.106	0.96	84
5d	Diaphragm	Reinforced rubber	3.897	1.55	76	4.466	1.57	76

Table 3 – Measurements at completion of test, wet.

Pre 86 Vehicle			2000 hr measurements (wet)					
GOV5-10 Ford Falcon			S.PULP			S.PULP.E5		
Part	Description	Material	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)
1	Seal, tank sender	rubber	10.243	13.5		11.186	14.29	
2a	Gasket, carburettor	gasket	2.31	0.84		2.753	1	
2b	Plunger, carburettor	rubber , plastic	2.448	4		2.487	4.06	
2c	Seat, carburettor float valve	brass	13.4	7.85		13.269	7.87	
2d	Needle, carburettor float valve	brass	2.033	17.22		2.039	17.4	
2e	Washer, sealing	brass	0.212	0.54		0.217	0.67	
2f	Washer, sealing	aluminium	0.165	0.79		0.163	0.8	
3	Throttle	aluminium & brass	160.7			165.98		
4	Fuel Filter	Plastic casing	46.15	9.4		51.932	9.73	
5a	Housing, fuel pump	Aluminium	107.992			123.55		
5b	Cap, fuel pump	Aluminium	16.732			14.928		
5c	Seal, Cap, fuel pump	Rubber	2.549	1.11	78	2.646	1.2	70
5d	Diaphragm	Reinforced rubber	4.347	1.63	80	5.336	1.87	71

Table 4 – Measurements at completion of test, dry.

Pre 86 Vehicle			Post test measurements (dry)					
GOV5-10 Ford Falcon			S.PULP			S.PULP.E5		
Part	Description	Material	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)
1	Seal, tank sender	rubber	8.775	12.75		8.563	12.65	
2a	Gasket, carburettor	gasket	1.31	0.78		1.339	0.89	
2b	Plunger, carburettor	rubber , plastic	2.387	4.01		2.395	4.01	
2c	Seat, carburettor float valve	brass	13.328	7.85		13.186	7.87	
2d	Needle, carburettor float valve	brass	2.023	17.22		2.03	17.32	
2e	Washer, sealing	brass	0.213	0.54		0.215	0.66	
2f	Washer, sealing	aluminium	0.168	0.79		0.165	0.8	
3	Throttle	aluminium & brass	160.13			165.2		
4	Fuel Filter	Plastic casing	41.365	9.4		42.362	9.57	
5a	Housing, fuel pump	Aluminium	107.796			123.27		
5b	Cap, fuel pump	Aluminium	16.648			14.897		
5c	Seal, Cap, fuel pump	Rubber	1.967	0.93	88	1.876	0.96	84
5d	Diaphragm	Reinforced rubber	3.347	1.48	85	3.82	1.49	80

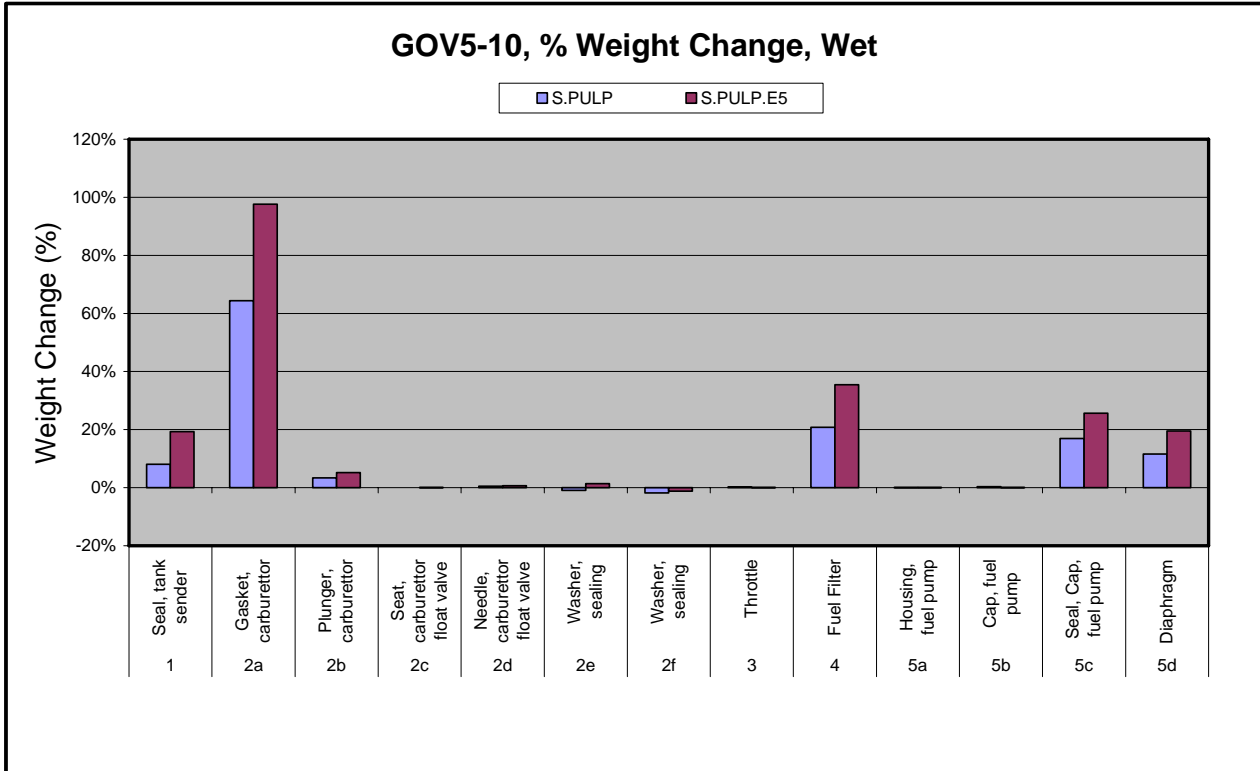


Figure 1 – Component weight change at test completion, wet.

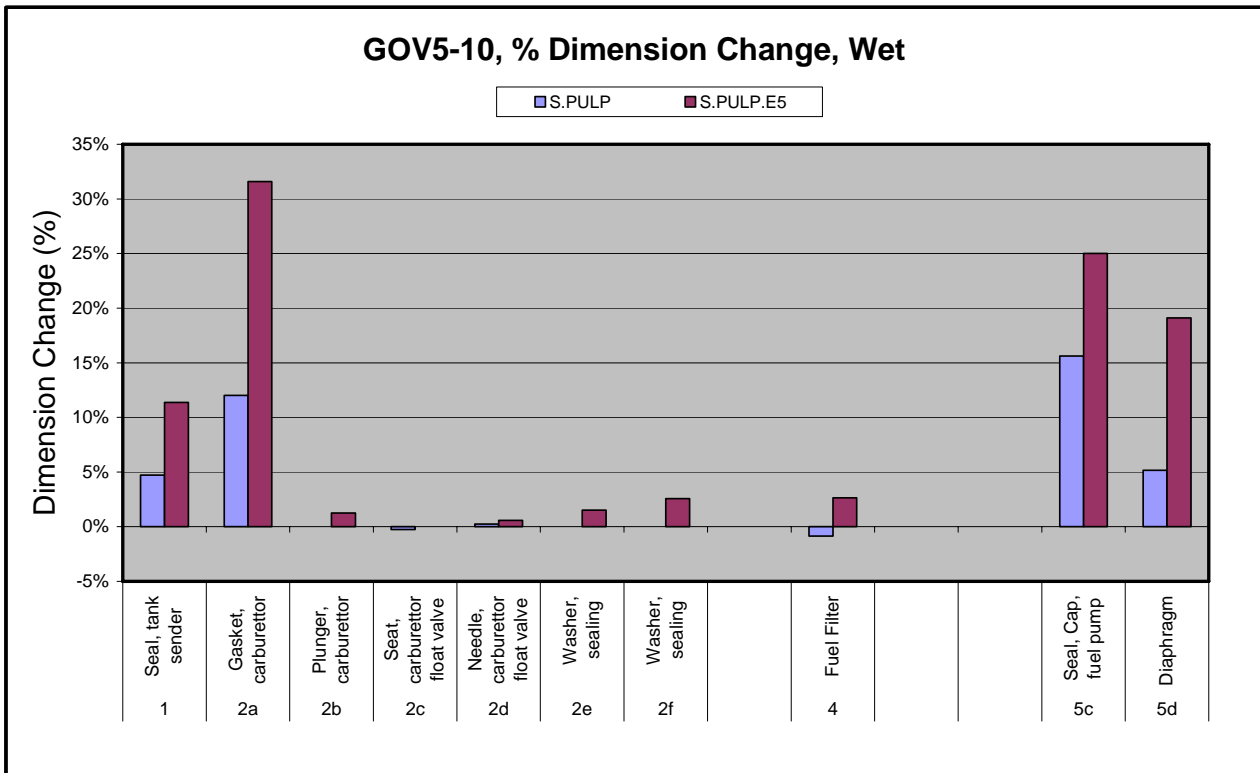


Figure 2 – Component thickness change at test completion, wet

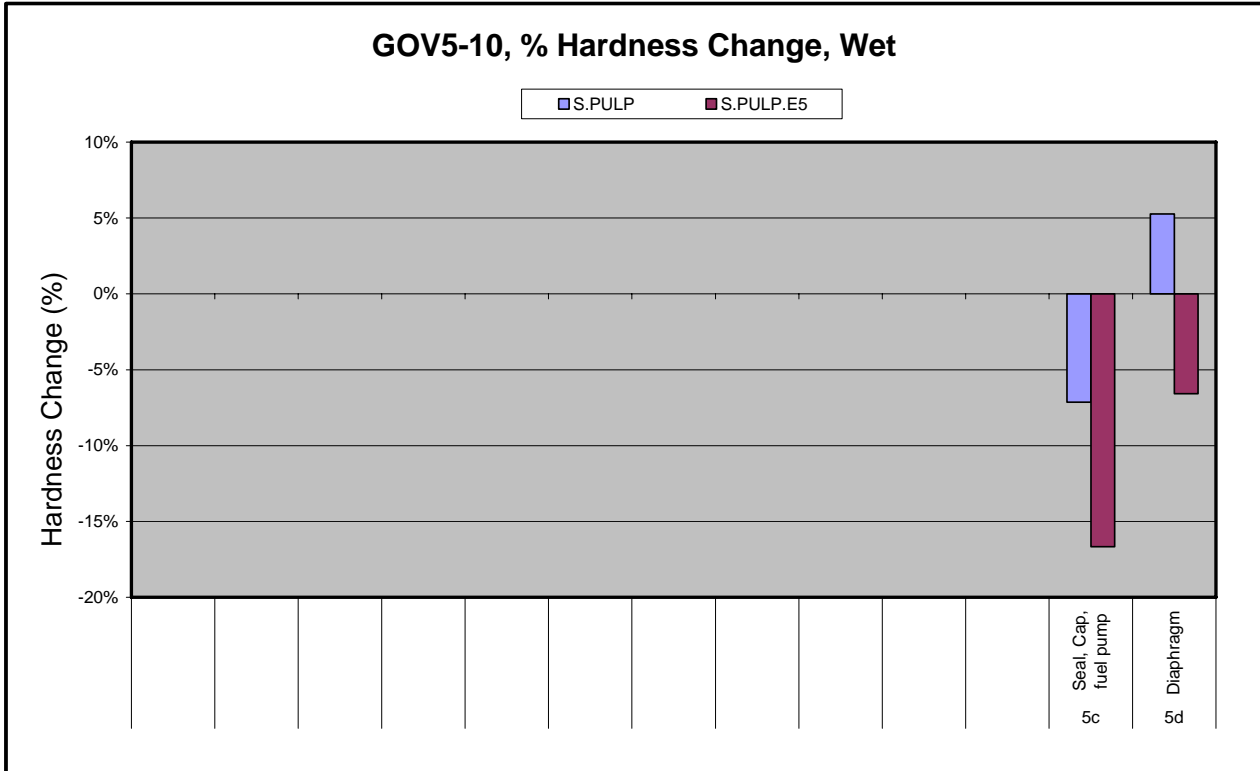


Figure 3 – Component hardness change at test completion, wet

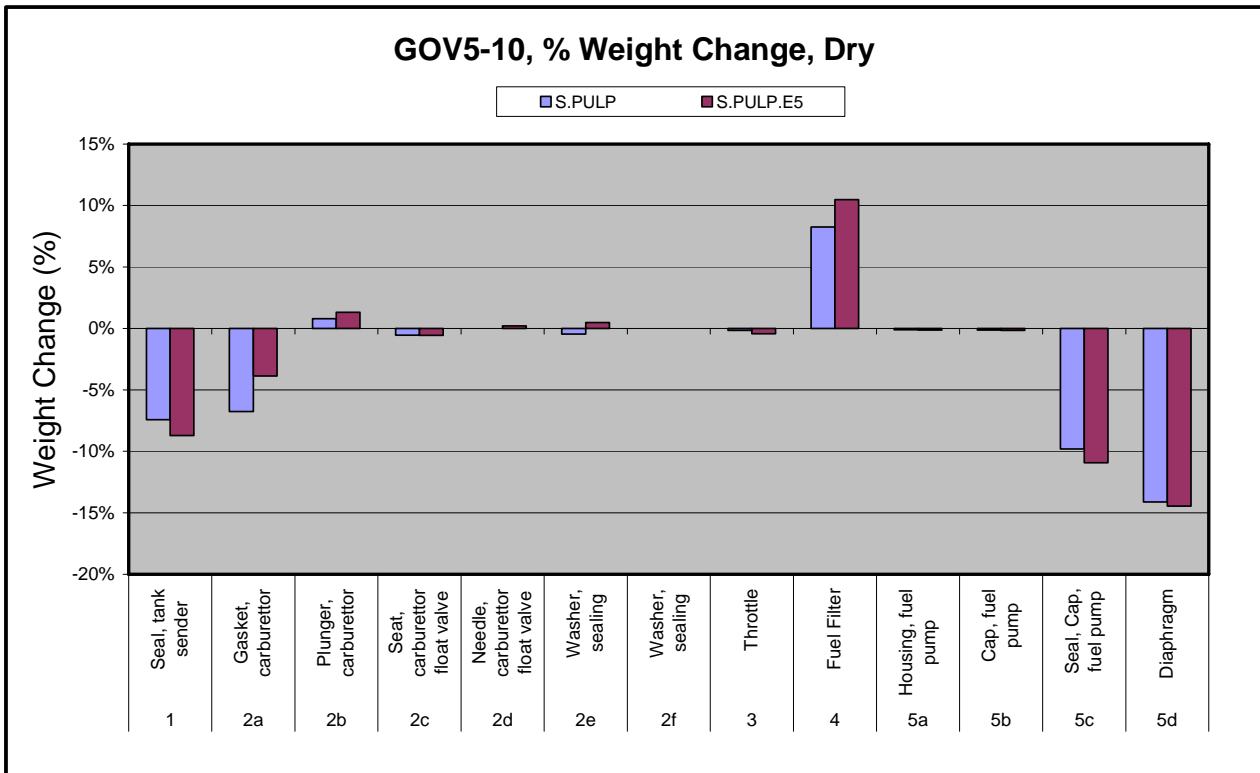


Figure 4 – Component weight change at test completion, dry

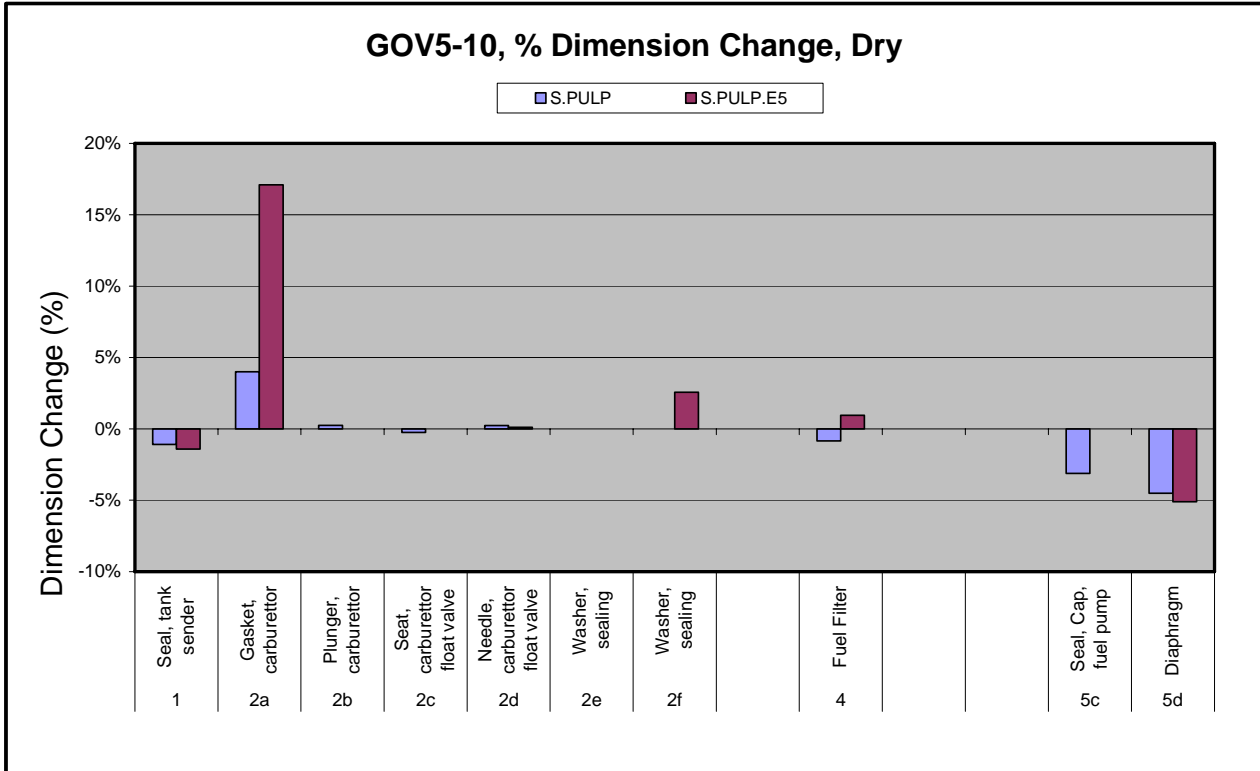


Figure 5 – Component thickness change at test completion, dry

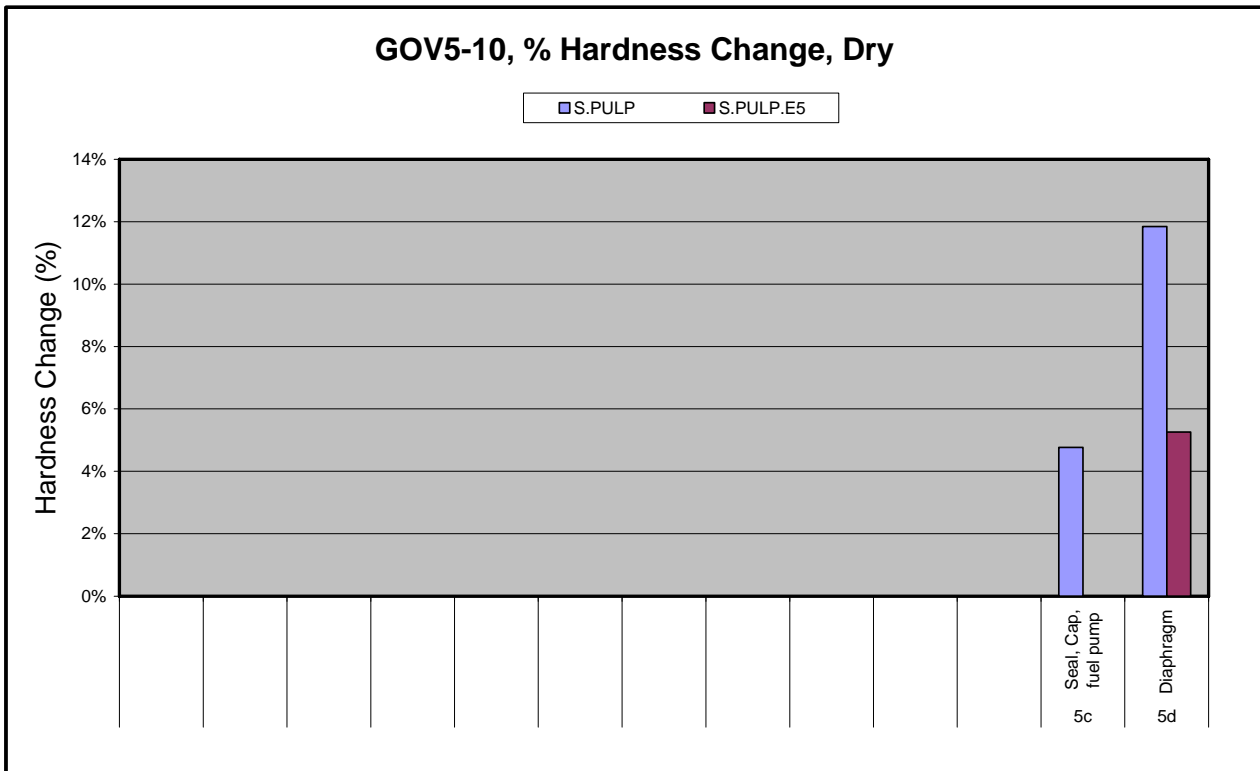


Figure 6 – Component hardness change at test completion, dry





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

Figure 7 Part # 3 Throttle

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

Figure 8 –Part # 2d Carburettor Float Valve Needle
GOV5-10 Material Compatibility Report

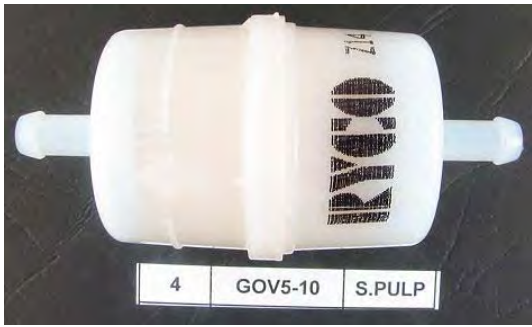



	S.PULP	S.PULP.E5
Pre Test		
Post Test (wet)		

Figure 9 Part # 4 Fuel Filter