

CUSTOMER	Department of the Environment and Heritage	PROJECT	GOV5 - 26
TITLE	Comparison of Vehicle Drivability Mitsubishi Magna – GOV5-13		

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	4.5	5.5	1.0
Warmed-up Start	5.8	7.0	1.3
Overall Restart	5.3	5.8	0.5
Idle Stability	6.3	6.3	0.0
Idle Roughness	6.3	6.0	-0.3
Launchability, Part Load	7.0	6.5	-0.5
Launchability, WOT	7.0	7.0	0.0
Acceleration Feel, Part Load	7.0	6.5	-0.5
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	6.5	6.5	0.0
Low speed shunt/chuggle	5.8	5.0	-0.8
Tip-in, Low gear	5.5	5.5	0.0
Tip-in, High gear	6.5	6.0	-0.5
Tip-out, Low gear	5.5	6.5	1.0
Tip-out, High gear	7.0	6.5	-0.5
Part Load, Steady State	6.0	7.0	1.0
Part Load, Accel (LTI, crowd)	7.0	7.0	0.0
Fuel Cut-off and re-intro shock	6.0	7.0	1.0
Full Load ,Torque Delivery	7.0	7.0	0.0
Knocking	7.0	7.0	0.0
Average	6.4	6.5	0.1
Minimum	4.5	5.0	-0.8
Maximum	7.0	7.0	1.3

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) Variability was high with this vehicle, but overall driveability and performance were similar when comparing the use of premium petrol and E5 fuels. The only difference an average driver is likely to notice is an improvement in warmed up starting. In detail:
 - a) Cold start and restart was very variable. The average improvement in start ratings is not considered to be significant due to this variability. The data does not indicate that an average driver would notice any differences.
 - b) Warmed up start results were more consistent, an average driver would probably notice improved starting with E5 over PULP.
 - c) The apparent deterioration in low speed shunt/chuggle with E5 is unlikely to be significant.

CONCLUSIONS CONTINUED OVER...

CONCLUSIONS/DISCUSSION continued

- d) The apparent improvements in part load steady state, low gear tip-out and fuel cut-off with E5 are down to a single test that gave poor results on PULP. It is unlikely that an average driver would notice any differences.
- 2) Unless discussed above, the subjective ratings, as assessed by two drivers, provided acceptable agreement.

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

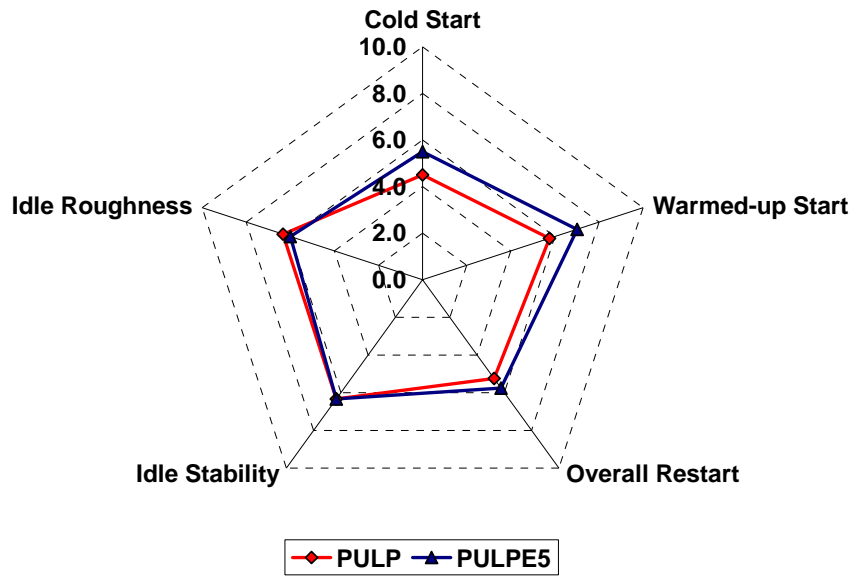


Figure 1 - Start and Idle Quality

Vehicle Performance

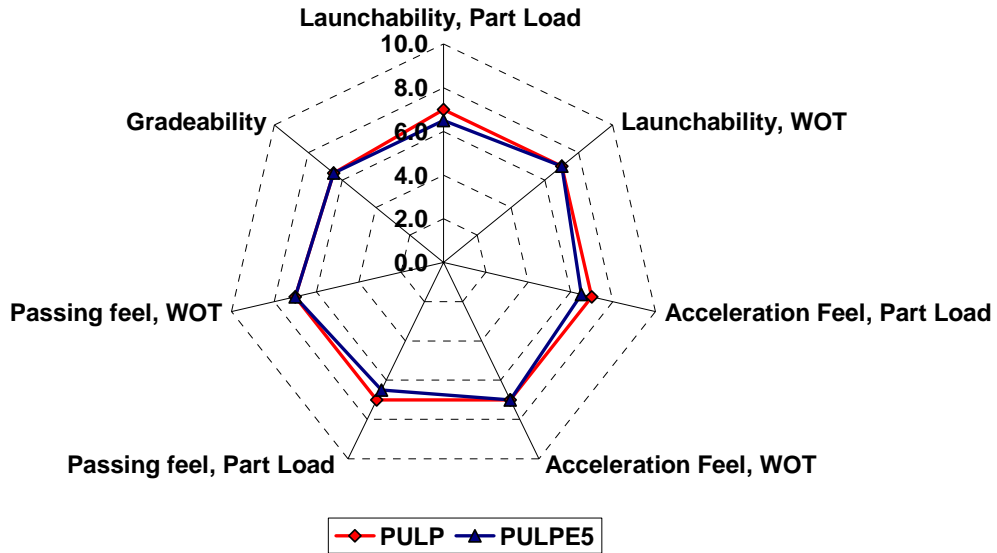


Figure 2 - Vehicle Performance Comparison

Warmed-up Driveability

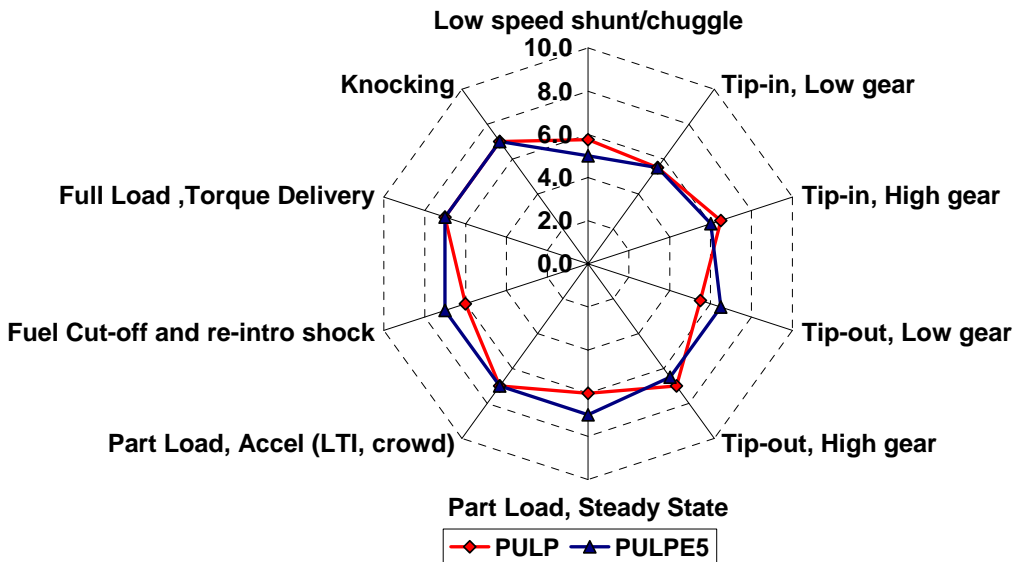


Figure 3. – Warmed – up Driveability Comparison

Attachment 2 Vehicle Appraisal Results #1 PULP

Vehicle Appraisal Form Fuel (1, driver A)

Vehicle name	GOV513 Mitsubishi	Test date	3/08/2006
Mileage (km)	190814	Test time	9:45
Ambient temperature (deg C)	approx 14	Test road	Balcatta Area
Barometric pressure (Kpa)	102.1	Engine	2.6L, In line, 4cyl
Test driver	HS1	Fuel	PULP
Co-driver		Oil	SAE 10W40

1. Startability		Rating	Remarks
Cold start	Starting Time	7	
	Flare to idle	1	
	Restartability	5	
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	
	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)	6	
Tip-out (1st and 2nd gear)		6	
Tip-in (3rd,4th and 5th gear)		6	
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	GOV513 Mitsubishi	Test date	4/08/2006
Mileage (km)	190828	Test time	3:00
Ambient temperature (deg C)	10.3	Test road	Balcatta Area
Barometric pressure (Kpa)	1020	Engine	2.6L, In line, 4cyl
Test driver	AT1	Fuel	PULP
Co-driver	DFN	Oil	SAE 10W40

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

Attachment 4 Vehicle Appraisal Results #1 PULPE5

Vehicle Appraisal Form (Fuel 2, driver A)

Vehicle name	GOV513 Mitsubishi	Test date	8/08/2006
Mileage (km)	190878	Test time	8:45
Ambient temperature (deg C)	13.5	Test road	Balcatta Area
Barometric pressure (Kpa)	102.6	Engine	2.6L, In line, 4cyl
Test driver	AT1	Fuel	PULPE5
Co-driver	DFN	Oil	SAE 10W40

1. Startability		Rating	Remarks
Cold start	Starting Time	4	Stall after start
	Flare to idle	4	
	Restartability	4	
Warmed up start	Starting Time	7	
	Flare to idle	7	
	Restartability	7	
2. Idle Quality		Rating	Remarks
RPM stability	No load	7	
	part load	6	
	Full load	6	
Idle roughness	No load	7	
	part load	5	
	Full load	5	
3. Performance		Rating	Remarks
Launch feel	Part throttle	7	
	WOT	7	
Accel feel	Part throttle	7	
	WOT	7	
Passing feel	Part throttle	7	
	WOT	7	
Gradeability		7	
Long hill climbing ability		7	
4. Acceleration Pedal Feel		Rating	Remarks
Effort	Start		
	End		
Linearity			
Stroke			
5. Clutch Pedal Feel		Rating	Remarks
Effort	Start		
	End		
Stroke			
Linkage noise			
6. Driveability		Rating	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)		5	
Low speed shunt/chuggle		5	
Tip-in (1st and 2nd gear)	("n/a" if auto)	6	
Tip-out (1st and 2nd gear)		6	
Tip-in (3rd,4th and 5th gear)		7	
Tip-out (3rd, 4th and 5th gear)		6	
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 5 Vehicle Appraisal Results #2 PULPE5

Vehicle Appraisal Form (Fuel 2, driver B)

Vehicle name	GOV513 Mitsubishi	Test date	8/08/2006
Mileage (km)	190894	Test time	15:30
Ambient temperature (deg C)	16.5	Test road	Balcatta Area
Barometric pressure (Kpa)	102.7	Engine	2.6L, In line, 4cyl
Test driver	HS1	Fuel	PULPE5
Co-driver	DFN	Oil	SAE 10W40

1. Startability		Rating	Remarks	
Cold start	Starting Time	7		
	Flare to idle	7		
	Restartability	5		
Warmed up start	Starting Time	7		
	Flare to idle	7		
	Restartability	7		
2. Idle Quality		Rating		Remarks
RPM stability	No load	7		
	part load	6		
	Full load	6		
Idle roughness	No load	7		
	part load	6		
	Full load	6		
3. Performance		Rating	Remarks	
Launch feel	Part throttle	6		
	WOT	7		
Accel feel	Part throttle	6		
	WOT	7		
Passing feel	Part throttle	6		
	WOT	7		
Gradeability		6		
Long hill climbing ability		6		
4. Acceleration Pedal Feel		Rating		Remarks
Effort	Start			
	End			
Linearity				
Stroke				
5. Clutch Pedal Feel		Rating		Remarks
Effort	Start			
	End			
Stroke				
Linkage noise				
6. Driveability		Rating	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)		5		
Low speed shunt/chuggle		5		
Tip-in (1st and 2nd gear)	("n/a" if auto)	5		
Tip-out (1st and 2nd gear)		7		
Tip-in (3rd,4th and 5th gear)		5		
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 Mitsubishi Magna – GOV5-13		

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)	2.2	1.2	2.2
Restart Time - 30min Soak (seconds)	1.0	1.1	1.0
Restart Time - Ext. Idle/20min Soak (seconds)	0.9	1.1	0.9
Hot Startability (10min. Soak)	5.8	5.5	-0.3
Hot Idle Quality (10min. Soak)	6.8	7.0	0.3
Hot Restartability (30min. Soak)	6.8	5.5	-1.3
Hot Idle Quality (30min. Soak)	6.8	6.5	-0.3
Hot Idle Quality (40min. Idle)	7.0	6.0	-1.0
Hot Startability (Ext. Idle/20min. Soak)	6.3	6.0	-0.3
Hot Idle Quality (Ext. Idle/20min. Soak)	6.8	6.5	-0.3
Hot Acceleration - Idle Racing Mode	6.3	6.5	0.3
Restart and idle after drive rating	6.0	5.9	-0.1
Hot Soak & Drive Idle Quality	6.0	6.0	0.0
Part Throttle Acceleration	6.7	6.6	-0.1
WOT acceleration	7.0	7.0	0.0
50km/h Steady State	7.0	6.8	-0.3
70km/h Steady State	7.0	7.0	0.0
Average all.	6.6	6.3	-0.2
Minimum	5.8	5.5	-1.3
Maximum	7.0	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. Two features of this may be noticed by an average driver. In detail:
 - a) After the 30 min soak E5 had a poorer restart than PULP. This may be noticed by an average driver with introduction of E5.
 - b) Hot idle quality after extended idle is reduced with E5. This may be noticed by an average driver.
 - c) Vehicle stalled on WOT pull-away with PULP on one run only. All other runs with both fuels rated normal so this is considered to be an isolated occurrence and not significant.
- 2) The objective start times recorded did not agree with the subjective ratings given by the drivers. This is thought to be due to errors in the recordings, so conclusions have been based on the driver's subjective ratings, ignoring the times recorded.
- 3) The Magna's driveability was variable; fuel type did not seem to have an affect on this.
- 4) With the exception of the driveability; the subjective ratings, as assessed by two drivers, provided acceptable agreement.

CONCLUSIONS CONTINUED OVER...

CONCLUSIONS/DISCUSSION continued

- 5) With the exception of hot 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

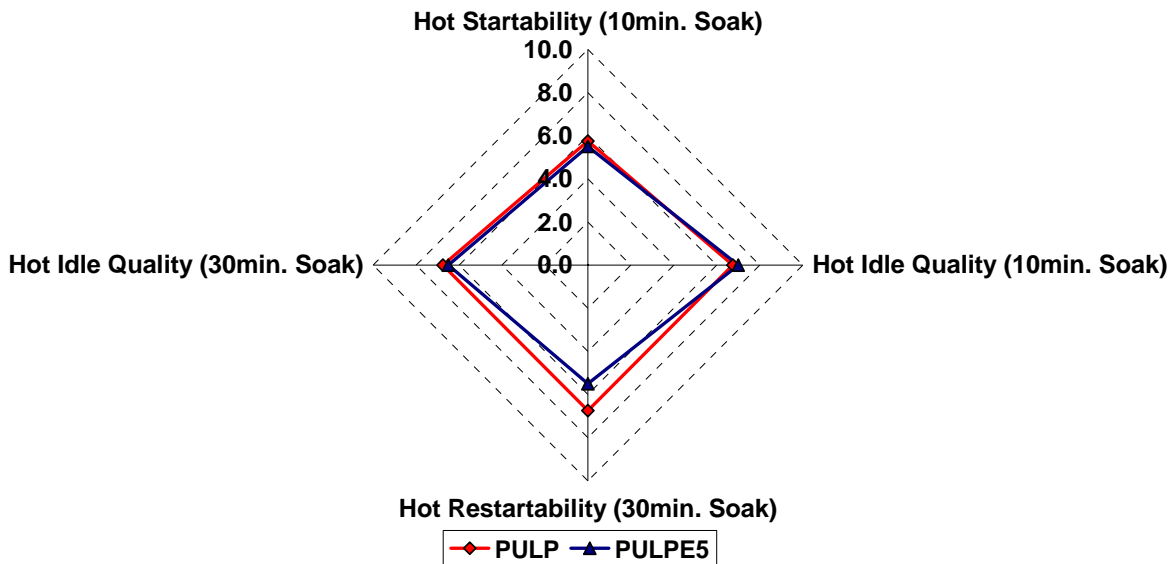


Figure 1 – Hot Start and Idle after Soak

Hot Extended Idle Test and 20min. Hot Soak

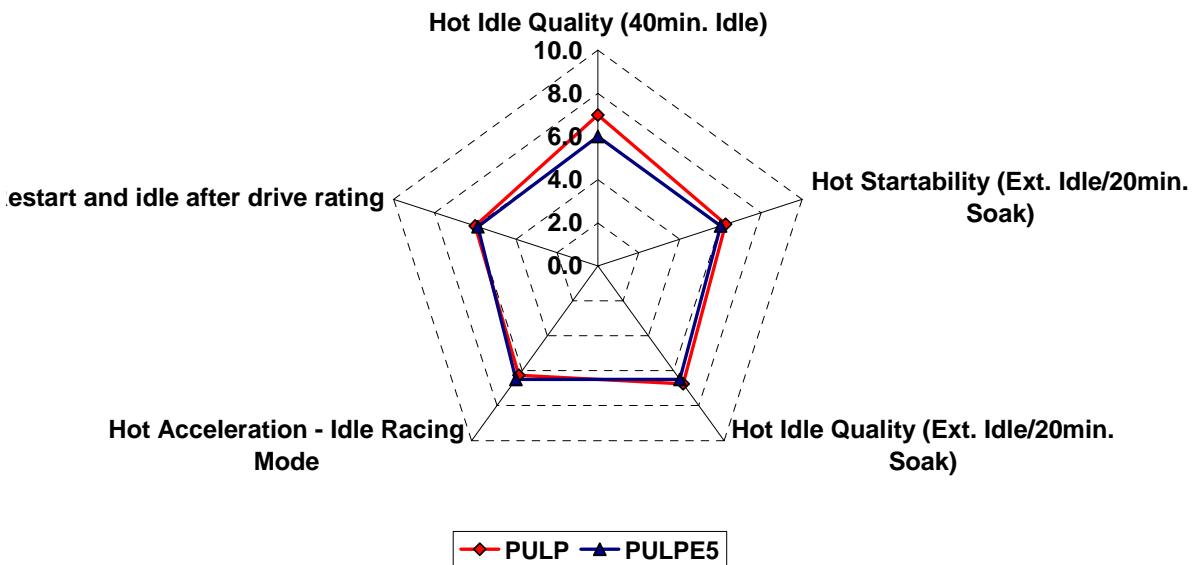


Figure 2 – Hot Start and Idle after extended idles and soaks

Hot Driveability Test

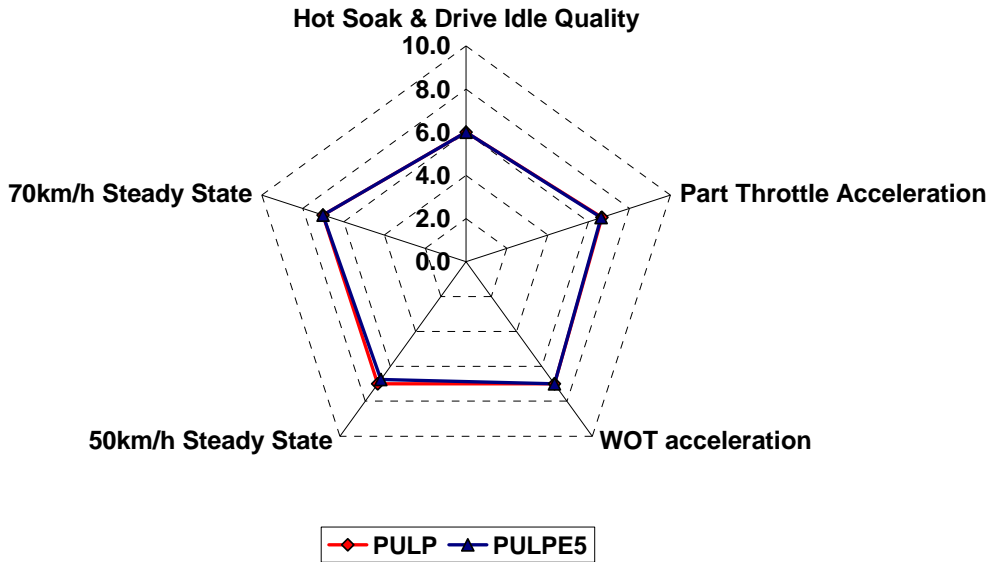


Figure 3 – Hot Driveability Comparison

Hot Start Times



*This data is average of two test measurements

Figure 3 – Hot Start Times

Attachment 2 Hot start and driveability evaluation results #1 PULP

Hot Start and Driveability Evaluation, 1a

Vehicle Number	GOV513	Registration	7HT 372
Vehicle name	Mitsubishi Magna	Test date	2/08/2006
Vehicle colour	Beige	Test time	11:06_13:30 drive
Mileage (km)	190774		
Ambient temperature (deg C)	19.1	Engine	2.6L, In line, 4cyl
Barometric pressure (Kpa)	101.8	Fuel	PULP
Test driver	AT1/ras	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	38	94	93
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.994		
Evaluate startability	5.5		
Evaluate idle roughness for 10 sec.	6.5		
Ignition-off and soak 30 minutes			
Ignition-on	37	68	68
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.292		
Evaluate re-startability	6.5		
Evaluate idle roughness for 10 sec.	6.5		

Data file names: C:\logsgov05veh_13_HTST1

Data file names: C:\logsgov05veh_13_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	41	92
Record data, 10 minute	7	42	87
Record data, 20 minute	7	38	91
Record data, 30 minute	7	38	89
Record data, 40 minute	7	38	88
Ignition-off and soak 20 minutes			
Ignition on	38	79	71
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.588		
Evaluate startability	5.5		
Evaluate idle roughness	6.5		

Data file names: C:\logsgov05veh_13_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

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	

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

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

Driveability Ratings:

Idle during drive	5.1
Start after various soak times	5.9
Average accel rating	6.8
Average Steady speed rating	7

Attachment 3 Hot start and driveability evaluation results #2 PULP

Hot Start and Driveability Evaluation, 1b

Vehicle Number	GOV513	Registration	7HT 372
Vehicle name	Mitsubishi Magna	Test date	2/08/2006
Vehicle colour	Beige	Test time	4:00:00 PM_18:00 drive
Mileage (km)	190784		
Ambient temperature (deg C)	16.8	Engine	2.6L, In line, 4cyl
Barometric pressure (Kpa)	102	Fuel	PULP
Test driver	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	47	61	94
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	2.4 >3s	No data, based on est/rating	
Evaluate startability	6	Data file names: C:\logsgov05veh_13_HTST4	
Evaluate idle roughness for 10 sec.	7		
Ignition-off and soak 30 minutes			
Ignition-on	40	66	70
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.767 >1s		
Evaluate re-startability	7		
Evaluate idle roughness for 10 sec.	7		
		Data file names: C:\logsgov05veh_13_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	44	103
Record data, 10 minute	6.5	42	84
Record data, 20 minute	6.5	43	84
Record data, 30 minute	7	43	84
Record data, 40 minute	7	41	84
Ignition-off and soak 20 minutes			
Ignition on	39	80	73
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.2 >1s	based on est/rating	
Evaluate startability	7	Data file names: C:\logsgov05veh_13_HTST6	
Evaluate idle roughness	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

6.5

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

Driveability Ratings:

Idle during drive	6.9
Start after various soak times	6.5
Average accel rating	5.8
Average Steady speed rating	7

Attachment 4 Hot start and driveability evaluation results #1 E5

Hot Start and Driveability Evaluation, 2a

Vehicle Number	GOV513	Registration	7HT 372
Vehicle name	Mitsubishi Magna	Test date	4/08/2006
Vehicle colour	Beige	Test time	14:20
Mileage (km)	190845		
Ambient temperature (deg C)	20	Engine	2.6L, In line, 4cyl
Barometric pressure (kPa)	102.1	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	45	92	93
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.993	1s est	
Evaluate startability	5	Data file names: C:\logs\gov05veh_13_HTST7	
Evaluate idle roughness for 10 sec.	7		
Ignition-off and soak 30 minutes			
Ignition-on	50	75	72
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.2	0.7s est (No data - est modified based on other starts)	
Evaluate re-startability	5		
Evaluate idle roughness for 10 sec.	7	Data file names: C:\logs\gov05veh_13_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	47	105
Record data, 10 minute	6	52	93
Record data, 20 minute	6	47	108
Record data, 30 minute	6	46	85
Record data, 40 minute	6	45	100
Record data, 40 minute			84
Record data, 40 minute			91
Record data, 40 minute			84
Record data, 40 minute			94
Ignition-off and soak 20 minutes			
Ignition on	38	81	77
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.258	0.7s est	
Evaluate startability	6	Data file names: C:\logs\gov05veh_13_HTST9	
Evaluate idle roughness	6		

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	6
50km/hr cruise	7
Stop and idle 10 seconds	7
WOT to 70km/hr	7
70km/hr cruise	7
Stop and idle 10 seconds	6
1/4 throttle to 50km/hr	7
50km/hr cruise	7
3/4 throttle to 70km/hr	6
70km/hr cruise	7
Stop and idle 10 seconds	6
Interrupted acceleration	6
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	6

Driveability Ratings:

Idle during drive	6.4
Start after various soak times	5.5
Average accel rating	6.6
Average Steady speed rating	7

Attachment 5 Hot start and driveability evaluation results #2 E5

Hot Start and Driveability Evaluation, 2b

Vehicle Number	GOV513	Registration	7HT 372
Vehicle name	Mitsubishi Magna	Test date	7/08/2006
Vehicle colour	Beige	Test time	08h15 ~ 11:00: drive
Mileage (km)	190870		
Ambient temperature (deg C)	18.6	Engine	2.6L, In line, 4cyl
Barometric pressure (Kpa)	101.1	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			
Ignition on	38	90	105
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.502	1s est	
Evaluate startability	6	Data file names: C:\logsgov05veh_ 13_HTST10	
Evaluate idle roughness for 10 sec.	7		
Ignition-off and soak 30 minutes			
Ignition-on	38	74	73
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	1.089	0.8s est	
Evaluate re-startability	6	Data file names: C:\logsgov05veh_ 13_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	40	85
Record data, 10 minute	6	38	84
Record data, 20 minute	6	43	87
Record data, 30 minute	6	44	89
Record data, 40 minute	6	44	90
Ignition-off and soak 20 minutes			
Ignition on	43	92	83
Crank after fuel pump relay is off. No start if crank time is > 10 seconds			
Crank time	0.9	modified looking at other data)	
Evaluate startability	6	Data file names: C:\logsgov05veh_ 13_HTST12	
Evaluate idle roughness	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

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	

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

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

Driveability Ratings:

Idle during drive	5.4
Start after various soak times	6.0
Average accel 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 Mitsubishi Magna – GOV5-13		

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)		1.7*	1.4	XXXX
Restart Time (seconds)		0.7*	0.8	XXXX
Cold Startability		7.0*	6.5	-0.5
Cold Restartability		7.0*	7.0	0.0
Cold Idle Roughness/Stability No Load		7.0	6.0	-1.0
Cold Idle Roughness/Stability Electrical load		7.0	6.0	-1.0
Cold Idle Roughness/Stability Elec+P/S load		7.0	6.0	-1.0
Cold Acceleration Idle racing mode		3.3	6.0	2.8
Warm-up idle Roughness/Stability		6.6	6.5	-0.1
Warmed up idle and restart		6.6	6.6	0.0
Part Throttle Acceleration		6.3	5.3	-1.0
Interrupted accel		5.0	6.0	1.0
WOT acceleration		3.5	5.0	1.5
50km/h steady state		6.5	7.0	0.5
60/70km/h steady state		6.7	6.3	-0.3
Average		5.9	6.2	0.1
Minimum		3.3	5.0	-1.0
Maximum		7.0	7.0	2.8

*result of single test 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. Variability was high with this vehicle. Although E5 did appear to improve some features of the vehicle's driveability, it caused stalling in some instances. In detail:
 - a. The Magna drove poorly on the colder, ½ and ¼ throttle accelerations. This was made worse by use of E5, causing stall or near stall on ¼ throttle accelerations. This effect is more severe than indicated by the chart; an average driver would probably notice it.
 - b. Idle racing smoke and response indicate an average driver would probably notice an improvement with E5.
 - c. The improvement in driveability for WOT and interrupted accelerations with E5 may be noticed by an average driver.
 - d. The idle degradation seen with E5 was due to a single test with no other supporting data. Any difference in idle quality is unlikely to be noticed by an average driver.
 - e. On one cold start with PULP the battery failed. The subsequent starts with a booster battery are likely to have been affected. Therefore this data has been excluded from the analysis. Any difference in cold start/restart is unlikely to be noticed by an average driver.

CONCLUSIONS CONTINUED OVER...

CONCLUSIONS/DISCUSSION continued

2. The objective start times recorded agree with the subjective ratings given by the drivers.
3. The Magna performance was variable on either fuel. 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

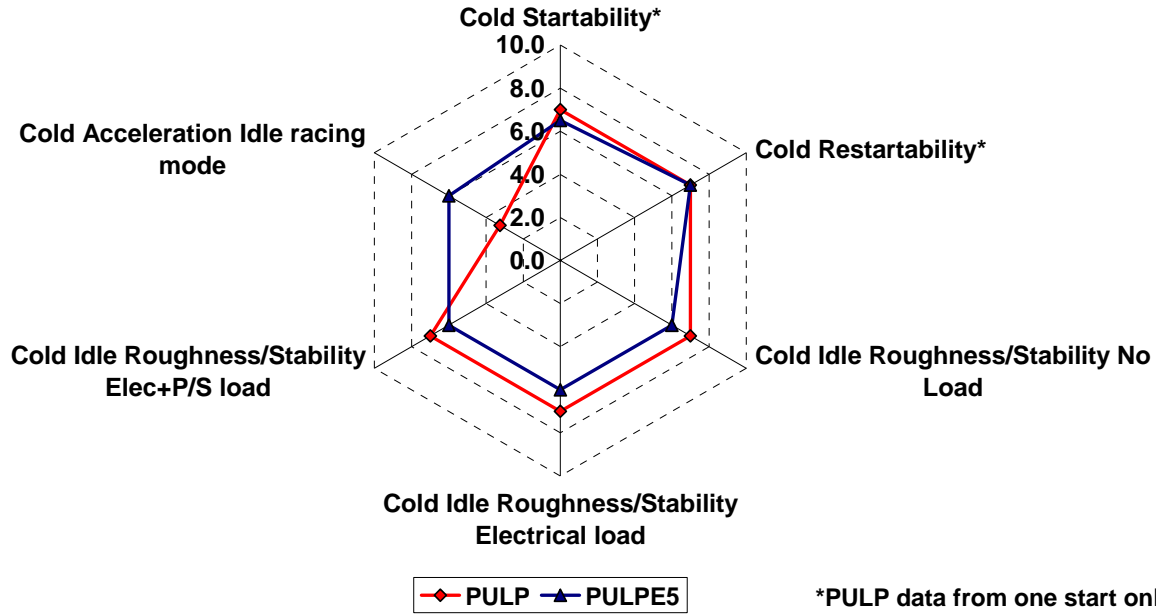


Figure 1 – Cold Start and Idle Quality

Warm-up Driveability after Cold Start

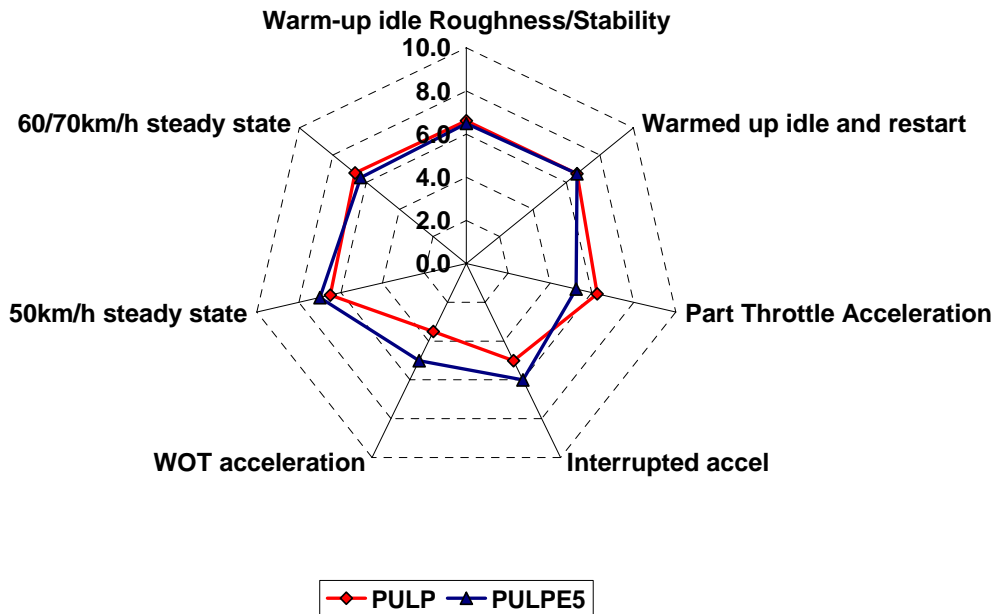
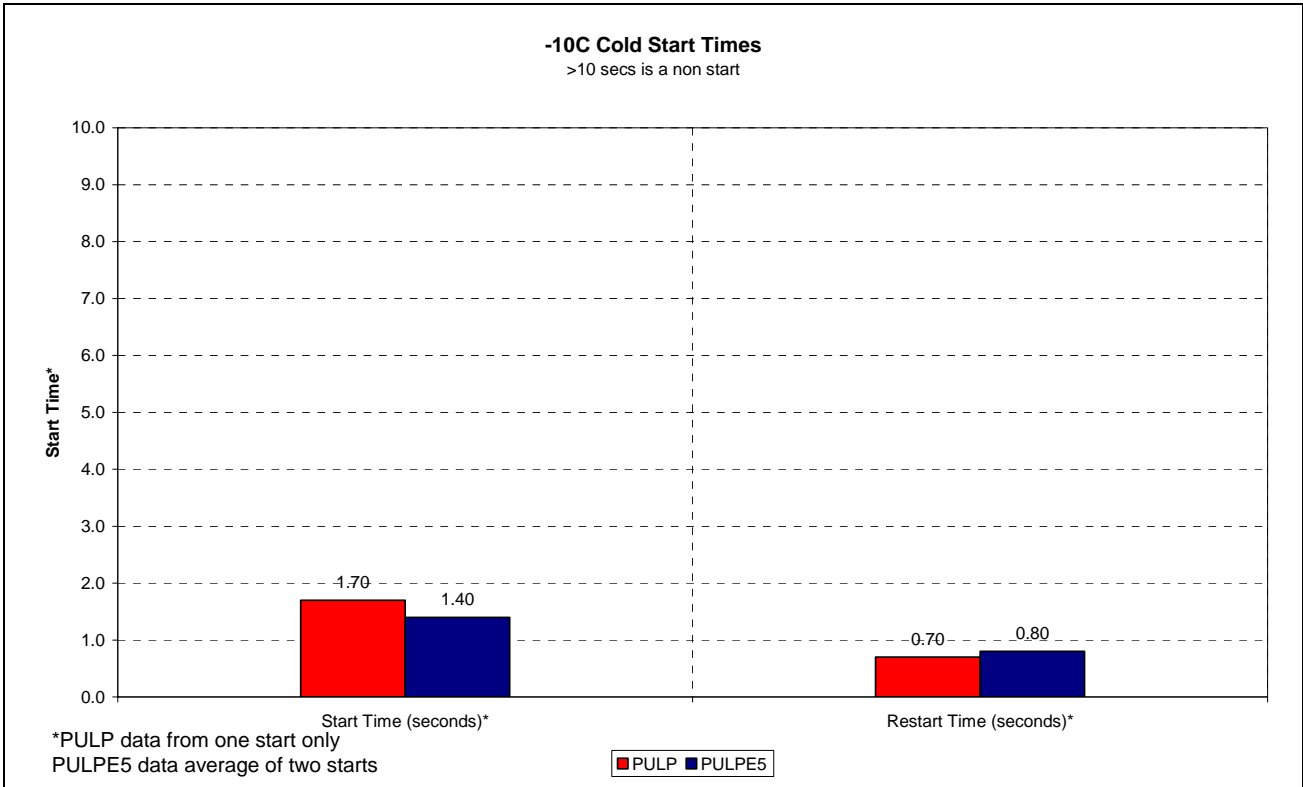


Figure 2 – Driveability during Warm-up



Attachment 2

Cold start and warm up evaluation results #1 PULP

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

Vehicle Number	GOV513	Registration	7HT 372
Vehicle name	Mitsubishi Magna	Test date	9/08/2006
Vehicle colour	Beige	Test time	09:30
Mileage (km)	190911		
Ambient temperature (deg C)	12	Engine	2.6L, In line, 4cyl
Barometric pressure (Kpa)	102.9	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)
		-12	-12	-11

Ignition on
Crank after fuel pump relay is off. No start if crank time is > 10 seconds
Crank time Battery flat: Jump start required. Crank speed :
Evaluate startability Stall
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_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

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="6"/>
Stop and idle 10 seconds	<input style="width: 50px;" type="text" value="7"/>
WOT to 70km/hr	<input style="width: 50px;" type="text" value="4"/>
70km/hr cruise	<input style="width: 50px;" type="text" value="6"/>
Stop and idle 10 seconds	<input style="width: 50px;" type="text" value="5"/>
1/4 throttle to 50km/hr	<input style="width: 50px;" type="text" value="6"/>
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="6"/>
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="6"/>
Steering lock to lock	<input style="width: 50px;" type="text" value="6"/>
Idle in P/N	<input style="width: 50px;" type="text" value="6"/>
Ignition off	<input style="width: 50px;" type="text" value="7"/>
Restart	<input style="width: 50px;" type="text" value="7"/>

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

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

Vehicle Number	GOV513	Registration	7HT 372
Vehicle name	Mitsubishi Magna	Test date	9/08/2006
Vehicle colour	Beige	Test time	16h00
Mileage (km)	190916		
Ambient temperature (deg C)	17.4	Engine	2.6L, In line, 4cyl
Barometric pressure (Kpa)	102.9	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	-10	-11

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

Crank time	1.7
Evaluate startability	7

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

Crank time	0.7
Evaluate re-startability	7

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

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?	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	7
1/2 throttle to 50km/hr	7

Cold Start and Warm-up Evaluation

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

50km/hr cruise	6
Stop and idle 10 seconds	7
WOT to 70km/hr	3
70km/hr cruise	6
Stop and idle 10 seconds	7
1/4 throttle to 50km/hr	5
50km/hr cruise	7
3/4 throttle to 70km/hr	7
70km/hr cruise	7
Stop and idle 10 seconds	7
Interrupted acceleration	3
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

severe tip out misfire.

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

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

Vehicle Number	GOV513	Registration	7HT 372
Vehicle name	Mitsubishi Magna	Test date	10/08/2006
Vehicle colour	Beige	Test time	0.354166667
Mileage (km)	190924		
Ambient temperature (deg C)	9.1	Engine	2.6L, In line, 4cyl
Barometric pressure (Kpa)	102.4	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)
	-11	-11	-10.5

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

Crank time	1.3
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	0.8
Evaluate re-startability	7

Data file: C:\..logs\gov05\veh_ 13_CST2a

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

Evaluate idle roughness (10 seconds)	7
--------------------------------------	---

Shift to D/R or clutch engaged

Evaluate idle roughness (10 seconds)	7
--------------------------------------	---

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

Evaluate idle roughness (10 seconds)	7
--------------------------------------	---

Turn power steering to the right end

Evaluate idle roughness (10 seconds)	7
--------------------------------------	---

Turn power steering to the left end

Evaluate idle roughness (10 seconds)	7
--------------------------------------	---

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	7
-----------------	---

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	5
----------------	---

70km/hr cruise	5
----------------	---

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

1/4 throttle to 50km/hr	1
-------------------------	---

Near stall

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	5
---------	---

Some throttle sticking led to higher idle than normal, which improved idle ratings and possibly masked tip-out issues.

Cable eased and will check on second test.

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

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

Vehicle Number	GOV513	Registration	7HT 372
Vehicle name	Mitsubishi Magna	Test date	11/08/2006
Vehicle colour	Beige	Test time	10h00
Mileage (km)	190929		
Ambient temperature (deg C)	16.5	Engine	2.6L In line, 4cyl
Barometric pressure (Kpa)	102.1	Fuel	PULPE5
Test driver	HS1/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	-10	-9.9

Ignition on

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

Crank time

1.5

Evaluate startability

7

Ignition -off within 5 seconds

Ignition-on

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

Crank time

0.8

Evaluate re-startability

7

Data file: C:..logsgov05\veh_ 13_CST2b

2. Cold idle

Cold idle quality rating

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

Evaluate idle roughness (10 seconds)

5

Shift to D/R or clutch engaged

5

Evaluate idle roughness (10 seconds)

5

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

Evaluate idle roughness (10 seconds)

5

Turn power steering to the right end

Evaluate idle roughness (10 seconds)

5

Turn power steering to the left end

Evaluate idle roughness (10 seconds)

5

Re-align steering

Turn off headlights, blower and defroster

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

7

1/2 throttle to 50km/hr

5

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

5

WOT to 70km/hr

5

70km/hr cruise

7

Stop and idle 10 seconds

7

1/4 throttle to 50km/hr

1

50km/hr cruise

7

3/4 throttle to 70km/hr

7

70km/hr cruise

6

Stop and idle 10 seconds

7

Interrupted acceleration

5

Tip-out misfire

1/2 throttle to 70km/hr

7

70km/hr cruise

6

Stop and idle 20 seconds

7

Steering lock to lock

7

Idle in P/N

7

Ignition off

Restart

6

CUSTOMER	Department of the Environment and Heritage	PROJECT	GOV005
TITLE	WOT Performance Test Mitsubishi Magna – GOV5-13		

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.

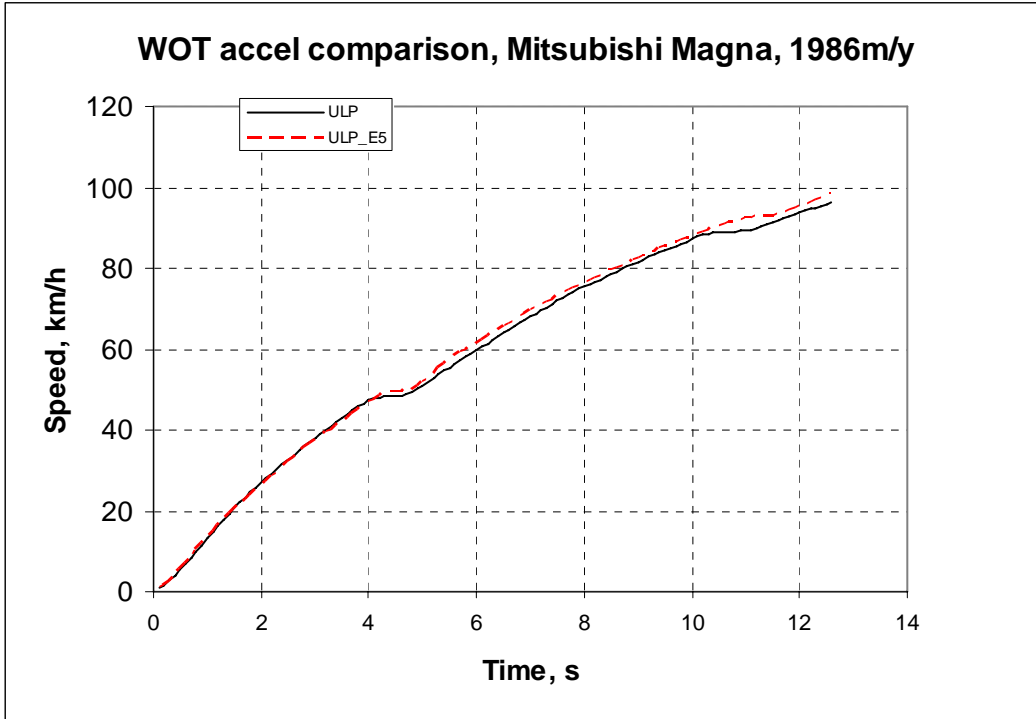


Figure 1 – Standing Start WOT Acceleration Comparison Between Petrol and E5

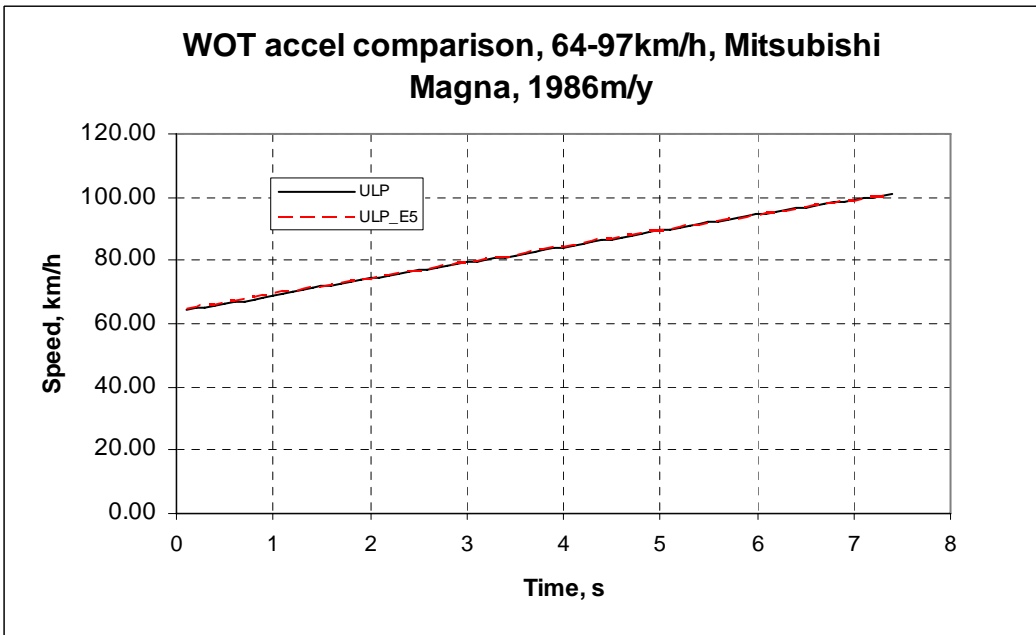


Figure 2 – 64 to 97 km/h WOT Acceleration Comparison Between Petrol and E5

Results:	ULP	ULP E5	% Improvement over Petrol. E5
0-48km/h elapsed time,s	4.23	4.07	4%
0-80km/h elapsed time,s	8.67	8.57	1%
0-97km/h elapsed time,s	12.63	12.27	3%
64-97km/h elapsed time,s	6.57	6.57	0%
0-5s distance covered, m	42.52	42.2	-1%
0-5s terminal speed, km/h	50.88	51.4	1%
0-350m elapsed time	17.43	17.3	1%
0-350m terminal speed, km/h	116.06	115.7	-0.3%
Uego Average	0.81	0.84	4%
Exhaust temp max.	825	848.9	3%

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

Table 1 – Averaged WOT Acceleration Performance Test Data

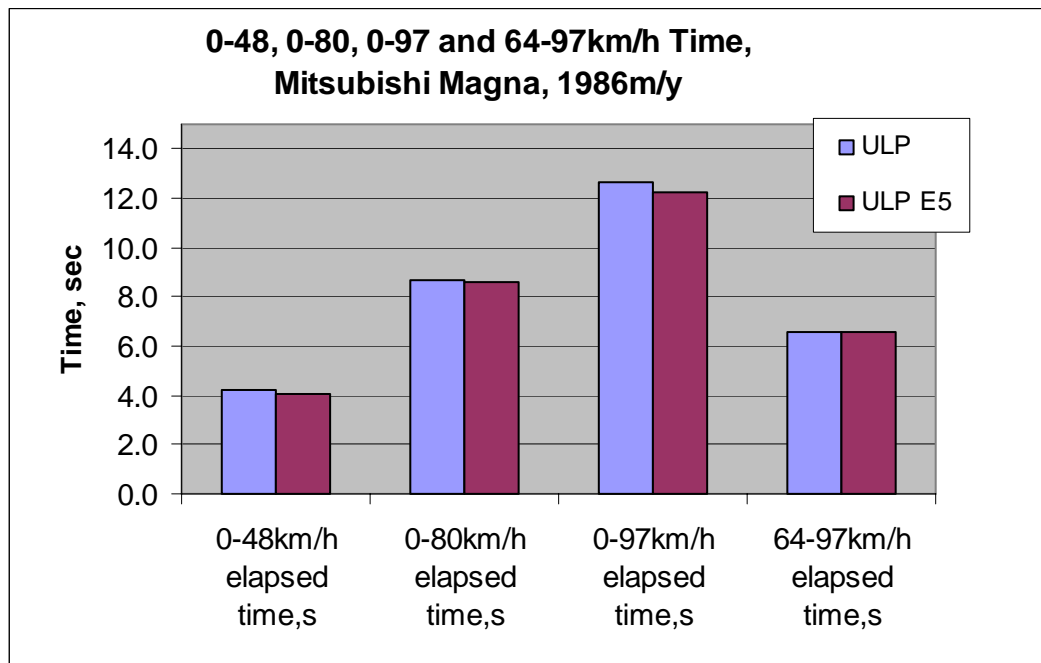


Figure 3 – Elapsed Times for WOT Accelerations

Overall the WOT acceleration test data indicates a small improvement in the acceleration times for E5 over Petrol. For the 0~97km/h test, E5 showed a 1~4% in the times to reach all speeds of 48, 80 and 97km/h. For accelerations from 64~97km/h km/h similar acceleration times were achieved for Petrol and E5 fuels.

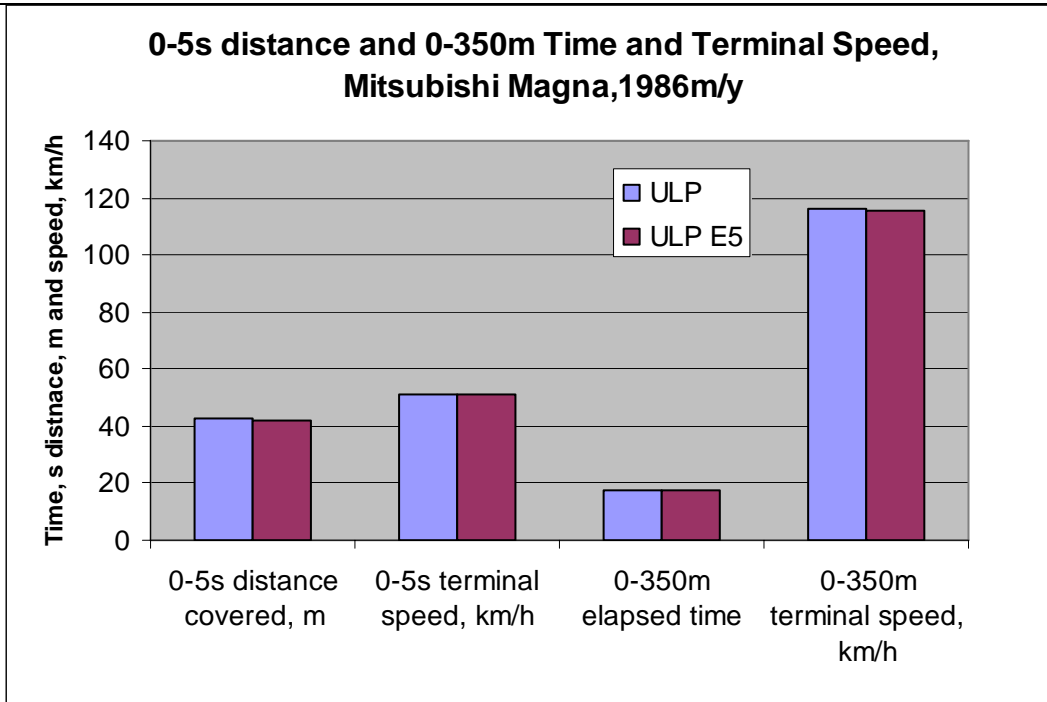


Figure 4 – 0 to 5s and 0 to 402m WOT Acceleration Performance Comparison

The 0~350m elapsed times were improved for E5 over Petrol, but the terminal speed was reduced by 0.3% for E5. Launch, as measured by the 0~5s distance was poorer for the E5 fuel by 1% compared to Petrol. Being a manual transmission vehicle, this was probably the result of driver technique, as the terminal speed after 5s was improved by 1% for E5 over Petrol.

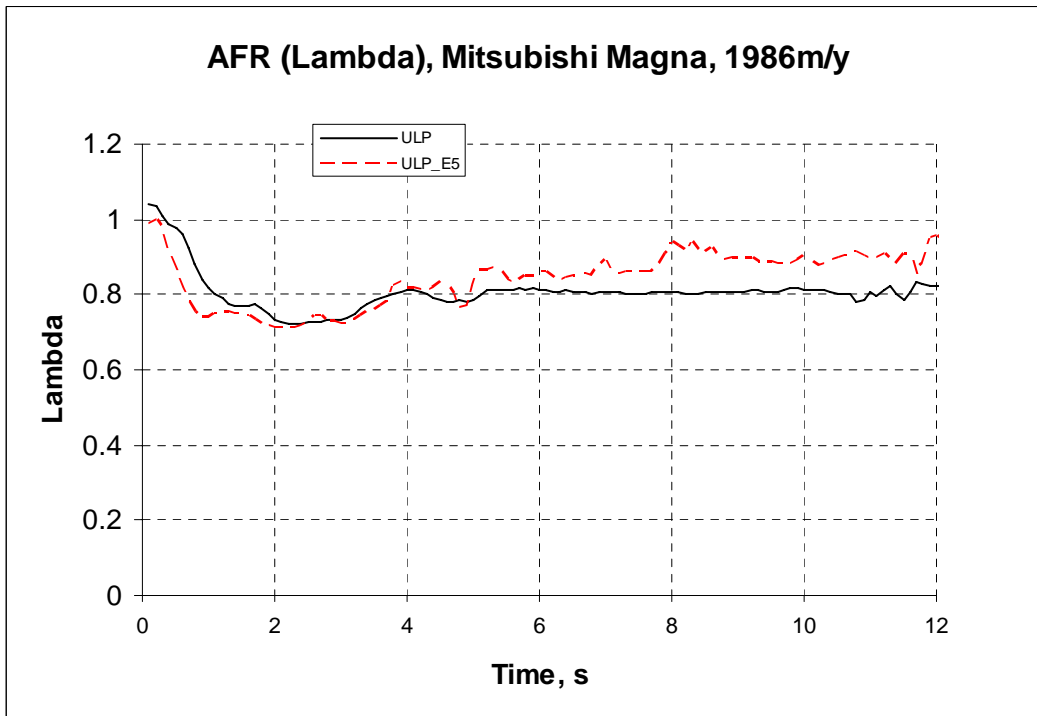


Figure 5 – Standing Start WOT Acceleration AFR Comparison

Figure 5 shows the Air/fuel Ratio (Lambda value) for the vehicle during the acceleration run. Table 1 shows that on average the engine was running 4% leaner for E5 compared to Petrol. This is consistent with a vehicle which does not apply learning to the AFR, although the measured value exceeded the expected enleanment for E5 fuel.

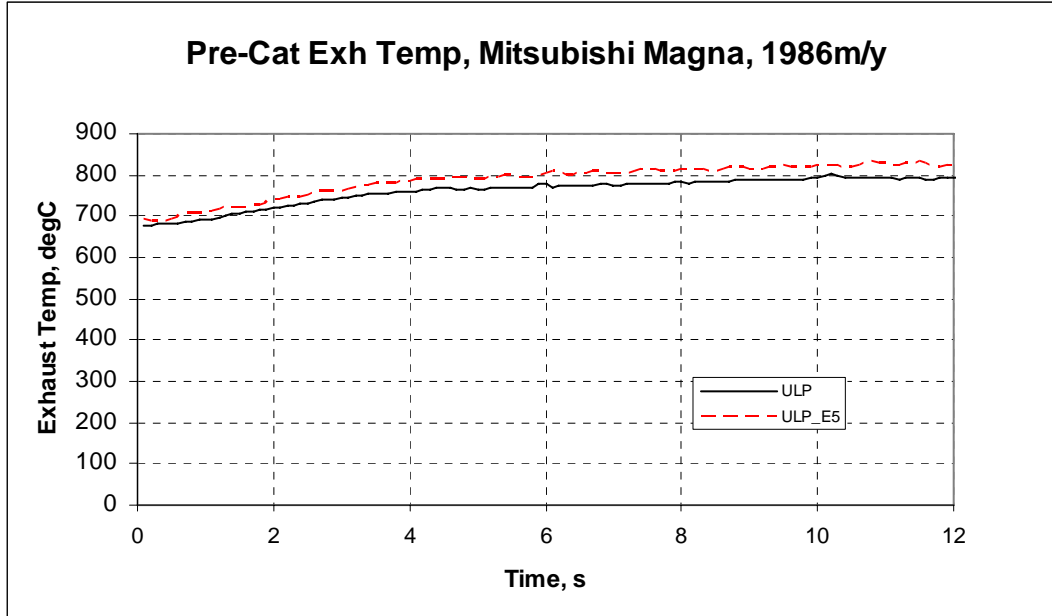


Figure 6 – Standing Start WOT Acceleration Exhaust Temperatures

The peak pre-catalyst exhaust gas temperature recorded at the end of each run was 3% higher (24degC) 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 Mitsubishi Magna indicate there is a slight improvement 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 unlikely to cause any detrimental effect on the vehicle. The increase in exhaust gas temperature to 848degC may be significant as the temperature is tending towards the limit applied to exhaust manifolds, which could lead to shorter life for this component than with petrol. However, as the temperature on E5 never exceeded the peak of 878degC recorded on one acceleration run with Petrol, this may not be an issue.

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.

Vehicle: Make <u>Mitsubishi</u> Model <u>Magna</u> Year <u>1986</u>		Test Date <u>27/09/2006</u>			
Odometer <u>191087</u> km		Car No <u>13</u>			
repeat test over 400m.					
Test Location <u>MACD no 1</u>	Driver <u>R Brooks</u>				
Start of test date <u>27/09/2006</u>	Time strt <u>15:00</u>				
End of test date <u>27/09/2006</u>	Time end <u>17:00</u>				
Transmission, type <u>5spd</u>	Automatic shift mode <u>Manual</u>				
Fuel Type <u>PULP</u>					
Remarks <u>64-97 recorded in 3rd and 4th gears, data for 4th gear below.</u>					
Ambient conditions for test:					
Temperature <u>19</u> °C	Barometric Pressure <u>102.1</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>			
Results:	Test1	Test2	Test3	Average	Variability (Max-mean)/mean
0-48km/h elapsed time,s	<u>4.8</u>	<u>3.8</u>	<u>4.1</u>	<u>4.23</u>	<u>13.39</u> %
0-80km/h elapsed time,s	<u>8.8</u>	<u>8.3</u>	<u>8.9</u>	<u>8.67</u>	<u>2.69</u> %
0-97km/h elapsed time,s	<u>12.9</u>	<u>12.1</u>	<u>12.9</u>	<u>12.63</u>	<u>2.11</u> %
64-97km/h elapsed time,s	<u>6.6</u>	<u>6.6</u>	<u>6.5</u>	<u>6.57</u>	<u>0.51</u> %
0-5s distance covered, m	<u>40.3</u>	<u>45.2</u>	<u>42.0</u>	<u>42.5</u>	<u>6.38</u> %
0-5s terminal speed, km/h	<u>48.8</u>	<u>54.4</u>	<u>49.5</u>	<u>50.9</u>	<u>6.85</u> %
0-350m elapsed time	<u>17.6</u>	<u>17.1</u>	<u>17.6</u>	<u>17.4</u>	<u>0.96</u> %
0-350m terminal speed, km/h	<u>116.1</u>	<u>116.7</u>	<u>115.4</u>	<u>116.1</u>	<u>0.56</u> %
Uego Average (Lambda)	<u>0.82</u>	<u>0.80</u>	<u>0.80</u>	<u>0.81</u>	<u>1.42</u> %
Exhaust temp max.	<u>872.4</u>	<u>833.8</u>	<u>819.8</u>	<u>824.8</u>	<u>5.76</u> %
File reference: P:\Projects\Government\GOV005\Test Data\GOV5-13 - Mitsubishi Sigma-Magna\WOT_MACD-Testing\VEH13_WOT01a_M01.xls\Report					

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

<u>Vehicle:</u> Make <u>Mitsubishi</u>		Model <u>Magna</u>	Year <u>1986</u>	Test Date <u>14/08/2006</u>	
Odometer <u>190938</u> km				Car No <u>13</u>	
<u>Test Location</u> <u>MACD no 1</u>		Driver <u>R Brooks</u>			
Start of test date <u>14/08/2006</u>		Time strt <u>15:00</u>			
End of test date <u>14/08/2006</u>		Time end <u>17:00</u>			
Transmission, type <u>5spd</u>		Automatic shift mode <u>Manual</u>			
<u>Fuel Type</u> <u>PULPE5</u>					
<u>Remarks</u> <u>64-97 recorded in 3rd and 4th gears, data for 4th gear below.</u>					
<u>Ambient conditions for test:</u>					
Temperature	<u>17</u> °C	Barometric Pressure	<u>101.8</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>4.1</u>	<u>4.1</u>	<u>4</u>	<u>4.07</u>	<u>0.82</u> %
0-80km/h elapsed time,s	<u>8.7</u>	<u>8.7</u>	<u>8.3</u>	<u>8.57</u>	<u>1.56</u> %
0-97km/h elapsed time,s	<u>12.5</u>	<u>12.3</u>	<u>12</u>	<u>12.27</u>	<u>1.90</u> %
64-97km/h elapsed time,s	<u>6.7</u>	<u>6.6</u>	<u>6.4</u>	<u>6.57</u>	<u>2.03</u> %
0-5s distance covered, m	<u>42.1</u>	<u>41.4</u>	<u>43.0</u>	<u>42.2</u>	<u>1.97</u> %
0-5s terminal speed, km/h	<u>51.3</u>	<u>50.3</u>	<u>52.7</u>	<u>51.4</u>	<u>2.41</u> %
0-350m elapsed time	<u>17.4</u>	<u>17.4</u>	<u>17.1</u>	<u>17.3</u>	<u>0.58</u> %
0-350m terminal speed, km/h	<u>114.1</u>	<u>116.6</u>	<u>116.5</u>	<u>115.7</u>	<u>0.74</u> %
Uego Average Lambda	<u>0.89</u>	<u>0.80</u>	<u>0.84</u>	<u>0.84</u>	<u>5.63</u> %
Exhaust temp max.	<u>846.8</u>	<u>850.5</u>	<u>850.0</u>	<u>848.9</u>	<u>0.19</u> %
File reference: P:\Projects\Government\GOV005\Test Data\GOV5-13 - Mitsubishi Sigma-Magna\WOT_MACD-Testing\VEH13_WOT02_M01.xls\Report					

Attachment 3

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

Vehicle: Make	Mitsubishi	Model	Magna	Year	1986	Test Date	14/08/2006
0 Odometer	191087 km					Car No	13
End Ods	184226 km						
Test Location	MACD no 1			Driver	R Brooks		
Start of test date	14/08/2006			Time strt	15:00		
End of test date	27/09/2006	Test 1 repeat		Time end	17:00		
Transmission, type	5spd			Automatic shift mode	Manual		
Fuel Type (base)	ULP						
Remarks							
Ambient conditions for test:							
Temperature	n/a °C	Barometric Pressure	n/a kPa	Relative Humidity	n/a		
Wind Velocity	roller speed km/h	Direction	Head-on	Peak wind velocity	Head-on		
Results:	<u>ULP</u>	<u>ULP E5</u>	<u>% Improvement over Petrol. E5</u>				
0-48km/h elapsed time,s	4.23	4.07	4%				
0-80km/h elapsed time,s	8.67	8.57	1%				
0-97km/h elapsed time,s	12.63	12.27	3%				
64-97km/h elapsed time,s	6.57	6.57	0%				
0-5s distance covered, m	42.52	42.2	-1%				
0-5s terminal speed, km/h	50.88	51.4	1%				
0-350m elapsed time	17.43	17.3	1%				
0-350m terminal speed, km/h	116.06	115.7	-0.3%				
Uego Average	0.81	0.84	4%				
Exhaust temp max.	825	848.9	3%				
File reference:	P:\Projects\Government\GOV005\Test Data\GOV5-13 - Mitsubishi Sigma-Magna\WOT_MACD-Testing\VEH13_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" Mitsubishi Magna GOV5-13		

AIM

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

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 Mitsubishi TM Magna or GJ Sigma, 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 GOV5-13 test parts completed 2016 hours of fluid exposure with interim progress inspections and recordings made at 500 hrs and at 1008 hours. The fluid effects noted were:

- swelling of elastomers when wet;
- shrinkage 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 4.

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, tank sender unit (part #2)
- Carburettor float (part # 3b)
- Pump gasket (part # 4b)
- Throttle gasket (part # 5)
- Fuel filter (part # 6)
- Fuel pump diaphragm (part # 7b)

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, tank sender unit (part #2)
- Diaphragm, carburettor pump (part # 4a)
- Pump gasket (part # 4b)
- Throttle gasket (part # 5)

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.

2000hr “Dry” Results for Elastomeric Components

Figure 3 shows the weight change of components when dried at the completion of the test. Of particular note was the weight loss of:

- Enrichment valve diaphragm (part #4c)

For this part 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 4 shows the change in a key dimension (where measured) of the part when dried after exposure to fuel. Typically outside diameter was measured for hoses, thickness for flat material and section diameter for O-rings. Of note was the greater shrinkage of:

- Enrichment valve diaphragm (part #4c)

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

Metal components at 2000 hrs

- Tarnishing of brass float valve seat (part # 4d), see Figure 5.
- Tarnishing of sealing washer (part # 4f), see Figure 6.

General Observations

- Discoloured filter housing (part # 6), see Figure 7.

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
- Greater weight loss by some elastomer components when dried after exposure to ethanol blends
- 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 O-rings, 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. In particular the diaphragm of the enrichment valve exhibited substantial changes of weight and thickness. Metal components which corroded during this accelerated test are

considered incompatible with the test fluid. Discolouration of the plastic fuel filter housing may indicate material compatibility.

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

ATTACHMENTS

The materials compatibility result sheets.

Table 1 – Components Tested

Pre 86 Vehicle		
GOV5-13 Mitsubishi Sigma/Magna		
Part	Description	Material
1	Throttle - carburettor	brass/steel
2	Seal, tank sender	gasket / o ring
3a	Float bowl - carburettor	plastic
3b	Float - carburettor GOV5-19 #3	plastic
4a	Pump diaphragm - carburettor	rubber/steel
4b	Pump gasket - carburettor	paper
4c	Diaphragm - enrichment valve	rubber
4d	Seat - float valve	brass
4e	Needle - float valve	brass/steel
4f	Washer - sealing	copper
4g	Washer - sealing	aluminium
4h	O-ring	rubber
5	Gasket - throttle body assy	paper
6	Fuel filter	plastic
7a	Housing - fuel pump	steel
7b	Diaphragm - fuel pump	rubber
7c	Inner Housing - fuel pump	plastic
8	Check valve assy	plastic

Note: The Carburettor components 4a – 4h were from a Fuelmiser overhaul kit MS-500B per the recommendation of the Mitsubishi dealer.

Table 2 – Measurements at beginning of test

Pre 86 Vehicle		
GOV5-13 Mitsubishi Sigma/Magna		
Part	Description	Material
1	Throttle - carburettor	brass/steel
2	Seal, tank sender	gasket / o ring
3a	Float bowl - carburettor	plastic
3b	Float - carburettor GOV5-19 #3	plastic
4a	Pump diaphragm - carburettor	rubber/steel
4b	Pump gasket - carburettor	paper
4c	Diaphragm - enrichment valve	rubber
4d	Seat - float valve	brass
4e	Needle - float valve	brass/steel
4f	Washer - sealing	copper
4g	Washer - sealing	aluminium
4h	O-ring	rubber
5	Gasket - throttle body assy	paper
6	Fuel filter	plastic
7a	Housing - fuel pump	steel

7b	Diaphragm - fuel pump	rubber
7c	Inner Housing - fuel pump	plastic
8	Check valve assy	plastic

Table 3 – Measurements at completion of test, wet.

Part	Pre 86 Vehicle		Pre Test measurements					
	GOV5-13 Mitsubishi Sigma/Magna		S.PULP			S.PULP.E5		
	Description	Material	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)
1	Throttle - carburettor	brass/steel	101.648			123.28		
2	Seal, tank sender	gasket / o ring	3.927	5.78		4.102	5.78	
3a	Float bowl - carburettor	plastic	15.129			28.675		
3b	Float - carburettor GOV5-19 #3	plastic	5.965	35.85		5.912	35.8	
4a	Pump diaphragm - carburettor	rubber/steel	6.829	0.45		6.395	0.45	
4b	Pump gasket - carburettor	paper	0.397	0.87		0.392	0.86	
4c	Diaphragm - enrichment valve	rubber	0.347	0.4		0.403	0.45	
4d	Seat - float valve	brass	6.735	6.81		6.699	6.83	
4e	Needle - float valve	brass/steel	1.088	18.9		1.093	18.8	
4f	Washer - sealing	copper	0.233	0.6		0.232	0.57	
4g	Washer - sealing	aluminium	0.73	0.6				
4h	O-ring	rubber	0.075	1.77				
5	Gasket - throttle body assy	paper	6.334	4		6.744	4	
6	Fuel filter	plastic	29.252	7.2		29.453		
7a	Housing - fuel pump	steel	8.422			9.655		
7b	Diaphragm - fuel pump	rubber	3.299	1.52	79	3.059	1.52	79
7c	Inner Housing - fuel pump	plastic	6.403	1.8		8.576	1.8	
8	Check valve assy	plastic	21.995	7.6		22.159	7.6	

Table 4 – Measurements at completion of test, dry.

Part	Pre 86 Vehicle		2000 hr measurements (wet)					
	GOV5-13 Mitsubishi Sigma/Magna		S.PULP			S.PULP.E5		
	Description	Material	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)	Weight (g)	Thickness/Dia (mm)	Hardness (Shore)
1	Throttle - carburettor	brass/steel	102.09			123.35		
2	Seal, tank sender	gasket / o ring	4.064	5.87		4.575	6.11	
3a	Float bowl - carburettor	plastic	15.134			28.672		
3b	Float - carburettor GOV5-19 #3	plastic	5.889	36.56		6.287	36.72	
4a	Pump diaphragm - carburettor	rubber/steel	6.943	0.51		6.538	0.53	
4b	Pump gasket - carburettor	paper	0.675	0.94		0.736	1.09	
4c	Diaphragm - enrichment valve	rubber	0.466	0.54		0.466	0.54	
4d	Seat - float valve	brass	6.764	6.8		6.697	6.83	
4e	Needle - float valve	brass/steel	1.101	18.9		1.114	18.82	
4f	Washer - sealing	copper	0.232	0.6		0.229	0.58	
4g	Washer - sealing	aluminium	0.75	0.61				
4h	O-ring	rubber	0.089	1.92				
5	Gasket - throttle body assy	paper	8.998	4.02		10.207	4.23	
6	Fuel filter	plastic	33.683	8		37.566		
7a	Housing - fuel pump	steel	9.482			9.705		
7b	Diaphragm - fuel pump	rubber	3.713	1.64	79	3.644		
7c	Inner Housing - fuel pump	plastic	6.409	1.85		9.189	1.85	
8	Check valve assy	plastic	23.553	7.64		23.852	7.66	

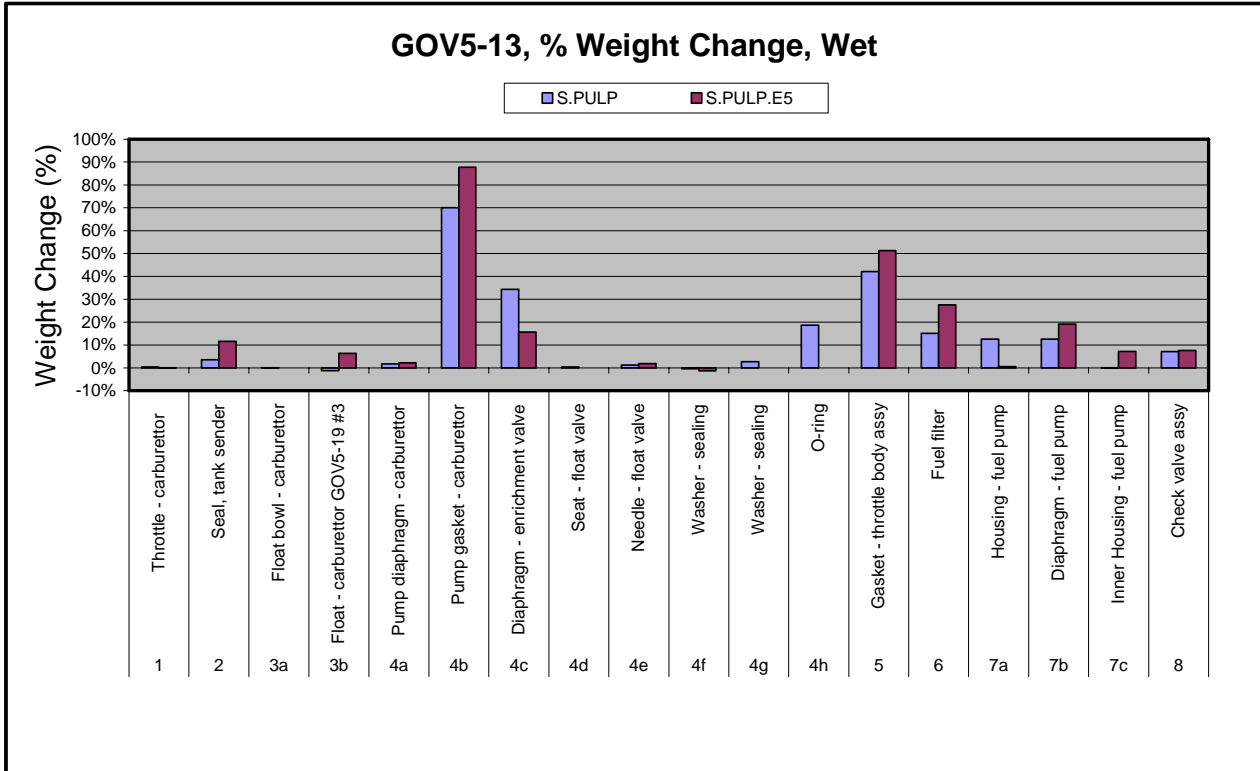


Figure 1 – Component weight change at test completion, wet.

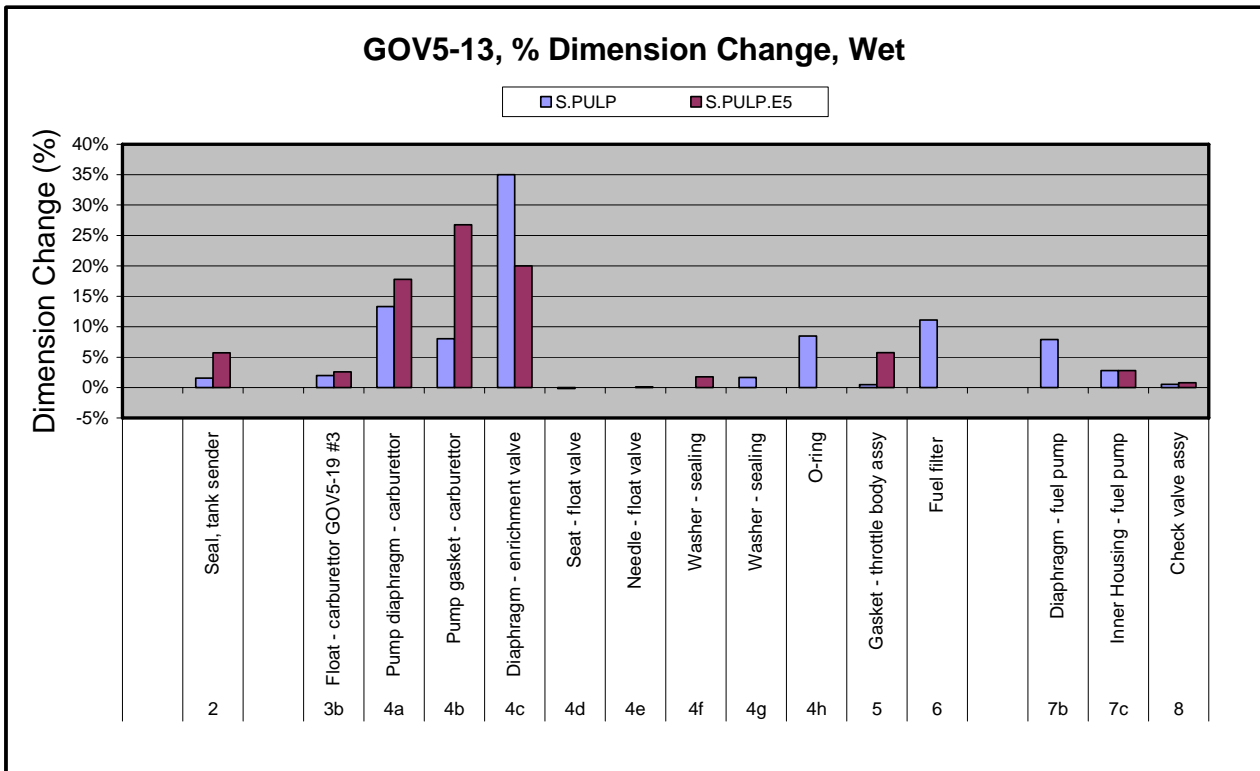


Figure 2 – Component thickness change at test completion, wet

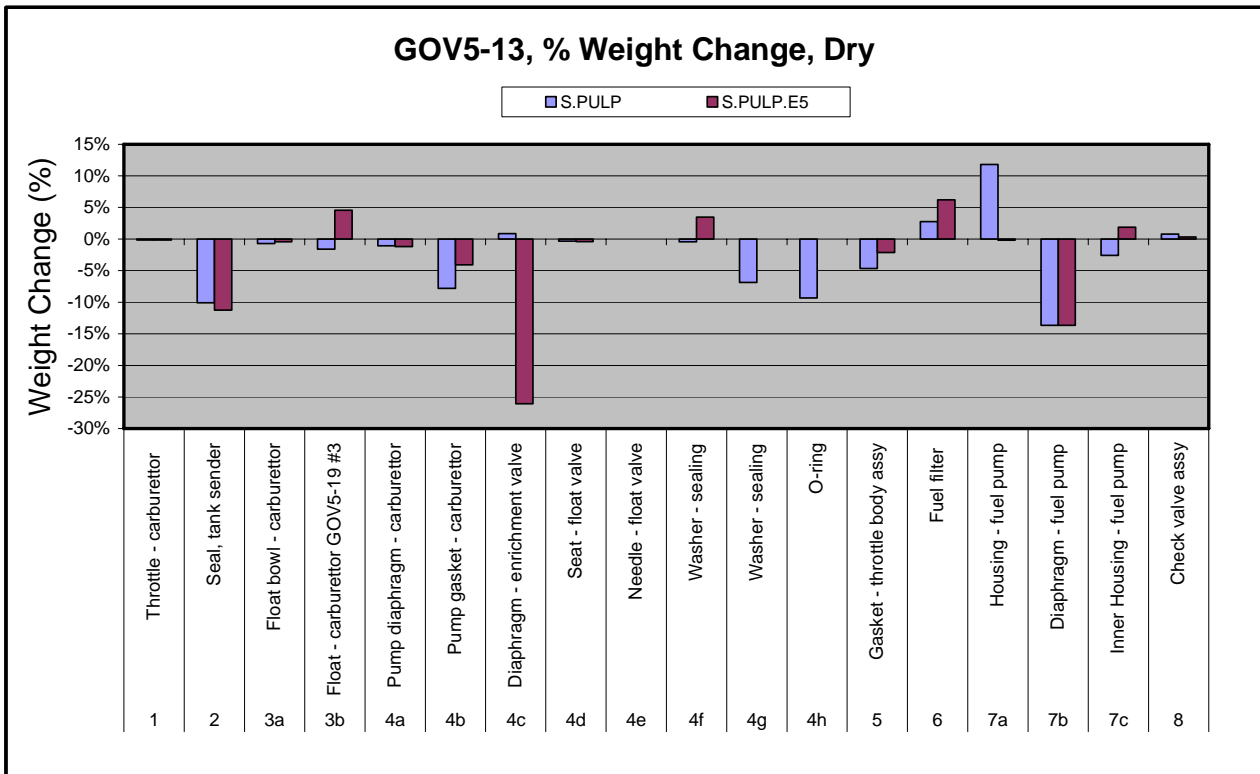


Figure 3 – Component weight change at test completion, dry

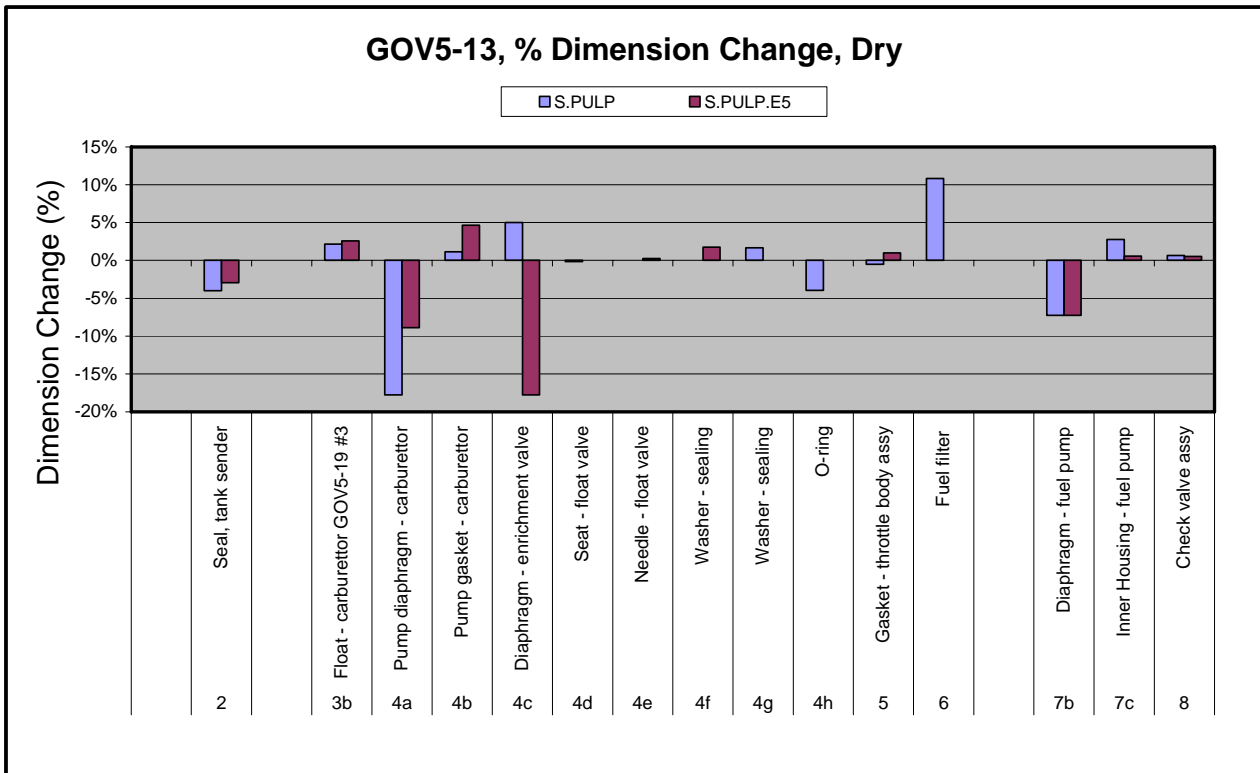


Figure 4 – Component thickness change at test completion, dry





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

Figure 5 –Part # 4d, Carburettor seat





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

Figure 6 Part # 4f, Sealing washer



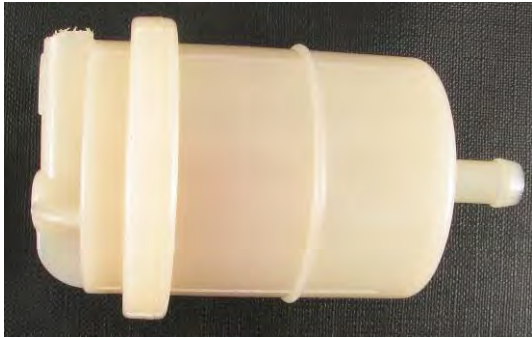

	S.PULP	S.PULP.E5
Pre Test		
Post Test (wet)		

Figure 7 Part # 6, Fuel Filter