

|                 |  |                |           |
|-----------------|--|----------------|-----------|
| <b>CUSTOMER</b> | Department of the<br>Environment and Heritage                          | <b>PROJECT</b> | GOV5 - 26 |
| <b>TITLE</b>    | <b>Comparison of Vehicle Drivability<br/>Nissan Bluebird – GOV5-15</b> |                |           |

**AIM**

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

**EQUIPMENT**

- N/A

**PROCEDURE**

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

**RESULTS**

| Average Driveability Ratings.   | PULP       | PULPE5     | Max. Delta ( $\Delta$ ) |
|---------------------------------|------------|------------|-------------------------|
| Cold Start                      | 6.0        | 7.0        | 1.0                     |
| Warmed-up Start                 | 7.0        | 7.0        | 0.0                     |
| Overall Restart                 | 7.0        | 6.8        | -0.3                    |
| Idle Stability                  | 6.5        | 6.7        | 0.2                     |
| Idle Roughness                  | 6.5        | 5.8        | -0.8                    |
| Launchability, Part Load        | 6.0        | 6.0        | 0.0                     |
| Launchability, WOT              | 6.0        | 6.0        | 0.0                     |
| Acceleration Feel, Part Load    | 7.0        | 7.0        | 0.0                     |
| Acceleration Feel, WOT          | 6.0        | 6.5        | 0.5                     |
| Passing feel, Part Load         | 7.0        | 6.5        | -0.5                    |
| Passing feel, WOT               | 6.5        | 6.5        | 0.0                     |
| Gradeability                    | 6.0        | 6.0        | 0.0                     |
| Low speed shunt/chuggle         | 7.0        | 6.8        | -0.3                    |
| Part Load, Steady State         | 7.0        | 7.0        | 0.0                     |
| Part Load, Accel (LTI, crowd)   | 6.5        | 6.0        | -0.5                    |
| Fuel Cut-off and re-intro shock | 7.0        | 7.0        | 0.0                     |
| Full Load ,Torque Delivery      | 6.8        | 7.0        | 0.3                     |
| Knocking                        | 7.0        | 7.0        | 0.0                     |
| P/N to D transition             | 6.0        | 7.0        | 1.0                     |
| Average                         | <b>6.6</b> | <b>6.6</b> | <b>0.0</b>              |
| Minimum                         | 6.0        | 5.8        | -0.8                    |
| Maximum                         | 7.0        | 7.0        | 1.0                     |

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

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

**CONCLUSIONS/DISCUSSION**

- 1) Overall, driveability and performance were very similar when comparing the use of PULP and E5 fuels.
  - a) The apparent improvement in cold start with E5 was due to a single start and stall with PULP. All the other starts were rated normal. As the stall was not repeated, it is not considered significant.
  - b) A slight improvement in park to neutral transition with E5 is unlikely to be noticed by an average driver.
  - c) A slight deterioration in idle roughness is unlikely to be noticed by an average driver.
- 2) Apart from a single stall on start (PULP), the subjective ratings, as assessed by two drivers, provided acceptable agreement.
- 3) An average driver is unlikely to notice any difference between PULP and E5.

**ATTACHMENTS**

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

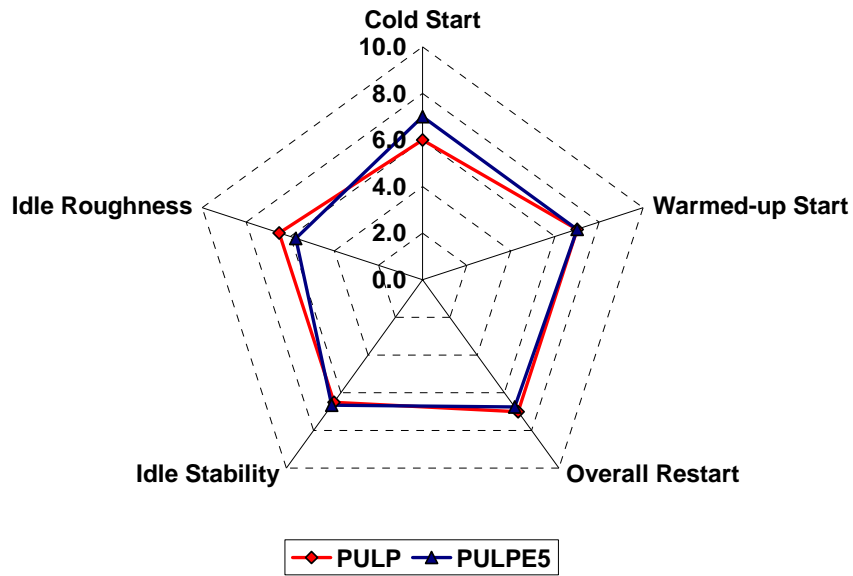
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**Attachment 1**

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

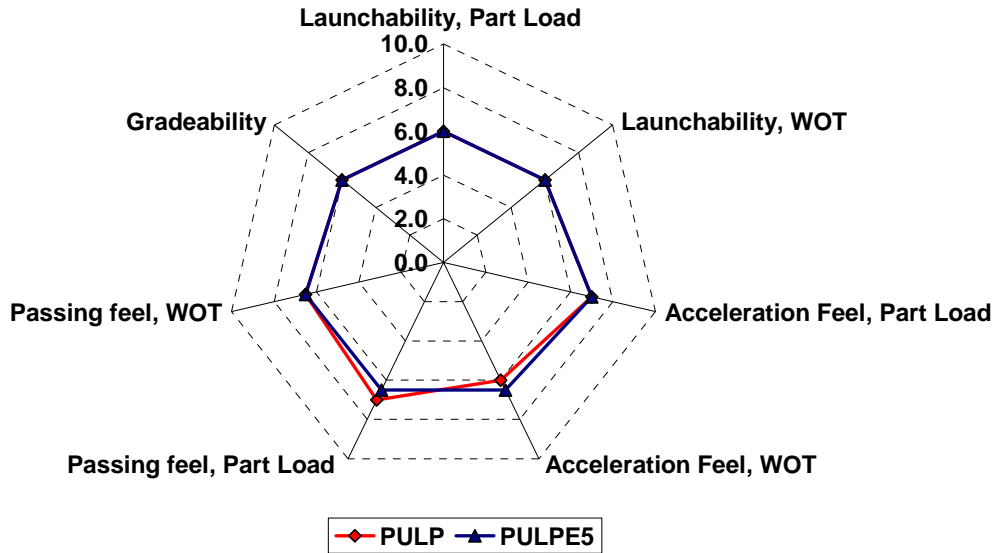
Each point on these charts is an average of two tests.

**Startability and Idle Quality**



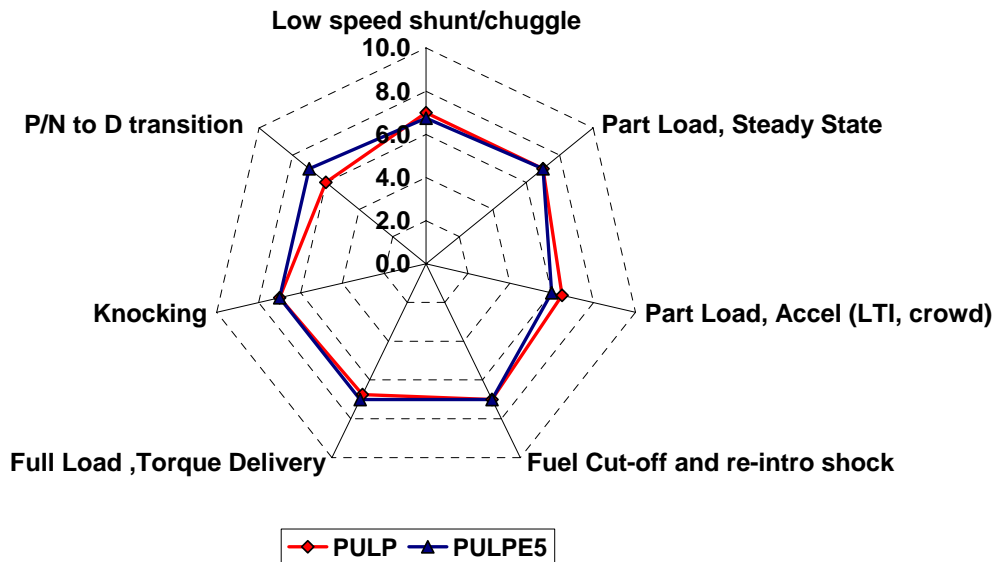
**Figure 1 - Start and Idle Quality**

**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                | GOV515 Nissan | Test date | 26/07/2006    |
| Mileage (km)                | 161191        | Test time | 09h30         |
| Ambient temperature (deg C) | 23.5          | Test road | Balcatta area |
| Barometric pressure (kPa)   | 101.2         | Engine    | Standard      |
| Test driver                 | HS1           | Fuel      | PULP          |
| Co-driver                   | DFN           | Oil       | SAE 10W40     |

| 1. Startability                 |                         | Rating | Remarks  |
|---------------------------------|-------------------------|--------|--|
| Cold start                      | Starting Time           | 3      | Stall. Should have pumped accelerator?<br>High idle, assume correct as received  |
|                                 | 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                 | 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                   | 7      |  |
|                                 | End                     | 7      |  |
| Linearity                       |                         | 7      |  |
| Stroke                          |                         | 7      |  |
| 5. Clutch Pedal Feel            |                         | Rating | Remarks  |
| Effort                          | Start                   | n/a    |  |
|                                 | End                     | n/a    |  |
| Stroke                          |                         | n/a    |  |
| Linkage noise                   |                         | n/a    |  |
| 6. Driveability                 |                         | Rating | <b>Subjective rating</b><br><br>1. Very bad<br>2. Bad<br>3. Very poor<br>4. Poor<br>5. Mediocre<br>6. Agreeable (just acceptable)<br>7. Satisfactory<br>8. Good<br>9. Very good<br>10. Excellent |
| Low speed driveability(<50 Kph) |                         | 7      |  |
| Low speed shunt/chuggle         |                         | 7      |  |
| Tip-in (1st and 2nd gear)       | ("n/a" if auto)         | n/a    |  |
| Tip-out (1st and 2nd gear)      |                         | n/a    |  |
| Tip-in (3rd,4th and 5th gear)   |                         | n/a    |  |
| Tip-out (3rd, 4th and 5th gear) |                         | n/a    |  |
| Part-throttle steady-state      |                         | 7      |  |
| Part-throttle acceleration      | inlc throttle crowding  | 7      |  |
|                                 | 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)          | 6      |  |

## Attachment 3 Vehicle Appraisal Results #2 PULP

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

|                             |               |           |               |
|-----------------------------|---------------|-----------|---------------|
| Vehicle name                | GOV515 Nissan | Test date | 27/07/2006    |
| Mileage (km)                | 161208        | Test time | 16:15         |
| Ambient temperature (deg C) | 11.5          | Test road | Balcatta area |
| Barometric pressure (kPa)   | 101.4         | Engine    | Standard      |
| Test driver                 | AT1           | Fuel      | PULP          |
| Co-driver                   | DFN           | Oil       | SAE 10W40     |

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

## Attachment 4 Vehicle Appraisal Results #1 PULPE5

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

|                             |               |           |               |
|-----------------------------|---------------|-----------|---------------|
| Vehicle name                | GOV515 Nissan | Test date | 11.09.06      |
| Mileage (km)                | 61466         | Test time | 13h00         |
| Ambient temperature (deg C) | 18            | Test road | Balcatta area |
| Barometric pressure (kPa)   | 101.2         | 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                 | 7      |  | misfire feel, but speed appeared stable |
|                                 | part load               | 7      |  |   |
|                                 | Full load               | 7      |  |   |
| Idle roughness                  | No load                 | 5      |  |   |
|                                 | part load               | 5.5    |  |   |
|                                 | Full load               | 5      |  |   |
| 3. Performance                  |                         | Rating | Remarks  |   |
| Launch feel                     | Part throttle           | 7      | Shudder on tip-in ascribed to gearbox<br>(Some thought that it could be misfire).  |   |
|                                 | 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 | <b>Subjective rating</b><br>1. Very bad<br>2. Bad<br>3. Very poor<br>4. Poor<br>5. Mediocre<br>6. Agreeable (just acceptable)<br>7. Satisfactory<br>8. Good<br>9. Very good<br>10. Excellent |   |
| Low speed driveability(<50 Kph) |                         | 7      |  |   |
| Low speed shunt/chuggle         |                         | 7      |  |   |
| Tip-in (1st and 2nd gear)       | ("n/a" if auto)         | n/a    |  |   |
| Tip-out (1st and 2nd gear)      |                         | n/a    |  |   |
| Tip-in (3rd,4th and 5th gear)   |                         | n/a    |  |   |
| Tip-out (3rd, 4th and 5th gear) |                         | n/a    |  |   |
| Part-throttle steady-state      |                         | 7      |  |   |
| Part-throttle acceleration      | inlc throttle crowding  | 7      |  |   |
|                                 | 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 5 Vehicle Appraisal Results #2 PULPE5

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

|                             |               |           |               |
|-----------------------------|---------------|-----------|---------------|
| Vehicle name                | GOV515 Nissan | Test date | 13.09.06      |
| Mileage (km)                | 61482         | Test time | 8:30          |
| Ambient temperature (deg C) | 12.6          | Test road | Balcatta area |
| Barometric pressure (kPa)   | 102.8         | Engine    | Standard      |
| Test driver                 | AT1           | Fuel      | PULPE5        |
| Co-driver                   | DFN           | Oil       | SAE 10W40     |

| 1. Startability                 |                         | Rating | Remarks  |            |
|---------------------------------|-------------------------|--------|--|------------|
| Cold start                      | Starting Time           | 7      |  |            |
|                                 | Flare to idle           | 7      |  |            |
|                                 | Restartability          | 7      |  |            |
| Warmed up start                 | Starting Time           | 7      |  |            |
|                                 | Flare to idle           | 7      |  |            |
|                                 | Restartability          | 6      |  |            |
| 2. Idle Quality                 |                         | Rating | Remarks  |            |
| RPM stability                   | No load                 | 6      |  |            |
|                                 | part load               | 7      |  |            |
|                                 | Full load               | 6      |  |            |
| Idle roughness                  | No load                 | 6      |  |            |
|                                 | part load               | 7      |  |            |
|                                 | Full load               | 6      |  |            |
| 3. Performance                  |                         | Rating | Remarks  |            |
| Launch feel                     | Part throttle           | 5      | hesitation on launch - misfire feel?   |            |
|                                 | WOT                     | 5      |  |            |
| Accel feel                      | Part throttle           | 7      |  |            |
|                                 | WOT                     | 6      |  |            |
| Passing feel                    | Part throttle           | 6      |  | feels flat |
|                                 | WOT                     | 6      |  |            |
| Gradeability                    |                         | 5      |  |            |
| Long hill climbing ability      |                         | 5      |  |            |
| 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 | Remarks  |            |
| Low speed driveability(<50 Kph) |                         | 6      | some hesitation<br><b>Subjective rating</b>  |            |
| Low speed shunt/chuggle         |                         | 7      |  |            |
| Tip-in (1st and 2nd gear)       | ("n/a" if auto)         | n/a    | <b>1. Very bad</b><br><b>2. Bad</b><br><b>3. Very poor</b><br><b>4. Poor</b><br><b>5. Mediocre</b><br><b>6. Agreeable (just acceptable)</b><br><b>7. Satisfactory</b><br><b>8. Good</b><br><b>9. Very good</b><br><b>10. Excellent</b> |            |
| Tip-out (1st and 2nd gear)      |                         | n/a    |  |            |
| Tip-in (3rd,4th and 5th gear)   |                         | n/a    |  |            |
| Tip-out (3rd, 4th and 5th gear) |                         | n/a    |  |            |
| Part-throttle steady-state      |                         | 7      |  |            |
| Part-throttle acceleration      |                         | 5      |  |            |
| 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      |  |            |

|                 |  |                |           |
|-----------------|--|----------------|-----------|
| <b>CUSTOMER</b> | Department of the Environment and Heritage                                 | <b>PROJECT</b> | GOV5 - 26 |
| <b>TITLE</b>    | <b>Hot Start and Driveability Evaluation<br/>Nissan Bluebird – GOV5-15</b> |                |           |

## AIM

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

## EQUIPMENT

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

## PROCEDURE

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

## RESULTS

| Average Ratings.                              | Fuel: | PULP       | PULPE5     | Max. Delta ( $\Delta$ ) |
|---|-------|------------|------------|-------------------------|
| Start Time - 10min Soak (seconds)             |       | 0.6        | 0.7        | <del>0.1</del>          |
| Restart Time - 30min Soak (seconds)           |       | 2.2        | 2.1        | <del>0.1</del>          |
| Restart Time - Ext. Idle/20min Soak (seconds) |       | 2.9        | 2.5        | <del>0.4</del>          |
| Hot Startability (10min. Soak)                |       | 7.0        | 7.0        | 0.0                     |
| Hot Idle Quality (10min. Soak)                |       | 7.0        | 6.8        | -0.3                    |
| Hot Restartability (30min. Soak)              |       | 6.5        | 6.8        | 0.3                     |
| Hot Idle Quality (30min. Soak)                |       | 7.0        | 7.0        | 0.0                     |
| Hot Idle Quality (40min. Idle)                |       | 7.0        | 6.8        | -0.3                    |
| Hot Startability (Ext. Idle/20min. Soak)      |       | 5.5        | 6.0        | 0.5                     |
| Hot Idle Quality (Ext. Idle/20min. Soak)      |       | 7.0        | 7.0        | 0.0                     |
| Hot Acceleration - Idle Racing Mode           |       | 7.0        | 6.0        | -1.0                    |
| Restart and idle after drive rating           |       | 6.6        | 6.8        | 0.2                     |
| Hot Soak & Drive Idle Quality                 |       | 6.8        | 6.6        | -0.1                    |
| Part Throttle Acceleration                    |       | 6.1        | 6.0        | -0.1                    |
| WOT acceleration                              |       | 5.5        | 5.0        | -0.5                    |
| 50km/h Steady State                           |       | 7.0        | 7.0        | 0.0                     |
| 70km/h Steady State                           |       | 7.0        | 7.0        | 0.0                     |
| <b>Average all.</b>                           |       | <b>6.6</b> | <b>6.5</b> | <b>-0.1</b>             |
| <b>Minimum</b>                                |       | <b>5.5</b> | <b>5.0</b> | <b>-1.0</b>             |
| <b>Maximum</b>                                |       | <b>7.0</b> | <b>7.0</b> | <b>0.5</b>              |

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

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

## CONCLUSIONS/DISCUSSION

- 1) Overall, hot start, idle and driveability performance were very similar when comparing the use of petrol and E5 fuels.
  - a) No significant differences in hot start and idle between fuels tested. A single poor rating for idle racing mode with E5 was not considered significant.
- 2) The subjective ratings, as assessed by two drivers, provided acceptable agreement except where mentioned previously.
- 3) The objective start times recorded agree with the subjective ratings given by the drivers.
- 4) 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

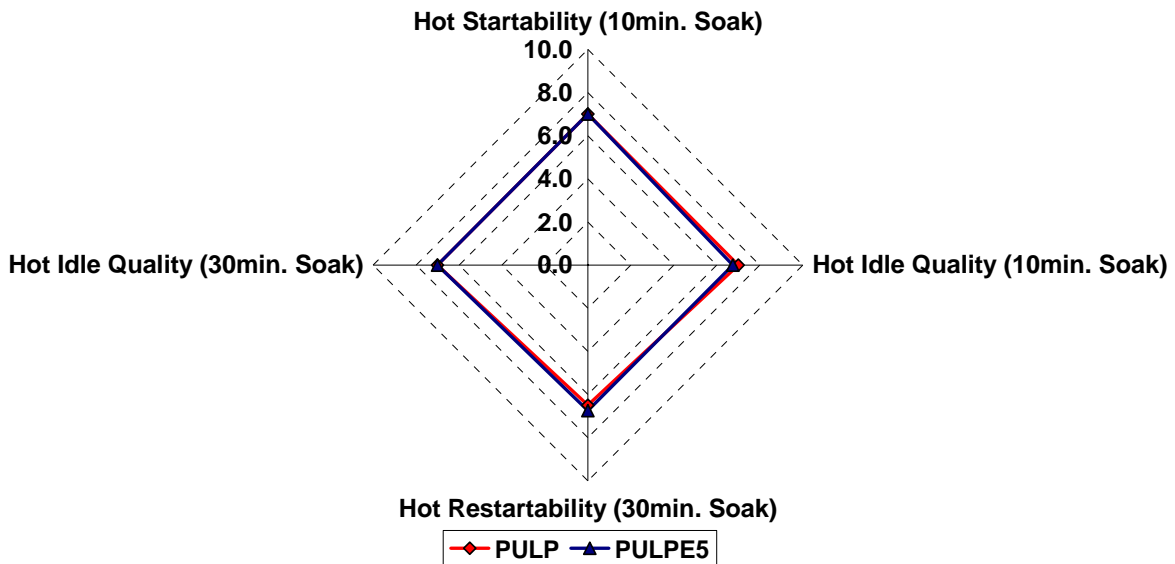
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**Attachment 1**

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

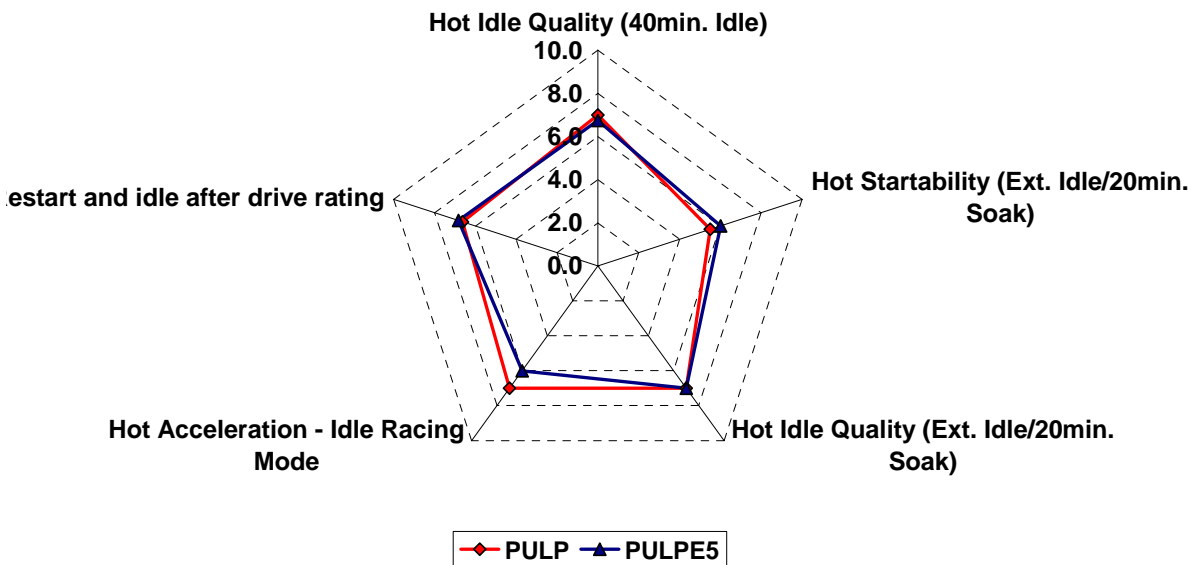
Each point on these charts is an average of two tests.

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



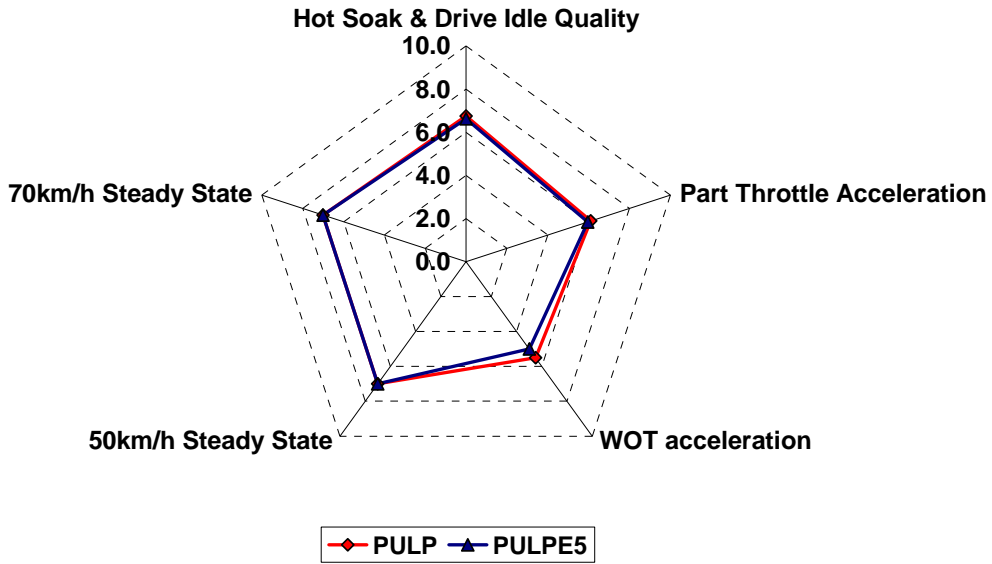
**Figure 1 – Hot Start and Idle after Soak**

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



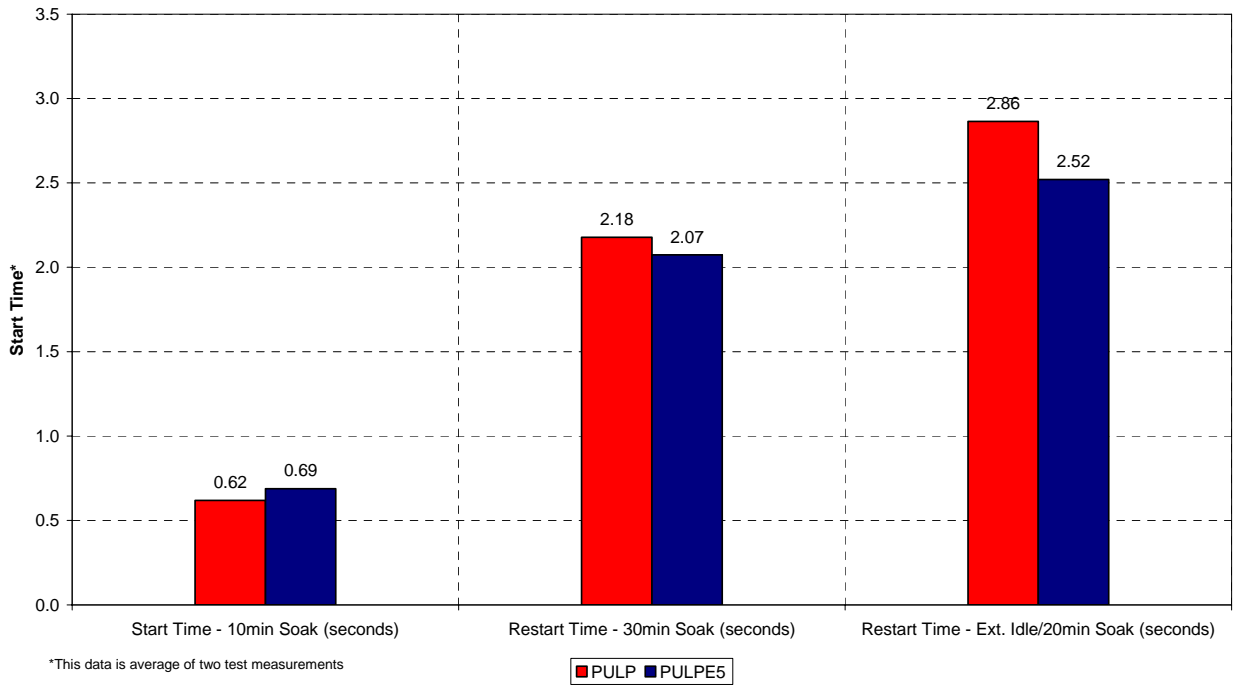
**Figure 2 – Hot Start and Idle after extended idles and soaks**

**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              | GOV515          | Registration | 7CK 696            |
| Vehicle name                | Nissan Bluebird | Test date    | 8/08/2006          |
| Vehicle colour              | Beige           | Test time    | 13:55-16:00 drive  |
| Mileage (km)                | 61243           |              |                    |
| Ambient temperature (deg C) | 15.7            | Engine       | 2L, In line, 4cyl  |
| Barometric pressure (kPa)   | 102.6           | 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/m<sup>2</sup>

#### 2. Hot soak

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

| Rating   | Ambient (°C) | Coolant (°C)                                     | oil (°C) |
|--|--------------|--|----------|
| Soak 10 minutes  |              |  |          |
| Ignition on  | 38           | 86   | 100      |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds |              |  |          |
| Crank time   | 0.62         | 0.6 est - est modified based on other recordings |          |
| Evaluate startability  | 7            | Data file names: C:\logsgov05veh_ 15_HTST1       |          |
| Evaluate idle roughness for 10 sec.  | 7            |  |          |
| Ignition-off and soak 30 minutes   |              |  |          |
| Ignition-on  | 40           | 68   | 65       |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds |              |  |          |
| Crank time   | 2.7          | no data - est based on other recordings          |          |
| Evaluate re-startability   | 6            |  |          |
| Evaluate idle roughness for 10 sec.  | 7            | Data file names: C:\logsgov05veh_ 15_HTST2       |          |

#### 3. Vehicle preparation

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

#### 4. Hot extended idle

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

| Rating  | Ambient (°C) | Coolant (°C)                                    | oil (°C) |
|---|--------------|---|----------|
| Extended idle for 40 minutes, in gear and A/C on (Blower medium, External air mode) |              |   |          |
| Record data, 0 minute   | 7            | 40  | 102      |
| Record data, 10 minute  | 7            | 38  | 103      |
| Record data, 20 minute  | 7            | 38  | 112      |
| Record data, 30 minute  | 7            | 39  | 112      |
| Record data, 40 minute  | 7            | 44  | 112      |
| Record data, 120 minute   |              |   | 124      |
| Ignition-off and soak 20 minutes  |              |   |          |
| Ignition on   | 51           | 91  | 89       |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds          |              |   |          |
| Crank time  | 3            | 3s est - est modified based on other recordings |          |
| Evaluate startability   | 5            | Data file names: C:\logsgov05veh_ 15_HTST3      |          |
| 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

|   |
|---|
| 7 |
|---|

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

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

stumbles slightly on tip in

#### Driveability Ratings:

|                                |     |
|--------------------------------|-----|
| Idle during drive              | 6.4 |
| Start after various soak times | 6.3 |
| Average accel rating           | 6.2 |
| Average Steady speed rating    | 7   |

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

### Hot Start and Driveability Evaluation, 1b

|                             |                 |              |                    |
|-----------------------------|-----------------|--------------|--------------------|
| Vehicle Number              | GOV515          | Registration | 7CK 696            |
| Vehicle name                | Nissan Bluebird | Test date    | 18/08/2006         |
| Vehicle colour              | Beige           | Test time    | 09:00-13:00 drive  |
| Mileage (km)                | 61313           |              |                    |
| Ambient temperature (deg C) | 20.7            | Engine       | 2L, In line, 4cyl  |
| Barometric pressure (kPa)   | 101.4           | Fuel         | PULP               |
| Test driver                 | AT1/dfn         | Oil          | SAE 10W40          |
|                             |                 | SOAK Temp    | 40degC (Set point) |

#### 1. Vehicle preparation

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

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

#### 2. Hot soak

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

| Rating   | Ambient (°C) | Coolant (°C) | oil (°C) |
|--|--------------|--------------|----------|
| Soak 10 minutes  |              |              |          |
| Ignition on  | 38           | 51           | 85       |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds |              |              |          |
| Crank time   | 0.618        |              |          |
| Evaluate startability  | 7            |              |          |
| Evaluate idle roughness for 10 sec.  | 7            |              |          |
| Ignition-off and soak 30 minutes   |              |              |          |
| Ignition-on  | 36           | 43           | 59       |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds |              |              |          |
| Crank time   | 1.656        |              |          |
| Evaluate re-startability   | 7            |              |          |
| Evaluate idle roughness for 10 sec.  | 7            |              |          |

Data file names: C:\logsgov05veh\_15\_HTST4  
 C:\logsgov05veh\_15\_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            | 42           | 90       |
| Record data, 10 minute  | 7            | 43           | 95       |
| Record data, 20 minute  | 7            | 43           | 97       |
| Record data, 30 minute  | 7            | 42           | 97       |
| Record data, 40 minute  | 7            | 41           | 97       |
| Ignition-off and soak 20 minutes  |              |              |          |
| Ignition on   | 43           | 80           | 86       |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds          |              |              |          |
| Crank time  | 2.728        |              |          |
| Evaluate startability   | 6            |              |          |
| Evaluate idle roughness   | 7            |              |          |

Data file names: C:\logsgov05veh\_15\_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          | 7 |
| 1/2 throttle to 50km/hr  | 7 |
| 50km/hr cruise           | 7 |
| Stop and idle 10 seconds | 7 |
| WOT to 70km/hr           | 5 |
| 70km/hr cruise           | 7 |
| Stop and idle 10 seconds | 7 |
| 1/4 throttle to 50km/hr  | 6 |
| 50km/hr cruise           | 7 |
| 3/4 throttle to 70km/hr  | 5 |
| 70km/hr cruise           | 7 |
| Stop and idle 10 seconds | 7 |
| Interrupted acceleration | 5 |
| 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 |
| Ignition off             | 7 |
| Restart                  | 7 |

Hesitation on tip in.

#### Driveability Ratings:

Idle during drive 6.9  
 Start after various soak times 6.8  
 Average accel rating 6  
 Average Steady speed rating 7

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

### Hot Start and Driveability Evaluation, 2a

|                             |                 |              |                    |
|-----------------------------|-----------------|--------------|--------------------|
| Vehicle Number              | GOV515          | Registration | 7CK 696            |
| Vehicle name                | Nissan Bluebird | Test date    | 19/09/2006         |
| Vehicle colour              | Beige           | Test time    | 9am-11:40drive     |
| Mileage (km)                | 615650          |              |                    |
| Ambient temperature (deg C) | 18.5            | Engine       | 2L, In line, 4cyl  |
| Barometric pressure (kPa)   | 102.4           | 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/m<sup>2</sup>

#### 2. Hot soak

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

| Rating   | Ambient (°C) | Coolant (°C) | oil (°C) |
|--|--------------|--------------|----------|
| Soak 10 minutes  |              |              |          |
| Ignition on  | 39           | 62           | 88       |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds |              |              |          |
| Crank time   | 0.692 1s     |              |          |
| Evaluate startability  | 7            |              |          |
| Evaluate idle roughness for 10 sec.  | 6.5          |              |          |
| Ignition-off and soak 30 minutes   |              |              |          |
| Ignition-on  | 40           | 56           | 68       |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds |              |              |          |
| Crank time   | 2.268 2.5    |              |          |
| Evaluate re-startability   | 6.5          |              |          |
| Evaluate idle roughness for 10 sec.  | 7            |              |          |

Data file names: C:\logsgov05veh\_ 15\_HTST7

#### 3. Vehicle preparation

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

#### 4. Hot extended idle

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

| Rating  | Ambient (°C) | Coolant (°C) | oil (°C) |
|---|--------------|--------------|----------|
| Extended idle for 40 minutes, in gear and A/C on (Blower medium, External air mode) |              |              |          |
| Record data, 0 minute   | 7            | 39           | 79       |
| Record data, 10 minute  | 7            | 41           | 85       |
| Record data, 20 minute  | 6.5          | 42           | 88       |
| Record data, 30 minute  | 6.5          | 42           | 89       |
| Record data, 40 minute  | 6.5          | 40           | 90       |
| Ignition-off and soak 20 minutes  |              |              |          |
| Ignition on   | 39           | 72           | 78       |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds          |              |              |          |
| Crank time  | 2.678 3s     |              |          |
| Evaluate startability   | 6            |              |          |
| Evaluate idle roughness   | 7            |              |          |

Data file names: C:\logsgov05veh\_ 15\_HTST9

### Hot Start and Driveability Evaluation

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

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

|   |
|---|
| 7 |
|---|

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

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

|                          |              |
|--------------------------|--------------|
| Idle 10 seconds          | 7            |
| 1/2 throttle to 50km/hr  | 7            |
| 50km/hr cruise           | 7            |
| Stop and idle 10 seconds | 7            |
| WOT to 70km/hr           | 5 hesitation |
| 70km/hr cruise           | 7            |
| Stop and idle 10 seconds | 7            |
| 1/4 throttle to 50km/hr  | 5            |
| 50km/hr cruise           | 7            |
| 3/4 throttle to 70km/hr  | 5            |
| 70km/hr cruise           | 7            |
| Stop and idle 10 seconds | 7            |
| Interrupted acceleration | 5            |
| 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 6.6  
 Average accel rating 5.8  
 Average Steady speed rating 7

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

### Hot Start and Driveability Evaluation, 2b

|                             |                 |              |                    |
|-----------------------------|-----------------|--------------|--------------------|
| Vehicle Number              | GOV515          | Registration | 7CK 696            |
| Vehicle name                | Nissan Bluebird | Test date    | 19/09/2006         |
| Vehicle colour              | Beige           | Test time    | 12:30-14:50 drive  |
| Mileage (km)                | 61571           |              |                    |
| Ambient temperature (deg C) | 17.6            | Engine       | 2L, In line, 4cyl  |
| Barometric pressure (kPa)   | 102.4           | Fuel         | PULPE5             |
| Test driver                 | AKM/vjm         | Oil          | SAE 10W40          |
|                             |                 | SOAK Temp    | 40degC (Set point) |

#### 1. Vehicle preparation

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

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

#### 2. Hot soak

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

| Rating   | Ambient (°C) | Coolant (°C) | oil (°C) |
|--|--------------|--------------|----------|
| Soak 10 minutes  |              |              |          |
| Ignition on  | 40           | 57           | 80       |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds |              |              |          |
| Crank time   | 0.684 1s     |              |          |
| Evaluate startability  | 7            |              |          |
| Evaluate idle roughness for 10 sec.  | 7            |              |          |
| Ignition-off and soak 30 minutes   |              |              |          |
| Ignition-on  | 40           | 44           | 55       |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds |              |              |          |
| Crank time   | 1.877 2s     |              |          |
| Evaluate re-startability   | 7            |              |          |
| Evaluate idle roughness for 10 sec.  | 7            |              |          |

Data file names: C:\logs\gov05veh\_15\_HTST10  
 C:\logs\gov05veh\_15\_HTST11

#### 3. Vehicle preparation

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

#### 4. Hot extended idle

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

| Rating  | Ambient  | Coolant | Intake |
|---|----------|---------|--------|
| Extended idle for 40 minutes, in gear and A/C on (Blower medium, External air mode) |          |         |        |
| Record data, 0 minute   | 40       | 75      | 107    |
| Record data, 10 minute  | 38       | 71      | 97     |
| Record data, 20 minute  | 38       | 70      | 93     |
| Record data, 30 minute  | 40       | 70      | 92     |
| Record data, 40 minute  | 38       | 69      | 93     |
| Ignition-off and soak 20 minutes  |          |         |        |
| Ignition on   | 51       | 48      | 64     |
| Crank after fuel pump relay is off. No start if crank time is > 10 seconds          |          |         |        |
| Crank time  | 2.362 3s |         |        |
| Evaluate startability   | 6        |         |        |
| Evaluate idle roughness   | 7        |         |        |

Data file names: C:\logs\gov05veh\_15\_HTST12

### Hot Start and Driveability Evaluation

#### Hot acceleration

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

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

|   |
|---|
| 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                   |  |
|--------------------------|--|
| Idle 10 seconds          | 6.5                                    |
| 1/2 throttle to 50km/hr  | 7                                      |
| 50km/hr cruise           | 7                                      |
| Stop and idle 10 seconds | 6                                      |
| WOT to 70km/hr           | 5 hesitation at start. May be gearbox. |
| 70km/hr cruise           | 7                                      |
| Stop and idle 10 seconds | 6.5                                    |
| 1/4 throttle to 50km/hr  | 6                                      |
| 50km/hr cruise           | 7                                      |
| 3/4 throttle to 70km/hr  | 5.5                                    |
| 70km/hr cruise           | 7                                      |
| Stop and idle 10 seconds | 6                                      |
| Interrupted acceleration | 7                                      |
| 1/2 throttle to 70km/hr  | 5 misfire                              |
| 70km/hr cruise           | 7                                      |
| Stop and idle 20 seconds | 6.5                                    |
| Steering lock to lock    | 7                                      |
| Idle in P/N              | 6                                      |
| Ignition off             |  |
| Restart                  | 7                                      |

**Driveability Ratings:**  
 Idle during drive 6.4  
 Start after various soak times 6.8  
 Average accel rating 5.7  
 Average Steady speed rating 7

|                 |  |                |           |
|-----------------|--|----------------|-----------|
| <b>CUSTOMER</b> | Department of the Environment and Heritage                             | <b>PROJECT</b> | GOV5 - 26 |
| <b>TITLE</b>    | <b>Cold Start and Warm-up Evaluation<br/>Nissan Bluebird – GOV5-15</b> |                |           |

## AIM

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

## EQUIPMENT

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

## PROCEDURE

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

## RESULTS

| Average Ratings.                              | Fuel: | PULP       | PULPE5     | Max. Delta ( $\Delta$ ) |
|---|-------|------------|------------|-------------------------|
| Start Time (seconds)                          |       | 3.4        | 3.0        | <del>XXXX</del>         |
| Restart Time (seconds)                        |       | 1.6        | 2.0        | <del>XXXX</del>         |
| Cold Startability                             |       | 4.5        | 4.0        | -0.5                    |
| Cold Restartability                           |       | 4.5        | 6.5        | 2.0                     |
| Cold Idle Roughness/Stability No Load         |       | 6.3        | 6.3        | 0.0                     |
| Cold Idle Roughness/Stability Electrical load |       | 6.0        | 6.0        | 0.0                     |
| Cold Idle Roughness/Stability Elec+P/S load   |       | 6.5        | 5.8        | -0.8                    |
| Cold Acceleration Idle racing mode            |       | 5.8        | 6.5        | 0.8                     |
| Warm-up idle Roughness/Stability              |       | 2.6        | 5.9        | 3.3                     |
| Warmed up idle and restart                    |       | 5.9        | 6.6        | 0.8                     |
| Part Throttle Acceleration                    |       | 5.3        | 5.6        | 0.3                     |
| Interrupted accel                             |       | 4.0        | 5.0        | 1.0                     |
| WOT acceleration                              |       | 7.0        | 4.0        | -3.0                    |
| 50km/h steady state                           |       | 6.0        | 6.8        | 0.8                     |
| 60/70km/h steady state                        |       | 6.2        | 7.0        | 0.8                     |
| <b>Average</b>                                |       | <b>5.4</b> | <b>5.8</b> | <b>0.4</b>              |
| <b>Minimum</b>                                |       | <b>2.6</b> | <b>4.0</b> | <b>-3.0</b>             |
| <b>Maximum</b>                                |       | <b>7.0</b> | <b>7.0</b> | <b>3.3</b>              |

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

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

## CONCLUSIONS/DISCUSSION

1. Generally the Bluebird ran poorly on either PULP or E5, stalling at start, with severe hesitations and stalling during warm-up. With one notable exception, E5 gave similar or better ratings than PULP. In detail:
  - a. Although the initial idle with maximum engine load shows PULP rates slightly higher than E5, this is more than outweighed by E5's reduction (but not elimination) of stalling at idle during warm-up. This probably would be noticed by an average driver.
  - b. Improved restart performance with E5 is probably due to reduced incidence of stalling at idle with E5. (Both PULP restarts were start and stalls). This may be noticed by an average driver.
  - c. WOT acceleration was significantly worse with E5, causing hesitations. This probably would be noticed by an average driver.
  - d. Other differences are of uncertain significance, and are unlikely to be noticed by an average driver.
2. The objective start times recorded agree with the subjective ratings given by the drivers. Note a start and immediate stall is rated as a three, regardless of the actual start time.

CONCLUSIONS CONTINUED OVER...

**CONCLUSIONS/DISCUSSION** continued

3. The behaviour of the vehicle was variable; both fuels had a test that was significantly better than the other. However, the differences mentioned above were repeatable.

**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

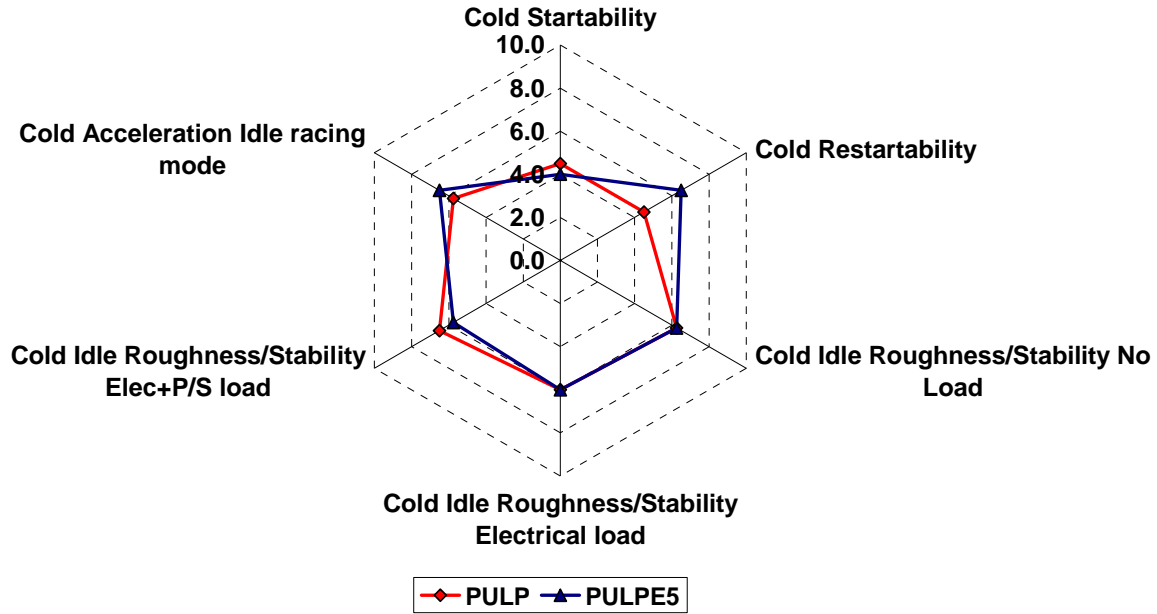
|  |  |  |  |
|--|--|--|--|
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

**Attachment 1**

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

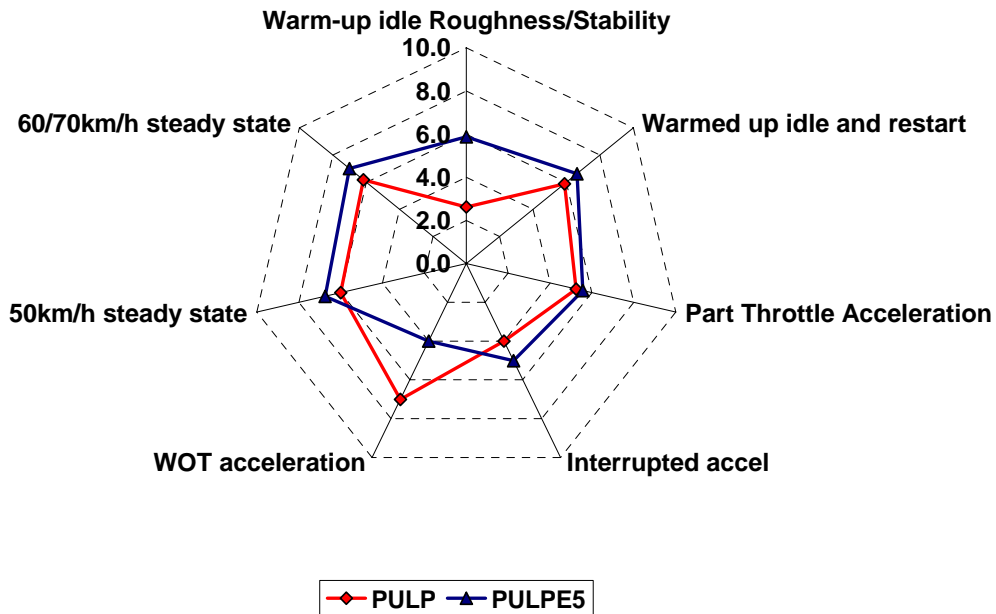
Each point on these charts is an average of two tests.

**Cold Starting and Idle**

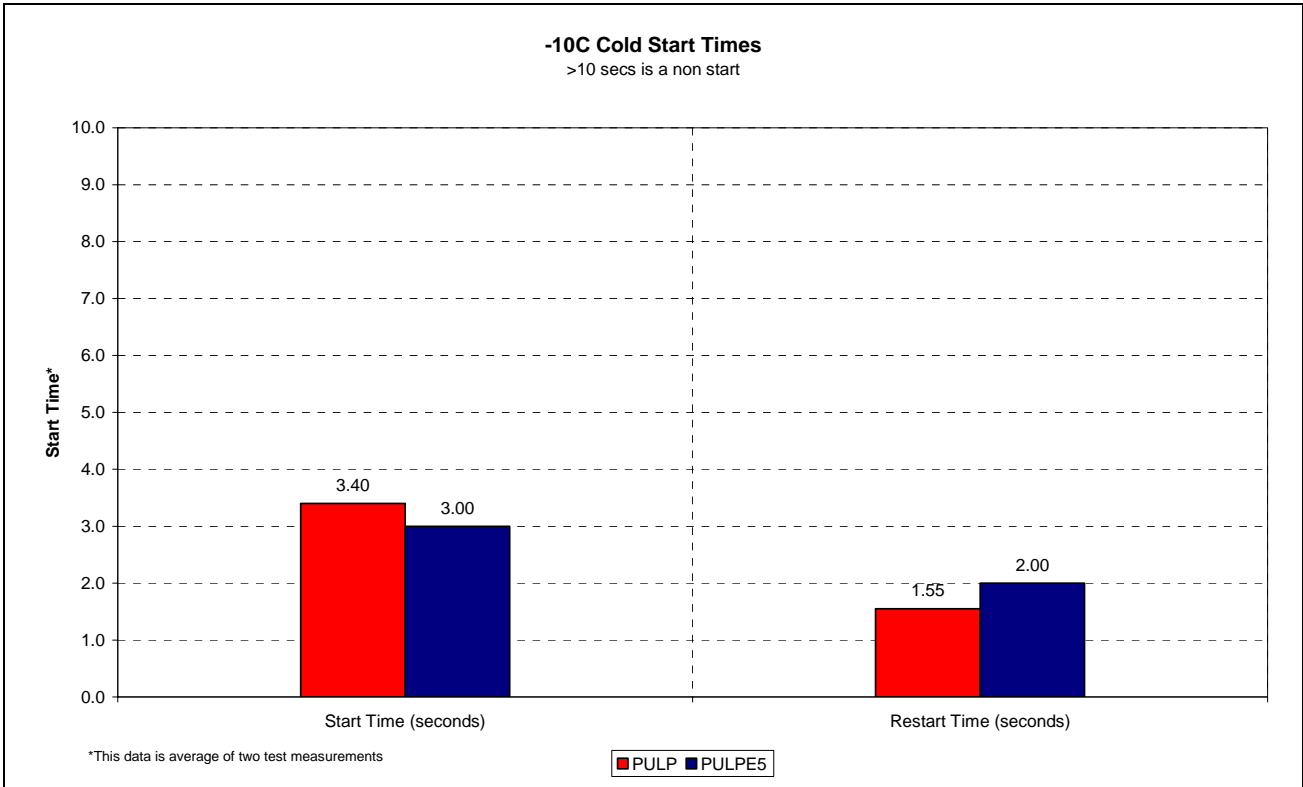


**Figure 1 – Cold Start and Idle Quality**

**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              | GOV515          | Registration | 7CK 696             |
| Vehicle name                | Nissan Bluebird | Test date    | 4/09/2006           |
| Vehicle colour              | Beige           | Test time    | 07h30               |
| Mileage (km)                | 61446           |              |                     |
| Ambient temperature (deg C) | 10.8            | Engine       | 2L. In line. 4cyl   |
| Barometric pressure (kPa)   | 102.1           | Fuel         | PULP                |
| Test driver                 | AKM             | Oil          | SAE 10W40           |
|                             |                 | SOAK Temp    | -10degC (Set point) |

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

|        |          |             |             |
|--------|----------|-------------|-------------|
| Rating | Oil (°C) | Coolant(°C) | Intake (°C) |
|        | -10.5    | -10.5       | -10.5       |

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

|                       |   |                 |
|-----------------------|---|-----------------|
| Crank time            | 4 | Start and stall |
| Evaluate startability | 3 |                 |

Ignition -off within 5 seconds

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

|                          |     |
|--------------------------|-----|
| Crank time               | 1.6 |
| Evaluate re-startability | 3   |

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

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

|   |   |
|---|---|
| Evaluate idle roughness (10 seconds)                        | 7 |
| Shift to D/R or clutch engaged                              |   |
| 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                   |   |

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

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

|                       |   |                            |
|-----------------------|---|----------------------------|
| Evaluate acceleration | 7 | Dark: 1, Grey:5, Normal: 7 |
| Black smoke present?  | 5 |                            |

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

Move the car to the test road

|                         |   |       |
|-------------------------|---|-------|
| Idle 10 seconds         | 1 | Stall |
| 1/2 throttle to 50km/hr | 5 |       |

### Cold Start and Warm-up Evaluation

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

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

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

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

|                             |                 |              |                     |
|-----------------------------|-----------------|--------------|---------------------|
| Vehicle Number              | GOV515          | Registration | 7CK 696             |
| Vehicle name                | Nissan Bluebird | Test date    | 6/09/2006           |
| Vehicle colour              | Beige           | Test time    | 14h00               |
| Mileage (km)                | 61462           |              |                     |
| Ambient temperature (deg C) | 17.6            | Engine       | 2L, In line, 4cyl   |
| Barometric pressure (kPa)   | 102.6           | Fuel         | PULP                |
| Test driver                 | HS1             | Oil          | SAE 10W40           |
|                             |                 | SOAK Temp    | -10degC (Set point) |

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

|        |          |             |             |
|--------|----------|-------------|-------------|
| Rating | Oil (°C) | Coolant(°C) | Intake (°C) |
|        | -10      | -10         | -10.2       |

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

|                       |     |
|-----------------------|-----|
| Crank time            | 2.8 |
| 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               | 1.5 |
| Evaluate re-startability | 6   |

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

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

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

Shift to D/R or clutch engaged

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

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) | 6 |
|--------------------------------------|---|

Turn power steering to the left end

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

Re-align steering

Turn off headlights, blower and defroster

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

Shift in P/N or disengage clutch (NIG)

Idle racing mode to 3000rpm

|                       |   |
|-----------------------|---|
| Evaluate acceleration | 7 |
|-----------------------|---|

Black smoke present?

|  |   |
|--|---|
|  | 4 |
|--|---|

Dark: 1, Grey:5, Normal: 7

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

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

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

Move the car to the test road

|                 |   |
|-----------------|---|
| Idle 10 seconds | 1 |
|-----------------|---|

|                         |   |
|-------------------------|---|
| 1/2 throttle to 50km/hr | 7 |
|-------------------------|---|

### Cold Start and Warm-up Evaluation

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

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

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

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

|                          |   |
|--------------------------|---|
| Stop and idle 10 seconds | 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 | 4 |
|-------------------------|---|

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

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

|                          |   |
|--------------------------|---|
| Interrupted acceleration | 5 |
|--------------------------|---|

|                         |   |
|-------------------------|---|
| 1/2 throttle to 70km/hr | 5 |
|-------------------------|---|

|                |   |
|----------------|---|
| 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 4 Cold start and warm up evaluation results #1 E5

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

|                             |                 |              |                     |
|-----------------------------|-----------------|--------------|---------------------|
| Vehicle Number              | GOV515          | Registration | 7CK 696             |
| Vehicle name                | Nissan Bluebird | Test date    | 14/09/2006          |
| Vehicle colour              | Beige           | Test time    | 08:30               |
| Mileage (km)                | 61541           |              |                     |
| Ambient temperature (deg C) | 16.6            | Engine       | 2L, In line, 4cyl   |
| Barometric pressure (kPa)   | 102.3           | Fuel         | PULPE5              |
| Test driver                 | AKM             | Oil          | SAE 10W40           |
|                             |                 | SOAK Temp    | -10degC (Set point) |

#### 1. Cold start

|  |          |                         |
|--|----------|-------------------------|
| <b>Cold startability rating</b>                            |          |                         |
| No start: 1, Start and stall : 3, Rough: 5, Normal: 7 more |          |                         |
| Rating   | Oil (°C) | Coolant(°C) Intake (°C) |

|             |  |       |       |       |
|-------------|--|-------|-------|-------|
| Ignition on |  | -10.3 | -10.6 | -10.9 |
|-------------|--|-------|-------|-------|

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

Crank time

Evaluate startability

Ignition -off within 5 seconds

Ignition-on

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

Crank time

Evaluate re-startability

Data file: C:\nlogs\gov05\veh\_ 15\_CST2a

Stall on engaging "D"

#### 2. Cold idle

|   |  |
|---|--|
| <b>Cold idle quality rating</b>                     |  |
| 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

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

Shift in P/N or disengage clutch (NIG)

Idle racing mode to 3000rpm

Evaluate acceleration

Black smoke present?

Dark: 1, Grey:5, Normal: 7

#### 4. Warm-up drive

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

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

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

Move the car to the test road

Idle 10 seconds

1/2 throttle to 50km/hr

### Cold Start and Warm-up Evaluation

#### 4. Warm-up drive

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

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

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

|                          |                                  |                                  |
|--------------------------|----------------------------------|----------------------------------|
| 50km/hr cruise           | <input type="text" value="7"/>   |                                  |
| Stop and idle 10 seconds | <input type="text" value="6"/>   |                                  |
| WOT to 70km/hr           | <input type="text" value="3"/>   | hesitation                       |
| 70km/hr cruise           | <input type="text" value="7"/>   |                                  |
| Stop and idle 10 seconds | <input type="text" value="6.5"/> |                                  |
| 1/4 throttle to 50km/hr  | <input type="text" value="5"/>   | misfire feel Most likely gearbox |
| 50km/hr cruise           | <input type="text" value="7"/>   |                                  |
| 3/4 throttle to 70km/hr  | <input type="text" value="4"/>   | hesitation                       |
| 70km/hr cruise           | <input type="text" value="7"/>   |                                  |
| Stop and idle 10 seconds | <input type="text" value="1"/>   | stall on stop                    |
| Interrupted acceleration | <input type="text" value="5"/>   | misfire feel Most likely gearbox |
| 1/2 throttle to 70km/hr  | <input type="text" value="5.5"/> | misfire feel Most likely gearbox |
| 70km/hr cruise           | <input type="text" value="7"/>   |                                  |
| Stop and idle 20 seconds | <input type="text" value="6.5"/> |                                  |
| Steering lock to lock    | <input type="text" value="6.5"/> |                                  |
| Idle in P/N              | <input type="text" value="6.5"/> |                                  |
| Ignition off             |                                  |                                  |
| Restart                  | <input type="text" value="5.5"/> | longish crank                    |

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

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

|                             |                 |              |                     |
|-----------------------------|-----------------|--------------|---------------------|
| Vehicle Number              | GOV515          | Registration | 7CK 696             |
| Vehicle name                | Nissan Bluebird | Test date    | 14/09/2006          |
| Vehicle colour              | Beige           | Test time    | 15h00               |
| Mileage (km)                | 61548           |              |                     |
| Ambient temperature (deg C) | 26.6            | Engine       | 2L, In line, 4cyl   |
| Barometric pressure (kPa)   | 101.7           | Fuel         | PULPE5              |
| Test driver                 | AT1             | Oil          | SAE 10W40           |
|                             |                 | SOAK Temp    | -10degC (Set point) |

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

|             |        |          |             |             |
|-------------|--------|----------|-------------|-------------|
|             | Rating | Oil (°C) | Coolant(°C) | Intake (°C) |
| Ignition on |        | -12      | -12.5       | -12.5       |

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

Crank time

Evaluate startability  Start and 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:..logsgov051veh\_ 15\_CST2b**

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

Evaluate idle roughness (10 seconds)

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

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

Shift in P/N or disengage clutch (NIG)

Idle racing mode to 3000rpm

Evaluate acceleration

Black smoke present?  **Dark: 1, Grey:5, Normal: 7**

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

Move the car to the test road

Idle 10 seconds

1/2 throttle to 50km/hr

### Cold Start and Warm-up Evaluation

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

|                          |   |
|--------------------------|---|
| 50km/hr cruise           | 6 |
| Stop and idle 10 seconds | 6 |
| WOT to 70km/hr           | 5 |
| 70km/hr cruise           | 7 |
| Stop and idle 10 seconds | 7 |
| 1/4 throttle to 50km/hr  | 6 |
| 50km/hr cruise           | 7 |
| 3/4 throttle to 70km/hr  | 5 |
| 70km/hr cruise           | 7 |
| Stop and idle 10 seconds | 7 |
| Interrupted acceleration | 5 |
| 1/2 throttle to 70km/hr  | 6 |
| 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 |

|                 |   |                |        |
|-----------------|---|----------------|--------|
| <b>CUSTOMER</b> | Department of the Environment and Heritage                | <b>PROJECT</b> | GOV005 |
| <b>TITLE</b>    | <b>WOT Performance Test<br/>Nissan Bluebird – GOV5-15</b> |                |        |

## AIM

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

## EQUIPMENT

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

## PROCEDURE

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

### Preparation

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

### WOT Accelerations from a Standing Start

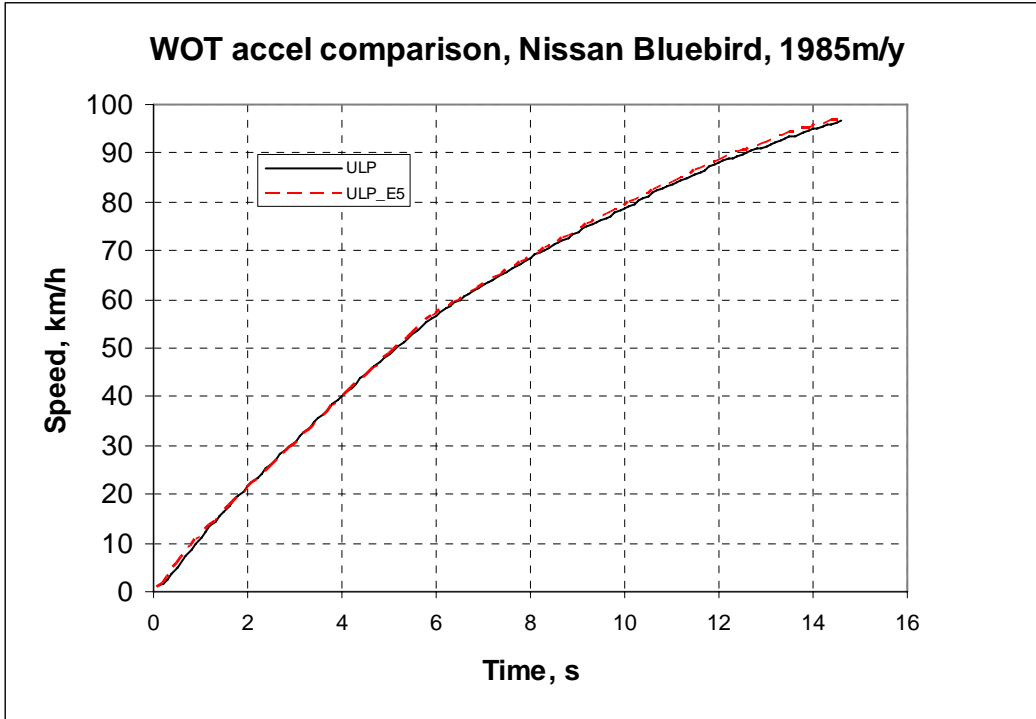
- The test was conducted in “drive” for automatic transmissions and gear shifts occurred at redline engine speed for manual transmissions.
- Three (3) WOT accelerations were performed from a standing start to a speed of no less than 100km/h, and covering no less than 402m.
- Each test followed the previous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

### WOT Accelerations from 64 km/h

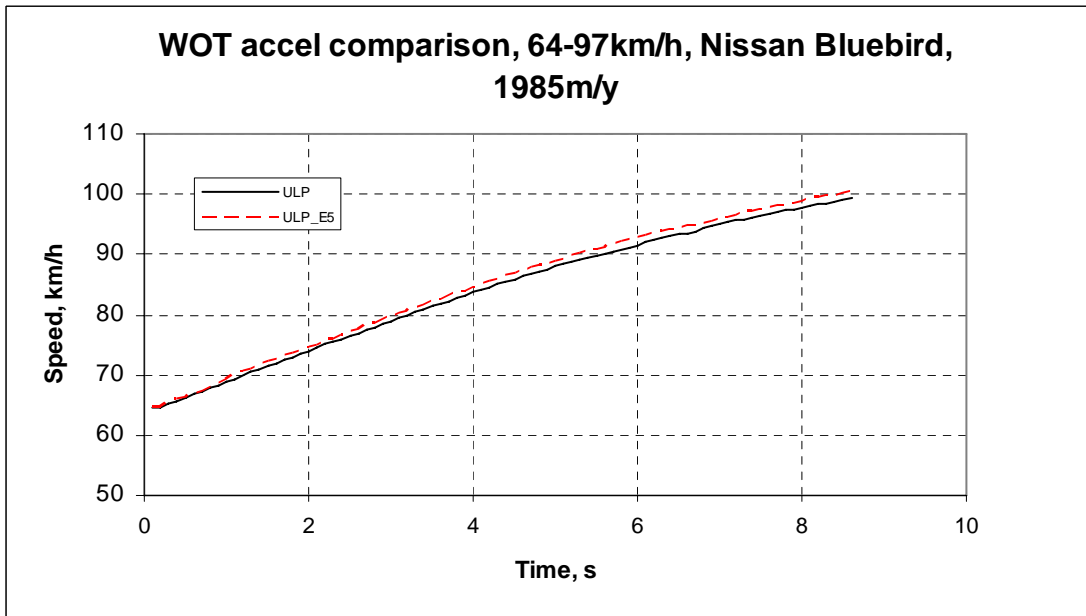
- From a stabilized speed of 64km/h ( $\pm 0.8$  km/h) the vehicle was accelerated at wide-open throttle to 97km/h.
- Separate tests for manual transmissions were run in top gear, and top gear less one, and not downshifted during the acceleration. Automatic transmissions were allowed to downshift as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

**RESULTS**

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



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

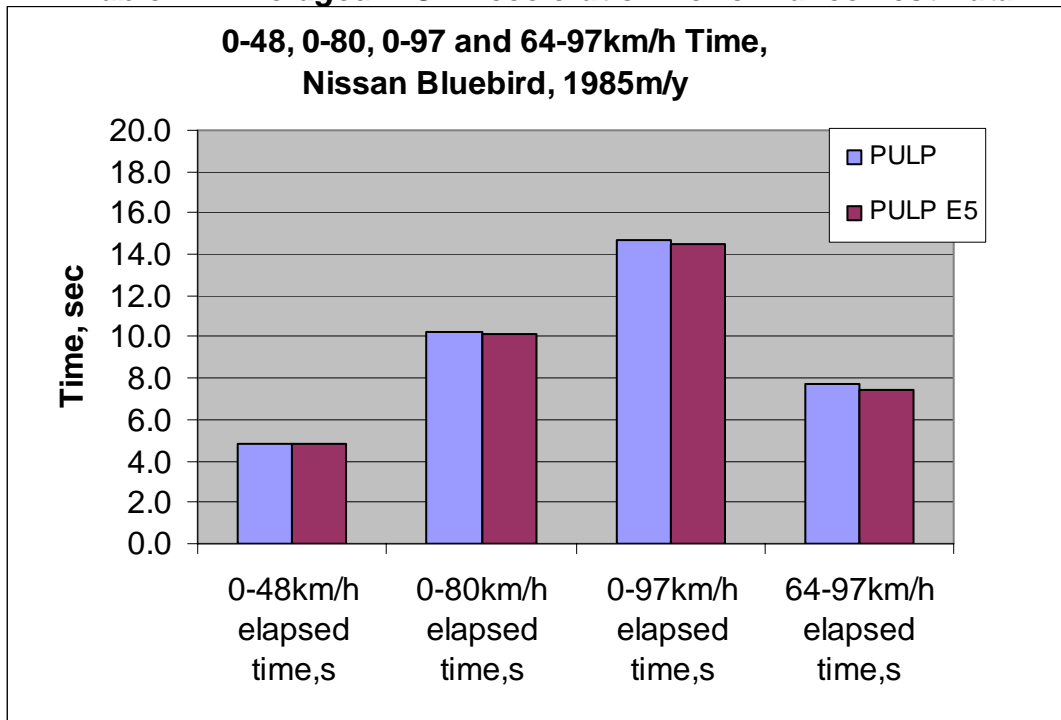


**Figure 2 – 64 to 97 km/h WOT Acceleration Comparison Between Petrol and E5**

| Results:                    | PULP   | PULP E5 | % Improvement over Petrol.<br>E5 |
|-----------------------------|--------|---------|----------------------------------|
| 0-48km/h elapsed time,s     | 4.83   | 4.87    | -1%                              |
| 0-80km/h elapsed time,s     | 10.23  | 10.10   | 1%                               |
| 0-97km/h elapsed time,s     | 14.70  | 14.47   | 2%                               |
| 64-97km/h elapsed time,s    | 7.73   | 7.47    | 3%                               |
| 0-5s distance covered, m    | 36.23  | 36.0    | -1%                              |
| 0-5s terminal speed, km/h   | 48.96  | 48.6    | -1%                              |
| 0-400m elapsed time         | 20.17  | 20.1    | 0%                               |
| 0-400m terminal speed, km/h | 110.36 | 111.2   | 0.8%                             |
| Uego Average (Lambda), 0-97 | 0.87   | 0.88    | 1.7%                             |
| Exhaust temp max.           | 772    | 753.6   | -2.3%                            |

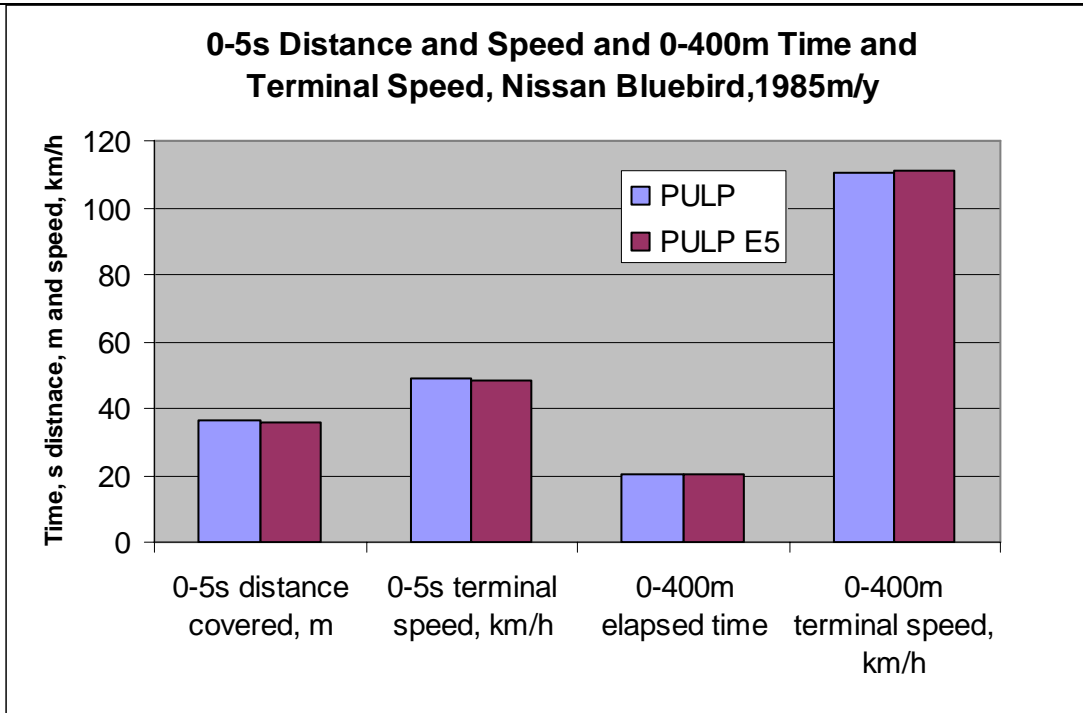
The values shown are average values, calculated from the three acceleration runs on each fuel.

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



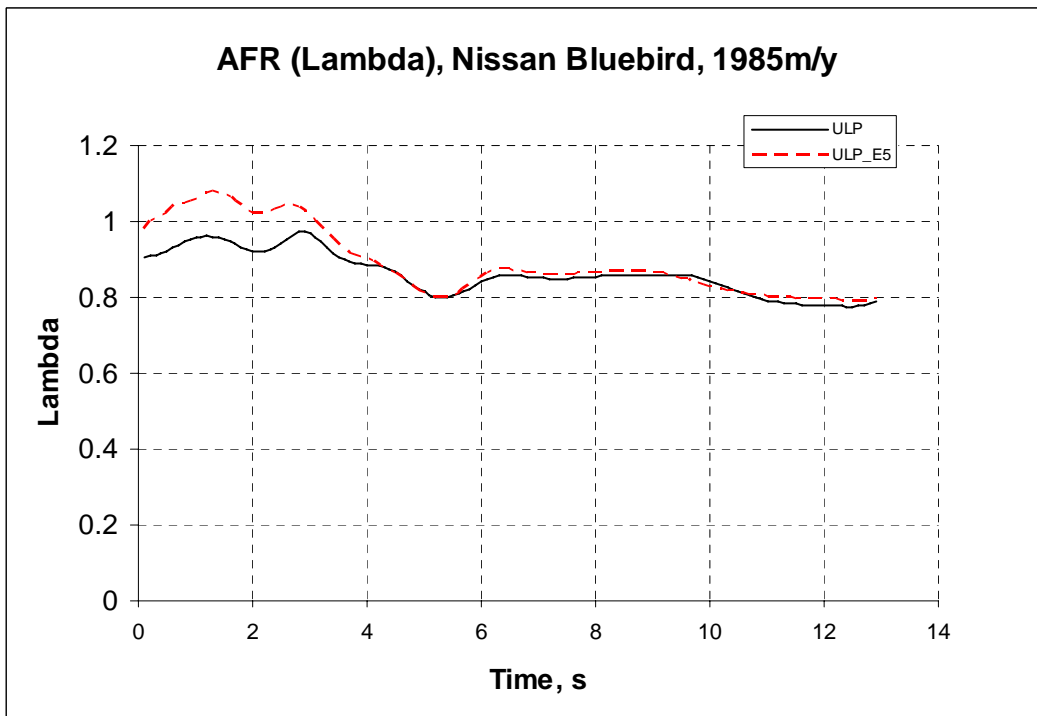
**Figure 3 – Elapsed Times for WOT Accelerations**

Overall the WOT acceleration test data indicates a small improvement in the acceleration times for E5 over Petrol. For the 0~97km/h run, E5 showed a 1~2% improvement in the times to reach all three terminal speeds, except for 0~48km/h which worsened by 1%. Similarly, for accelerations from 64~97km/h km/h acceleration times improved by 3% for E5 over Petrol.



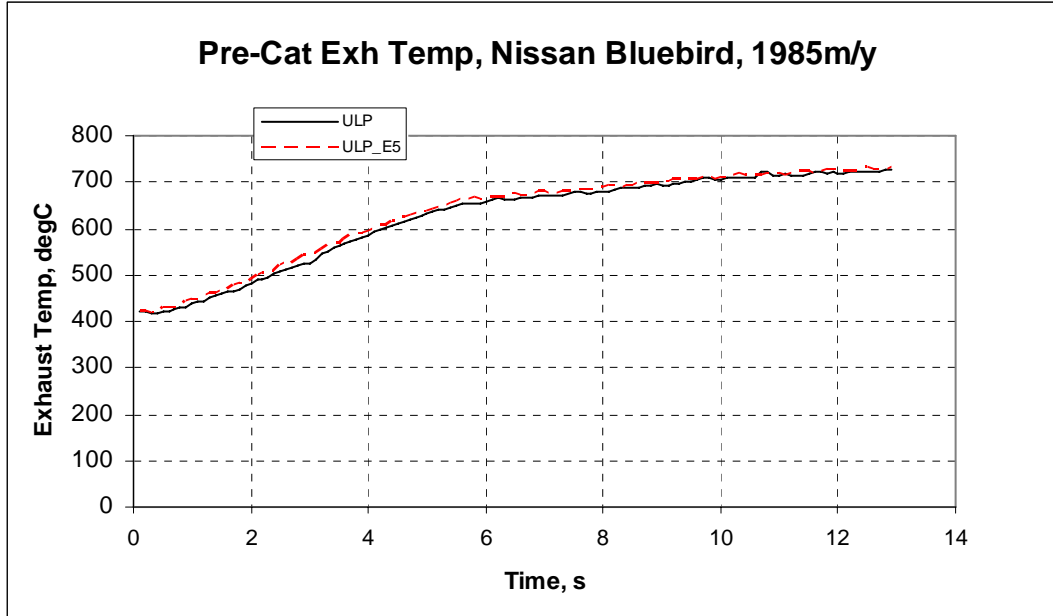
**Figure 4 – 0 to 5s and 0 to 402m WOT Acceleration Performance Comparison**

The 0~400m elapsed times and the terminal speeds were similar for Petrol and E5, to within 1%. Launch, as measured by the 0~5s distance and the terminal speed after 5s was similar for the E5 fuel and Petrol to within 1%.



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

Figure 5 shows that on average the engine was running 1.7% leaner for E5 compared to Petrol during the 0-97km/h test. This is consistent with a vehicle which does not apply learning to the AFR, and is close to the expected enleanment for E5 fuel.



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

The peak pre-catalyst exhaust gas temperature recorded at the end of each run was 2% less for the E5 fuel than the Petrol figure. This does not follow the trend of other vehicles, but is probably the result of test to test variability.

## CONCLUSIONS/DISCUSSION

The WOT acceleration results on the Nissan Bluebird indicate there is a slight improvement in some performance measures and a slight decrease with others with the use of E5 fuel. However the magnitude is such that any changes due to the use of E5 on the WOT performance would not be noticeable.

The enleanment noted is not likely to cause any detrimental effect on the vehicle. No increase in exhaust temperature was noted.

## 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.

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

|  |                          |                                   |                |                    |                                |
|--|--------------------------|-----------------------------------|----------------|--------------------|--------------------------------|
| <u>Vehicle:</u> Make <u>Nissan</u> Model <u>Bluebird</u> Year <u>1985</u>  |                          | Test Date <u>8/11/2006</u>        |                |                    |                                |
| Odometer <u>61707</u> km   |                          | Car No <u>15</u>                  |                |                    |                                |
| <u>Test Location</u> <u>MACD no 1</u>  |                          | Driver <u>CSB</u>                 |                |                    |                                |
| Start of test date <u>8/11/2006</u>  |                          | Time strt <u>12:30</u>            |                |                    |                                |
| End of test date <u>8/11/2006</u>  |                          | Time end <u>13:50:00 PM</u>       |                |                    |                                |
| Transmission, type <u>3a/t</u>   |                          | Automatic shift mode <u>Drive</u> |                |                    |                                |
| Fuel Type <u>PULP</u>  |                          |                                   |                |                    |                                |
| <u>Remarks</u>   |                          |                                   |                |                    |                                |
| <u>Ambient conditions for test:</u>  |                          |                                   |                |                    |                                |
| Temperature  | <u>26</u> °C             | Barometric Pressure               | <u>101.6</u>   | Relative Humidity  | <u>46</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<br>(Max-mean)/mean |
| 0-48km/h elapsed time,s  | <u>4.9</u>               | <u>4.6</u>                        | <u>5</u>       | <u>4.83</u>        | <u>3.45</u> %                  |
| 0-80km/h elapsed time,s  | <u>10.2</u>              | <u>10</u>                         | <u>10.5</u>    | <u>10.23</u>       | <u>2.61</u> %                  |
| 0-97km/h elapsed time,s  | <u>14.6</u>              | <u>14.5</u>                       | <u>15</u>      | <u>14.70</u>       | <u>2.04</u> %                  |
| 64-97km/h elapsed time,s   | <u>7.8</u>               | <u>7.7</u>                        | <u>7.7</u>     | <u>7.73</u>        | <u>0.86</u> %                  |
| 0-5s distance covered, m   | <u>36.0</u>              | <u>39.2</u>                       | <u>33.4</u>    | <u>36.2</u>        | <u>8.31</u> %                  |
| 0-5s terminal speed, km/h  | <u>48.7</u>              | <u>50.9</u>                       | <u>47.3</u>    | <u>49.0</u>        | <u>3.94</u> %                  |
| 0-400m elapsed time  | <u>20.2</u>              | <u>19.9</u>                       | <u>20.4</u>    | <u>20.2</u>        | <u>1.16</u> %                  |
| 0-400m terminal speed, km/h  | <u>110.9</u>             | <u>110.0</u>                      | <u>110.1</u>   | <u>110.4</u>       | <u>0.53</u> %                  |
| Uego Average, Lambda, 0-97   | <u>0.87</u>              | <u>0.86</u>                       | <u>0.85</u>    | <u>0.86</u>        | <u>0.83</u> %                  |
| Exhaust temp max.  | <u>733.0</u>             | <u>782.3</u>                      | <u>774.8</u>   | <u>771.6</u>       | <u>1.39</u> %                  |
| File reference: P:\Projects\Government\GOV005\Test Data\GOV5-15 - Nissan Bluebird\MACD WOT testing\[VEH15_WOT01aa_M01.xls]Report |                          |                                   |                |                    |                                |

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

|   |                          |                                   |                  |                            |                                |
|---|--------------------------|-----------------------------------|------------------|----------------------------|--------------------------------|
| <u>Vehicle:</u> Make <u>Nissan</u>  |                          | Model <u>Bluebird</u>             | Year <u>1985</u> | Test Date <u>8/11/2006</u> |                                |
| Odometer <u>61665</u> km  |                          |                                   |                  | Car No <u>15</u>           |                                |
| <u>Test Location</u> <u>MACD no 1</u>   |                          | Driver <u>CSB</u>                 |                  |                            |                                |
| Start of test date <u>8/11/2006</u>   |                          | Time strt <u>23:00</u>            |                  |                            |                                |
| End of test date <u>8/11/2006</u>   |                          | Time end <u>12:00</u>             |                  |                            |                                |
| Transmission, type <u>3a/t</u>  |                          | Automatic shift mode <u>Drive</u> |                  |                            |                                |
| <u>Fuel Type</u> <u>PULP</u>  |                          |                                   |                  |                            |                                |
| <u>Remarks</u> _____  |                          |                                   |                  |                            |                                |
| <u>Ambient conditions for test:</u>   |                          |                                   |                  |                            |                                |
| Temperature   | <u>26</u> °C             | Barometric Pressure               | <u>101.6</u>     | Relative Humidity          | <u>51</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<br>(Max-mean)/mean |
| 0-48km/h elapsed time,s   | <u>4.9</u>               | <u>4.9</u>                        | <u>4.8</u>       | <u>4.87</u>                | <u>0.68</u> %                  |
| 0-80km/h elapsed time,s   | <u>10.2</u>              | <u>10.1</u>                       | <u>10</u>        | <u>10.10</u>               | <u>0.99</u> %                  |
| 0-97km/h elapsed time,s   | <u>14.5</u>              | <u>14.5</u>                       | <u>14.4</u>      | <u>14.47</u>               | <u>0.23</u> %                  |
| 64-97km/h elapsed time,s  | <u>7.4</u>               | <u>7.5</u>                        | <u>7.5</u>       | <u>7.47</u>                | <u>0.45</u> %                  |
| 0-5s distance covered, m  | <u>35.2</u>              | <u>36.1</u>                       | <u>36.7</u>      | <u>36.0</u>                | <u>2.02</u> %                  |
| 0-5s terminal speed, km/h   | <u>48.0</u>              | <u>48.8</u>                       | <u>49.1</u>      | <u>48.6</u>                | <u>0.99</u> %                  |
| 0-400m elapsed time   | <u>20.2</u>              | <u>20.1</u>                       | <u>20</u>        | <u>20.1</u>                | <u>0.50</u> %                  |
| 0-400m terminal speed, km/h   | <u>111.7</u>             | <u>111.1</u>                      | <u>110.9</u>     | <u>111.2</u>               | <u>0.43</u> %                  |
| Uego Average Lambda, 0-97   | <u>0.89</u>              | <u>0.88</u>                       | <u>0.88</u>      | <u>0.88</u>                | <u>0.85</u> %                  |
| Exhaust temp max.   | <u>737.3</u>             | <u>756.6</u>                      | <u>757.7</u>     | <u>753.6</u>               | <u>0.55</u> %                  |
| File reference: P:\Projects\Government\GOV005\Test Data\GOV5-15 - Nissan Bluebird\MACD WOT testing\VEH15_WOT02aa_M01.xls\Report |                          |                                   |                  |                            |                                |

### Attachment 3

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

|                                     |   |                       |                                      |                                      |                   |
|-------------------------------------|---|-----------------------|--------------------------------------|--------------------------------------|-------------------|
| <u>Vehicle:</u>                     | Make <u>Nissan</u>  | Model <u>Bluebird</u> | Year <u>1985</u>                     | Base fuel test date <u>8/11/2006</u> | Car No <u>15</u>  |
|                                     | Odometer <u>61665</u> km  |                       |                                      |                                      |                   |
|                                     | End Ods <u>61707</u> km   |                       |                                      |                                      |                   |
| <u>Test Location</u>                | <u>MACD no 1</u>  |                       |                                      | Driver <u>CSB</u>                    |                   |
| Start of test date                  | <u>8/11/2006</u>  |                       |                                      | Time strt <u>various</u>             |                   |
| End of test date                    | <u>8/11/2006</u>  |                       |                                      | Time end <u>various</u>              |                   |
| Transmission, type                  | <u>3a/t</u>   |                       |                                      | Automatic shift mode <u>Drive</u>    |                   |
| <u>Fuel Type</u> (base)             | <u>PULP</u>   |                       |                                      |                                      |                   |
| <u>Remarks</u>                      | <u> </u>  |                       |                                      |                                      |                   |
| <u> </u>                            |   |                       |                                      |                                      |                   |
| <u>Ambient conditions for test:</u> |   |                       |                                      |                                      |                   |
| Temperature                         | <u>26-26</u> °C   | Barometric Pressure   | <u>101.6-101.6</u>                   | Relative Humidity                    | <u>46-51</u> %    |
| Wind Velocity                       | <u>roller speed</u> km/h  | Direction             | <u>Head-on</u>                       | Peak wind velocity                   | <u>Road speed</u> |
| <u>Results:</u>                     | <u>PULP</u>   | <u>PULP E5</u>        | <u>% Improvement over Petrol. E5</u> |                                      |                   |
| 0-48km/h elapsed time,s             | <u>4.83</u>   | <u>4.87</u>           | <u>-1%</u>                           |                                      |                   |
| 0-80km/h elapsed time,s             | <u>10.23</u>  | <u>10.10</u>          | <u>1%</u>                            |                                      |                   |
| 0-97km/h elapsed time,s             | <u>14.70</u>  | <u>14.47</u>          | <u>2%</u>                            |                                      |                   |
| 64-97km/h elapsed time,s            | <u>7.73</u>   | <u>7.47</u>           | <u>3%</u>                            |                                      |                   |
| 0-5s distance covered, m            | <u>36.23</u>  | <u>36.0</u>           | <u>-1%</u>                           |                                      |                   |
| 0-5s terminal speed, km/h           | <u>48.96</u>  | <u>48.6</u>           | <u>-1%</u>                           |                                      |                   |
| 0-400m elapsed time                 | <u>20.17</u>  | <u>20.1</u>           | <u>0%</u>                            |                                      |                   |
| 0-400m terminal speed, km/h         | <u>110.36</u>   | <u>111.2</u>          | <u>0.8%</u>                          |                                      |                   |
| Uego Average (Lambda), 0-97         | <u>0.87</u>   | <u>0.88</u>           | <u>1.7%</u>                          |                                      |                   |
| Exhaust temp max.                   | <u>772</u>  | <u>753.6</u>          | <u>-2.3%</u>                         |                                      |                   |
| File reference:                     | P:\Projects\Government\GOV005\Test Data\GOV5-15 - Nissan Bluebird\MACD WOT testing\VEH15_WOTaa_comp_twofuels.xls]Report |                       |                                      |                                      |                   |

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|-----------------|---|----------------|--------|
| <b>CUSTOMER</b> | Department of Environment and Heritage  | <b>PROJECT</b> | GOV005 |
| <b>TITLE</b>    | 2000hr Materials Compatibility Testing of Fuel System Components for a "Pre 1986" Nissan Bluebird GOV5-15 |                |        |

## AIM

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

## EQUIPMENT

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

## PROCEDURE

- A selection of fuel system components was made based on them having contact with fuel and potentially influencing the integrity and function of the fuel system. These components were characterised accordingly and their features recorded. A photographic record of the components was also taken.
- All components were labelled with part numbers according to the appropriate SAE standard. A listing of the components tested is shown in Table 1.
- Parts tested were from a MY1985 Nissan Bluebird 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 GOV5-15 test parts completed 2016 hours of fluid exposure with interim progress inspections and recordings made at 480 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 5.

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

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

- Seals (part # 2, 3a)
- Gaskets (part # 3b, 3c, 6b)
- Fuel pump diaphragm (part # 6c)
- Carburettor fuel float (part # 7)

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:

- Seals (part # 2, 3a)
- Gaskets (part # 3b, 3c, 6b)
- Fuel pump diaphragm (part # 6c)

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

**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:

- Seals (part # 2, 3a)
- Gasket (part # 6b)

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 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 shrinkage of:

- Seals (part # 2, 3a)
- Fuel pump diaphragm (part # 6c)

These parts reduced in thickness more when dried after exposure to E5 than after exposure to S.PULP.

Also noted was the continued swelling of:

- Gaskets (part # 3b, 3c)

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

**Metal components at 2000 hrs**

- Corrosion on throttle (part #1), see Figure 5

**General Observations**

- Discoloured filter housing (part # 6), see Figure 6
- Loose filter in the filter housing (part #6), see Figure 6

**CONCLUSIONS/DISCUSSION**

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

- Increased weight gain of elastomer components due to increased absorption of fuel for ethanol blend.
- Increased swelling of elastomer components due to exposure to ethanol blends
- Greater weight loss by some elastomer components when dried after exposure to ethanol blends
- Retained weight increase by some elastomers when dried after exposure to ethanol blend.

- Corrosion of some metal components when exposed to ethanol blends
- Discolouration of some plastics when exposed to ethanol blend.

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. The swelling of plastic components may cause the loosening of the filter in the filter housing. The loss of filtration in the fuel system makes the jets and valves in the fuel system vulnerable to contamination by foreign material. Materials experiencing significant changes due to contact with E5 are considered unacceptable. Metal components which corroded during this accelerated test are considered incompatible with the test fluid. Discolouration of the plastic fuel filter housing may indicate material compatibility.

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.

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Table 1 – Components Tested

| Pre 86 Vehicle          |                                       |             |
|-------------------------|---------------------------------------|-------------|
| GOV5-15 Nissan Bluebird |                                       |             |
| Part                    | Description                           | Material    |
| 1                       | Throttle                              | steel/brass |
| 2                       | Seal - fuel sender                    | rubber      |
| 3a                      | Seal - carburettor                    | rubber      |
| 3b                      | Gasket - carburettor float bowl cover | composite   |
| 3c                      | Gasket - carburettor                  | steel       |
| 4                       | Fuel filter casing                    | plastic     |
| 5                       | Check valve casing                    | plastic     |
| 6a                      | Fuel pump cover                       | Alumimium   |
| 6b                      | Fuel pump cover gasket                | Rubber      |
| 6c                      | Diaphragm - fuel pump                 | Rubber      |
| 7                       | Float - carburettor GOV5-19 # 5       | plastic     |

Table 2 – Measurements at beginning of test

| Pre 86 Vehicle          |                                       |             | Pre Test measurements |                    |                  |            |                    |                  |
|-------------------------|---------------------------------------|-------------|-----------------------|--------------------|------------------|------------|--------------------|------------------|
| GOV5-15 Nissan Bluebird |                                       |             | S.PULP                |                    |                  | S.PULP.E5  |                    |                  |
| Part                    | Description                           | Material    | Weight (g)            | Thickness/Dia (mm) | Hardness (Shore) | Weight (g) | Thickness/Dia (mm) | Hardness (Shore) |
| 1                       | Throttle                              | steel/brass | 260.51                |                    |                  | 211.25     |                    |                  |
| 2                       | Seal - fuel sender                    | rubber      | 3.21                  | 4.5                |                  | 3.108      | 4.5                |                  |
| 3a                      | Seal - carburettor                    | rubber      | 2.418                 | 2.96               |                  | 2.468      | 3.02               |                  |
| 3b                      | Gasket - carburettor float bowl cover | composite   | 1.521                 | 0.9                |                  | 1.397      | 0.84               |                  |
| 3c                      | Gasket - carburettor                  | steel       | 8.96                  | 3.25               |                  | 9.021      | 3.27               |                  |
| 4                       | Fuel filter casing                    | plastic     | 35.358                | 6.87               |                  | 43.357     | 6.8                |                  |
| 5                       | Check valve casing                    | plastic     | 18.943                | 80                 |                  |            |                    |                  |
| 6a                      | Fuel pump cover                       | Alumimium   | 95.098                |                    |                  | 74.308     |                    |                  |
| 6b                      | Fuel pump cover gasket                | Rubber      | 1.353                 | 0.49               |                  | 1.358      | 0.48               |                  |
| 6c                      | Diaphragm - fuel pump                 | Rubber      | 7.039                 | 1.4                |                  | 6.95       | 1.44               |                  |
| 7                       | Float - carburettor GOV5-19 # 5       | plastic     | 11.655                | 50.8               |                  | 12.051     | 51.33              |                  |

Table 3 – Measurements at completion of test, wet.

| Pre 86 Vehicle          |                                       |             | 2000 hr measurements (wet) |                    |                  |            |                    |                  |
|-------------------------|---------------------------------------|-------------|----------------------------|--------------------|------------------|------------|--------------------|------------------|
| GOV5-15 Nissan Bluebird |                                       |             | S.PULP                     |                    |                  | S.PULP.E5  |                    |                  |
| Part                    | Description                           | Material    | Weight (g)                 | Thickness/Dia (mm) | Hardness (Shore) | Weight (g) | Thickness/Dia (mm) | Hardness (Shore) |
| 1                       | Throttle                              | steel/brass | 260.89                     |                    |                  | 211.36     |                    |                  |
| 2                       | Seal - fuel sender                    | rubber      | 3.657                      | 4.62               |                  | 3.846      | 4.85               |                  |
| 3a                      | Seal - carburettor                    | rubber      | 2.448                      | 2.99               |                  | 2.619      | 3.13               |                  |
| 3b                      | Gasket - carburettor float bowl cover | composite   | 2.043                      | 1.08               |                  | 2.168      | 1.17               |                  |
| 3c                      | Gasket - carburettor                  | steel       | 9.837                      | 3.42               |                  | 10.581     | 3.7                |                  |
| 4                       | Fuel filter casing                    | plastic     | 43.491                     | 6.81               |                  | 48.826     | 6.88               |                  |
| 5                       | Check valve casing                    | plastic     | 21.642                     | 79.18              |                  |            |                    |                  |
| 6a                      | Fuel pump cover                       | Alumimium   | 95.272                     |                    |                  | 74.536     |                    |                  |
| 6b                      | Fuel pump cover gasket                | Rubber      | 1.49                       | 0.55               |                  | 1.587      | 0.59               |                  |
| 6c                      | Diaphragm - fuel pump                 | Rubber      | 7.39                       | 1.53               |                  | 8.04       | 1.64               |                  |
| 7                       | Float - carburettor GOV5-19 # 5       | plastic     | 11.663                     | 51.2               |                  | 13.2       | 51.75              |                  |

Table 4 – Measurements at completion of test, dry.

| Pre 86 Vehicle          |                                       |             | Post test measurements (dry) |                    |                  |            |                    |                  |
|-------------------------|---------------------------------------|-------------|------------------------------|--------------------|------------------|------------|--------------------|------------------|
| GOV5-15 Nissan Bluebird |                                       |             | S.PULP                       |                    |                  | S.PULP.E5  |                    |                  |
| Part                    | Description                           | Material    | Weight (g)                   | Thickness/Dia (mm) | Hardness (Shore) | Weight (g) | Thickness/Dia (mm) | Hardness (Shore) |
| 1                       | Throttle                              | steel/brass | 260.34                       |                    |                  | 211.17     |                    |                  |
| 2                       | Seal - fuel sender                    | rubber      | 3.079                        | 4.51               |                  | 2.902      | 4.4                |                  |
| 3a                      | Seal - carburettor                    | rubber      | 2.149                        | 2.91               |                  | 2.161      | 2.93               |                  |
| 3b                      | Gasket - carburettor float bowl cover | composite   | 1.533                        | 0.96               |                  | 1.407      | 0.95               |                  |
| 3c                      | Gasket - carburettor                  | steel       | 8.701                        | 3.27               |                  | 8.953      | 3.4                |                  |
| 4                       | Fuel filter casing                    | plastic     | 39.031                       | 6.81               |                  | 38.749     | 6.73               |                  |
| 5                       | Check valve casing                    | plastic     | 19.602                       | 79.26              |                  |            |                    |                  |
| 6a                      | Fuel pump cover                       | Alumimium   | 94.948                       |                    |                  | 74.118     |                    |                  |
| 6b                      | Fuel pump cover gasket                | Rubber      | 1.236                        | 0.45               |                  | 1.205      | 0.45               |                  |
| 6c                      | Diaphragm - fuel pump                 | Rubber      | 6.147                        | 1.28               |                  | 6.173      | 1.27               | 70               |
| 7                       | Float - carburettor GOV5-19 # 5       | plastic     | 11.581                       | 50.88              |                  | 12.797     | 51.53              |                  |

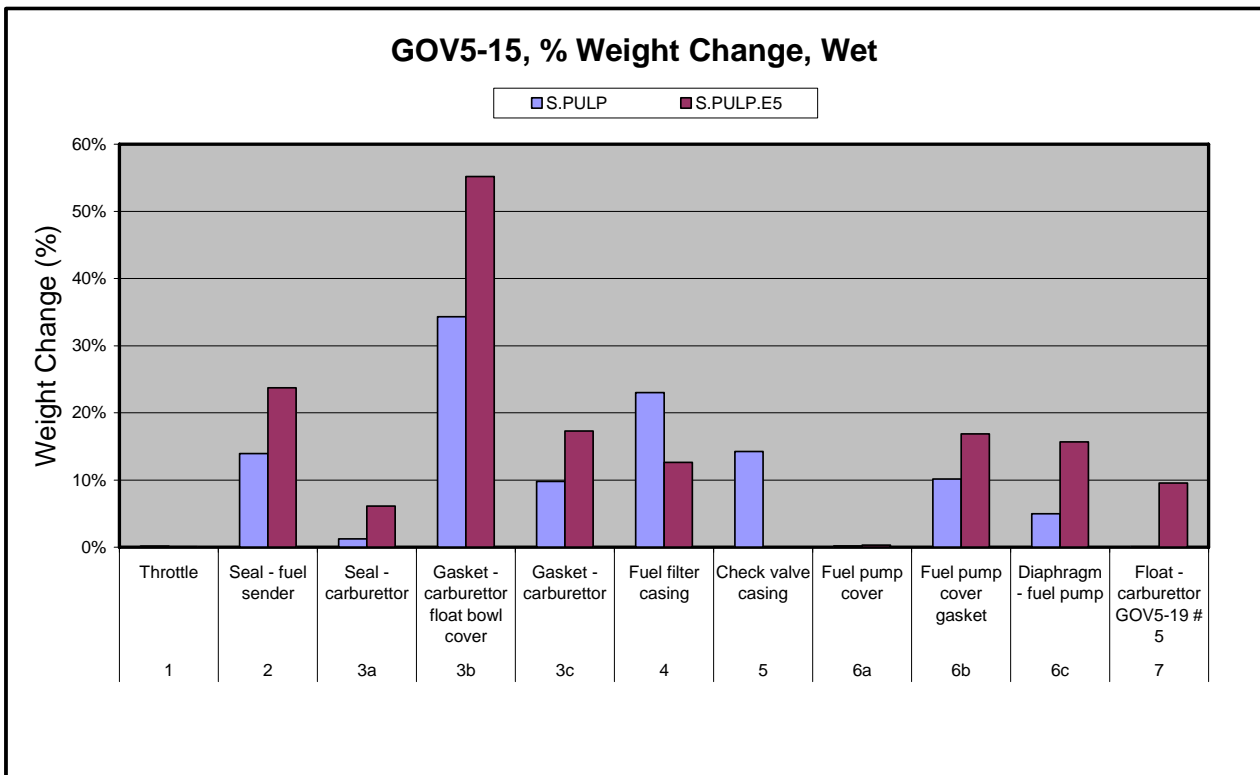


Figure 1 – Component weight change at test completion, wet.

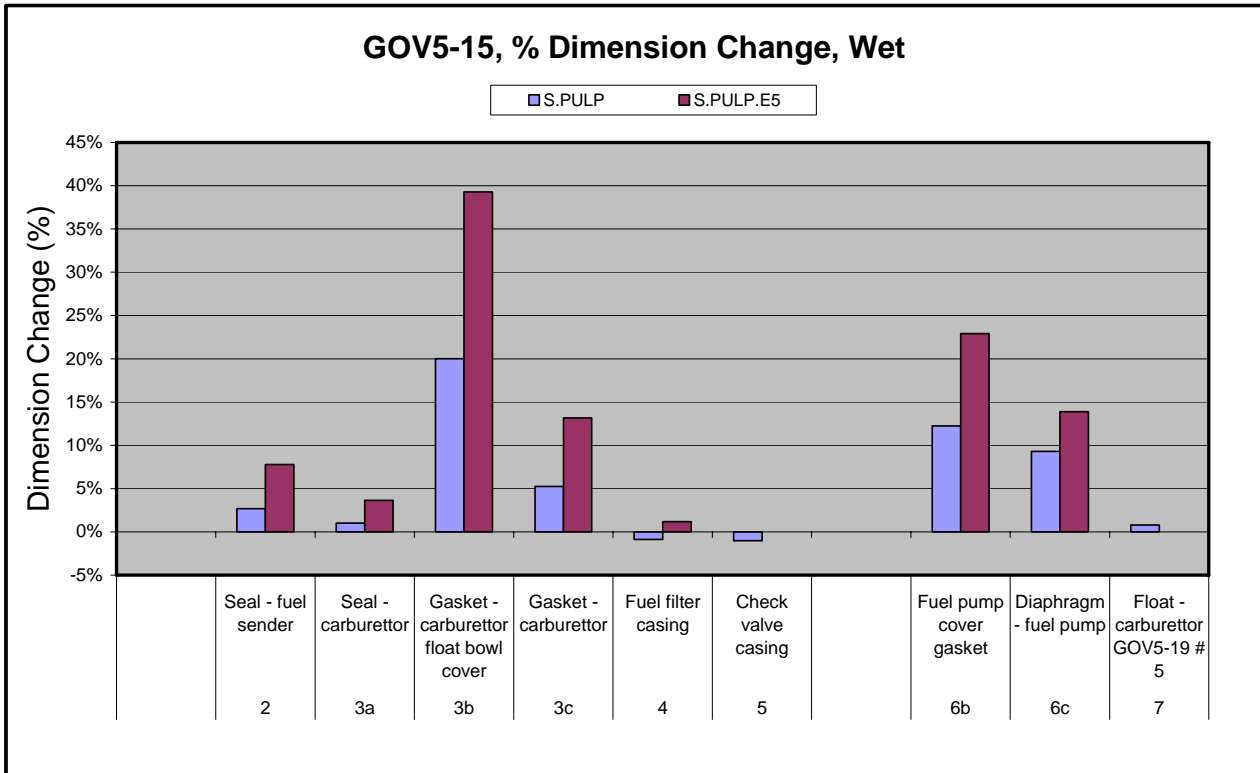


Figure 2 – Component thickness change at test completion, wet

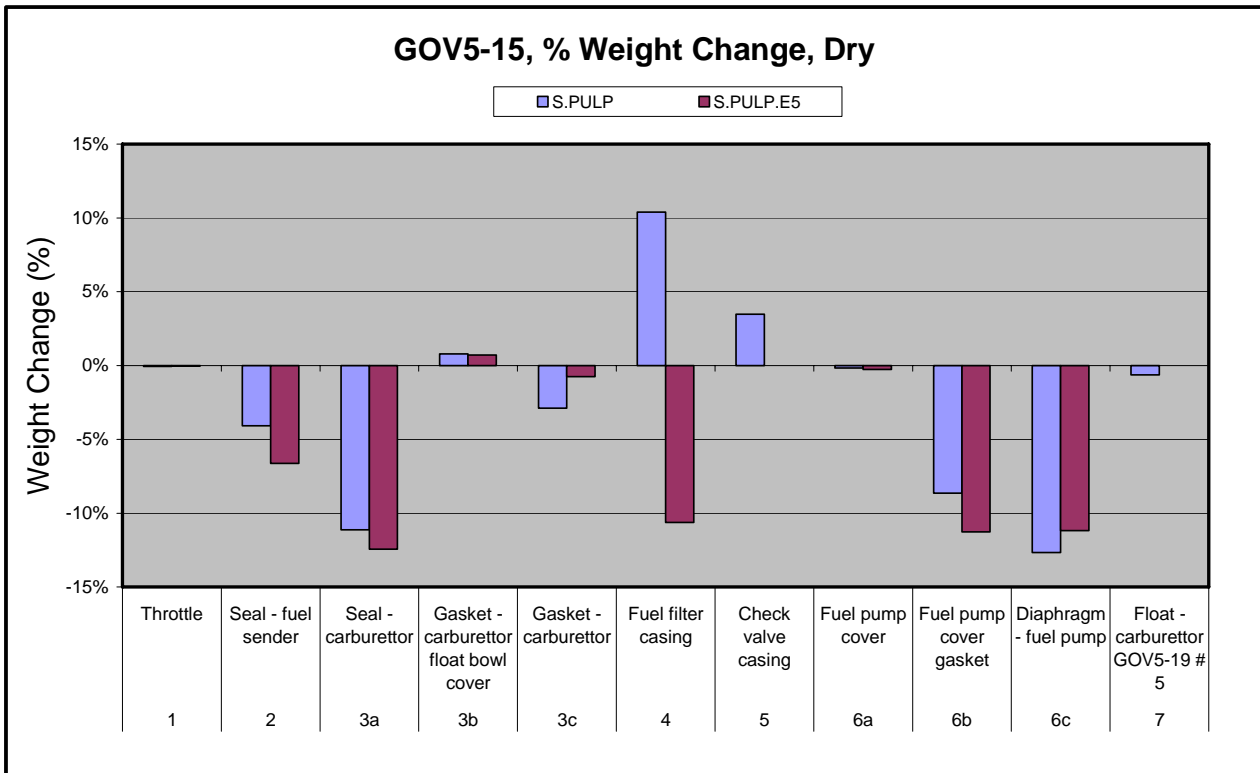


Figure 3 – Component weight change at test completion, dry

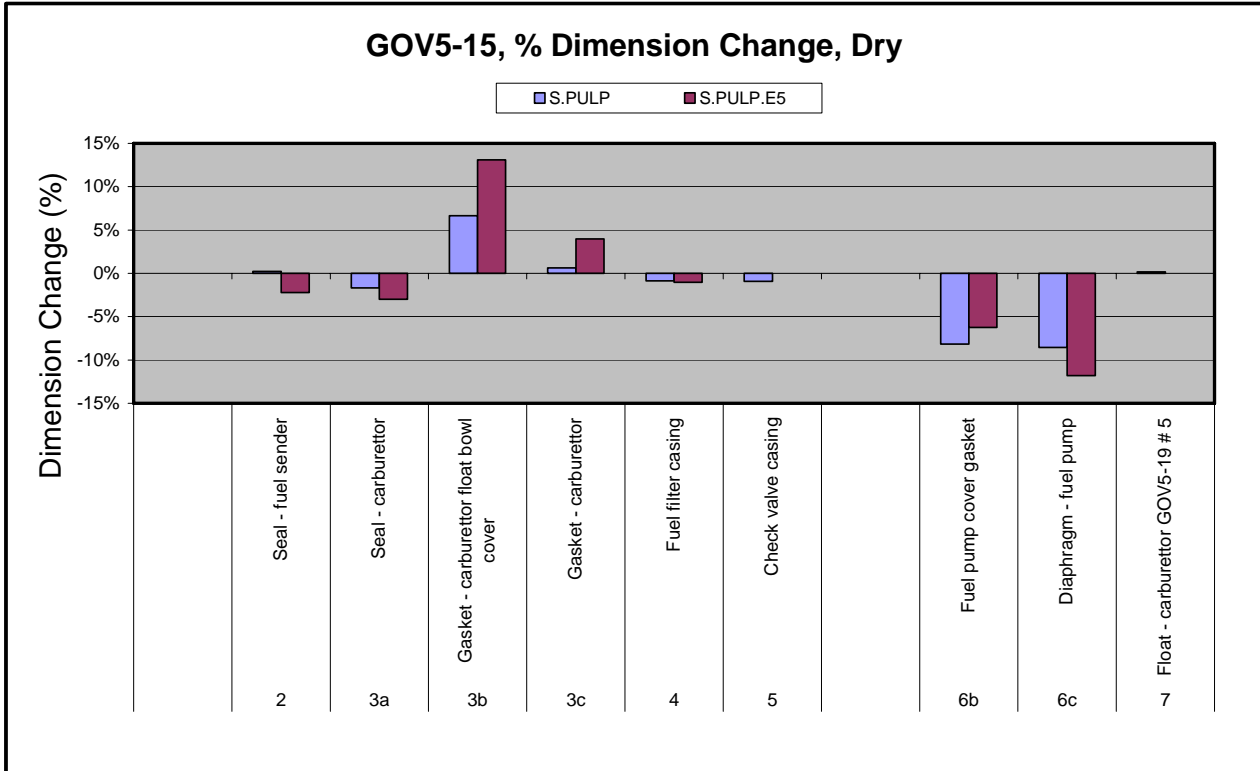


Figure 4 – Component thickness change at test completion, dry

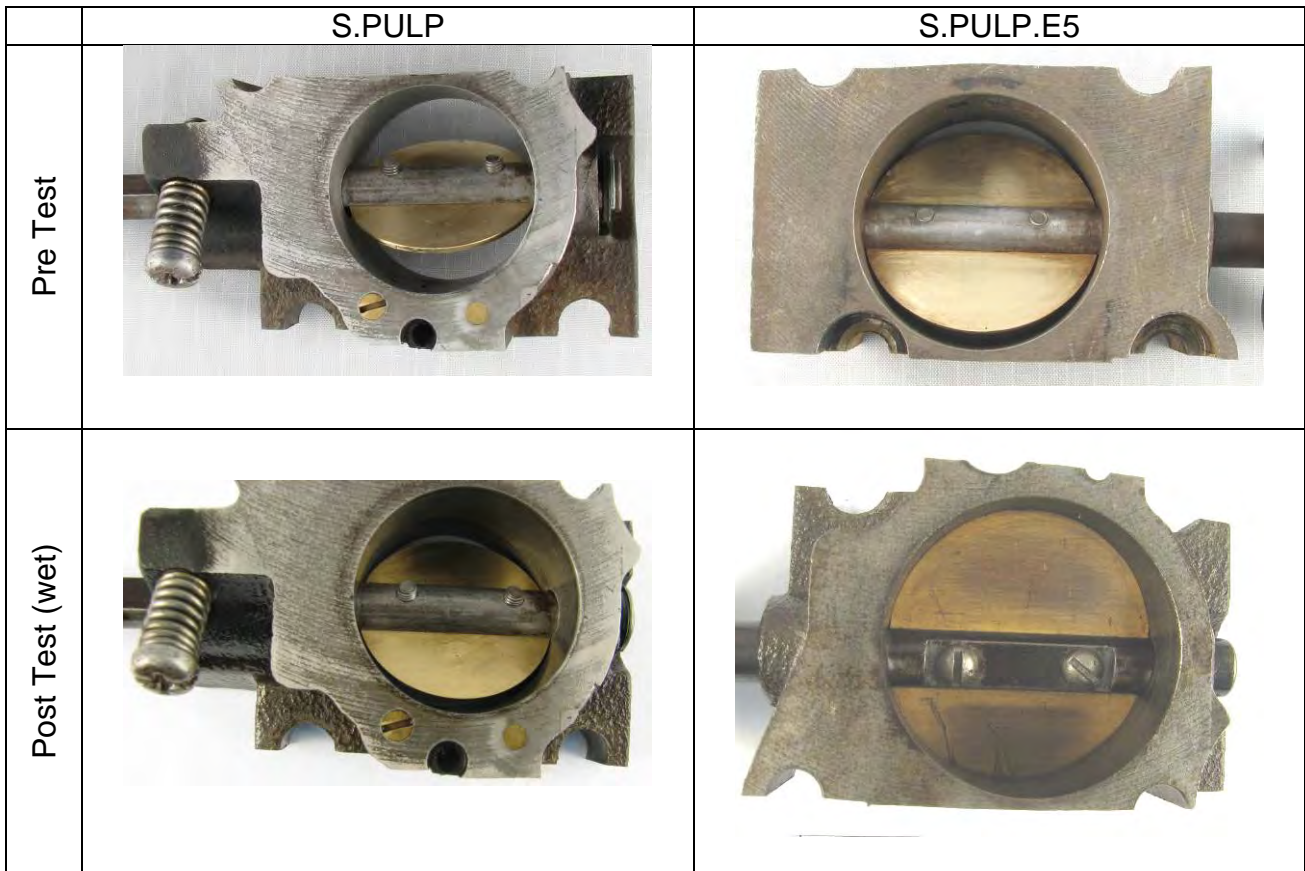


Figure 5 –Part # 1, Throttle





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

Figure 6 Part # 4, Fuel Filter Casing