CITA-Applus+ Urea Emulator
Emission Tampering

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► AD BLUE EMULATORS
► TESTS
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Gasoline: 3WCC

- **SEMI-PASSIVE SYSTEM**
  - CORRECT TEMPERATURE
  - NEAR TO STOICHIOMETRIC MIXTURE
  - CATALYTIC REACTION (NO CONSUMABLE)
  - INOPERATIVE DEVICES ARE EASY TO DETECT

\[
\begin{align*}
2\text{NO} & \rightarrow \text{N}_2 + \text{O}_2 \\
2\text{NO}_2 & \rightarrow \text{N}_2 + 2\text{O}_2 \\
2\text{CO} + \text{O}_2 & \rightarrow 2\text{CO}_2 \\
\text{HC} + \text{O}_2 & \rightarrow \text{CO}_2 + \text{H}_2\text{O}
\end{align*}
\]
**SCR BASICS**

**SCR**

- **DOC** increases NO₂ to NO ratio increasing SCR effectivity
- **DPF** blocks PM and oxidizes it during regeneration
- **Noₓ Reduction**
  - \(4 \text{NH}_3 + 4 \text{NO} + \text{O}_2 \rightarrow 4 \text{N}_2 + 6 \text{H}_2\text{O}\)
  - \(4 \text{NH}_3 + 2 \text{NO} + 2 \text{NO}_2 \rightarrow 4 \text{N}_2 + 6 \text{H}_2\text{O}\)
- **AOC** oxidises excess ammonia

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**Image**: [https://dieselnet.com/](https://dieselnet.com/)
SCR BASICS

SCR

- UREA NEEDED AS AN ADDITIVE
- ADBLUE / DEF (DIESEL EXHAUST FLUID)
- EGR / SCR BALANCE NEEDED
- COMPLEX SYSTEM THAT INCREASES VEHICLE INITIAL AND OPERATION COST
- NOX REDUCTION STRATEGIES HAVE BECOME AN IMPORTANT INDUSTRIAL SECRET
- DUE TO THE COMPLEXITY OF THE INJECTION STRATEGY IS NOT EASY TO DO A QUICK SYSTEM FUNCTION TEST

Image: https://https://www.camionactualidad.es/
## SCR vs 3WCC

<table>
<thead>
<tr>
<th></th>
<th>3WCC</th>
<th>SCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Cost</td>
<td>Medium</td>
<td>Very High</td>
</tr>
<tr>
<td>Operation cost</td>
<td>None</td>
<td>UREA</td>
</tr>
<tr>
<td>Repair cost</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Enforcement</td>
<td>Easy</td>
<td>Very complex</td>
</tr>
</tbody>
</table>
AD BLUE EMULATORS

https://www.canbusemulator.com/en/
TEST LAB

- VEHICLE TESTED BY APPLUS IDIADA IN SPAIN
- CREDENTIALS
  - ISO 17025 ACCREDITED LABORATORY
  - DESIGNATED TECHNICAL SERVICE SPAIN
  - >15 YEARS ON-BOARD FUEL/ENERGY CONSUMPTION AND EMISSIONS

Timeline:
- 1st PEMS acquisition for R&D projects
- EU 582/2011 PEMS – HDV regulation in force
- RDE-LDV EU regulation
- PEMS testing deployment Brasil
- Fuel & energy consumption services in China
- E/M laboratory operation Itatiaia (Brasil)
- CETESB accreditation

Events:
- 2004
- 2011
- 2016
- 2018
- Q3 2019
- Q4 2019
- Q1 2020
- Q2 2020
- Q3 2020
- Q4 2020
- 2021
TEST LAB

- OFFERING F/E & EMISSIONS ABROAD FOR HDV
- REGULATED AND NON-REGULATED TESTS
  - SORT, R.49, EU582/2011, VTP
- BENCHMARKING PROGRAMS
- CUSTOMISED TESTS
- VEHICLE & SYSTEM LAYOUTS
- ENGINE DYNOMETER & VEHICLE TESTING
## Test Vehicle

<table>
<thead>
<tr>
<th>Truck</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>[Redacted]</td>
</tr>
<tr>
<td>VIN</td>
<td>[Redacted]</td>
</tr>
<tr>
<td>Engine</td>
<td>Fuel</td>
</tr>
<tr>
<td>Test weight (kg)</td>
<td>38818Kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trailer</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VIN</td>
<td>VSRSP3M06ML068738</td>
</tr>
<tr>
<td>Tyres - Pressure (bar)</td>
<td>1\textsuperscript{st} and 2\textsuperscript{nd} axle: Bridgestone R164 160K 158L 285/65 R22.5 – 8.0 3\textsuperscript{rd} axle: Dunlop SP 244 160K 158L 285/65 R22.5 – 8.0</td>
</tr>
</tbody>
</table>
UT: UREA TANK
USM: UREA SUPPLY MODULE
ECM: ENGINE CONTROL MODULE

1: LEVEL AND TEMPERATURE UREA TANK
2: HUMIDITY SENSOR
3: NH₃ SENSOR
4: AFTER CATALYST NOₓ SENSOR
5: AFTER CATALYST TEMPERATURE SENSOR
6: BEFORE SCR TEMPERATURE SENSOR
7: UREA INJECTOR
8: DPF DELTA-P SENSOR
9: BEFORE CATALYST TEMPERATURE SENSOR
10: BEFORE CATALYST NOₓ SENSOR
11: UREA TEMPERATURE SENSOR
12: UREA PRESSURE SENSOR
13: UREA PUMP CONTROL SIGNAL
TEST INSTRUMENTATION

1: UREA MASS FLOW (g/s)
2: UREA PRESSURE SENSOR (kPA)
3: CAN_H AND CAN_L
4: UREA INJECTOR CURRENT (A)
12: UREA PRESSURE SENSOR
13: UREA PUMP CONTROL SIGNAL
Urea emulator installation connection points:

1. Urea pressure sensor signal, ○
2. Urea pump control signal.
3. CAN_H and CAN_L and
   Vehicle 24V Fuse
   Vehicle GND
INCA - Urea pressure sensor signal, ○
INCA – Urea pump control signal. ●

3 CAN_H and CAN_L ○ and ●
Vehicle 24V Fuse ●
Vehicle GND ●
TEST ROUTE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test duration</td>
<td>s</td>
<td>9.700</td>
</tr>
<tr>
<td>Distance</td>
<td>km</td>
<td>194</td>
</tr>
<tr>
<td>Average speed</td>
<td>km/h</td>
<td>75.00</td>
</tr>
<tr>
<td>Maximum altitude</td>
<td>m</td>
<td>577.0</td>
</tr>
<tr>
<td>Medium altitude</td>
<td>m</td>
<td>344.0</td>
</tr>
<tr>
<td>Minimum altitude</td>
<td>m</td>
<td>129.0</td>
</tr>
</tbody>
</table>
RESULTS

OBD VALIDATION

► MIL ACTIVATED AND COUNTER INCREASES
► TORQUE REDUCTION AFTER 10 HOURS
► 2 DTC PRESENT
  • DTC2012 = P208B  Reductant Pump “A” Control Performance/Stuck Off
  • DTC2012 = P208A  Reductant Pump “A” Control Circuit/Open
► VEHICLE BEHAVES AS EXPECTED

<table>
<thead>
<tr>
<th>Step</th>
<th>Date</th>
<th>Time</th>
<th>Emulator installed? (Y/N)</th>
<th>Driven mileage (km)</th>
<th>Driven hours (h)</th>
<th>Comments</th>
<th>Reagent quality counter (h)</th>
<th>Reagent consumption counter (h)</th>
<th>Dosing counter (h)</th>
<th>EGR valve counter (h)</th>
<th>Monitoring system counter (h)</th>
<th>NOx Warning System</th>
<th>Level One Inducement</th>
<th>Ad Blue ON?</th>
<th>Torque reduction? (Y/N)</th>
<th>MIL ON?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>08/04/2021</td>
<td>8:00</td>
<td>No</td>
<td>0</td>
<td>0</td>
<td>Original Conditions</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>Inactive</td>
<td>Inactive</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>1</td>
<td>08/04/2021</td>
<td>13:52</td>
<td>No</td>
<td>239.12</td>
<td>3.52</td>
<td>USM Isolated</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>Active</td>
<td>Inactive</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>2</td>
<td>08/04/2021</td>
<td>18:19</td>
<td>No</td>
<td>271.58</td>
<td>4.56</td>
<td>USM Isolated</td>
<td>0h</td>
<td>0h</td>
<td>3-7h</td>
<td>0h</td>
<td>Active</td>
<td>Inactive</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>3</td>
<td>09/04/2021</td>
<td>13:03</td>
<td>No</td>
<td>134.64</td>
<td>2.28</td>
<td>USM Isolated - Torque reduction 10h</td>
<td>0h</td>
<td>0h</td>
<td>7-10h</td>
<td>0h</td>
<td>Active</td>
<td>Active</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>4</td>
<td>09/04/2021</td>
<td>17:26</td>
<td>No</td>
<td>101.2</td>
<td>1.71</td>
<td>USM Isolated - Torque reduction</td>
<td>0h</td>
<td>0h</td>
<td>10-12h</td>
<td>0h</td>
<td>Active</td>
<td>Active</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>
RESULTS AD BLUE EMULATOR

► NO MIL ACTIVATED NOR COUNTERS STARTED
► NO TORQUE REDUCTION
► COMPLETE UREA SYSTEM OVERRIDE
► NO UREA INJECTED

<table>
<thead>
<tr>
<th>Route</th>
<th>Date</th>
<th>Time</th>
<th>Emulator installed? (Y/N)</th>
<th>Driven mileage (km)</th>
<th>Driven hours (h)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route 5</td>
<td>13/04/2021</td>
<td>16:49</td>
<td>Yes</td>
<td>239.6</td>
<td>3.65</td>
<td>No MILs present and no counters increased.</td>
</tr>
<tr>
<td>Route 6</td>
<td>14/04/2021</td>
<td>16:26</td>
<td>Yes</td>
<td>237.75</td>
<td>3.46</td>
<td>No MILs present and no counters increased.</td>
</tr>
</tbody>
</table>
RESULTS  PARALEL MODE

- The emulator uses CAN messages to detect vehicle ignition
- Control and actuator signals are replaced by constant voltages
- The ECM is feed with fake max injection pressure
- The pump is required not to inject
RESULTS

DEVICE EVALUATION

- The system **completely avoids** the urea injection.
- The system **avoids** any DTC, MIL or induction mode activation.
- NO\textsubscript{x} emissions **increased** around 400% in the test.
- AD blue **savings** added to around 5€/200 KM.
- Savings **around** 20€ per day.
- Device **payback** is around 6 **days** for an international truck.

- **Think of the incentives**
RESULTS

DEVICE EVALUATION

► INCENTIVES

► DURING VEHICLE LIFETIME SAVING SEVERAL TENTHS OF THOUSAND EUROS

► SINGLE TRUCK OWNER IMPORTANT INCREASE ON PROFITS

► FOR A FLEET IT MAY REPRESENT A COMPETITIVE ISSUE

► DETECTION BY PTI OR POLICE BODIES ALMOST IMPOSSIBLE BY DESIGN AND LACK OF REFERENCES
CONCLUSIONS

► TAMPERING IS MORE THAN A TECHNICAL ISSUE, IT IS BEHAVIORAL

► EXPERIENCE SHOWS THAT TECHNOLOGY PROGRESS WILL CHALLENGE ANY TAMPERING PROTECTION BY DESIGN IN FEW MONTHS

► TO PREVENT TAMPERING, WE NEED BOTH DESIGNS MORE TAMPERING PROOF AND TO FACILITATE DETECTION

► THE DIAS PROJECT IS AN EXCELLENT INITIATIVE FOR MORE ROBUST DESIGNS. IT NEEDS TO BE COMPLETED TO FACILITATE TAMPERING DETECTION HTTPS://DIAS-PROJECT.COM/

► ADAS, AD AND EV MAY ALSO FACE SIMILAR INCENTIVE PROBLEMS

► THE WHOLE LIFE OF THE VEHICLE, THE INCENTIVES GENERATED AND THE ENFORCEMENT NEED TO BE CONSIDERED WHEN PLANNING FUTURE AUTOMOTIVE REGULATIONS
Thank you for your attention!

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