SCANIA DC12 01 Euro 3 engine
Emission measurements for VTI and COST 346

Anders Hedbom
Ulf Hammarström (Editor)
Preface
VTI has on commission of VINNOVA and the Swedish Road Administration (SRA) participated in COST 346: "Emissions and fuel consumption from heavy duty vehicles". In this commission VTI has engaged AVL MTC Motortestcenter AB. The research efforts at AVL MTC have been executed by Anders Hedbom. This report, VTI notat 52A-2005, constitutes a documentation of exhaust emission measurements for one engine, SCANIA DC12 01 Euro 3. In the COST 346 project AVL MTC has performed exhaust emission measurements on three engines in total.

Project leader at VTI has been Ulf Hammarström. Contact persons: Carl Naumburg at VINNOVA and Håkan Johansson at SRA. Gunilla Sjöberg, VTI, has performed the final revision of this document.

Linköping, December 2005

Ulf Hammarström
## Contents

<table>
<thead>
<tr>
<th></th>
<th>Engine</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Engine</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Facilities</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>Program</td>
<td>17</td>
</tr>
<tr>
<td>4</td>
<td>Results</td>
<td>21</td>
</tr>
<tr>
<td>5</td>
<td>Comparison MTC – TUG</td>
<td>39</td>
</tr>
</tbody>
</table>
1 Engine and measuring arrangements
### SCANIA DC12 ENGINE
- 6 INLINE CYLINDER DIESEL ENGINE
- TURBO, AIR/AIR INTERCOOLER
- ELECTRONIC UNIT INJECTORS
- 4 VALVES PER CYLINDER
- 6 CYLINDER HEADS
- SWEPT VOLUME 11.7 LITRES

#### Euro 2
- **Environmental class**: Euro 2
- **Injection system**: Electronic unit injectors
- **Compression ratio**: 18:1
- **Max. power**: 420 hp (309 kW) at 1,700-1,800 r/min
- **Max. torque**: 2,000 Nm at 1,050-1,450 r/min
- **Min. specific fuel consumption**: 187 g/kWh
- **Recommended engine speed**: 1,200-1,500 r/min
- **Exhaust brake power**: 230 kW at 2,300 r/min

#### Euro 3
- **Environmental class**: Euro 3
- **Injection system**: Electronic unit injectors
- **Compression ratio**: 18:1
- **Max. power**: 420 hp (309 kW) at 1,900 r/min
- **Max. torque**: 2,000 Nm at 1,100-1,300 r/min
- **Min. specific fuel consumption**: 191 g/kWh
- **Recommended engine speed**: 1,200-1,500 r/min
- **Exhaust brake power**: 230 kW at 2,300 r/min

---

**Figure 1**

**Figure 2**
Figure 5

SCANIA DC12 01 EURO3 ENGINE

VTI notat 52A-2005
2 Facilities
3 Program
MEASUREMENT PROGRAM

ARTEMIS PROGRAM
FULLLOAD PERFORMANCE
STEADY STATE CYCLES
► ECE R49
► ESC
► ARTEMIS SS 29 POINTS
► ARTEMIS SS 15 POINTS

TRANSIENT CYCLES
► ETC
► ELR
► TNO-REAL WORLD CYCLE
► TUG-REAL WORLD CYCLE

MTC PROGRAM
FULLLOAD PERFORMANCE
STEADY STATE CYCLES
► ECE R49
► ESC
► ARTEMIS SS 29 POINTS + 5
► ARTEMIS SS 15 POINTS + 2

TRANSIENT CYCLES
► ETC
► ELR
► TNO-REAL WORLD CYCLE (12.5 kW/ton)
► TUG-REAL WORLD CYCLE

ALL CYCLES RUN TWICE
PROGRAM PERFORMED WITH 2 DIFFERENT DIESEL FUELS

Figure 19

SCANIA DC12 01 EURO3 ENGINE

FUEL KEY PARAMETERS

<table>
<thead>
<tr>
<th>ANALYSIS</th>
<th>UNIT</th>
<th>TUG</th>
<th>EC1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cetan Number</td>
<td>-</td>
<td>53.0</td>
<td>52.5</td>
</tr>
<tr>
<td>Cetan Index</td>
<td>-</td>
<td>56.3</td>
<td>52.9</td>
</tr>
<tr>
<td>Density @ 15°C</td>
<td>kg/m³</td>
<td>836.5</td>
<td>814.7</td>
</tr>
<tr>
<td>Viscosity @ 40°C</td>
<td>cSt</td>
<td>3.259</td>
<td>1.972</td>
</tr>
<tr>
<td>Calorific Value</td>
<td>MJ/kg</td>
<td>42.92</td>
<td>43.17</td>
</tr>
<tr>
<td>CFPP</td>
<td>°C</td>
<td>-17</td>
<td>&lt; -35</td>
</tr>
<tr>
<td>Flash Point</td>
<td>°C</td>
<td>90</td>
<td>72</td>
</tr>
<tr>
<td>Aromatics total</td>
<td>%vol</td>
<td>17.2</td>
<td>4.3</td>
</tr>
<tr>
<td>Monoaromatics</td>
<td>%vol</td>
<td>15.7</td>
<td>4</td>
</tr>
<tr>
<td>Diaromatics</td>
<td>%vol</td>
<td>1.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Polyaromatics, tri and higher</td>
<td>%vol</td>
<td>0.11</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>Sulphur content</td>
<td>mg/kg</td>
<td>245</td>
<td>3</td>
</tr>
<tr>
<td>Distillation IBP</td>
<td>°C</td>
<td>207.9</td>
<td>189.4</td>
</tr>
<tr>
<td>50 % recovered @</td>
<td>°C</td>
<td>276.4</td>
<td>235.0</td>
</tr>
<tr>
<td>90 % recovered @</td>
<td>°C</td>
<td>328.6</td>
<td>270.0</td>
</tr>
<tr>
<td>95 % recovered @</td>
<td>°C</td>
<td>346.8</td>
<td>282.1</td>
</tr>
<tr>
<td>FBP</td>
<td>°C</td>
<td>357.3</td>
<td>294.2</td>
</tr>
<tr>
<td>HRRR</td>
<td>μm</td>
<td>335</td>
<td>370</td>
</tr>
</tbody>
</table>

Figure 20 (All test with TUG fuel are single tests and with EC1, double tests.)

SCANIA DC12 01 EURO3 ENGINE
4 Results
Figure 21 (mg/st: milligram fuel per engine stroke)

Based on measurements 5736Q008+5739Q003

Figure 22 Measurements have been performed with two fuel qualities, EC1 and TUG fuel. (Mg/st: milligram fuel per engine stroke. FSU = Filter Smoke Units (smoke density).)
Figure 23

SCANIA DC12 01 EURO3 ENGINE

Figure 24

Measured ETC points and the ESC control area.

SCANIA DC12 01 EURO3 ENGINE

VTI notat 52A-2005
Figure 25 The full load performance curve for SCANIA DC1201 compared to MAN D2866 LF20. (This MAN engine has been of importance for definition of the ARTEMIS measuring points.)

Figure 26 ECE R49 measurements at rated engine speed were excluded for this engine since they were close to both ESC and ARTEMIS points.
Figure 27

Figure 28
Map calculations based on Artemis SS29+5 (A-file), Artemis SS15+2 (B-file), full load (Q-file) and ESC (S-file) measurements.

Figure 29

Figure 30
Figure 31

SCANIA DC12 01 EURO3 ENGINE

Map calculations based on Artemis SS29+5 (A-file), Artemis SS15+2 (B-file), full load (Q-file) and ESC (S-file) measurements.

Test id: 5728A007.AAD
Test date: 20-DEC-01
Test time: 15:22:04
Operator: KE.Å/U.S

Figure 32

SCANIA DC12 01 EURO3 ENGINE

Map calculations based on Artemis SS29+5 (A-file), Artemis SS15+2 (B-file), full load (Q-file) and ESC (S-file) measurements.

Test id: 5728A007.AAD
Test date: 20-DEC-01
Test time: 15:22:04
Operator: KE.Å/U.S
Figure 37

SCANA DC12 01 EURO3 ENGINE

PM measured by TEOM instrument.

Map calculations based on Artemis SS29+5 (A-file), Artemis SS15+2 (B-file), full load (Q-file) and ESC (S-file) measurements.

Figure 38

SCANA DC12 01 EURO3 ENGINE

PM measured by TEOM instrument.

Map calculations based on Artemis SS29+5 (A-file), Artemis SS15+2 (B-file), full load (Q-file) and ESC (S-file) measurements.
Figure 39

SCANIA DC12 01 EURO3 ENGINE

Figure 40

SCANIA DC12 01 EURO3 ENGINE
Figure 41

SCANIA DC12 01 EURO3 ENGINE

MTC

Date: 2002-03-12
Time: 08:57:07
Anders Hedbom

Map calculations based on Artemis SS29+5 (A-file), Artemis SS15+2 (B-file), full load (Q-file) and ESC (S-file) measurements.

Test id: 5728A007.AAD
Test date: 20-DEC-01
Test time: 15:22:04
Operator: KE.Å/U.S

Figure 42

SCANIA DC12 01 EURO3 ENGINE

MTC

Date: 2002-03-12
Time: 08:57:17
Anders Hedbom

Map calculations based on Artemis SS29+5 (A-file), Artemis SS15+2 (B-file), full load (Q-file) and ESC (S-file) measurements.

Test id: 5728A007.AAD
Test date: 20-DEC-01
Test time: 15:22:04
Operator: KE.Å/U.S

VTI notat 52A-2005
Map calculations based on Artemis SS29+5 (A-file), Artemis SS15+2 (B-file), full load (Q-file) and ESC (S-file) measurements.

Figure 43

SCANIA DC12 01 EURO3 ENGINE

Figure 44

SCANIA DC12 01 EURO3 ENGINE
Figure 45

SCANIA DC12 01 EURO3 ENGINE

Figure 46

SCANIA DC12 01 EURO3 ENGINE
Figure 47  TUG and EC1, fuel qualities, see figure 20. Rnn: ETC-test number nnn.

Figure 48  TUG and EC1, fuel qualities, see figure 20. Rnn: ETC-test number nnn.
SCANIA DC12 01 EURO3 ENGINE

Figure 49

Figure 50

VTI notat 52A-2005 37
Figure 51

SCANIA DC12 01 EURO3 ENGINE

Figure 52

CORRELATION PSS TEOM vs. PSS TRANSIENT CYCLES

y = 0.893x + 0.016

R² = 0.985
5 Comparison MTC – TUG
Figure 55 The same engine model has been measured both at MTC and TUG. TUG fuel has been used in both measurements.

Figure 56 The same engine model has been measured both at MTC and TUG. TUG fuel has been used in both measurements.
Figure 57  Compare with figure 56 (TUG fuel).

Figure 58  Measurements at two laboratories with the same engine model and TUG fuel. Differences between MTC and TUG values are to same extent explained by figure 60.
Figure 59

SCANIA DC12 01 EURO3 ENGINE

Figure 60

(Measurements with the same engine model at MTC (EC1 and TUG fuel) and at TUG (TUG fuel).)
VTI är ett oberoende och internationellt framstående forskningsinstitut som arbetar med forskning och utveckling inom transportsektorn. Vi arbetar med samtliga trafikslag och kärnkompetensen finns inom områdena säkerhet, ekonomi, miljö, trafik- och transportanalys, beteende och samspelet mellan människa–fordon–transportsystem samt inom vägkonstruktion, drift och underhåll. VTI är världssedande inom ett flertal områden, till exempel simulatorteknik.

VTI har tjänster som sträcker sig från förstudier, oberoende kvalificerade utredningar och expertutlåtanden till projektledning samt forskning och utveckling. Vår tekniska utrustning består bland annat av körsimulatorer för väg- och järnvägstrafik, väglaboratorium, däckprovingsanläggning, krockbanor och mycket mer. Vi kan även erbjuda ett brett utbud av kurser och seminarier inom transportområdet.

VTI is an independent, internationally outstanding research institute which is engaged on research and development in the transport sector. Our work covers all modes, and our core competence is in the fields of safety, economy, environment, traffic and transport analysis, behaviour and the man-vehicle-transport system interaction, and in road design, operation and maintenance. VTI is a world leader in several areas, for instance in simulator technology. VTI provides services ranging from preliminary studies, highlevel independent investigations and expert statements to project management, research and development. Our technical equipment includes driving simulators for road and rail traffic, a road laboratory, a tyre testing facility, crash tracks and a lot more. We can also offer a broad selection of courses and seminars in the field of transport.