WELCOME

Evolving Interchange Guidelines and Tests

ICIS Base Oils and Lubricants Conference
London, 22 February 2019
Today’s session - what we will cover

01 Insights into API and European approaches to interchange guidelines and tests

02 What are the options for running European interchange projects?

03 Hear a case study as well as views on industry hurdles and future initiatives
Evolution of European (ACEA) Specification
Engine Oil Specifications driven by Emission Legislation

Initially focus on $SO_2$, $NO_x$ and PM emission reduction

Now more focus on $CO_2$ Emission Reduction

Evolution main Viscosity Grades

- 15W-40
- 10W-40
- 5W-30
- 0W-20

Implications for base oil requirements

- Group I
- Group I
- Group III
- Group III
- Group II
- Group III
- Group IV
- Group III
- Group III
- Group IV

Increased use of Group II and III base oils in Light and Heavy Duty
- Very limited BOI interchange guidelines for Grp II and III
- Current guidelines focused around group 1 base stocks

Interchange Guidelines did not hold pace with specification evolution
The Complexity Challenge

Interchange Guidelines help to manage increasing complexity

From 8 to 14 Categories

- 1996: A1, A2, A3, A4, B1, B2, B3, E1
- 1998: A1, A2, A3, A4, B1, B2, B3, E1
- 2002: A1, A2, A3, B1, B2, B3, B4, B5, E2, E3
- 2004: A1, A2, A3, B1, B2, B3, B4, B5, E2, E3, E5
- 2007: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E2, E3, E5, E7
- 2008: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E4, E6, E7
- 2010: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E4, E6, E7
- 2012: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E4, E6, E7
- 2016: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E4, E6, E7
- 2019: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E4, E6, E7, E11

From 8 to 14 Categories

- 1996: A1, A2, A3, A4, B1, B2, B3, E1
- 1998: A1, A2, A3, A4, B1, B2, B3, E1
- 2002: A1, A2, A3, B1, B2, B3, B4, B5, E2, E3
- 2004: A1, A2, A3, B1, B2, B3, B4, B5, E2, E3, E5
- 2007: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E2, E3, E5, E7
- 2008: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E4, E6, E7
- 2010: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E4, E6, E7
- 2012: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E4, E6, E7
- 2016: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E4, E6, E7
- 2019: A1, A2, A3, B1, B2, B3, B4, B5, C1, C2, E4, E6, E7, E11

“Interchange Guidelines help to manage increasing complexity.”
New Engine Tests Add Complexity

Proposed new engine tests in “ACEA 2019 Sequences”

Heavy Duty

- CEC OM471LS  
- Mack T-13

Light Duty

- M271 EVO Sludge  
- Toyota Turbocharger  
- Seq IVB Wear  
- Seq. VH Sludge  
- Seq. IX LSPI  
- Seq. X Chain Wear

- For new CEC Tests no VGRA/BOI interchange guidelines available
- For tests the North American (API) Interchange guidelines are applied
The Industry Response

Complexity Increase

- Number of ACEA categories increased from 8 to 14
- New and more engine tests in ACEA Sequence for which there are no interchange guidelines
- Changing viscosity grades
- New and more base oils appearing on the market

Interchange Guidelines

- Viscosity Grade Read Across and base oil interchange can contribute to managing the increased complexity and reduce engine oil development costs, while continuing to assure final product performance.
- ATIEL and ATC joined forces to move the development of read across guidelines for (new) CEC tests forward.
NA vs European Approach
Differences between API and ACEA systems

**API**

**Engine Oil Licensing & Certification System (EOLCS)**
- One organisation (API) representing OEMs, Oil and Additives industries
- API develops and owns lubricant classifications
- Enabled development of licensing system
- Logo and policing system
- Fee-based licensing
- Licensing (‘Donut’) still voluntary

**Voluntary code**
- Different organisations representing OEMs, Oil and Additives industries
- ACEA owns Oil Sequences, but chooses not to license
- Not legally possible for ATIEL to license/police against the Oil Sequences
- Voluntary code, with signatory system (Letter of Conformance) - required by ACEA to make performance claims
Differences between API and ACEA systems (Cont’d)

API

Read Across Guideline development embedded in test development

- Viscosity Grade Read Across and Base Oil Interchange Guidelines are developed as integral part of new test development.
- Read across guidelines available at start of new category.
- Funding:
  - Light Duty OEMs, ILSAC members
  - Heavy Duty OEMs, EMA members
  - Additive companies, ACC members
  - Oil marketers, API members.

ACEA

Read Across Guideline Development separated from test development

- Viscosity Grade read Across and Base Oil Interchange Guidelines are responsibility of ATIEL
- No read across guidelines available at start of new tests.
- Funding:
  - Oil Marketers, ATIEL members
  - Additive companies, ATC Members
The EP6 VGRA Programme

First European Industry Read Across Test Programme
Interchange Guideline development in Europe

First ACEA Sequences
Interchange Guidelines based on agreed technical principles and combined engine test data of ATIEL members

After 1996
Interchange guidelines since then primarily based on “grandfathering” as most tests were evolution of existing tests.

ATC/ATIEL
ATIEL and ATC workgroup to progress development of interchange guidelines.

2015
ATIEL and ATC cooperation resulted in VGRA and BOI interchange rule based on collective data from ATC/ATIEL members and a full statistical evaluation.

EP6 VGRA
ATC/ATIEL established funding mechanism to run a statistically designed full E6 engine VGRA test programme.

2018
50/50 funded ATIEL and ATC sponsored test programme was completed resulting in a new VGRA guideline for the EP6 test engine to be published in ATIEL CoP in 2019.
Prior to 2016, there was no process in place to develop read-across guidelines for new engine tests.

ATIEL/ATC developed a framework for read-across guideline development, with plans to apply this framework to the new ACEA 2016 engine tests.

Agreement was reached to proceed with EP6 VGRA as the first read-across guideline development programme.

The EP6 VGRA Working Group Objectives:

• Develop & validate EP6 VGRA guidelines for the ATIEL Code of Practice.
  – Plan and run a statistically designed experiment in the EP6, exploring the effect of base oil viscosity and viscosity modifier treat-rate on test performance.
  – Interpret results and recommend VGRA guidelines for incorporation into the ATIEL Code of Practice.
**Test Matrix Design**

- **Viscosity Grade coverage from 0W-20 to 10W-40**
  - Maximises change in base oil viscosity and VM Level to achieve high statically power to identify effects above the noise of the test
- **Three technologies, across three suppliers**
  - Maximises opportunity to identify unexpected effects and interactions.
- **BOI is not being considered** – base stock slate will be consistent within each Technology

**EP6 Test Order**

<table>
<thead>
<tr>
<th>Technologies A &amp; B (12 Tests)</th>
<th>Sufficient Data?</th>
<th>STOP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>YES</td>
<td>12 tests</td>
</tr>
<tr>
<td></td>
<td>NO</td>
<td>STOP</td>
</tr>
<tr>
<td>Technology C (+4 Runs)</td>
<td></td>
<td>16 tests</td>
</tr>
</tbody>
</table>

**Technology C** will only be required if:

- Analysis of the first two technologies gives neutral results
- Initial conclusions conflict with technical judgement and experience
- Results demonstrate strong interactions and read-across cannot be permitted

**Program costs** ~ € 1 million for 16 tests
Table VGRA.5 VGRA guidelines for the VW TDI or OM646LA Bio or EP6CDT engine test
(Applicable only to engine lubricants with non-dispersant type of viscosity modifier)

<table>
<thead>
<tr>
<th>Test run on</th>
<th>Can be read across to</th>
</tr>
</thead>
<tbody>
<tr>
<td>0W-20</td>
<td>yes</td>
</tr>
<tr>
<td>0W-30</td>
<td>yes</td>
</tr>
<tr>
<td>0W-40</td>
<td>yes</td>
</tr>
<tr>
<td>5W-20</td>
<td>yes</td>
</tr>
<tr>
<td>5W-30</td>
<td>yes</td>
</tr>
<tr>
<td>5W-40</td>
<td>yes</td>
</tr>
<tr>
<td>5W-50</td>
<td>yes</td>
</tr>
<tr>
<td>10W-20</td>
<td>yes</td>
</tr>
<tr>
<td>10W-30</td>
<td>yes</td>
</tr>
<tr>
<td>10W-40</td>
<td>yes</td>
</tr>
<tr>
<td>10W-50</td>
<td>yes</td>
</tr>
<tr>
<td>15W-20</td>
<td>yes</td>
</tr>
<tr>
<td>15W-30</td>
<td>yes</td>
</tr>
<tr>
<td>15W-40</td>
<td>yes</td>
</tr>
<tr>
<td>15W-50</td>
<td>yes</td>
</tr>
<tr>
<td>20W-20</td>
<td>yes</td>
</tr>
<tr>
<td>20W-30</td>
<td>yes</td>
</tr>
<tr>
<td>20W-40</td>
<td>yes</td>
</tr>
<tr>
<td>20W-50</td>
<td>yes</td>
</tr>
</tbody>
</table>

(*) Yes, VGRA is permitted if the viscosity modifier concentration increase in the read-across viscosity grade vs the tested viscosity grade is less than 15% mass fraction relative.

If the viscosity modifier concentration increase is larger than 15% mass fraction relative, VGRA can be permitted if technical support data as defined in Section h.15 of the ATC Code of Practice is available to justify read-across.
The new VGRA Guideline for the EP6CDT test provides more flexibility

VGRA is permitted if the viscosity modifier concentration is decreased, or if the increase in the read-across viscosity grade vs the tested viscosity grade is less than 15% mass fraction relative.

This VGRA guideline is the result of a statistically designed matrix of EP6 test oils run by ATIEL and ATC in a diverse range of technologies.

If the viscosity modifier concentration increase is larger than 15% mass fraction relative, VGRA can be permitted if technical support data as defined in Section h.15 of the ATC Code of Practice is available to justify read-across.
Future Programmes

Viscosity Grade Read Across
Industry currently in the process of selecting the next VGRA programme:

- Consensus now forming to develop interchange guidelines for the Toyota Turbocharger test as no interchange guidelines for this new test are available.
Future Programmes

Base Oil Interchange Options
Base Oil Interchange Matrix Design

• Design example for e.g. the EP 6 Engine test (cost per test ~ € 67,300)

• Assumption that two base oil groups, including intra-group read-across is a minimum requirement for BOI to be worthwhile.
# Possible Base Oil Interchange Matrix

<table>
<thead>
<tr>
<th>1</th>
<th>Technology A</th>
<th>10W-30</th>
<th>Group II</th>
<th>Group III</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Technology B</td>
<td>5W-40</td>
<td>Slate 1</td>
<td>Slate 1</td>
</tr>
<tr>
<td>3</td>
<td>Technology C</td>
<td>5W-30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Technology A</td>
<td>10W-30</td>
<td>Group II</td>
<td>Group III</td>
</tr>
<tr>
<td>5</td>
<td>Technology B</td>
<td>5W-40</td>
<td>Slate 2</td>
<td>Slate 2</td>
</tr>
<tr>
<td>6</td>
<td>Technology C</td>
<td>5W-30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Technology A</td>
<td>10W-30</td>
<td>Group II</td>
<td>Group III</td>
</tr>
<tr>
<td>8</td>
<td>Technology B</td>
<td>5W-40</td>
<td>Slate 3</td>
<td>Slate 3</td>
</tr>
<tr>
<td>9</td>
<td>Technology C</td>
<td>5W-30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Technology A
  - 10W-30
  - 10W-30
  - 10W-30

- Technology B
  - 5W-40
  - 5W-40
  - 5W-40

- Technology C
  - 5W-30
  - 5W-30
  - 5W-30

- Technology A
  - 10W-30
  - 10W-30
  - 10W-30

- Technology B
  - 5W-40
  - 5W-40
  - 5W-40

- Technology C
  - 5W-30
  - 5W-30
  - 5W-30

- Technology A
  - 10W-30
  - 10W-30
  - 10W-30

- Technology B
  - 5W-40
  - 5W-40
  - 5W-40

- Technology C
  - 5W-30
  - 5W-30
  - 5W-30

<table>
<thead>
<tr>
<th>3 BO slates</th>
<th>2 base oil groups</th>
<th>3 VG’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 tests</td>
<td>4 duplicates</td>
<td>22 tests</td>
</tr>
</tbody>
</table>
Base Oil Interchange Matrix

- Assumption that two base oil groups, including intra-group read-across is a minimum requirement for BOI to be worthwhile.
- Testing may become prohibitively expensive very quickly when additional base oil groups are added (see example with EP6 below).

### EP6 Test Cost

<table>
<thead>
<tr>
<th>Condition</th>
<th>Number of Tests</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two base oil groups (including intra-group interchange)</td>
<td>22</td>
<td>1,480,000 EUR</td>
</tr>
<tr>
<td>Three base groups (including intra-group interchange)</td>
<td>+ 9 = 31</td>
<td>+ 606,000 EUR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,086,000 EUR</td>
</tr>
</tbody>
</table>
Base Oil Interchange Matrix Simplification

• BOI Experimental Matrix is much more expensive than the VGRA Matrix  
  • Approximately at least twice as expensive

• How can we reduce the costs ?  
  • Take a more practical approach  
    • Is it necessary to include Group II <-> Group III interchange ?  
    • Is interchange in same group not sufficient ?  
  • Step by step including stopping rules
BOI Matrix/Stopping rules - Stepwise Approach

Technology A
(6 Tests)
Sufficient Data?
YES
NO
Repeats Needed?
YES
Repeat Testing (+2 Tests)
NO
Repeat Testing (+2 Tests)

Technology B
(6 Tests)
Sufficient Data?
YES
NO
Repeats Needed?
YES
Repeat Testing (+2 Tests)
NO
Repeat Testing (+2 Tests)

Technology C
(6 Tests)
Sufficient Data?
YES
NO
Repeats Needed?
YES
Repeat Testing (+2 Tests)
NO
Repeat Testing (+2 Tests)

STOP 1 technology tested
STOP 2 technologies tested
STOP 3 technologies tested
Base Oil Interchange Matrix/Stopping rules

Application to EP6

<table>
<thead>
<tr>
<th></th>
<th>No Repeats</th>
<th>All Repeats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology A</td>
<td>403 800 EUR</td>
<td>538 400 EUR</td>
</tr>
<tr>
<td>Technology A+B</td>
<td>807 600 EUR</td>
<td>1 076 800 EUR</td>
</tr>
<tr>
<td>Technology A+B+C</td>
<td>1 211 400 EUR</td>
<td>1 615 200 EUR</td>
</tr>
</tbody>
</table>

• Opportunity to stop testing after Technology A if:
  • Confidence is sufficiently high in read-across
  • No read-across is possible
Main Industry Challenges

01 Alignment
Industry alignment within and across organisations (ATC and ATIEL)

02 Cost
- Especially Base Oil Interchange Programs require significant level of funding
- Currently only PCMO
- HDDO will be even more expensive

03 Funding
Funding mechanism
- How to distribute costs amongst beneficiaries?

04 Test Engines
Availability of test engines
Main Industry Challenges

• It is ATIEL’s position that ultimately the best option is to include VGRA and/or BOI in the CEC test development phase (similar to API approach)
  • Most cost effective overall solution
  • Possibly delays engine test development
• This will require further industry alignment and funding

ATIEL is committed to progress the development of interchange guidelines for the benefit of its members and the industry
Thank you!

For more information visit:

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www.eelqms.eu

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