Bitumen, black or shades of grey?

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Nynas AB
Bitumen, black or shades of grey?

• Bitumen supply & demand in Europe
• Bitumen quality – Specification & Performance
• Bitumen durability – Long Term Ageing
Global bitumen demand ~ 100 Mt
European bitumen demand ~ 15 Mt

Source: Nynas estimates based on various sources.

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Where is bitumen produced in Europe?

Refineries
- Refineries with bitumen

Demand

Capacity

Spare

Possible New entrants

Closures

2000

2015

2018

2015

-5000

5000

15000

25000

150

0

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Energy traders plan to increase their bitumen market share

“There is a perception that the world is going to be more disconnected - supply and demand-wise - and we are there to help connect the dots. You can expect our presence and our interest to be where there are significant opportunities and shorts in the market.” (Puma Energy)

“It used to be mostly a small distribution business. Now it is more of a whole arbitrage business requiring a global reach and shipping capacity.” (Vitol)

“We see a definite upward trend in the number of nautical miles for bitumen.” (VALT)

Source: Bloomberg, July 14, 2016
Bitumen grades in Europe

FORMAL DEMANDS

Construction Products Regulation (EU) No 305/2011

- Establishes ‘Basic Requirements’
  - Mechanical resistance and stability
  - Safety in case of fire
  - Hygiene, health and the environment
  - Safety and accessibility in use
  - Protection against noise
  - Energy economy and heat retention
  - Sustainable use of natural resources

- Must be incorporated into bitumen standards

Paving Grades
EN 12591 + EN 13924-1

Modified
EN 14023

Industrial
EN 13304

Polymer
Modifie
## Bitumen Specification – EN 12591

### Table 1 — Paving grade bitumen specifications for grades from 20 x 0.1mm to 220 x 0.1mm penetration

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Unit</th>
<th>Test method</th>
<th>Class 0</th>
<th>20/30</th>
<th>30/45</th>
<th>35/50</th>
<th>40/60</th>
<th>50/70</th>
<th>60/80</th>
<th>70/100</th>
<th>100/150</th>
<th>160/220</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration at 25°C</td>
<td>0.1 mm</td>
<td>EN 1256</td>
<td>/</td>
<td>20 – 30</td>
<td>30 – 45</td>
<td>35 – 50</td>
<td>40 – 60</td>
<td>50 – 70</td>
<td>60 – 80</td>
<td>70 – 100</td>
<td>100 – 150</td>
<td>160 – 220</td>
</tr>
<tr>
<td>Resistance to hardening at 163°C</td>
<td></td>
<td>EN 1267-1</td>
<td>/</td>
<td>≥ 55</td>
<td>≥ 53</td>
<td>≥ 53</td>
<td>≥ 50</td>
<td>≥ 50</td>
<td>≥ 46</td>
<td>≥ 43</td>
<td>≥ 37</td>
<td></td>
</tr>
<tr>
<td>Retained penetration</td>
<td>%</td>
<td>EN 1267-1</td>
<td>/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase in softening point, max - Severity 1 or 2</td>
<td>°C</td>
<td>EN 1267-1</td>
<td>/</td>
<td>≤ 8</td>
<td>≤ 8</td>
<td>≤ 8</td>
<td>≤ 9</td>
<td>≤ 9</td>
<td>≤ 9</td>
<td>≤ 10</td>
<td>≤ 11</td>
<td>≤ 11</td>
</tr>
<tr>
<td></td>
<td>°C</td>
<td>EN 1267-1</td>
<td>/</td>
<td>≤ 10</td>
<td>≤ 11</td>
<td>≤ 11</td>
<td>≤ 11</td>
<td>≤ 11</td>
<td>≤ 11</td>
<td>≤ 12</td>
<td>≤ 12</td>
<td></td>
</tr>
<tr>
<td>Flash point</td>
<td>°C</td>
<td>EN ISO 2592</td>
<td>≥ 240</td>
<td>≥ 240</td>
<td>≥ 240</td>
<td>≥ 240</td>
<td>≥ 230</td>
<td>≥ 230</td>
<td>≥ 230</td>
<td>≥ 230</td>
<td>≥ 220</td>
<td></td>
</tr>
<tr>
<td>Change of mass after RTFOT</td>
<td>%</td>
<td>EN 1267-1</td>
<td>/</td>
<td>≤ 0,5</td>
<td>≤ 0,5</td>
<td>≤ 0,5</td>
<td>≤ 0,5</td>
<td>≤ 0,5</td>
<td>≤ 0,8</td>
<td>≤ 0,8</td>
<td>≤ 1,0</td>
<td></td>
</tr>
<tr>
<td>Penetration index</td>
<td></td>
<td>Annex A</td>
<td>NR</td>
<td>-1.5 to +0,7</td>
<td>-1.5 to +0,7</td>
<td>-1.5 to +0,7</td>
<td>-1.5 to +0,7</td>
<td>-1.5 to +0,7</td>
<td>-1.5 to +0,7</td>
<td>-1.5 to +0,7</td>
<td>-1.5 to +0,7</td>
<td></td>
</tr>
<tr>
<td>Kinematic viscosity at 135°C</td>
<td>mm²/s</td>
<td>EN 12595</td>
<td>NR</td>
<td>≥ 530</td>
<td>≥ 400</td>
<td>≥ 370</td>
<td>≥ 325</td>
<td>≥ 296</td>
<td>≥ 230</td>
<td>≥ 175</td>
<td>≥ 135</td>
<td></td>
</tr>
<tr>
<td>Dynamic viscosity at 60°C</td>
<td>Pa s</td>
<td>EN 12596</td>
<td>NR</td>
<td>≥ 440</td>
<td>≥ 260</td>
<td>≥ 225</td>
<td>≥ 175</td>
<td>≥ 145</td>
<td>≥ 90</td>
<td>≥ 55</td>
<td>≥ 30</td>
<td></td>
</tr>
<tr>
<td>Fraass breaking point</td>
<td>°C</td>
<td>EN 12693</td>
<td>NR</td>
<td>≤ -5</td>
<td>≤ -5</td>
<td>≤ -7</td>
<td>≤ -8</td>
<td>≤ -10</td>
<td>≤ -12</td>
<td>≤ -12</td>
<td>≤ -15</td>
<td></td>
</tr>
</tbody>
</table>

- **Class 0**: can only be selected for non-mandated properties. These properties are optional. The decision to apply or not to apply a property is taken by the National Standardisation Body (NSB). If chosen it becomes "required", if not, class 0 is to be selected.
- **When Severity 2 is selected, it shall be associated with Fraass breaking point and/or penetration index.**
- **Reference to normative Annex A in the present document, dealing with calculation of the penetration index, to.**
- **NR: Not Required**, this class is used when there is no mandated requirement for a property.
Bitumen specification timeline from empirical to more fundamental performance

- Eurobitume Task Force
  - completed review of all available performance related test methods.
  - proposed to CEN to formally standardise appropriate methods.
- CEN – Specifications are to be more performance related based on fundamental properties
- Questionnaire to Industry stakeholder (EAPA, FEHRL,...) on future performance related specifications.
- Regional ‘BitSpec’ seminars from 2001 to 2003.
- BiTSpec seminar, Brussels (June 2003) – Agreed “road map” to performance related specification framework.
- Eurobitume Task Force
  - completed literature review over suitability, shortcomings and opportunities of proposed test methods.
  - Report published in 2006
- Data Collection completed and analysed.
- Position Paper published
- Transfer to CEN TC 336.
- CEN/TC 336 publication
  - CEN/TR 15352
- Eurobitume Data Collection project started.
## Bitumen Quality ...?

### Table 1 — Paving grade bitumen specifications for grades from 20 x 0.1 mm to 220 x 0.1 mm penetration

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Unit</th>
<th>Test method</th>
<th>Class 0&lt;sup&gt;a&lt;/sup&gt;</th>
<th>20/30</th>
<th>30/45</th>
<th>35/50</th>
<th>40/60</th>
<th>50/70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration at 25°C</td>
<td>0.1 mm</td>
<td>EN 1426</td>
<td>/</td>
<td>20–30</td>
<td>30–45</td>
<td>35–50</td>
<td>40–60</td>
<td>50–70</td>
</tr>
<tr>
<td>Softening point</td>
<td>°C</td>
<td>EN 1427</td>
<td>/</td>
<td>55–63</td>
<td>52–60</td>
<td>50–58</td>
<td>48–56</td>
<td>46–53</td>
</tr>
<tr>
<td>Resistance to hardening at 163°C</td>
<td></td>
<td>EN 12607-1</td>
<td>/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retained penetration</td>
<td>%</td>
<td></td>
<td>/</td>
<td>≥55</td>
<td>≥53</td>
<td>≥53</td>
<td>≥50</td>
<td>≥50</td>
</tr>
<tr>
<td>Increase in softening point, max - Severity 1</td>
<td>°C</td>
<td></td>
<td>/</td>
<td>≤8</td>
<td>≤8</td>
<td>≤8</td>
<td>≤9</td>
<td>≤9</td>
</tr>
<tr>
<td>or</td>
<td></td>
<td></td>
<td>or</td>
<td>or</td>
<td>or</td>
<td>or</td>
<td>or</td>
<td>or</td>
</tr>
<tr>
<td>Increase in softening point, max - Severity 2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>°C</td>
<td></td>
<td>/</td>
<td>≤10</td>
<td>≤11</td>
<td>≤11</td>
<td>≤11</td>
<td>≤11</td>
</tr>
<tr>
<td>Flash point&lt;sup&gt;b&lt;/sup&gt;</td>
<td>°C</td>
<td>EN ISO 2592</td>
<td>/</td>
<td>≥240</td>
<td>≥240</td>
<td>≥240</td>
<td>≥230</td>
<td>≥230</td>
</tr>
<tr>
<td>Solubility&lt;sup&gt;b&lt;/sup&gt;</td>
<td>%</td>
<td>EN 12592</td>
<td>/</td>
<td>≥99</td>
<td>≥99</td>
<td>≥99</td>
<td>≥99</td>
<td>≥99</td>
</tr>
<tr>
<td>Change of mass after RTFOT&lt;sup&gt;b&lt;/sup&gt;</td>
<td>%</td>
<td>EN 12607-1</td>
<td>/</td>
<td>≤0.5</td>
<td>≤0.5</td>
<td>≤0.5</td>
<td>≤0.5</td>
<td>≤0.5</td>
</tr>
</tbody>
</table>

<sup>a</sup> For Class 0<sup>a</sup> the requirements refer to the size of the asphalt mixture in which the bitumen is used.

<sup>b</sup> These tests are conducted at a specific temperature and under controlled conditions.
Ageing induced cracking:

Observations:
Block cracking can occur on aged pavements without reaching BBR $T_{\text{critical}}$
Materials rank differently for block vs. transverse cracking

Two binder parameters have been introduced in 2010
• $\Delta T_c$ from Bending Beam Rheometer
• Glove – Rowe from Dynamic Shear Rheometer ($G^*, \delta$ at $T=15^\circ\text{C}$ and $\omega=0.005$ s\(^{-1}\)$)
Bending Beam Rheometer (EN 14771)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration</td>
<td>42</td>
<td>64</td>
<td>52</td>
<td>52</td>
<td>67</td>
</tr>
<tr>
<td>Softening Point</td>
<td>51.3</td>
<td>47.7</td>
<td>49.8</td>
<td>49.0</td>
<td>46.8</td>
</tr>
<tr>
<td>PI</td>
<td>-1.3</td>
<td>-1.2</td>
<td>-1.2</td>
<td>-1.4</td>
<td>-1.4</td>
</tr>
<tr>
<td>Fraass Breaking Point</td>
<td>-15</td>
<td>-14</td>
<td>-17</td>
<td>-14</td>
<td>-17</td>
</tr>
<tr>
<td>EN Grade</td>
<td>40/60</td>
<td>50/70</td>
<td>50/70</td>
<td>50/70</td>
<td>50/70</td>
</tr>
</tbody>
</table>

- On RTFOT-PAV aged sample a constant load is applied, the deformation is followed with time.
- Stiffness ‘S’ and slope of the creep curve ‘m’ (after 60s)
- To prevent fracture; a low stiffness and/or a large m-value are preferred
- More recently $\Delta T_c$ is measured
Impact of re-refined engine oil bottoms on binder properties and mix performance on two pavements in Minnesota
Gerald Reinke, Andrew Hanz, R. Michael Anderson, Mary Ryan, Steven Engber, Douglas Herlitzka
E&E Congress 2016
Ageing is a Process

Fresh

Short Term Aged

Long Term Aged
Affect of Ageing on: $\Delta T_c$ (BBR): $LmT - LST$

The stiffness is limiting.

The relaxation is limiting.

40/60

50/70

50/70

50/70

50/70

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Short and Long Term Ageing
Short and Long Term Ageing

Eurobitume database 168 bitumen available in the EU market, measured by Eurobitume members,
Nordic data base 38 bitumen available in the Nordic market, measured at SINTEF
Estonia report on 7 bitumens
Nynas data 28 bitumens
Conclusions

• Bitumen “travels further” today than it used to, giving more diversity in source and supply chain operations
• Specifications must reflect performance including the long term durability
• Wide variations observed in $\Delta T_c$ of bitumens available Europe
• Long term performance expected to be different, and
• Selection of bitumen all the more important

Not just black but many shades of grey
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