The Advantages of Kixx LUBO 220N

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GS Caltex
Introduction

The Leader in Providing Total Energy Service

- 50/50 JV of GS Holdings and Chevron since 1967
- A Leading energy company in Korea
  - Crude Oil Refining: 770,000 BPCD
  - Heavy Oil Cracking: 153,000 BPCD
  - Aromatics: 2.8 million Ton/year
  - Lubricants: 9,000 BPCD
  - Base Oils: 17,000 BPCD
- Business Areas
  - Petroleum & Petrochemical
  - Power generation
  - LNG & City gas supply
  - Alternative energy
Overview of HOU

- Invested $1.6 billion in heavy oil upgrading facility
- Joint-design with Chevron Lummus Global
  - Vacuum Distillation Unit : 150 KBPCD
  - Hydrocracker : 60 KBPCD
  - Lube Base Oil Plant : 17 KBPCD
- Mechanical Completion
  - August 31, 2007
- Commercial Production
  - End of October, 2007
Base Oil Manufacturing

- Using the newest ISODEWAXING® technology
  - Jointly designed with Chevron Lummus Global

- Multiple Group II / III production flexibility
  - Group II: 13,000 BPCD (150N / 220N / 600N)
  - Group III: 4,000 BPCD (2cSt / 4cSt / 6 cSt / 8 cSt)

- Start-Up
  - November 2007
Production Process

- 2 stage hydrocracker produces lube oil plant feed
- ISODEWAXING produces high quality Group II/III

*Remark: VDU (Vacuum Distillation Unit), VGO (Vacuum Gas Oil), HCR (HydroCRacker), LOP (Lube Oil Plant), IDW (Iso Dewaxing), HDF (Hydro Finishing)
Introduction Kixx LUBO

**GS Caltex Base Oil**

- **Kixx** : GS Caltex Family Brand Name
- **LUBO** : Lube Base Oil
Market Trends

- Growing demand for high performance lubricants are driving growth in Group II base oil capacities in Asia.

<table>
<thead>
<tr>
<th>Year</th>
<th>Group II (kTons)</th>
<th>Group I (kTons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1825</td>
<td>7895</td>
</tr>
<tr>
<td>2007</td>
<td>2057</td>
<td>8021</td>
</tr>
<tr>
<td>2008</td>
<td>2319</td>
<td>8150</td>
</tr>
<tr>
<td>2009</td>
<td>2615</td>
<td>8280</td>
</tr>
<tr>
<td>2010</td>
<td>2950</td>
<td>8413</td>
</tr>
<tr>
<td>2011</td>
<td>3174</td>
<td>8581</td>
</tr>
<tr>
<td>2012</td>
<td>3415</td>
<td>8752</td>
</tr>
<tr>
<td>2013</td>
<td>3675</td>
<td>8927</td>
</tr>
<tr>
<td>2014</td>
<td>3954</td>
<td>9106</td>
</tr>
<tr>
<td>2015</td>
<td>4255</td>
<td>9288</td>
</tr>
</tbody>
</table>

- Group II demand is increasing.
- Group I demand is relatively flat.
Growing demand in China & India makes exports volume increase from Jan. 2008
Advantages of 220N Grade

- High performance lubricant products
- Cost effective operation in production
Formulation Benefits

- Turbine Oil
- Hydraulic Oil
- Engine Oil

Formulation Benefits
Turbine Oil (formulation benefit)

- **Performance test (Regal R&O 32)**
  - Additive package is the same for all the oils tested
  - Kixx LUBO shows better oxidation & thermal stability

- **Oxidation Stability (ASTM D 2272, RPVOT)**

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
<th>Kixx LUBO</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>319</td>
<td>272</td>
<td>428</td>
</tr>
<tr>
<td>B</td>
<td>314</td>
<td>339</td>
<td>434</td>
</tr>
<tr>
<td>C</td>
<td>150N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>220N</td>
<td></td>
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</tr>
</tbody>
</table>

- Energy Leader
- GS Caltex Corporation

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Turbine Oil (formulation benefit)

- **Performance test (Regal R&O 32)**
  - Additive package is the same for all the oils tested
  - Kixx LUBO shows better oxidation & thermal stability

- **Thermal Stability**

  ![Thermal Stability](image)

  ASTM D2070 method (150℃, 168h)

  ![In-house Method](image)

  In-house Method (140℃, 240h)
Hydraulic Oil (formulation benefit)

- **Performance test (HVI Hydraulic Oil)**
  - Additive package is the same for all the oils tested, except VM content
  - Kixx LUBO shows better thermal stability

- **Thermal Stability**

  - **ASTM D2070 method (150°C, 168h)**
  - **In-house Method (140°C, 240h)**

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<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>150N</td>
<td>220N</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>150N</td>
<td>220N</td>
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</tbody>
</table>
Hydraulic Oil (formulation benefit)

- **Performance test (HVI Hydraulic Oil)**
  - Additive package is the same for all the oils tested, except VM content
  - Kixx LUBO shows better thermal stability & cost effective formulation

- **VM Contents (KV 44.00 @40℃, VI 157)**

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<tbody>
<tr>
<td>KV</td>
<td>6.07</td>
<td>5.87</td>
<td>5.65</td>
<td>4.69</td>
<td>5.00</td>
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<tr>
<td>VI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17.6%</td>
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</table>
Engine Oil (formulation benefit)

- Formulation test (15W40 Engine Oil)
  - Additive package is the same for all the oils tested, except VM content
  - Kixx LUBO shows cost effective formulation

- VM Contents (KV 15.00 @100°C, VI 140)

<table>
<thead>
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<th>Group I</th>
<th>Group II</th>
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<tbody>
<tr>
<td>A</td>
<td>14.0</td>
<td></td>
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<tr>
<td>B</td>
<td>13.4</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>12.6</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>11.8</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>11.0</td>
<td></td>
</tr>
</tbody>
</table>

Kixx LUBO
Engine Oil (formulation benefit)

Formulation test (15W40 Engine Oil)
- Additive package is the same for all the oils tested, except VM content
- Kixx LUBO shows better cold property & volatility

Cold Property (CCS @ -20°C, cP)
Engine Oil (formulation benefit)

- Formulation test (15W40 Engine Oil)
  - Additive package is the same for all the oils tested, except VM content
  - Kixx LUBO shows better volatility

- Volatility (NOACK, wt.%)

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<tr>
<th>Group</th>
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<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11.7</td>
<td>11.8</td>
<td>11.1</td>
<td>11.1</td>
<td>8.4</td>
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<tr>
<td>Group II</td>
<td>5.4</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Why?

Distillation distribution (Simulated distillation)

- Sample A shows double peaks, which come from 150N & 600N base oil.
- Sample B shows only one peak.
Summary

- Market trends suggest Asia Pacific market need for high performance base oils

- Kixx LUBO: the newest high performance base oils in Asia Pacific
  - Latest cutting edge base oil manufacturing technology
  - Formulation benefits (especially 220N)
The newest high performance base oils in Asia Pacific

Thank You!