Polyalkylene Glycols as Performance Wear Lubricant Additives in Straight Oil

Synthetic Polymeric Technology as Performance Lubricity Additive to Straight Oil Metalworking Fluids
Key Messages

• Lubricant Base Groups Evolution
• Polyalkylene Glycol Synthesis
• Metalworking Fluids Concept
• Study Base
• Formulations Information
• Experimental Procedure
• Results & Discussion
• Findings
Lubricants by Group

- Chemistry purity
- Chemistry stability
- Better VI – Viscosity Index
- Additive performance
- Excellent cost-benefit

Source: API – American Petroleum Institute
Typical Polyalkylene Glycol (G-V) Synthesis

Types of PAGs by chemical family

EO Homo-polymers
PO Homo-polymers
EO/PO Block Copolymer
EO/PO Block Copolymer
EO/PO Random Copolymer

Note: PAG - Polyalkylene Glycol | EO - Ethylene Oxide | PO - Propylene Oxide
Oil Soluble Polyalkylene Glycol

Attributes

Proposed as both a base fluid and a performance enhancing additive in lubricants. Some examples of their use include:

• Friction modifiers
• Deposit control
• Viscosity boosters
• Additive solubility aid in Group III and IV hydrocarbon oils
• Lubricity aid and cleanliness additive in water based metalworking fluids and neat oils
• Rheology modifier in greases
# Metalworking Fluids

## Concept

Metalworking Fluids are Engineering Materials that optimize Metalworking Processes

<table>
<thead>
<tr>
<th>Predominance</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>Straight Oils</td>
<td>Petroleum or vegetable oil that is used without water as component.</td>
</tr>
<tr>
<td></td>
<td>Soluble Oil</td>
<td>Mineral oil base aqueous emulsions, forming milky emulsion.</td>
</tr>
<tr>
<td>Water</td>
<td>Semi-synthetic</td>
<td>Mineral oil base emulsions, forming opalescent emulsion.</td>
</tr>
<tr>
<td></td>
<td>Synthetic</td>
<td>Clear and transparent solution. Basically, formulated with Polyalkylene Glycol as lubricant.</td>
</tr>
</tbody>
</table>
**Boundary antiwear additives**

*Characteristic & Attributes*

Main attribution and characteristics:

1. Polar molecules
2. Metal surface adsorption
3. Adhesive wear and metal contact prevention.

Source: W. Bruce, Robert (Edited by), 2nd Edition - Handbook of Lubrication and Tribology
Study Base

• Study Objectives:
  screen oil soluble polyalkylene glycol behavior

• Fluids Proposal:
  naphthenic mineral oil base $V_{40} = 90$ cSt

• Additive Proposal:
  lubricity improver – boundary antiwear additive
Experimental Procedures

Modified ASTM D4172 - 94(2016)

Modified ASTM D4172 - 94(2016);

1 – Comparative Conditions:
1725 +/- 60 RPM; 60 kgf; 30 +/- 1 min; Load;

2 – Precision:
Repeatability - Results obtained by the same operator with the same apparatus under constant operating conditions;

3 – Results:
Average the three readings and report as scar area in square millimeters, using microscope and software for area reading.

Note: ASTM - American Society for Testing and Materials
Results & Discussion
Soluble Oil Polyalkylene Glycol

**Additives Screened**

<table>
<thead>
<tr>
<th>Additive</th>
<th>Chemical Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MO-HBN90</td>
<td>Naphthenic Mineral Oil Base $KV_{40} = 90$ cSt</td>
</tr>
<tr>
<td>A1-OSP-32</td>
<td>Oil Soluble Polyalkylene Glycol – 32 cSt @40 °C</td>
</tr>
<tr>
<td>A2-OSP-68</td>
<td>Oil Soluble Polyalkylene Glycol – 68 cSt @40 °C</td>
</tr>
<tr>
<td>A3-OSP-460</td>
<td>Oil Soluble Polyalkylene Glycol – 460 cSt @40 °C</td>
</tr>
<tr>
<td>A4-OSP-680</td>
<td>Oil Soluble Polyalkylene Glycol – 680 cSt @40 °C</td>
</tr>
</tbody>
</table>

Note: These are typical properties, not to be construed as specifications.
# Formulation Information

**Straight Metalworking Fluid**

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Function</th>
<th>PAG Test Formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naphthenic Mineral Oil KV 90 cSt</td>
<td>Lubricant Base</td>
<td>95-100%</td>
</tr>
<tr>
<td>Oil Soluble Polyalkylene Glycol (OSP)</td>
<td>Boundary Lubricant Additive</td>
<td>1-5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

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4-Ball Comparison

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Viscosity

**KV\textsubscript{100} influence**

Note: These are typical properties, not to be construed as specifications.
Viscosity Index

Note: These are typical properties, not to be construed as specifications.
Main findings

• In 4-ball wear tests, oil soluble polyalkylene glycols exhibited antiwear properties in Naphthenic base oil.

• The antiwear performance was excellent for oil soluble polyalkylene glycols of different molecular weight and viscosities.
References


[6] wwwjmpcom/support/help/Compare_Mean.shtml#81061


Authors contribution:

Camila da Silva
Dow DIS LAA  R&D Technician
ccdasilva1@dow.com
Thank You

Eduardo Lima, M.Sc.
Latin America Technical Service Specialist
Dow Industrial Solutions

phone: +55.11.5188.9949
mobile: +55.11.9645.0547
e-mail: eglima@dow.com

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