K-FLEX® polyester diols are used primarily as modifiers for acrylic, alkyd, epoxy and polyester formulations with isocyanate or melamine crosslinkers. The low molecular weight and narrow molecular weight distribution (NMWD) of the K-FLEX polyesters allows the formulation of VOC compliant systems without exempt solvents, while also providing improved performance. Primary hydroxyl groups provide high reactivity for lower temperature cure. Typical modification levels are 5% to 15% on total resin solids.

**Formulate lower VOC coatings**

**Lower cure temperature**

**Increase flexibility & maintain hardness**

**Maintain higher crosslink density**

**Improve adhesion**

**Excellent resistance properties**

**Excellent compatibility**

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</tr>
</tbody>
</table>

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<tr>
<th><strong>Lower temperature cure, pg. 4</strong></th>
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<tbody>
<tr>
<td>With K-FLEX polyester diols, it is possible to achieve a reaction at lower temperatures for wood and plastic applications.</td>
</tr>
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<th><strong>Solvent viscosity reduction, pg. 4</strong></th>
</tr>
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<tr>
<td>K-FLEX polyester diols can provide efficient viscosity reduction in order to formulate a sprayable system.</td>
</tr>
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<table>
<thead>
<tr>
<th><strong>K-FLEX blends and viscosity reduction, pg. 4</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher viscosity K-FLEX polyester diols can be blended with their lower viscosity counterparts in order to achieve a desired viscosity.</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th><strong>Flexibility and hardness, pg. 5</strong></th>
</tr>
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<tbody>
<tr>
<td>K-FLEX polyester diols increase flexibility and maintain hardness in 2K PU and melamine systems.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Chemical resistance, pg. 6</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>A study shows increased gasoline and transmission fluid resistance in a 2K PU system with K-FLEX XM-337 modification.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Plastics adhesion, pg. 7</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>A study shows increased adhesion to plastics in a 2K PU system with K-FLEX 188 modification.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Exterior durability, pg. 7</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Two studies show improved Florida exposure and QUV-A performance with K-FLEX 188 modification.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Mar and scratch resistance, pg. 7</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>A study shows increased mar and scratch resistance in a melamine baking system modified with K-FLEX A308.</td>
</tr>
</tbody>
</table>
**K-FLEX®** polyester diols are presented in two different charts below. The top chart includes K-FLEX polyester diols with hydroxyl numbers between 220 to 265. These diols display a positive correlation between Tg, viscosity, film hardness, moisture resistance and exterior durability. These values tend to increase with increasing Tg.

The bottom chart includes K-FLEX polyester diols with lower hydroxyl numbers, ranging from 122 to 140. Due to the lower hydroxyl numbers, there is a lower crosslinker demand (isocyanate or melamine) compared to the resins in the above table. Both K-FLEX A307 and K-FLEX 171-90 typically provide good flexibility.

### Product Typical Properties

<table>
<thead>
<tr>
<th>System</th>
<th>% Active</th>
<th>Hydroxyl # as Supplied</th>
<th>Viscosity 25°C (cP)</th>
<th>Tg</th>
<th>Attributes / Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Crosslinker Demand</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XM-337</td>
<td>SB, WB</td>
<td>100%</td>
<td>220</td>
<td>55,000</td>
<td>Provides increased toughness and chemical resistance for solvent based and high solids systems. Highest Tg and modulus.</td>
</tr>
<tr>
<td>188</td>
<td>SB, WB</td>
<td>100%</td>
<td>230</td>
<td>10,000</td>
<td>Improves flexibility while maintaining hardness. Also improves salt spray, humidity resistance and exterior durability. Most versatile.</td>
</tr>
<tr>
<td>148</td>
<td>SB</td>
<td>100%</td>
<td>235</td>
<td>3,750</td>
<td>Improves flexibility and gloss. Increases solids at lower viscosity. Good flow and leveling. Recommended for primers.</td>
</tr>
<tr>
<td>XM-366</td>
<td>SB, WB</td>
<td>100%</td>
<td>265</td>
<td>2,000</td>
<td>Newest polyester with medium hardness. Great flexibility and gloss.</td>
</tr>
<tr>
<td>A308</td>
<td>SB</td>
<td>100%</td>
<td>260</td>
<td>1,500</td>
<td>Medium hardness with great flexibility. Best for mar and scratch resistance.</td>
</tr>
<tr>
<td>XM-332</td>
<td>SB</td>
<td>100%</td>
<td>265</td>
<td>400</td>
<td>Lowest viscosity for lowest VOC. Softer films. Low temperature impact resistance.</td>
</tr>
</tbody>
</table>

*Lower viscosity version available. Contact for information

### K-FLEX Viscosity / Tg & Film Hardness

Lowest

1. XM-332
2. A308
3. XM-366
4. 188
5. XM-337

Highest

**Low Crosslinker Demand**

<table>
<thead>
<tr>
<th>System</th>
<th>% Active</th>
<th>Hydroxyl # as Supplied</th>
<th>Viscosity 25°C (cP)</th>
<th>Tg</th>
<th>Attributes / Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>A307</td>
<td>SB</td>
<td>100%</td>
<td>140</td>
<td>5,400</td>
<td>Flexibility modifier with lower crosslinker demand.</td>
</tr>
<tr>
<td>171-90**</td>
<td>SB</td>
<td>90%</td>
<td>122</td>
<td>3,700</td>
<td>Offering longer pot life, improved adhesion and flexibility. Lower crosslinker demand.</td>
</tr>
</tbody>
</table>

**Supplied 90% solids in xylene / n-butyl acetate

**K-FLEX®** polyester diols can be used in solvent based (SB), waterborne (WB) or 100% non-volatile coatings, inks, adhesives, sealants and elastomer thermoset systems. This brochure will focus on the SB coatings market. Some of the top applications for K-FLEX polyester diols include:

- **Aerospace**
- **Agricultural & Construction Equipment**
- **Marine**
- **Anti-ballistics**
- **Can & Coil**
- **Automotive OEM & Refinish**
- **Flooring**
- **Metro/Rail**
**K-FLEX® Formulation Advantages**

### Resin Compatibility and Solubility

**K-FLEX®** polyester diols are soluble at 10-50% by weight in most organic solvents including exempt and non-exempt solvents. Other polyester polyol resins and caprolactone diols have poor solubility in difficult to use, weak solvents like Oxsol® 100 and t-butyl acetate. K-FLEX polyester diols demonstrate nearly universal solubility in comparison.

Due to their NMWD, the K-FLEX polyester diols are very effective at compatibilizing other resins that are not otherwise compatible. Increasing K-FLEX 188 level, increases the compatibility of Sovermol® 750 with Basonat® HI-100 (HDI Trimer), seen on the right.

### Low Temperature Cure

Due to the primary hydroxyl groups of the K-FLEX polyester diols, it is possible to achieve a reaction at lower temperatures than other resins. To the right is a comparison of the low temperature cure of K-FLEX 188 compared to other competitive polyol technologies.

### Solvent Viscosity Reduction

**K-FLEX®** polyester diols provide efficient viscosity reduction with low levels of solvent due to their NMWD and hydrogen bonding of a low MW diol with ester groups and primary hydroxyl groups. A spray viscosity is possible with K-FLEX 188 at around 80-90% solids. Efficient viscosity reduction of K-FLEX 188 with typical solvents is demonstrated in the graph below.

### K-FLEX Blends and Viscosity Reduction

**K-FLEX® 188** has a high viscosity (10,000 cPs) at 100% active without solvent. The high viscosity of K-FLEX 188 can be reduced by blending it with other K-FLEX polyester diols. Shown below is the effect of blending 25% of a lower viscosity K-FLEX polyester diol with K-FLEX 188. Blends provide some synergy to these diols.
**Flexibility and Hardness - Melamine**

In the King formulation below (HS-19), **K-FLEX® 188** polyl is used as a modifier to provide improved flexibility, hardness and chemical resistance to a high solids polyester/melamine coating. Additionally, the K-FLEX modified systems resulted in better water resistance and a major viscosity reduction.

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>Control</th>
<th>K-FLEX 188 18% on TRS</th>
<th>K-FLEX 188 23% on TRS</th>
<th>K-FLEX 188 34% on TRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS 57-5776b/K-188/Cymel® 325</td>
<td>75/-25</td>
<td>54/18/28</td>
<td>46/23/31</td>
<td>33/34/33</td>
</tr>
<tr>
<td>Total resin solids, weight %</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Brookfield viscosity (cPs), 25°C</td>
<td>1000</td>
<td>440</td>
<td>340</td>
<td>220</td>
</tr>
</tbody>
</table>

**FILM PROPERTIES**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Control</th>
<th>K-FLEX 188 18% on TRS</th>
<th>K-FLEX 188 23% on TRS</th>
<th>K-FLEX 188 34% on TRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pencil hardness</td>
<td>H-2H</td>
<td>H-2H</td>
<td>H-2H</td>
<td>H-2H</td>
</tr>
<tr>
<td>MEK Resistance (2X Rubs)</td>
<td>90</td>
<td>120</td>
<td>130</td>
<td>150</td>
</tr>
<tr>
<td>Crosshatch adhesion</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Direct impact (in-lbs)</td>
<td>50-60</td>
<td>100-110</td>
<td>160+</td>
<td>160+</td>
</tr>
<tr>
<td>Reverse impact (in-lbs)</td>
<td>5</td>
<td>30-40</td>
<td>140-150</td>
<td>150-160</td>
</tr>
<tr>
<td>Water soak, 360 hr @ 50°C</td>
<td>MD/9</td>
<td>MD/9</td>
<td>MD/9</td>
<td>MD/9</td>
</tr>
</tbody>
</table>

**Flexibility and Hardness - 2K PU**

King Industries formulation API-20 is summarized below. Various K-FLEX products are compared as modifiers of a pigmented (0.65:1.0 P:B ratio) high solids aliphatic acrylic 2K PU formulation. When typical low MW polyols are used to lower VOC, it usually comes at a cost of some performance criteria, such as hardness, flexibility, water resistance, UV resistance, or exterior durability. With K-FLEX polyester diols, VOC compliance is achieved while providing improved film properties and resistance properties. Please note in the table below, the reduction in VOC at equal viscosity with K-FLEX modification. VOC is reduced by as much as 18%.

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>Acrylic Control</th>
<th>K-FLEX XM-337 14% on TRS</th>
<th>K-FLEX 188 13.9% on TRS</th>
<th>K-FLEX XM-366 13.7% on TRS</th>
<th>K-FLEX A308 13.7% on TRS</th>
<th>K-FLEX XM-332 13.6% on TRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total resin solids, weight %</td>
<td>67</td>
<td>73</td>
<td>73.3</td>
<td>73.5</td>
<td>73.4</td>
<td>73.5</td>
</tr>
<tr>
<td>VOC, g/l (calc)</td>
<td>407</td>
<td>343</td>
<td>339</td>
<td>336</td>
<td>337</td>
<td>334</td>
</tr>
<tr>
<td>Viscosity (cPs), 25°C</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
</tr>
</tbody>
</table>

**FILM PROPERTIES**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Acrylic Control</th>
<th>K-FLEX XM-337 14% on TRS</th>
<th>K-FLEX 188 13.9% on TRS</th>
<th>K-FLEX XM-366 13.7% on TRS</th>
<th>K-FLEX A308 13.7% on TRS</th>
<th>K-FLEX XM-332 13.6% on TRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pendulum hardness, cycles</td>
<td>121</td>
<td>118</td>
<td>116</td>
<td>106</td>
<td>110</td>
<td>77</td>
</tr>
<tr>
<td>Pencil hardness</td>
<td>2H-3H</td>
<td>3H-4H</td>
<td>2H-3H</td>
<td>H-2H</td>
<td>2H-3H</td>
<td>H-2H</td>
</tr>
<tr>
<td>Reverse impact (in-lbs)</td>
<td>20-30</td>
<td>120-130</td>
<td>160+</td>
<td>160+</td>
<td>160+</td>
<td>160+</td>
</tr>
<tr>
<td>Direct impact (in-lbs)</td>
<td>90-100</td>
<td>160+</td>
<td>160+</td>
<td>160+</td>
<td>160+</td>
<td>160+</td>
</tr>
</tbody>
</table>

Dry Film Thickness: 25µ (1 mil)
Substrate: Iron Phosphated cold rolled steel
Cure Schedule: 2 weeks ambient cure
Chemical Resistance

Modification of this filled 100% non-volatile 2K polyurethane floor coating formulation (PI-13) demonstrates higher hardness, tensile strength, elongation, elastic modulus, tear strength and improved gasoline and transmission fluid stain resistance. The control system was modified with 10% K-FLEX®. It partially replaced the branched polyether-polyester triol and the linear polyether diol. Mechanical properties can be found in the table below and chemical resistance advantages are demonstrated in the lower images.

<table>
<thead>
<tr>
<th>FILM PROPERTIES</th>
<th>Control</th>
<th>XM-337</th>
<th>188</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shore D hardness</td>
<td>53</td>
<td>65</td>
<td>60</td>
</tr>
<tr>
<td>Tensile strength, psi</td>
<td>1,022</td>
<td>1,440</td>
<td>1,041</td>
</tr>
<tr>
<td>Elongation, %</td>
<td>40</td>
<td>63</td>
<td>50</td>
</tr>
<tr>
<td>Elastic modulus, psi</td>
<td>5,951</td>
<td>10,067</td>
<td>5,013</td>
</tr>
<tr>
<td>Break/load - Die C, pli</td>
<td>43</td>
<td>86</td>
<td>76</td>
</tr>
<tr>
<td>Tear strength - Die C, psi</td>
<td>176</td>
<td>305</td>
<td>272</td>
</tr>
<tr>
<td>Taber abrasion, wear index</td>
<td>56</td>
<td>54</td>
<td>39</td>
</tr>
<tr>
<td>Crockmeter, rating</td>
<td>6</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Taber Abrasion and Crockmeter: Lower number = Better performance

Cure & Application Conditions

**Cure Schedule:** 2 weeks ambient  
**Dry Film Thickness:** 3 mm  
**Substrate:** 2K PU castings

---

**K-FLEX**

**Gasoline Soak, 30 Hours**

<table>
<thead>
<tr>
<th>Exposure days</th>
<th>Control</th>
<th>K-FLEX XM-337</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>188</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>40</td>
</tr>
</tbody>
</table>

**Transmission Fluid, 3 Day Spot Test**

<table>
<thead>
<tr>
<th>Exposure days</th>
<th>Control</th>
<th>K-FLEX XM-337</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Plastics Adhesion

K-FLEX polyester diols provide excellent adhesion to most substrates including plastics. K-FLEX 188 crosslinked with Desmodur® N-75 (formulation PM-6) or with Resimene® 747 (Formulation PI-5) provides 100% crosshatch adhesion to ABS, RIM, RRIM, Polycarbonate, PVC, SMC and Xenoy. Improved adhesion is also possible over TPO with a CPO adhesion promoter. To the left is an example of K-FLEX 188 improving the adhesion of a polyester/NCO 2K PU system.

Exterior Durability

K-FLEX polyester diols do not have any ether functionality nor an acid number. Absence of an acid number helps to minimize water and salt spray sensitivity. The K-FLEX polyester diols are completely aliphatic and saturated. As a result, we could expect excellent performance in QUV testing and exterior durability, which has been demonstrated below for two different systems:

Mar & Scratch Resistance

K-FLEX polyester diols when crosslinked with melamine or isocyanate will usually improve the mar and scratch resistance of coatings. The example below illustrates the improved mar and scratch resistance found with K-FLEX A308 compared to competitive polyol technologies in a melamine baking system, baked 30 minutes at 80°C and catalyzed with K-CURE 129B.
Solvent Based High Solids 2K PU (K-FLEX Polyester Diol Modified)

PI-5  **Polyester**: adhesion to xenoy, flexibility with K-FLEX 188

API-4  **Pigmented acrylic**: improved adhesion to bare steel, flexibility, gasoline resistance with K-FLEX 188

API-5  **Pigmented acrylic**: abrasion resistance, flexibility, elongation, adhesion metals/plastics with K-FLEX 188

API-11  **Pigmented acrylic**: flexibility and salt spray resistance with K-FLEX A307

API-12  **Clearcoat acrylic**: elongation, abrasion resistance, flexibility with K-FLEX A307

API-18  **Pigmented acrylic modified with exempt solvents**: improved flexibility (Zero VOC)

API-20  **Pigmented acrylic modified with conventional solvents**: improved flexibility (Low VOC)

100% Non-Volatile 2K PU (K-FLEX Polyester Diol modified)

PI-13  **Highly filled polyether-polyester triol modified floor coating**: hardness, elongation, tensile strength, tear strength, gasoline resistance, transmission fluid resistance (Zero VOC)

Solvent Based High Solids Melamine baking System (K-FLEX Polyester Diol modified)

APM-9  **Pigmented acrylic**: improved flexibility with hardness, QUV resistance, humidity and salt spray resistance

APM-10  **Pigmented acrylic**: higher gloss, flexibility, humidity resistance and improved FL exposure with K-FLEX 188

HS-19  **Clearcoat polyester**: lower temperature cure, hardness, MEK resistance, flexibility, water soak resistance (50°C) with K-FLEX 188

PM-3  **Clearcoat polyester**: low temp. cure, improved adhesion to polycarbonate, inter-coat adhesion, with K-FLEX 188

PM-6  **Clearcoat polyester**: plastic adhesion to different plastics compared to other low MW polyester diols, low temperature cure, hardness, MEK resistance with K-FLEX 188

PM-7  **Clearcoat polyester**: low temperature cure compared to other low molecular weight diols, hardness and MEK resistance with K-FLEX 188

Trademark References

1. OXSOL  Makhteshim Agan
2. SOVERMOL  BASF
3. BASONAT  BASF
4. POLYMAC  Polyn
t5. CYMEL  Allnex
6. DESMODUR  Covestro
7. RESIMENE  INEOS
8. DESMOPHEN  COVESTRO
9. TOLONATE  VENCOREX
10. LUMIFLON  AGC

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