



K-FLEX®

Polyester Diol Selection Guide
For High Performance VOC Compliant Coatings

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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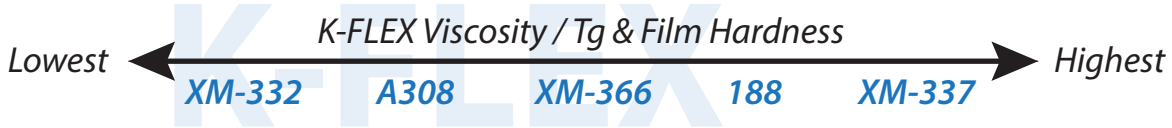
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K-FLEX® polyester diols are presented in two different charts below. The top chart includes K-FLEX polyester diols with hydroxyl numbers between 220 to 265. These diols display a positive correlation between Tg, viscosity, film hardness, moisture resistance 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.

		System	% Active	Hydroxyl # as Supplied	Viscosity 25°C (cP)	Tg	Attributes / Uses
	XM-337*	SB, WB	100%	220	55,000	-20	Provides increased toughness and chemical resistance for solvent based and high solids systems. Highest Tg and modulus.
	188	SB, WB	100%	230	10,000	-32	Improves flexibility while maintaining hardness. Also improves salt spray, humidity resistance and exterior durability. Most versatile.
	148	SB	100%	235	3,750	-42	Improves flexibility and gloss. Increases solids at lower viscosity. Good flow and leveling. Recommended for primers.
	XM-366	SB, WB	100%	265	2,000	-45	Newest polyester with medium hardness. Great flexibility and gloss.
	A308	SB	100%	260	1,500	-59	Medium hardness with great flexibility. Best for mar and scratch resistance.
	XM-332	SB	100%	265	400	-68	Lowest viscosity for lowest VOC. Softer films. Low temperature impact resistance.

*Lower viscosity version available. Contact for information



Low Crosslinker Demand

A307	SB	100%	140	5,400	-50	Flexibility modifier with lower crosslinker demand.
171-90**	SB	90%	122	3,700	-30	Offering longer pot life, improved adhesion and flexibility. Lower crosslinker demand.

**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**

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 Oxsol¹ 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 Sovermol² 750 with Basonat³ HI-100 (HDI Trimer), seen on the right.

Resin Compatibilization

Polyol/HDI Trimer (NCO:OH = 1.04:1.00)



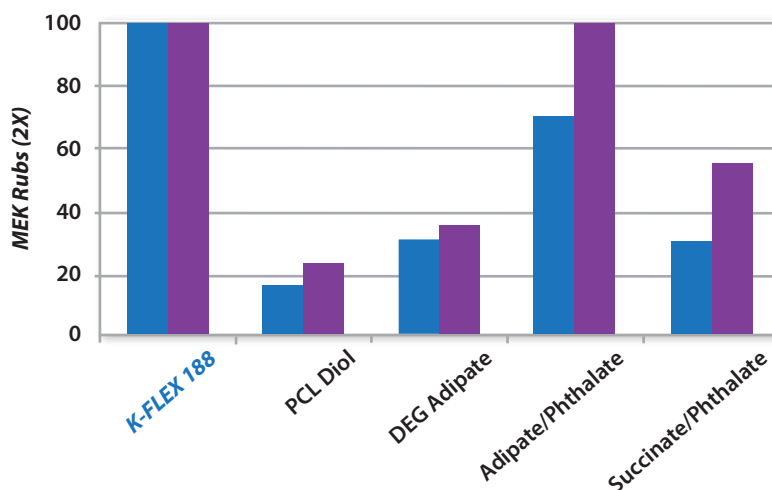
Solvermol 750 100% Solvermol 750 / **K-FLEX 188**
90/10 85/15 80/20

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.

Polyester/HMMM: 60/40
10 Minute Bake
Solids %: 90
NACURE® 155 % on TRS: 1.8
■ 200°F
■ 225°F

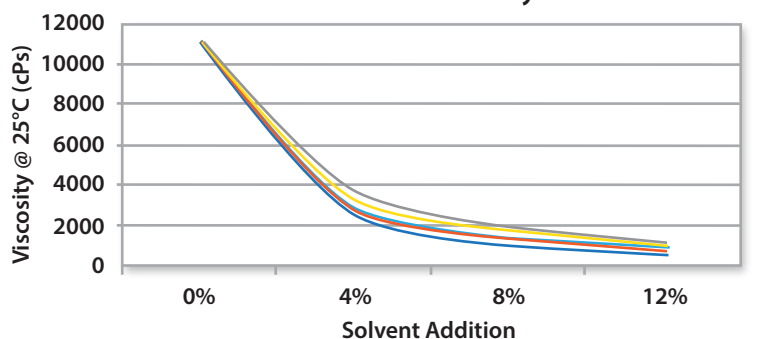
Cure Evaluation - K-FLEX 188 vs. Competitive Technology



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 188 Solvent Viscosity Reduction

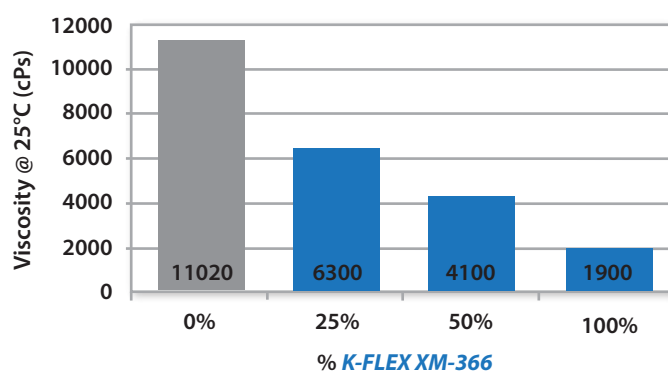


K-FLEX Blends and Viscosity Reduction

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.

K-FLEX Blends

K-FLEX 188 blended with K-FLEX XM-366



Flexibility and Hardness - Melamine

In the King formulation below (HS-19), **K-FLEX® 188** polyol 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.

Film Performance - Benefits

-  Improved impact resistance
-  Reduced viscosity
-  Maintained hardness
-  Improved MEK resistance
-  Better blushing resistance



CHARACTERISTICS	Control	K-FLEX 188 18% on TRS	K-FLEX 188 23% on TRS	K-FLEX 188 34% on TRS
HS 57-5776 ⁴ /K-188/Cymel ⁵ 325	75/-/25	54/18/28	46/23/31	33/34/33
Total resin solids, weight %	75	75	75	75
Brookfield viscosity (cPs), 25°C	1000	440	340	220
FILM PROPERTIES				
Pencil hardness	H-2H	H-2H	H-2H	H-2H
MEK Resistance (2X Rubs)	90	120	130	150
Crosshatch adhesion	100	100	100	100
Direct impact (in-lbs)	50-60	100-110	160+	160+
Reverse impact (in-lbs)	5	30-40	140-150	150-160
Water soak, 360 hr @ 50°C	MD/9 Blushed	MD/9	MD/9	MD/9

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%.



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

CHARACTERISTICS	Acrylic Control	K-FLEX XM-337 14% on TRS	K-FLEX 188 13.9% on TRS	K-FLEX XM-366 13.7% on TRS	K-FLEX A308 13.7% on TRS	K-FLEX XM-332 13.6% on TRS
Total resin solids, weight %	67	73	73.3	73.5	73.4	73.5
VOC, g/l (calc)	407	343	339	336	337	334
Viscosity (cPs), 25°C	600	600	600	600	600	600
FILM PROPERTIES						
Pendulum hardness, cycles	121	118	116	106	110	77
Pencil hardness	2H-3H	3H-4H	2H-3H	H-2H	2H-3H	H-2H
Reverse impact (in-lbs)	20-30	120-130	160+	160+	160+	160+
Direct impact (in-lbs)	90-100	160+	160+	160+	160+	160+

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.

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

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



Control



K-FLEX XM-337

10% on TRS

Transmission Fluid, 3 Day Spot Test



1 2 3

Exposure days

Control



1 2 3

Exposure days

K-FLEX XM-337

Plastics Adhesion

Polyester 2K PU - Adhesion to Plastics



Control



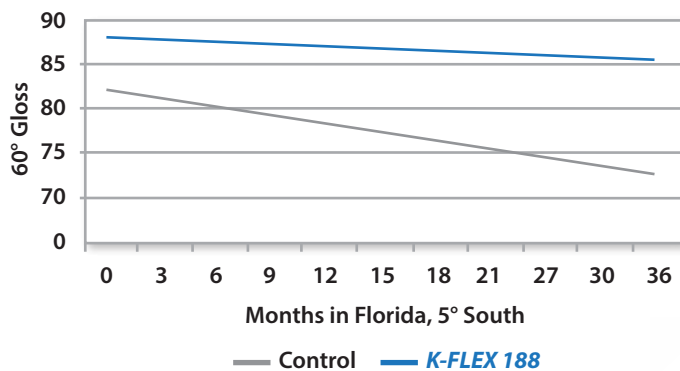
13% K-FLEX 188

K-FLEX polyester diols provide excellent adhesion to most substrates including plastics. K-FLEX 188 crosslinked with Desmodur⁶ N-75 (*formulation PM-6*) or with Resimene⁷ 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.

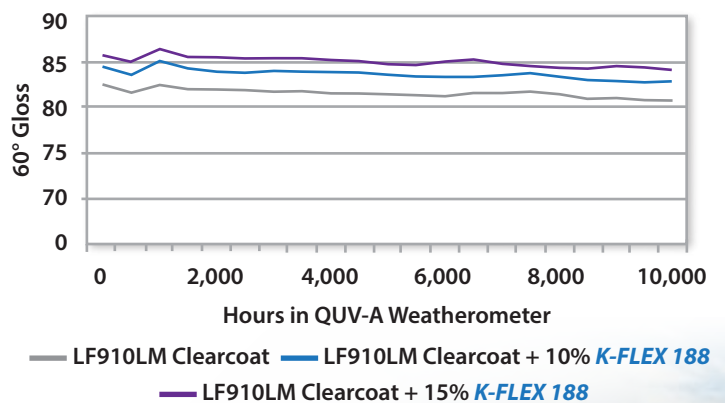
Exterior Durability

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:

60° Gloss - Desmophen⁸ 651A-65/Tolonate⁹ HDB-75X
36 Months Florida Exposure



60° Gloss - Lumiflon¹⁰ LF910LM Clearcoat Formulation*
10,000 hours QUV-A



Mar & Scratch Resistance

*Study courtesy of AGC, Ltd.

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.

Mar & Scratch Resistance - K-FLEX A308 vs. Competitive Technology



Competitor A



Competitor B



K-FLEX A308



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)
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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	7. RESIMENE	INEOS
2. SOVERMOL	BASF	8. DESMOPHEN	COVESTRO
3. BASONAT	BASF	9. TOLONATE	VENCOREX
4. POLYMAC	Polynt	10. LUMIFLON	AGC
5. CYMEL	Allnex		
6. DESMODUR	Covestro		

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