KING INDUSTRIES
SPECIALTY CHEMICALS

K-FLEX®

Urethane Diol Selection Guide

For High Performance VOC Compliant Coatings

K-FLEX® Urethane Diols are low molecular weight (MW) diols with an aliphatic urethane backbone and a narrow MW distribution. They allow the formulation of ***higher solids, lower VOC*** waterborne coatings. They have been developed to help achieve VOC compliance with the added benefit of ***improved film performance.*** Their low molecular weight provides a higher crosslink density yielding harder films with greater exterior durability.

The aliphatic urethane backbone of ***K-FLEX Urethane Diols*** provides excellent light stability. It also allows the incorporation of aliphatic urethane functionality without the use of isocyanates. The urethane diols are used primarily as modifiers for melamine and isocyanate crosslinked coatings. They are compatible with polyester, polyether, acrylic and alkyd resins.

Blocked Isocyanates
2K Polyurethanes

Amino Crosslinked Systems
Prepolymer Synthesis

K-FLEX urethane diols are soluble in most polar organic solvents and in water. They are not soluble in more hydrophobic solvents like aliphatic or aromatic hydrocarbons. However, varying levels of hydrophobic solvents can be tolerated depending on the solubility parameters of the other solvents present.

Advantages in Waterborne Coatings

K-FLEX Urethane Diols act as cosolvents by reducing the viscosity of the system. They can be used to replace volatile cosolvents in order to increase solids, increase crosslink density, improve flow and leveling and yield higher gloss.

Additionally, K-FLEX urethane diols enable the reduction or replacement of amine in the coating, resulting in lower VOC and faster cure of melamine baking systems.

- **Higher hardness**
- **Lower VOC (higher solids)**
- **Excellent chemical resistance**
- **Excellent hydrolytic stability**
- **Improved wet adhesion**
- **Excellent gloss**

Product	Supplied	Hydroxyl # *On Solids*	Viscosity 25°C (cPs)	Attributes / Uses
UD-350W	88% active urethane diol in water for WB coatings	350	4,000	Higher solids, improved flow, gloss, hardness and resistance properties.
UD-320	82% active urethane diol for SB coatings	350	9,000	Increases application solids and hardness. Improves chemical resistance, exterior durability and hydrolytic stability.
UD-320-100	100% active urethane diol	350	7,000 at 50°C	Prepolymer synthesis. For water or solvent. Preparation of polyester urethanes.
XM-386	100% active urethane diol for SB and WB coatings	390	45,000	All primary hydroxyl groups. Excellent low temperature cure response. Good moisture resistance.

K-FLEX UD-350W is an aqueous solution of an aliphatic, low molecular weight urethane diol oligomer. It is recommended as a modifier for amino crosslinked water soluble and emulsified acrylic, alkyd, urethane and polyester resins. It is used to increase solids, increase crosslink density and to improve film/resistance properties and flow/leveling.

King Formulation UDW-12

Grind	**Description**	**Pounds**
Joncryl[1] 540	Acrylic Emulsion	41.8
AMP[2] 95	Amine	1.0
Surfynol[3] 104 (Versum)	Wetting Agent	1.0
Ti-Pure[4] R-960	Rutile TiO_2	48.6
Water	Diluent	48.6

Letdown	**Description**	**Acrylic Control**	**K-FLEX Modification**	
Acrylic/K-FLEX/HMMM	Composition %	70/0/30	65/5/30	57/10/33
Grind	See Grind	100	100	100
Joncryl 540	Acrylic Emulsion	58.3	50.9	39.1
HMMM	Crosslinker	19.9	19.9	29.1
2-Butoxyethanol	Solvent	11.4	-	-
K-FLEX UD-350W	***Urethane Polyol Modifier***	-	***3.6***	***7.2***
NACORR® 1552	Corrosion Inhibitor and Accelerator	1.3	1.3	1.3
Water	Diluent	43	23	25
Total		233.9	198.7	201.7

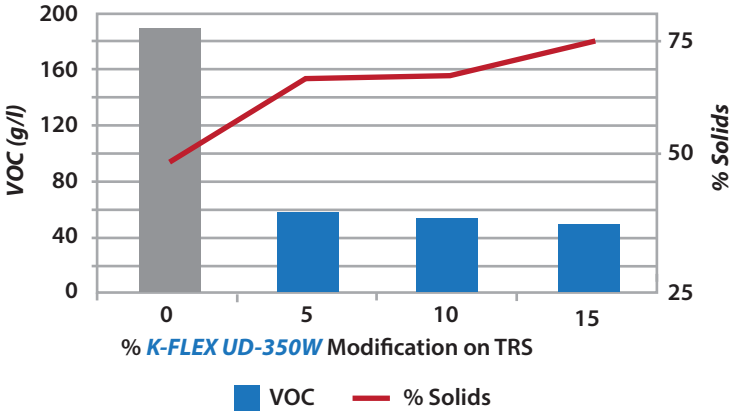
Acrylic Melamine Emulsion Performance

Urethane diol modification of a white acrylic/melamine emulsion (below) demonstrated several advantages, including improved flow/leveling, resulting in higher gloss, improved gloss retention, higher solids (lower VOC) and improved resistance properties seen below.

Modification levels of 5, 10 and 15% were evaluated. Optimum levels of 5 and 10% are detailed below and on *Page 4*.

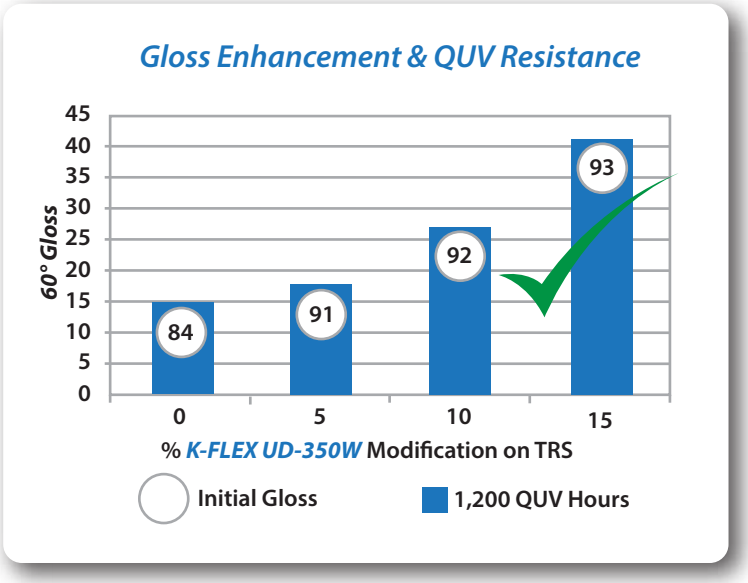
VOC Reduction, Co-solvent Replacement

(Joncryl 540/HMMM)



K-FLEX® UD-350W - Waterborne Gloss Performance

K-FLEX UD-350W urethane diol provides improved wetting over various substrates, as well as improved flow and leveling. The end result is higher gloss waterborne coatings.



K-FLEX UD-350W - Waterborne Performance

The urethane backbone of the urethane diols provides excellent hydrolytic stability for long term storage in waterborne formulations. This excellent hydrolytic stability also provides improvements in the humidity, salt spray and boiling water resistance of fully crosslinked films. The results shown demonstrate these improvements in water reducible polyester/HMMM baking enamel.

King Formulation UDW 16

HMMM Crosslinked Baking Enamel		Humidity Resistance (350 hrs) 60° Gloss % Reflectance	Salt Spray Resistance (350 hrs) Blisters*	Salt Spray Resistance (350 hrs) mm Creep	Boiled Water Resistance (1 hour) Blisters*
Polymac[5] WR 72-7203	Control	5	4D	2	8D
Water Reducible Polyester (UDW-16)	***K-FLEX UD-350W*** ***% on TRS***	59	***4 F***	***1***	***10 No Attack***

*Blister Rank (ASTM D714): 10 = no blister, 1 = large blister
D = Dense, M = Medium, F = Few

K-FLEX UD-320 is a high solids, aliphatic, low molecular weight urethane diol. It is soluble in polar organic solvents and has broad compatibility with acrylic, polyester and alkyd resins. When used to modify a 2-component polyurethane, it will increase hardness and flexibility.

K-FLEX UD-320 will increase the hardness and humidity resistance of a melamine crosslinked system. Typical applications include general industrial and automotive OEM coatings.

The formulation below illustrates the effect of K-FLEX UD-320 diol modification of a high solids automotive acrylic melamine coating. Benefits include higher solids, higher hardness and improved adhesion, chemical resistance, gloss and Florida exposure.

King Formulation UD-3

Material	**Description**	**Acrylic Control**	***K-FLEX UD-320 Modification***		
			7%	***13%***	***19%***
Acrylic Resin	Acrylic Resin	64.2	57.2	50.2	43.5
K-FLEX	***Urethane Diol***	-	***5.2***	***10.3***	***15.3***
HMMM	Crosslinker	20.9	22.8	24.7	26.6
NACURE® 5528	Blocked Catalyst	1.3	1.3	1.4	1.4
DISPARLON® L-1985-50	Leveling Agent	0.2	0.2	0.2	0.2
Xylene	Solvent	10.7	10.6	10.6	10.4
Methanol	Solvent	2.7	2.7	2.6	2.6
Total		100	100	100	100
Characteristics					
Acrylic / K-FLEX / Mel		69/0/31	61/7/32	52/13/35	44/19/37
60 min., 110°C % Solids		61.6	62.4	63.5	63.5
Viscosity, 25°C (cPs)		156	158	156	157

Cure & Application Conditions

Cure Schedule: 20 min / 120°C

Dry Film Thickness: 37.5µ

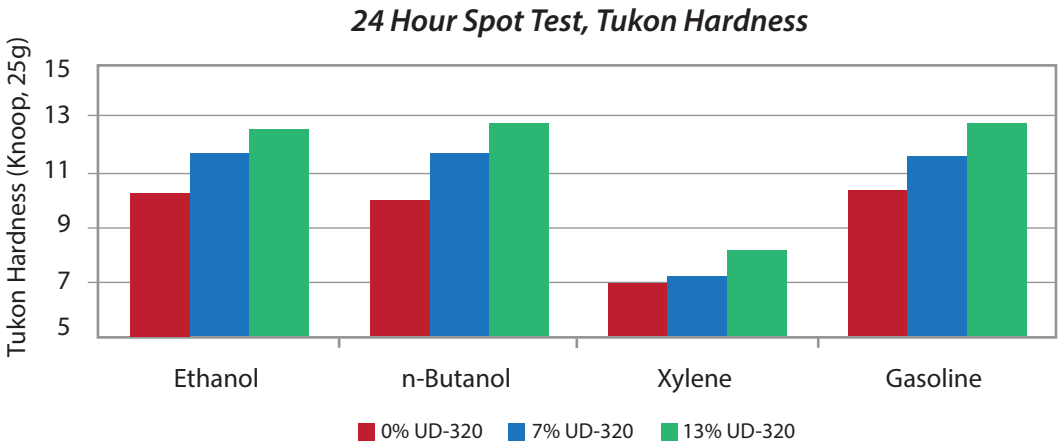
Substrate: Iron Phosphated CRS

FILM PROPERTIES	**Control**	***7%***	***13%***	***19%***
Pencil Hardness, Cycles	F-H	F-H	H-2H	H-2H
% Crosshatch Adhesion	0	20	90	100
Reverse impact, in-lbs	10-20	10-20	10-20	20-40
Direct impact, in-lbs	10-20	40-60	40-60	60-80

Film Properties - Chemical Resistance, QUV, Florida Exposure

The control formulation was modified with 7% and 13% ***K-FLEX UD-320*** for testing chemical resistance. With each modification level, we increased the melamine content slightly, to accommodate the high hydroxyl number of the K-FLEX UD-320.

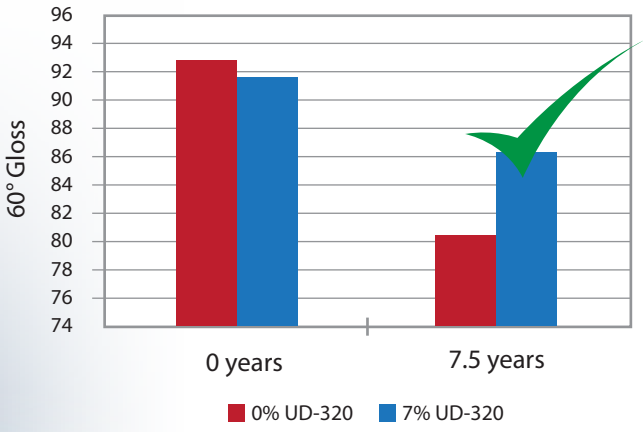
A 24 hour spot test was conducted to evaluate the chemical resistance to ethanol, n-butanol, xylene and gasoline. For each of these solvents tested, we see an improvement in the chemical resistance with a K-FLEX UD-320 modification. In addition, the chemical resistance increases with modification level.



Florida Exposure Study - Gloss Retention & Crack Resistance

60° Gloss Results - Florida Exposure (7.5 years)

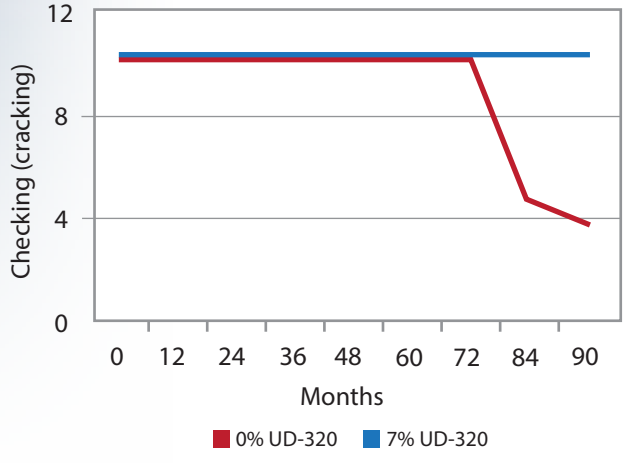
Modification with 7% **K-FLEX UD-320** drastically improved long term gloss stability in harsh environments as shown in the chart to the right.



Florida Exposure - Checking (crack) Resistance

The chart to the right demonstrates improved checking resistance with **K-FLEX UD-320** modification versus the acrylic control after 90 months (7.5 years) exposure in Florida at 5° South without UV stabilizers.

Modification at the 7% level provided the best overall cracking resistance.



Notes:

Trademark References

1. Joncryl	BASF
2. AMP	Dow
3. Versum	Evonik
4. Ti-Pure	Chemours
5. Polymac	Polynt

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