Innovative Polyester Acrylates – Solutions for Industrial Market Needs

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Allnex

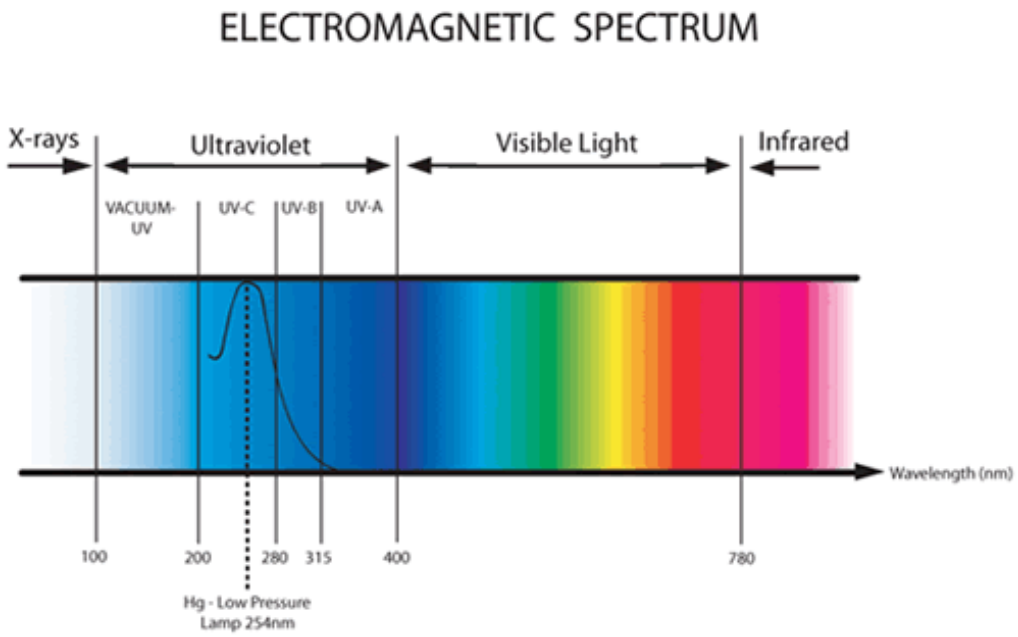
All About Resins

Agenda

- Energy Curing
  - Definitions and benefits
- Polyester Acrylates for IC Wood Applications
  - PEA 1 - Low viscosity combined with high cure speed, high Tg, and low shrinkage
  - PEA 2 - Raw materials from recycled plastic
- Performance
- Conclusions

What is Ultra-Violet (UV) curing?

- Using UV energy or visible light, as opposed to heat, solvent evaporation, or oxidation (air-drying), to convert a liquid formulation into a solid material
- Types of energy used:
  - Ultra Violet (UV): 200 – 400 nm
  - Visible light: typically 380 - 450 nm



Productivity, Productivity, Productivity

Seconds to cure vs. minutes or hours

No reaction until exposure to UV energy

"Cure on Demand", long pot life and reduced waste

Single component formulas

Eliminates mixing errors found in 2 component systems

Lower Overall Cost (per cured part)

100% solids, cure speed, recycling of coating, etc.

Regulatory concerns (VOC emissions)

Low to no VOC

Energy Costs

Line of sight curing

- All areas of the part must be exposed to UV energy
- Lamp placement critical, but not difficult

Absorbance of system

- Components that absorb/block UV may interfere with cure
- Select components that don't absorb UV or select PI that absorbs in another region of the UV spectrum

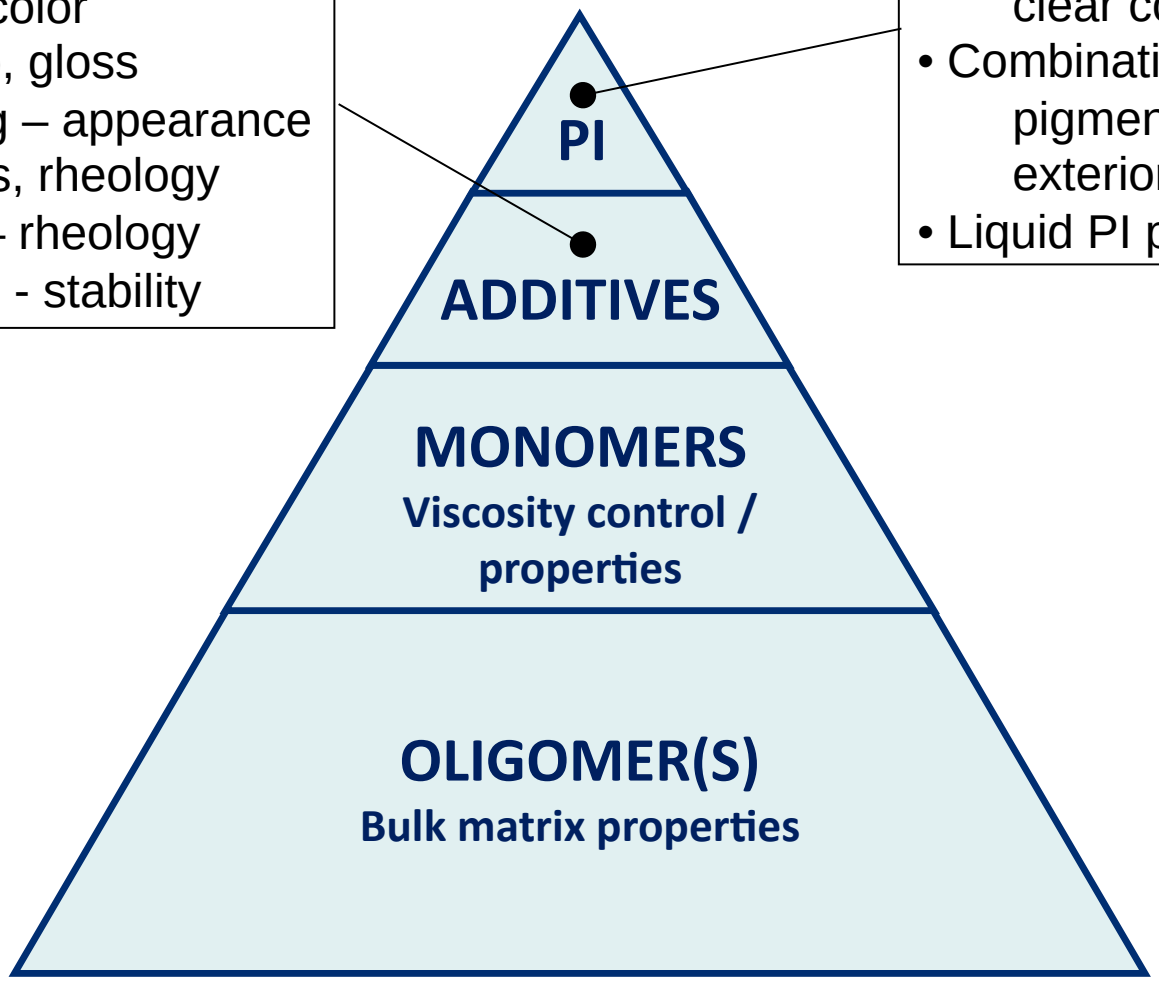
Shrinkage

- All reactions generate shrinkage, which may lead to poorer adhesion
- Mitigate with selection of diluents, oligomers
- Use of WB systems can reduce shrinkage (no monomers needed to reduce viscosity)

Energy Curing

100% Solids Formulation

- Matting agents – gloss
- Pigments – color
- Waxes – slip, gloss
- Flow/leveling – appearance
- Silica – gloss, rheology
- Thickeners – rheology
- pH adjusters - stability

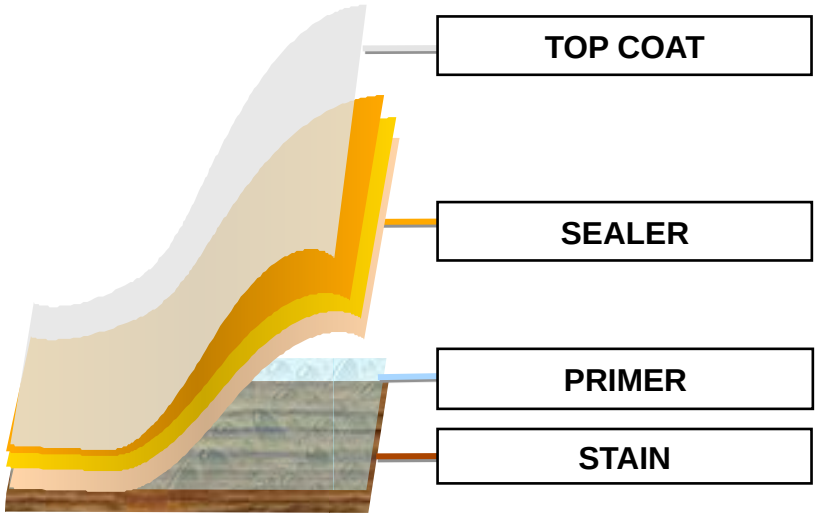


- Single PI – clear coatings
- Combination PI - pigmented, highly filled, exterior durable
- Liquid PI preferred

UV Curable Coatings for Wood

Floor Coating Layers

- Stain
- Primer - functional layer for adhesion
- Sealer - functional layer for abrasion resistance, may contain e.g. alumina to meet different abrasion tests (e.g. Taber, grit feeder or S42)
- Top Coat - functional layer for scratch resistance, gloss



New PEA Resins for Industrial Wood Coatings

- **PEA 1 (experimental)**
  - **Low viscosity combined with high cure speed and low shrinkage**
  - **Good overall properties (hardness / flexibility) with high Tg**
  - **Good component for UV LED due to high reactivity**
  - **Biobased, 56% Renewable Content**
- **PEA 2 (experimental)**
  - **Recycled raw materials for cost benefit**
  - **Good performance properties**
  - **Excellent flow when filled**

PEA 1 Physical Properties

Appearance	Yellow amber liquid
Viscosity 25°C mPa.s	5000
Color (Gardner)	3
Diluent content %	0
Tg °C [(1)] max Tan δ - DTMA	84
Tensile strength [(1)] MPa	16.5
Young modulus[(1)] MPa	1990
Elongation at break[(1)] %	0.9
Shrinkage – picnometer volume contraction (%)	6.52

(1) 80 µm film; electron beam cured

PEA 1 shows excellent thermal and mechanical properties combined with low viscosity

PEA 1 Shrinkage Comparison

UV Resin	% Volume shrinkage
PEA 1	-6.5
Bisphenol A based diacrylate	-6.2
Hard, trifunctional PEA	-8.1
Hard, hexafunctional UA	-8.4

PEA 1 has less volumetric contraction than hard PEA and UA

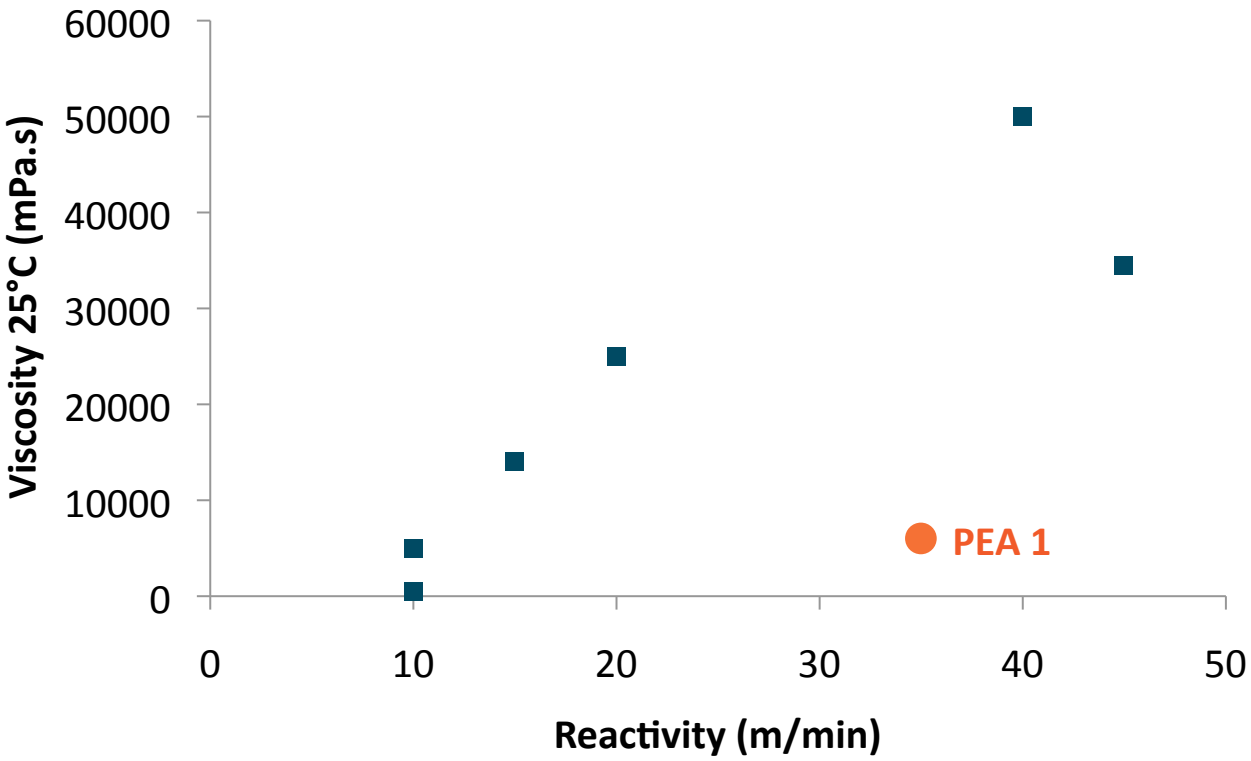
PEA 1 Cure Speed and Hardness

Formulation	
PEA 1	100
Photoinitiator Blend	5
Total	**105**
Cure speed[1] & Hardness[2]	
Viscosity - c&p - CSR20 @ 25°C mPas	3330
Cure speed Fingernail scratch (m/min)	35
Cure speed 100 Acetone double rubs (m/min)	< 50
Persöz hardness (s) Curing : 2 x 35 m/min	161

(1) 10 µm – 80 W/cm Hg lamp
(2) 60 µm coat on glass cured at 2 x 35 m/min

PEA 1 shows high cure speed and hardness

PEA 1 Comparison with other PEAs



PEA 1 combines a high reactivity with a low viscosity without the addition of a diluent

PEA 1 - Scratch Resistance Topcoat for Parquet SPF

Formulation	Parts
PEA 1	**55**
DPGDA	29.5
Flow and Leveling Agent	0.5
Photoinitiator 1	4
Photoiniitator 2	1
Silica 1	8
Silica 2	1
Wax	2
Substrate Wetting Agent	1

PEA 1 - Scratch Resistance Topcoat for Parquet SPF

Stain resistance	80 µm coat on Leneta	120 µm coat on beech with WB primer
	24 hours Stain test (1 – 5 rating)	
Bleach water	5	3
ETOH/ water 1/1	5	5
10% Na_2CO_3	5	3
Coffee	5	5
Mustard	5	5
Adhesion/flexibility	**120 µm coat on beech with WB primer**	
Hamberger (N)	38<	
Erichsen (N)	27	
Coin test	OK	
Gloss on Black Leneta	**80 µm coat on Leneta paper**	
20° 60°	7 40	

Coating on Beech and Leneta paper cured with 80-120W Hg lamp

PEA 1 can be used as Topcoat for Parquet Flooring

PEA 1 Sprayable High Gloss Pigmented Topcoat SPF

Formulation	Parts
Trifunctional, hard PEA	35
PEA 1	**35**
DPGDA	30
White pigment paste	10
Wetting agent	0.5
Antisettling agent	2
Photo-initiator blend	3

Viscosity Cup 4 25°C : < 1 min 35 sec

PEA 1 Sprayable High Gloss Pigmented Topcoat SPF

Stain- & solvent resistance	80 µm coat on Leneta paper
	24 hours Stain test (rating 1 – 5)
Bleach water	3
EtOH/ water 1/1	5
10% Na2CO3	3
Coffee	5
Mustard	3
Acetone DR	>100

80 µm wet coat	80 µm coating on MDF with 100% solids primer and sealer
Coin test	Pass without burnish mark

Gloss on Black Leneta	80 µm coat on Leneta paper
20°	36
60°	73

PEA 1 can be used as 100% sprayable formulation for Furniture

PEA 1 LED Curing with Co-Initiator SPF

Formulation	A	B	C
PEA 1	50	65	75
Hexafunctional UA	25	10	
Co-Initiator	25	25	25
Phosphine Oxide Photo initiator	5	5	5
Cure speed : 10 µm on Leneta paper			
Surface cure (m/min) measured by fingernail	1x10	1x5	2x5
Through cure measured by number of double acetone rubs	>100	>100	>100

Curing : 8W/cm2 - 395 nm – 1 cm distance

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  - Low viscosity combined with high cure speed and low shrinkage
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  - Good component for UV LED due to high reactivity
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- **PEA 2 (experimental)**
  - **Recycled raw materials for cost benefit**
  - **Good performance properties**
  - **Excellent flow when filled**

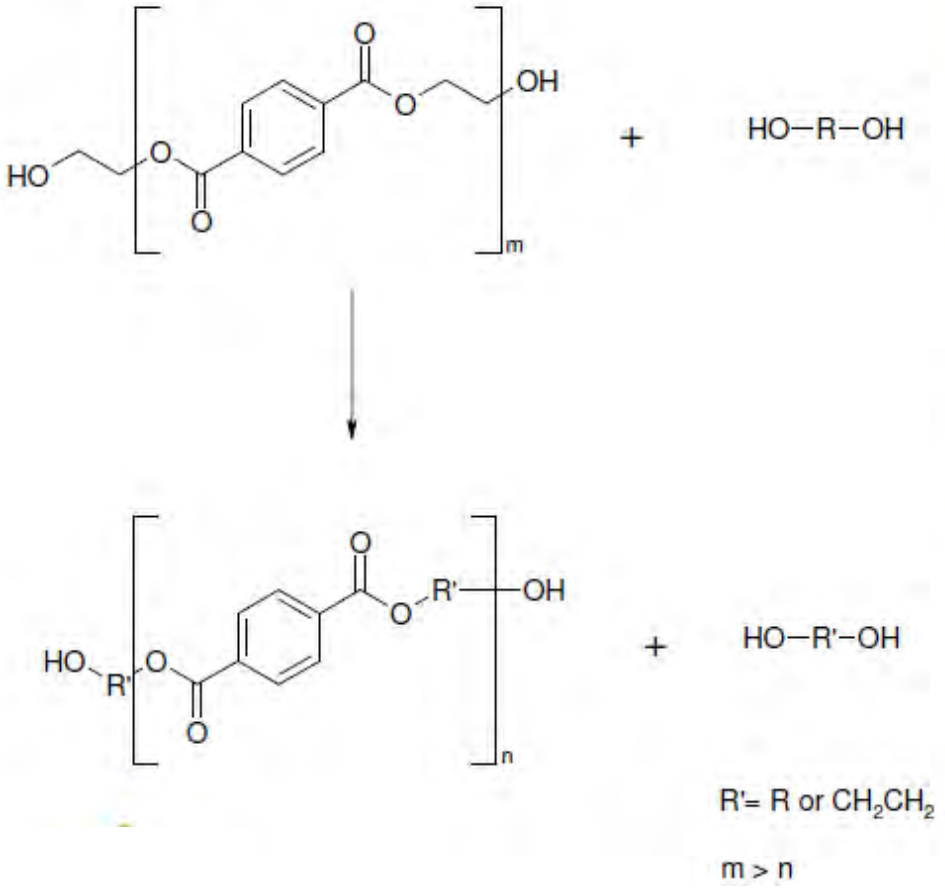
Raw Materials From Recycled Plastics

- Different scrap shapes : cut, grinded, extruded pellets
- Different colors
- Different qualities

Europe (2011):
1.6 million tons of PET bottles collected
1.12 million tons of PET flake produced

Raw Materials From Recycled Plastics

PET glycolysis



Influence of:

- Diol and stoichiometry
- Catalyst
- Temperature
- Time

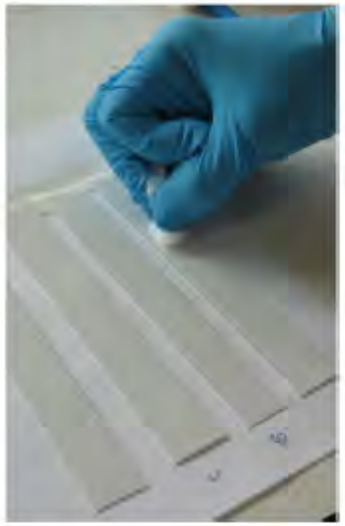
- On

- Color
- Viscosity
- Crystallinity
- Molecular Weight

Coating Properties of PEA 2

Properties	PEA 2
Viscosity 25°C (mPa.s)	17000
% recycled / renewable content	**33**
FORMULATION	
Polyester acrylate	80
TPGDA	20
BCPK	4
Viscosity 25°C (mPa.s)	1950
RESULTS	
Graphite (m/min)	7
Acetone Double rubs at 2x5 m/min	> 100
Persoz hardness (Seconds)	200

Graphite test



Acetone double rubs test

Persoz hardness

Physical Properties of PEA 2

TYPICAL PHYSICAL PROPERTIES	VALUE
Appearance	Clear liquid
Color, Gardner scale	<5
Density, g/ml at 21.5°C	1.28
Functionality, theoretical	2
Resin solids, %	100
Viscosity, 25°C, mPa·s	5000
Tensile strength, psi (MPa)	>2000
Elongation @ break, %	~1
Young's Modulus, psi (MPa)	>275,000
Glass Transition temperature, °C	>80

Coating Properties of PEA 2

	PEA 2
TABER HAZE : • 10-15u coatings on PC sheet • Cure 2x5m/min @ 300 WPI • CS10F wheels, 500g, 100 cycles	9.8
TABER ABRASION: • 25u coatings on PVC • Cure 3x5 min @ 300 WPI • CS17, 1 kg. load, wt. loss after 100/300 cycles	3.9 / 12.8
Flexibility: Mandrel test 25u coating Cure 2x5 min@ 300 WPI on Al / PC	5mm / 4mm
Coin Test: 25u coating on oak Cure 2x5 m/min @ 300 WPI (0=bad, 5=good)	3

Taber CS 10F/ CS17

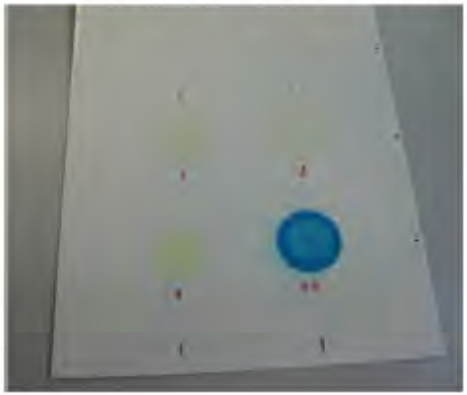
Cylindrical mandrel flexibility (BS EN 435:1994)

Coin test

Coating Properties of PEA 2

	PEA 2
Adhesion: cure 2x5 m/min @ 300WPI, cross hatch adhesion	
25u on sanded oak	80%
40u on sanded oak	80%
25u on PVC floor	100%
Stain/Solvent resistance – 25u white Leneta chart (5=best, 0=worst)	
Olive oil (16h)	5
Coffee (16 h)	3
Black marker (5 min)	2
Betadine (16 h)	3
Mustard (16 h)	3
Ammonia 10% (16 h)	4
Ethanol 48% (16 h)	5

Cross hatch adhesion test



Stain resistance

Coating Properties of PEA 2

	Control	PEA 2
Flow: 1 gram coating (4% silica) on vertical Leneta chart, cm		
Flow after 1 minute	0.1	10.5
Flow after 5 minutes	0.2	> 20

Conclusions

- Two new PEAs are in development which give formulators greater latitude
- PEA 1 delivers high cure speed, high Tg and low shrinkage at low viscosity, with the additional benefits of high reactivity for LED curing and high renewable content for our environment
- PEA 2 delivers good performance properties with excellent flow when filled with the additional benefit of using recycled raw materials for cost control and for our environment

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Thank you for your attention!

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All About Resins

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Helios Products for Wood Floors – ABRASION RESISTANCE

Abrasion Testing

- Related to toughness
- Different tests require different sealers to pass
- Taber abrasion more common in NA

S 42
Rubber wheels +
Abrasive Paper

Grit feeder
Leather wheels +
Falling Sand

Taber CS 10/CS 17
CS 10/CS17 wheels