STONEBRIDGE
TECHNICAL SERVICES
Division of Stonebridge Technical Enterprises, Ltd.

April 5, 2006

Mr. Thomas Choate
Nanovere Technologies
4023 S. Old US 23
Suite 102
Brighton, MI 48114

Re.: STS Project No. 306_5A – Testing of DuPont Automotive Clearcoat

Dear Mr. Choate:

We have completed the testing of your Zyvere clearcoat versus PPG's CeramiClear product and DuPont's OEM Acrylic Silane Melamine Clearcoat. In all categories tested, the Zyvere product performed better than or equivalent to the CeramiClear and DuPont's OEM clearcoats. Compared to CeramiClear; Zyvere is superior in abrasion resistance, hardness, impact and MEK resistance. It outperformed the OEM clearcoat in abrasion resistance, flexibility and impact resistance. Table 3 details the test results.

The physical properties of the Zyvere and CeramiClear clearcoats are listed in Table 1. The DuPont clearcoat was tested from previously prepared panels made by ACT Laboratories, Inc.

Table 1: Clearcoats

Sample	**A**	**B**	**C**
Clearcoat	**Zyvere**	**D8126/D8226 CeramiClear**	**SB Acrylic Silane Melamine OEM**
Manufacturer	**Nanovere Technologies**	**PPG Industries**	**DuPont**
% Non-Volatile (Weight)	62%	---	---
% Non-Volatile (Volume)	---	49.8%	---
Volatile Organic Content less Exempts	Solvents are VOC Exempt	2.01 lbs/gal	---
Mix Ratio (by Volume)	1 : 1	2 : 1	---
Potlife @ 68°F / 20°F	1 hour	1 hour	---
Recommended Dry Film Thickness	2 - 3 mils	2 - 2.5 mils	---
Dry Times:			
Dust-Free @ 68-72°F	30 minutes	30 minutes	---
Dry-to-Handle @ 68-72°F	4 hours	4 hours	---
Dry-to-Handle @ 150°F	30 minutes	30 minutes	---

Both Zyvere and CeramiClear clearcoats were mixed according to their directions and applied to coated steel panels, within 15 minutes of mixing, using wire wound applicator method. They were allowed to flash off for 3 – 5 minutes prior to baking for 30 minutes at 150^{o}F. They were aged for 24 hours under ambient conditions prior to testing. Total clearcoat thickness for both clearcoats was 1.8 – 2.0 mils. Table 2 details the test panels that were prepared.

Table 2: Test Panels

Panel ID	A1	A2	B1	B2	C1
Clearcoat	Zyvere	Zyvere	D8126/D8226 CeramiClear	D8126/D8226 CeramiClear	RK8010A DuPont OEM Clearcoat
Basecoat Code	BWB8554R White	271926L Fine Silver Birch	BWB8554R White	271926L Fine Silver Birch	542AC301 White
Basecoat Description	Waterborne Acrylic Melamine from PPG for GM	Solventborne Acrylic from DuPont for GM	Waterborne Acrylic Melamine from PPG for GM	Solventborne Acrylic from DuPont for GM	---
Primer	1177224ER	764204	1177224ER	764204	None
E-Coat	ED6060	ED6060	ED6060	ED6060	ED6060
Pretreatment	Immersion DIW: Unpolish	B952 P60 DIW: Unpolish	Immersion DIW: Unpolish	B952 P60 DIW: Unpolish	Immersion DIW: Unpolish
Substrate	Cold Rolled Steel	Cold Rolled Steel	Cold Rolled Steel	Cold Rolled Steel	Cold Rolled Steel
ACT Labs Product ID No.	APR45472	APR45808	APR45472	APR45808	APR44364

Panels were tested for appearance, chemical and mechanical properties. Descriptions of test methods can be found at the end of this report.

The Zyvere clearcoat was superior to the CeramiClear product in abrasion resistance, hardness, impact and MEK resistance. It was comparable to CeramiClear in gloss, adhesion and chemical resistance. The Zyvere clearcoat was superior to the DuPont OEM clearcoat in abrasion, flexibility via mandrel bend and impact resistance. It was comparable to the OEM clearcoat in gloss, adhesion, hardness, chemical and MEK resistance. Table 3 details the test results.

Commentary from DLH: During MEK double rubs, the Zyvere clearcoat exhibited a lot of lubricity where the MEK seemed to have no impact on the clearcoat (even after 1,500 double rubs). In my experience with automotive clearcoats, there is a certain amount of "drag" felt at the beginning or within 100 double rubs of the test. This "drag" was felt with the CeramiClear and DuPont products, but not with the Zyvere clearcoat. The same phenomenon was noted when attempting to write on the clearcoat with a permanent marker. We were able to mark easily on the CeramiClear and DuPont products with ink pen and permanent marker, but not on the Zyvere clearcoat.

Further testing is recommended to demonstrate weatherability (QUV and/or WOM), humidity resistance, and possible corrosion resistance versus comparable clearcoat(s).

Table 3: Detailed Test Results

Sample	**A**	**B**	**C**
Clearcoat	**Zyvere**	**CeramiClear**	**SB Acrylic Silane Melamine OEM**
Manufacturer	**Nanovere**	**PPG**	**DuPont**
Cure Schedule	**30' @ 150 °F**	**30' @ 150 °F**	**OEM**
Clearcoat DFT (mils)	**1.8 - 2.0**	**1.8 - 2.0**	**2.1 - 2.0**
Gloss per ASTM D523 (20 °/60°)	86.0 / 92.2	85.8 / 92.0	88.1 / 94.1
Adhesion per ASTM D3359 Method B to White (A1 & B1)	5B / 100%	5B / 100%	5B / 100%
Adhesion per ASTM D3359 Method B to Silver (A2 & B2)	0B / 0%	0B / 0%	---
Pencil Hardness - Scratch per ASTM D3363	6H	F	4H
Pencil Hardness - Gouge per ASTM D3363	4B	3B	2B
Pencil Hardness - Gouge per ASTM D3363 After 24 Hr. Recovery	3B	3B	2B
Taber Abrasion per ASTM D4060 (mg lost per 1,000 cycles)	19.85	36.20	52.20
Impact Resistance per ASTM D2794 - Initial			
Direct (inch-pounds)	150 Fail / 140 Pass	90 Fail / 80 Pass	50 Fail / 40 Pass
Reverse (inch-pounds)	160 Pass	120 Fail / 100 Pass	10 Fail / 5 Pass
Impact Resistance per ASTM D2794 - After 48 Hrs. @ 250°F (inch-pounds)			
Direct (inch-pounds)	70 Fail / 60 Pass	60 Fail / 50 Pass	20 Fail / 10 Pass
Reverse (inch-pounds)	5 Fail	5 Fail	5 Fail
Flexibility per ASTM D522	Pass 1/4	n/a	Fail 3/4" / Pass 1" **
Chemical Spot Resistance per ASTM D1308			
10% Sulfuric Acid	No Effect	No Effect	No Effect
10% Hydrochloric Acid	No Effect	No Effect	No Effect
10% Sodium Hydroxide	No Effect	No Effect	No Effect
10% Ammonium Hydroxide	No Effect	No Effect	No Effect
Isopropyl Alcohol	No Effect	No Effect	No Effect
Xylene	Slight Softening	Slight Softening	Slight Swelling
Xylene (24 hour recovery)	No Effect	No Effect	No Effect
MEK	No Effect	No Effect	No Effect
Gasoline (87 Octane)	No Effect	No Effect	No Effect
MEK Resistance per ASTM D4752 (Double Rubs)	> 1,500	260	> 1,500

** Failure occurred at the e-coat/steel interface.

DESCRIPTION OF TEST METHODS

Adhesion – Per ASTM D3359 Method B. This method assesses the adhesion of coating films to coated metallic substrates by applying and removing pressure-sensitive tape over cuts made in the film. The cutting tool used scribed the paint film into 25 small 3 mm square squares. The test method illustrates with pictorial standards, but the rating system is as follows:

Rating	Percent Area Removed	Percent Adhesion
5B	0% (None)	100%
4B	Less than 5%	>95%
3B	5 – 15%	85-95%
2B	15 – 35%	65-85%
1B	35 – 65%	35-65%
0B	Greater than 65%	<35%

Gloss – Per ASTM D523. This method covers the measurement of specular gloss of non-metallic specimens for glossmeter geometries 20^{o}, 60^{o} and 85^{o}.

Pencil Hardness – Per ASTM D3363. This method covers a procedure for rapid determination of film hardness of an organic coating on a substrate in terms of drawing leads or pencil leads of known hardness (see hardness scale below). There are two end points that can be measured; gouge hardness and scratch hardness. Gouge hardness is reported as the hardest pencil that will leave the film unmarred for a stroke length of 1/8 inch (no dent observed). Scratch hardness is reported as the hardest pencil that will not rupture, cut or scratch the film.

Softer ——— Harder

6B – 5B – 4B – 3B – 2B – B – HB – F – H – 2H – 3H – 4H – 5H – 6H – 7H – 8H – 9H

Taber Abrasion – Per ASTM D4060. This method covers the determination of the resistance or organic coatings to abrasion produced by the Taber Abraser on coatings applied to a plane, rigid surface, such as a metal panel. Abrasion resistance is calculated as loss in weight at a specified number of abrasion cycles. For this test, the harsh calibrase wheels were used (CS-17), with 500 mg weight applied for 1,000 cycles.

Impact Resistance – Per ASTM D2794. This method covers a procedure for rapidly deforming by impact a coating film and its substrate. A standard weight is dropped a distance so as to strike an indenter that deforms the coating and the substrate. The indentation can be either an intrusion (direct impact) or extrusion (reverse impact). Films generally fail by cracking. The results are reported as the maximum number of inch-pounds of force applied to the coating and substrate at which the coating does not crack (P for pass) or when the coating cracks (F for fail).

Flexibility – Per ASTM D522 Test Method A – Conical Mandrel Bend. This method covers the determination of the resistance to cracking (flexibility) of organic coatings attached to substrates. The coated substrates are bent over a mandrel and the resistance of cracking is determined. In Method A, the coated substrates are bent over a cone-shaped mandrel having the smallest diameter of 1/8" and the largest diameter of 1 ½". The panels are bent and then measure for the distance of cracking along the axis of the cone which represents specified mandrel sizes.

Chemical Spot Resistance – Per ASTM D1308. This method covers the determination of the effect of chemicals on clear or pigmented organic finishes, resulting in objectionable alteration in the surface, such as discoloration, change in gloss, blistering, softening, swelling, loss of adhesion, etc. Ten drops of each of the eight chemicals used in this evaluation were applied to a ¾" square piece of paper toweling, then covered with watch glasses and allowed to set for 24 hours under ambient conditions. The watch glasses and saturated paper towel pieces were wiped off and the areas evaluated for appearance and physical changes. The eight chemicals that were used are listed in Table 3.

MEK Resistance – Per ASTM D4752. This method describes a solvent rub technique for assessing the MEK resistance of coatings. It is a good indication of the degree of cure of a coating. The results are reported as the number of double rubs (up & down motion) where the coating film wears/breaks through or 300 double rubs are reached.

Please call me should you have questions or comments at (810)750-0040. Thank you for the opportunity to perform the above work for Nanovere Technologies.

We look forward to working with you in the future.

Sincerely,

Debora L. Hense

Consultant