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Evaluation of VCI Film Samples, Manufactured by Northern Technologies, Used by Customer for Export Shipment of Customer Components

To: Mike Gabor

For: Customer

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Project #: 16-228-1125.bis

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Background: A customer packages export parts for their customer, and they are currently using NTIC VCI films for corrosion protection. Cortec Laboratories has been asked to evaluate various different samples of this film for corrosion protection abilities, as well as mechanical properties. The NTIC film samples will also be tested side by side with Cortec's VpCI-126, for comparison.

Sample Received: Five film samples, about 10-20 square feet each, received 10/4/16 in good condition. See below for picture of samples as received. Samples are as follows:

Sample A: NTIC yellow flat bag, about 2.5 mils
Sample B: NTIC 18' green sheeting, about 3 mils
Sample C: NTIC dark green transmission bag, about 3 mils
Sample D: NTIC light green transmission bag, about 3 mils
Sample E: NTIC engine bag, about 3 mils

Figure 1: NTIC films as received. From left to right: A, B, C, D, and E

Method:
VIA Test, CC-027
FTIR Analysis, CC-006
Razor Blade Test, CC-004
Nitrite/Nitrate Test
Mechanical Properties[+]

[+]Mechanical Properties testing performed by:
Cambridge Advanced Films
410 East First Ave
Cambridge, MN 55008

Materials: VIA test kit
Razor Blade test kit
Nitrite/Nitrate test strips, lot HC553793
Paragon 1000 FTIR
VpCI-126, 3 mils, lot 36030
VpCI-126, 4 mils, lot 39064
Polyethylene film, used as a control

Procedure: All tests were performed according to their standard procedures.

Results:

VIA Test Results

Sample	Plug 1	Plug 2	Plug 3	Overall
NTIC A (Yellow)	0	1	1	Fail
NTIC B (Green)	1	2	0	Fail
NTIC C (Green)	0	2	0	Fail
NTIC D (Green)	2	1	1	Fail
NTIC E (Green)	1	1	1	Fail
VpCI-126, 3 mils	2	2	2	Pass
VpCI-126, 4 mils	2	3	3	Pass
Control	1	0	-	-

Carbon Steel Razor Blade Test Results

Sample	Panel 1	Panel 2	Panel 3	Overall
NTIC A (Yellow)	Pass	Pass	Pass	Pass
NTIC B (Green)	Pass	Pass	Pass	Pass
NTIC C (Green)	Pass	Pass	Fail	Pass
NTIC D (Green)	Pass	Pass	Pass	Pass
NTIC E (Green)	Pass	Pass	Pass	Pass
VpCI-126, 3 mils	Pass	Pass	Pass	Pass
VpCI-126, 4 mils	Pass	Pass	Pass	Pass
Control	Fail	Fail	Fail	-

Copper Razor Blade Test Results

Sample	Panel 1	Panel 2	Panel 3	Overall
NTIC A (Yellow)	Fail	Fail	Fail	Fail
NTIC B (Green)	Fail	Fail	Fail	Fail
NTIC C (Green)	Fail	Fail	Fail	Fail
NTIC D (Green)	Fail	Fail	Fail	Fail
NTIC E (Green)	Fail	Fail	Fail	Fail
VpCI-126, 3 mils	Pass	Pass	Pass	Pass
VpCI-126, 4 mils	Pass	Pass	Fail	Pass
Control	Fail	Fail	Fail	-

Mechanical Properties Testing

Property		Test Method	Units	NTIC A	NTIC B	NTIC C	NTIC D	NTIC E	VpCI-126 3 mil	VpCI-126 4 mil
Caliper		ASTM D6988	mil	2.88	2.93	3.16	3.17	2.97	3.45	3.99
Breaking Factor	MD	ASTM D882-02	lbs/in	13.60	11.38	16.38	14.43	19.44	12.34	14.55
	TD			12.29	11.35	16.07	14.45	15.77	11.63	16.09
Tensile Strength at Break	MD	ASTM D882-02	psi	4504.00	4034.00	5611.00	4746.00	6353.00	3972.00	3833.00
	TD			4181.00	4082.00	5541.00	4667.00	5446.00	3865.00	4125.00
Elongation at Break	MD	ASTM D882-02	%	718.09	765.64	834.70	768.94	813.58	577.27	646.78
	TD			791.42	16.46	878.10	848.29	863.54	696.81	788.50
Yield Strength	MD	ASTM D882-02	psi	2030.68	1628.77	1888.92	1735.02	1679.47	1864.25	1792.65
	TD			1424.96	1400.51	1917.84	1418.76	1555.11	1746.26	1689.20
Puncture Resistance	Outside	MIL-STD-3010, TM 2065	lbf	4.55	3.76	5.46	4.81	4.62	5.50	6.74
Puncture Resistance	Inside	MIL-STD-3010, TM 2065	lbf	4.87	3.82	5.80	4.83	5.05	5.23	7.04
Tear Strength	MD	ASTM D1922-06A	gram force	896.00	963.20	928.00	1004.80	819.20	579.20	603.20
	TD			1516.80	1632.00	1795.20	908.80	1881.60	1836.80	1788.80
Coefficient of Friction		ASTM D1894	static	0.07	0.09	0.09	0.05	0.06	0.28	0.24
			kinetic	0.18	0.17	0.16	0.14	0.09	0.35	0.42

FTIR Analysis

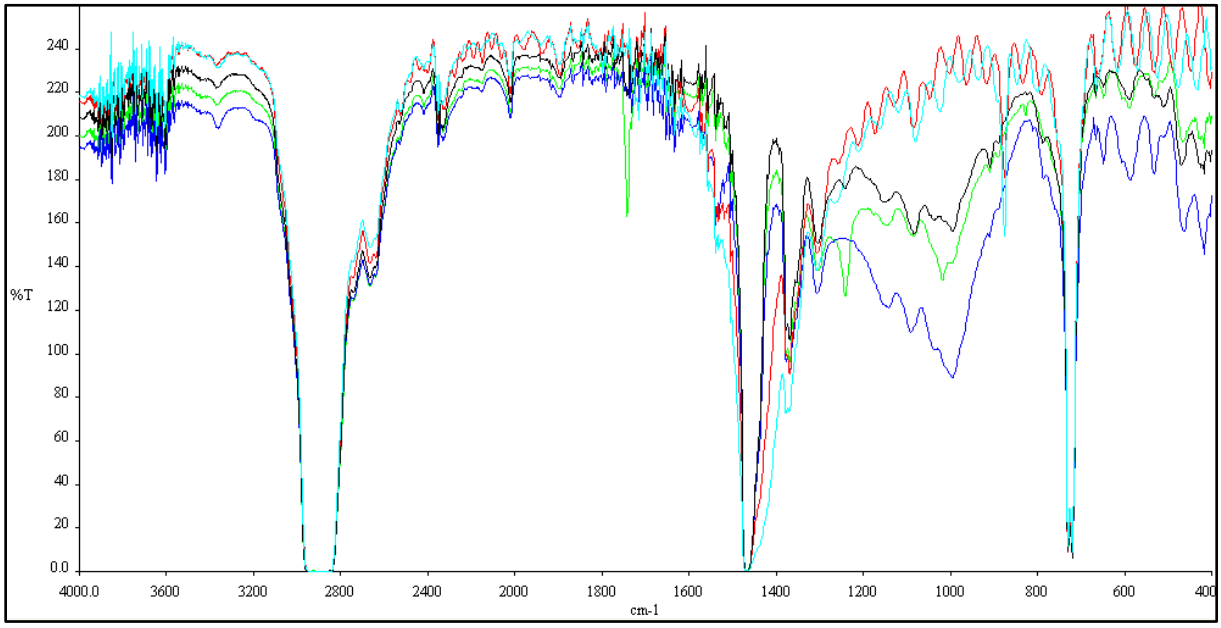
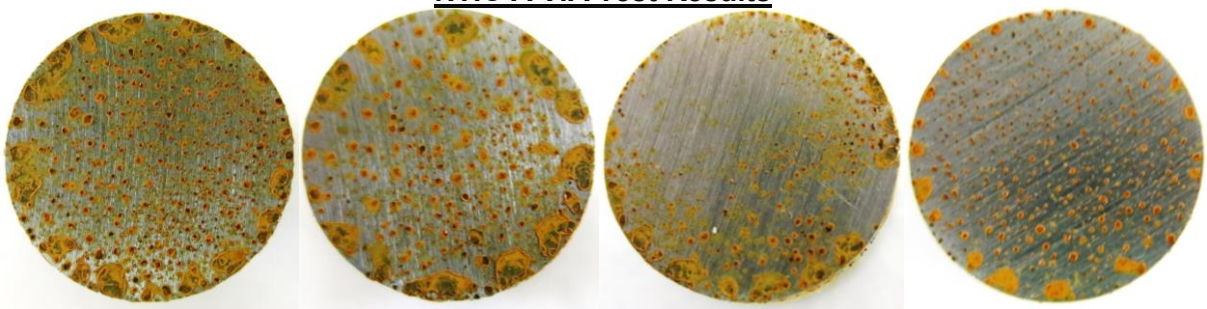


Figure 2: Sample A (green), Sample B (indigo), Sample C (red), Sample D (black), and Sample E (light blue)

Results relate only to the items tested

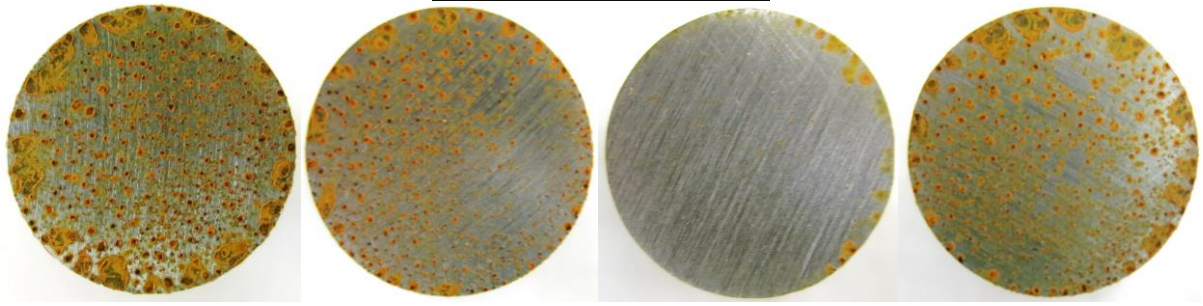
Photos:

NTIC A VIA Test Results



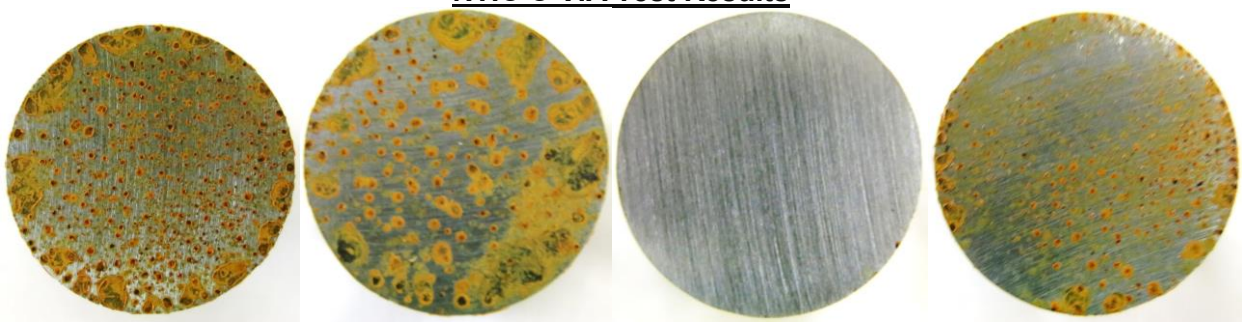
Control Plug 1 Plug 2 Plug 3

NTIC B VIA Test Results



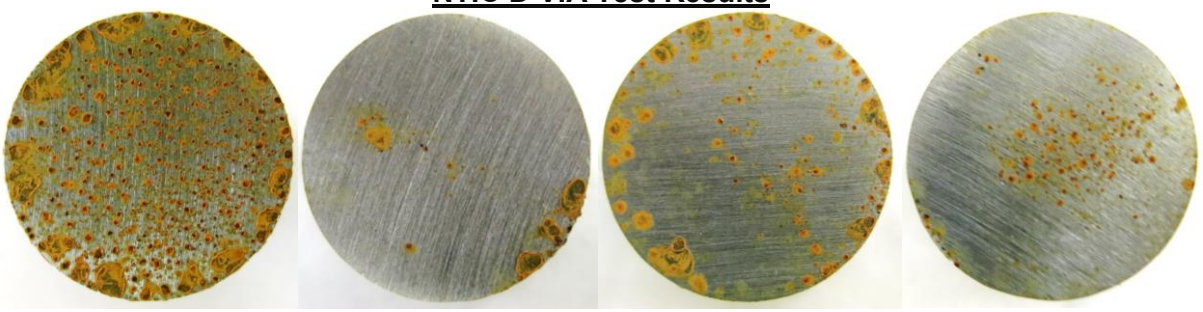
Control Plug 1 Plug 2 Plug 3

NTIC C VIA Test Results



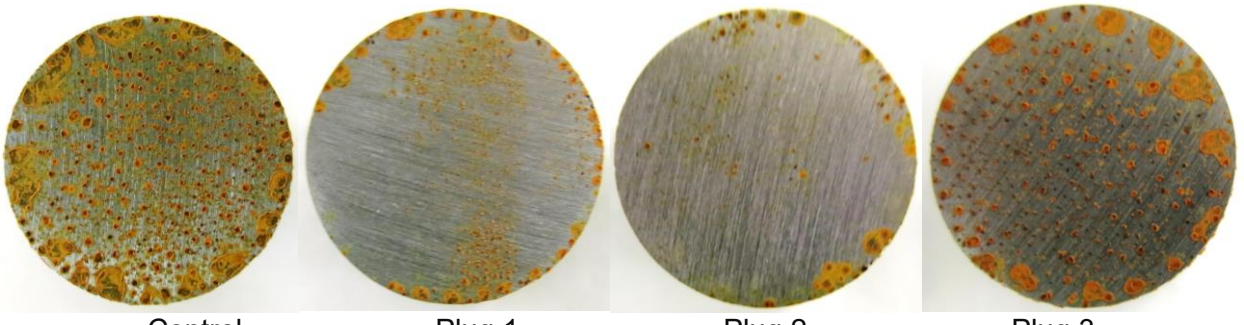
Control Plug 1 Plug 2 Plug 3

NTIC D VIA Test Results



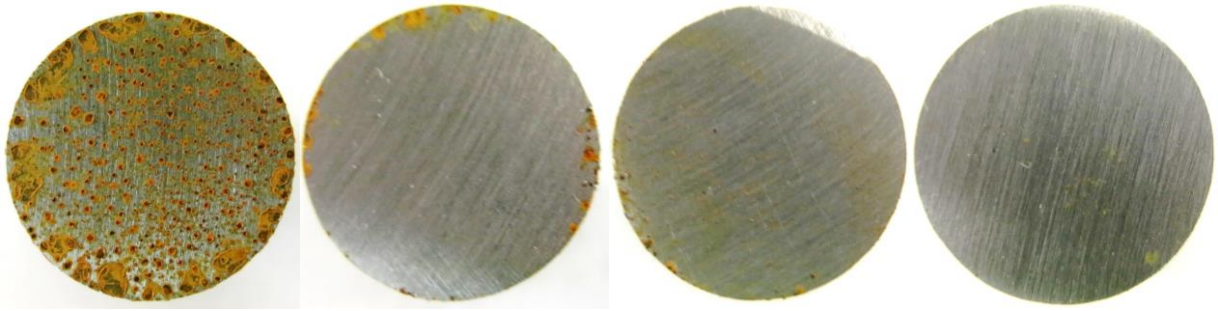
Control Plug 1 Plug 2 Plug 3

NTIC E VIA Test Results



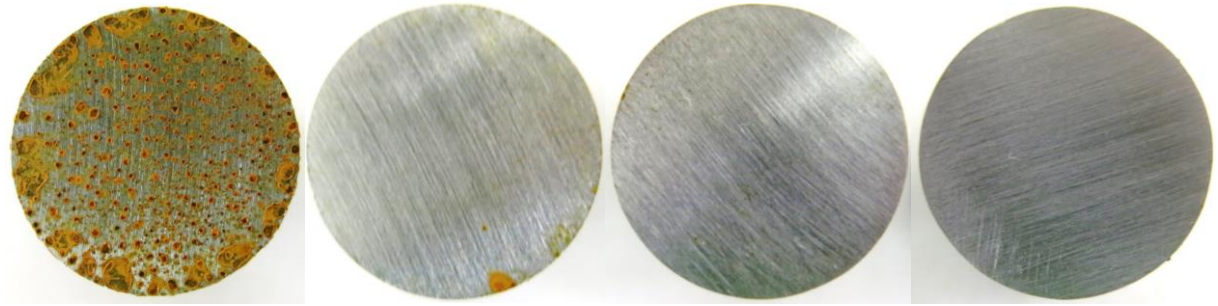
Control Plug 1 Plug 2 Plug 3

VpCI-126, 3 mils VIA Test Results



Control Plug 1 Plug 2 Plug 3

VpCI-126, 4 mils VIA Test Results

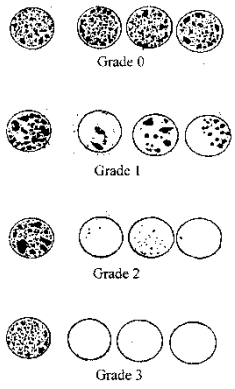


Control Plug 1 Plug 2 Plug 3

VIA Test Grading

All three plugs must be grade 2 or better to pass the test

Grade 0:	Blind test No corrosion inhibiting effect
Grade 1:	Blind test Minute corrosion inhibiting effect
Grade 2:	Blind test Medium corrosion inhibiting effect
Grade 3:	Blind test Good corrosion inhibiting effect



Interpretations: The goal of this project was to evaluate five NTIC film samples used by a customer, for packaging their customer's parts for export. Four of these samples (B-E) were purported to be the same product. Upon receipt, it was obvious that these products were not the same. Visually, all the films looked different. All of the subsequent testing confirmed differences in corrosion protection and mechanical properties amongst the films.

Corrosion protection testing showed that the NTIC films provide adequate contact phase protection for steel, according to razor blade results. However, these films do not protect copper materials, according to copper razor blade test results. Additionally, the NTIC films did not provide vapor phase corrosion protection, according to VIA test results. Conversely, VpCI-126 film (both 3- and 4-mil) protects both steel and copper in contact and vapor phase.

FTIR analysis shows the active components of the NTIC films are comprised of nitrites and desiccant. This was confirmed by nitrite strip analysis. The presence of nitrite based VCI chemistry explains the contact protection for steel, and failure for the remaining corrosion protection tests. In addition, according to FTIR results, desiccant was only found in samples A, B, and D, and within those samples, it occurred in varying types and amounts. Desiccant is not a true VCI, but it does provide some corrosion protection for short periods of time, by reducing humidity in the space close to the film by absorbing moisture from the air. However, once the desiccant compound has reached its saturation limit, it can no longer absorb any moisture and becomes ineffective. This is another reason why VIA results for NTIC films were inconsistent.

Mechanical properties testing also showed significant variation in the NTIC film samples, even among samples B-E, which are being sold to the customer as the same product. These inconsistencies can also be seen by visual examination (see figure 1).