



"Failure Avoidance Through Laboratory Testing"

Coating Testing Laboratory
Consulting Services
Field Inspection

SPECIALTY POLYMER COATINGS, INC.

LABORATORY TESTING OF SP2831 LOW TEMPERATURE CURE

0154-01-05-T

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EXECUTIVE SUMMARY

This report details the findings of a study conducted at Charter Coating Service Ltd. for Specialty Polymer Coatings, Inc. The objective of this study was to evaluate the performance and related characteristics of the coating SP2831 Low Temperature Cure.

This study included the following:

- Bend/Flex of Substrate CAN/CSA Z245.20-98 (Section 12.11, modified)
- Direct Impact CAN/CSA Z245.20-98 (Section 12.12, modified).
- Wet Adhesion CAN/CSA Z245.20-98 (Section 12.14).
- Cathodic Disbondment CAN/CSA Z245.20 (section 12.18)
- Pull-Off Strength ASTM D4541-98 A4
- Hardness ASTM D2240 – 86

Results obtained from this test program are summarized in Table 1 and given in the data sheets at the end of each test section.

Table 1. Summary of Test Results – SP2831 Low Temperature Cure Coating

TEST & CONDITIONS	Standard Method	Application of Test Panels	Summary of Test Results
Flexibility at 21°C/69.8°F as received.	CSA Z245.20-98, Section 12.11	Coating Application and Curing at 0°C/32°F	Passed the 0.3°/PAD
Flexibility at 0°C/32°F.			Failed the 0.3°/PAD
Flexibility at -30°C/-22°F.			Failed the 0.3°/PAD
Impact Resistance at 21°C/69.8°F with 1.5J	CSA Z245.20-98, Section 12.12	Coating Application and Curing at 0°C/32°F	No Cracking or Holidays
Impact Resistance at 0°C/32°F with 1.5J			75% of the tested panels showed no Cracking or Holidays
Impact Resistance at -30°C/-22°F with 1.5J.			75% of the tested panels showed no Cracking or Holidays
Wet Adhesion by knife, after immersion in tap water at 75°C/167°F for 28 days.	CSA Z245.20-98 Section 12.14	Coating Application and Curing at 0°C/32°F	Maintained excellent to very good adhesion as a result of testing
		Coating Application and curing at 21°C/69.8°F	Maintained excellent to very good adhesion as a result of testing
Cathodic Disbondment, 1.5V, 28 days at 65°C/149°F.	CSA Z245.20 - 98 Section 12.8	Coating Application and Curing at 0°C/32°F	An average radius of disbondment of 9.11mm
		Coating Application and Curing at 21°C/69.8°F	An average radius of disbondment of 8.23 mm
Pull-Off Strength	ASTM D4541-98 A4	Coating Application and Curing at 0°C/32°F	Exhibited Cohesive and Glue fracturing with an average Pull-Off value of 2022 psi
Hardness	ASTM 2240-86	Coating Application and Curing at 0°C/32°F	D Durometer hardness was 83-85 after 72 hours at 0°C/32°F

INTRODUCTION

Charter Coating Service Ltd. conducted a test program for Specialty Polymer Coatings, Inc. This was done in order to evaluate the performance and related characteristics of SP2831 Low Temperature Cure Coating recommended for low temperature applications of 0°C/32°F. The report is divided into sections, with each test constituting a different section.

OBJECTIVE

The objective of this study was to evaluate the performance and related characteristics of Specialty Polymer coating, SP2831 Low Temperature Cure.

SCOPE

The scope of this project was as follows:

1. The Specialty Polymer Coatings, Inc. representative selected the candidate coating.
2. The client did the selection of the different parts of the project, which included the following:
 - Coating application and curing to be preformed by Charter Coating Service Ltd. at 0°C/32°F.
 - Specialty Polymer Coatings, Inc, of Langley B.C to supply test panels coated and cured at 21°C/69.8°F.
 - Testing to be preformed by Charter Coating Service Ltd.
 - Testing conditions.

APPLICATION AND INSPECTION

INTRODUCTION

Improper application of field applied pipeline coatings has been the source of many coating failures. Problems in the application may be attributed to one or more of the following factors:

- Application specifications either do not exist or have limited detail.
- Quality control of the application work is limited and often performed by individuals with minimal knowledge of the coating system.
- Training of the field applicators is insufficient.

Charter Coating Service Ltd. performed the epoxy coating applications as requested by Specialty Polymer Coatings, Inc.

APPLICATION CHARACTERISTICS

The coating application was conducted as per the manufacturer's recommended practice. This was done using an analytical scale, stir rod, and paint brush.

Coating Application on Bare Steel Pipe:

The general procedure for coating application used in this study was as follows:

Surface Preparation:

Test panels were sand blasted with 12/50-grade silica to near white metal (SSPC SP-10) and had a surface profile of 2 –3 mils.

Coating Mixing Ratio

Resin (100g) and hardener (22g)

Coating Application:

Brush application was carried out at 0°C/32°F and the wet film thickness measurements were 24 – 35 mils.

Curing:

The coated samples were kept in the cold box at 0°C/32°F for seven days to insure complete curing.

FLEXIBILITY TEST

INTRODUCTION

In the field, coatings are subject to bending forces. These forces are present in tanks and vessels and are caused by the weight of the fluid in the tank or vessel. The coating's ability to 'bend' or 'flex' with the substrate and remain adhered is an important property.

The objective of this test was to determine the coating (applied and cured at 0°C/32°F) to bend and flex without cracking or breaking.

CONCLUSIONS

The following can be concluded as a result of this test:

- The coating passed the 0.3°/PAD flexibility test at 21°C/70°F.
- The coating failed the 0.3°/PAD flexibility test at 0°C/32°F and at -30°C/-22°F.

METHODOLOGY

The flexibility test was conducted according to CSA Z245.20-98 Section 12.11. The test was modified by using fixed radius mandrels to determine failure point. Test specimens (1" wide x 8" length x 1/4" thick) were prepared from the coated samples. Tests were carried out at three different temperatures of 21°C/70°F, 0°C/32°F and -30°C/-22°. Five (5) coated samples were tested at each test temperature. The flexibility was conducted by placing the test specimen in the test apparatus. The samples were clamped at one end of the bar, half an inch from the sample end, and a force was applied to the other end of the sample and each sample was bent over the mandrel for a thirty (30) second time period. The bent specimens were visually inspected for cracks and disbondment.

RESULTS

The results are shown in Figures 1-3 and given in the attached data sheet at the end of this section.

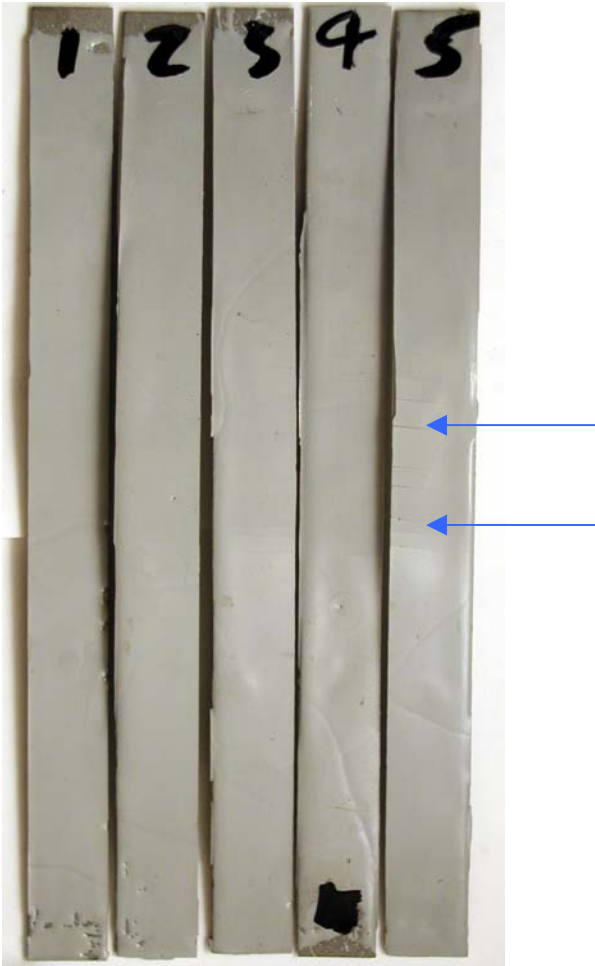


Figure 1. Post-Test Overview – Flexibility Test at 21°C/70°F

Above is the post-test overview of the bend test samples. The coating showed no cracks as a result of being bent over the 840 mm mandrel. Note the cracks (blue arrows) as a result of bending over the 414 mm mandrel.

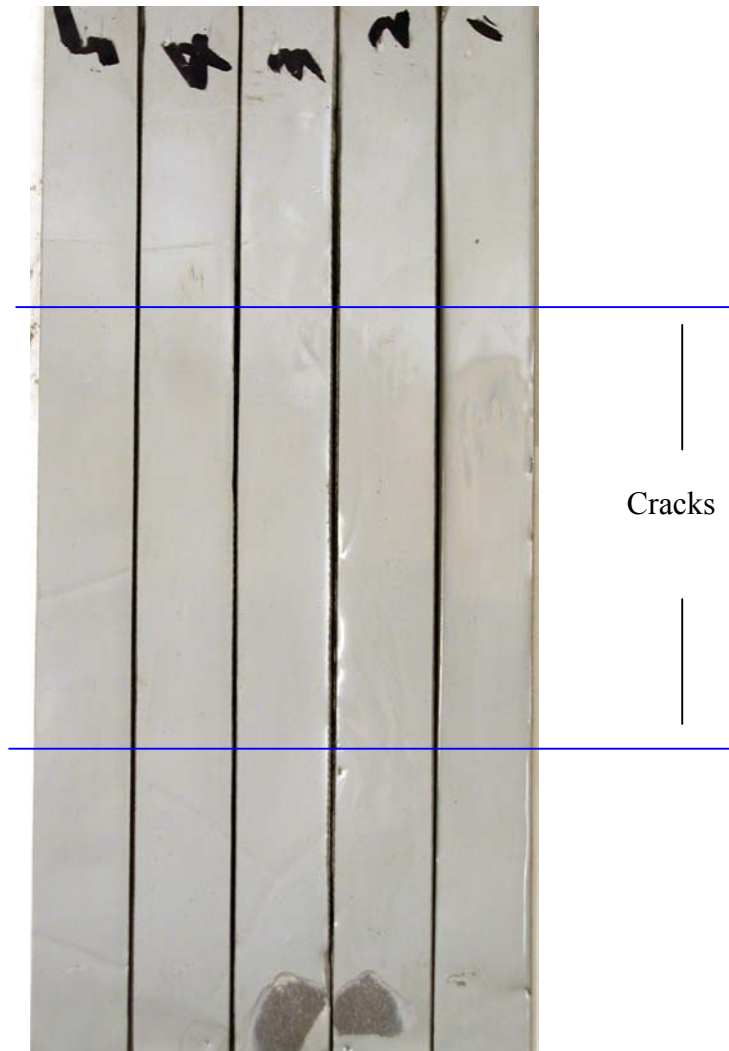


Figure 2. Post-Test Overview – Flexibility 0°C/32°F

Above is the post-test overview of the bend test samples. The coating showed cracks, which were not associated with holidays as a result of being bent over 840 mm mandrel.

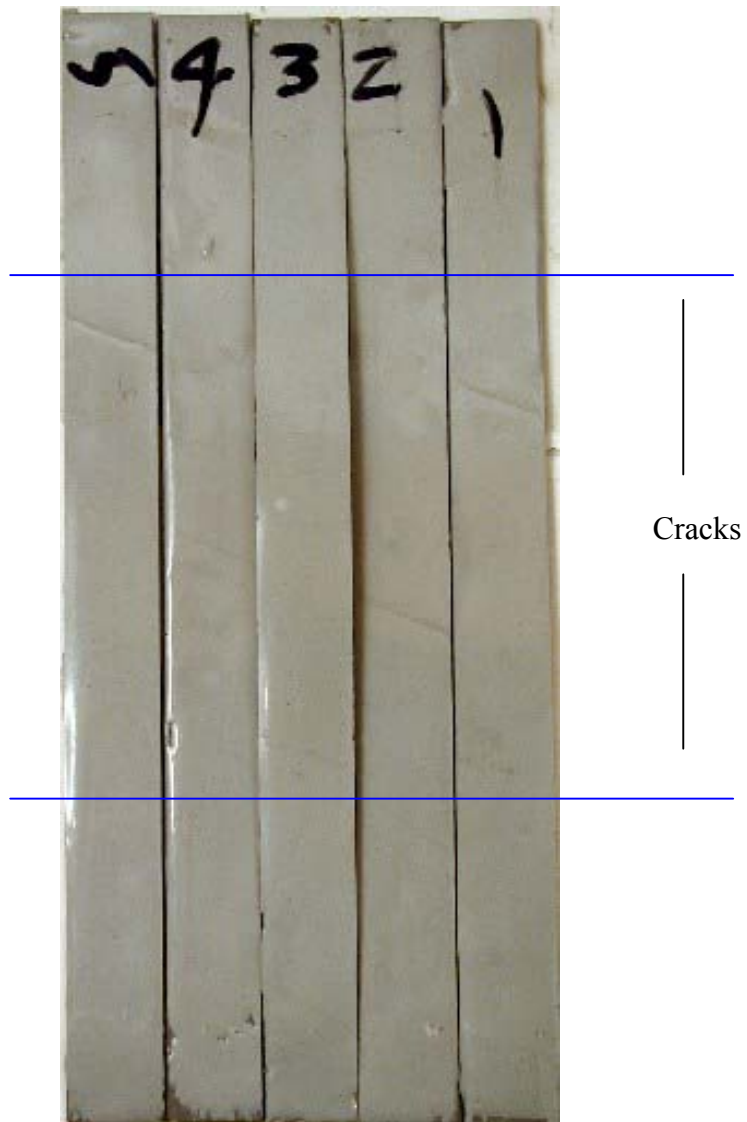


Figure 3. Post-Test Overview – Flexibility -30°C/-22°F

Above is the post-test overview of the bend test samples tested at. The coating showed cracks and holidays as a result of being bent over the 840 mm mandrel.

CHARTER COATING SERVICE LTD
FLEXIBILITY TEST DATA SHEET
(CAN/CSA Z245.20-98, Clause 12.11)

WORK ORDER NO: 154 – 01 - 05

TEMPERATURE: 21°C/70°C

TECHNICIAN: J.Hartt /R.Sun

COATING: SP2831

DATE: November 19, 2001

Sample #	Film Thickness (mils)	Mandrel Size (Radius in mm)	Cracks/Holidays	° /PAD	%Elongation
1	22 – 37	840	None	0.30	0.30
		414	Yes/Yes	0.60	0.61
2	23 – 26	840	None	0.30	0.30
		414	None	0.61	0.60
		280	Yes/None	0.90	0.89
		210	Yes/Yes	1.20	1.19
3	26 – 28	840	None	0.30	0.31
		414	None	0.62	0.62
		280	Yes/ None	0.91	0.91
		210	Yes/Yes	1.22	1.22
4	26 – 29	840	None	0.31	0.31
		414	Yes/ None	0.62	0.63
		280	Yes/Yes	0.92	0.92
5	28 – 35	840	None	0.30	0.30
		414	None	0.61	0.60
		280	Yes/ None	0.90	0.88
		210	Yes/Yes	1.20	1.18

CHARTER COATING SERVICE LTD
FLEXIBILITY TEST DATA SHEET
(CAN/CSA Z245.20-98, Clause 12.11)

WORK ORDER NO: 154 – 01 - 05

TEMPERATURE: 0°C/32°C

TECHNICIAN: J.Hartt / R.Sun

COATING: SP2831

DATE: November 21, 2001

Sample #	Film Thickness (mils)	Mandrel Size (Radius in mm)	Cracks/Holidays	° /PAD	%Elongation
1	14 – 28	840	Yes/Yes	0.27	0.26
2	22 – 40	840	Yes/ None	0.29	0.30
		414	Yes/Yes	0.59	0.61
3	20 – 30	840	Yes/ None	0.34	0.34
		414	Yes/Yes	0.70	0.68
4	28 – 32	840	Yes/ None	0.29	0.30
		414	Yes/Yes	0.60	0.61
5	25 – 40	840	Yes/ None	0.28	0.29
		414	Yes/Yes	0.57	0.59

CHARTER COATING SERVICE LTD
FLEXIBILITY TEST DATA SHEET
(CAN/CSA Z245.20-98, Clause 12.11)

WORK ORDER NO: 154 – 01 - 05
TECHNICIAN: J.Hartt / R.Sun
DATE: November 22, 2001

TEMPERATURE: -30°C/-22°C
COATING: SP2831

Sample #	Film Thickness (mils)	Mandrel Size (Radius in mm)	Cracks/Holidays	° /PAD	%Elongation
1	17 – 28	840	Yes/Yes	0.27	0.27
2	25 – 35	840	Yes/Yes	0.29	0.30
3	28 – 35	840	Yes/None	0.29	0.29
		414	Yes/Yes	0.60	0.59
4	20 – 30	840	Yes/Yes	0.28	0.28
5	21 – 35	840	Yes/Yes	0.29	0.29

IMPACT RESISTANCE

INTRODUCTION

To protect steel from corrosion, a coating film must be continuous. Breaks in the coating will allow the environment to permeate to the steel substrate and initiate corrosive degradation.

The objective of this test is to evaluate the resistance of the coating to damage from impact by a blunt ended object. Test panels coated and cured at 0°C/32°F were used.

CONCLUSIONS

As a result of this test, the following can be concluded:

- The coating passed the 1.5 Joules impact test at 21°C/70°F. No cracking, breaking or adhesion loss was observed as a result of testing.
- Seventy-five percent (75%) of the tested panels passed the 1.5 Joules impact test at 0°C/32°F.
- Only fifty percent (50%) of the tested panels have passed the 1.5 Joules impact test at -30°C/-22°F.

METHODOLOGY

The impact test was conducted according to CSA Z245.20-98, Section 12.12. Samples were pre-conditioned for 1 hour before testing at the test temperatures of 21°C/70°F, 0°C/32°F and -30°C/-22°F. The drop height (in order to give 1.5 Joules force) was determined by calculation. Each sample was impacted three (3) times within thirty (30) seconds, and with each impact point greater than 50 mm apart. Damage assessment of the impacted areas was carried out at room temperature using 67.5V holiday detector.

RESULTS

Results obtained are shown in Figures 4-6 and given in the attached data sheet.

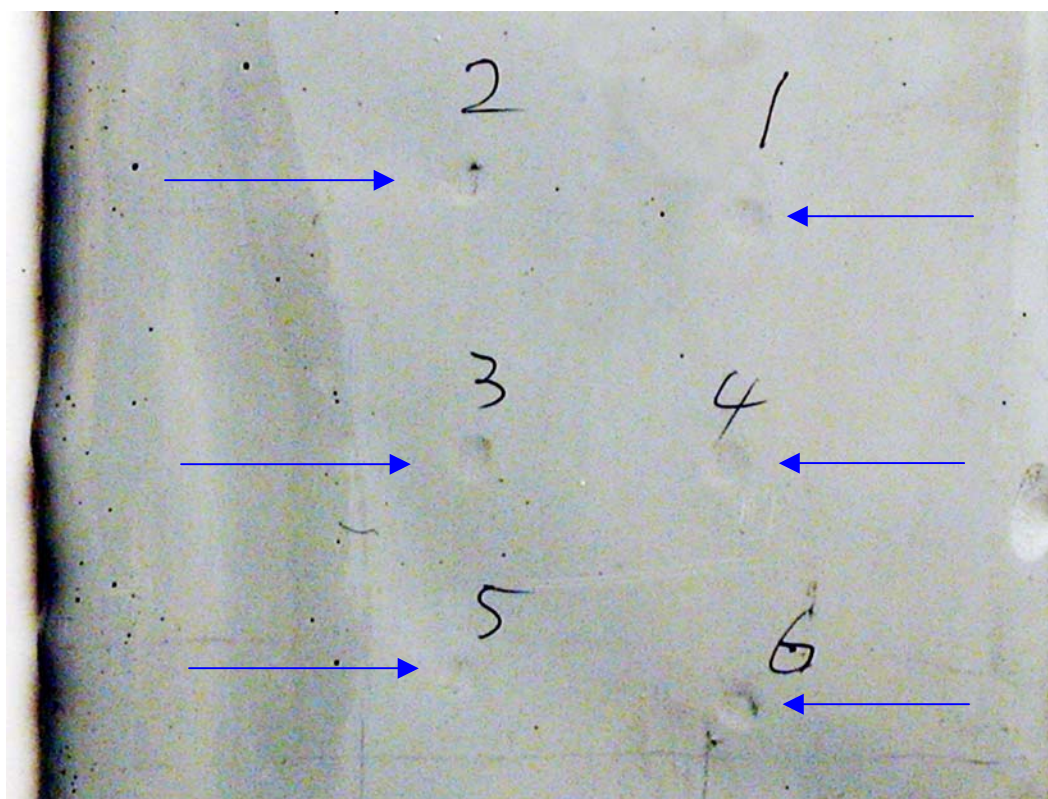


Figure 4. Post-Test Overview - Impact Test at 21°C/70°F

The above shows an overview of one of the tested samples. The blue arrows indicate the locations of where the sample was impacted. No cracks or any other noticeable defects were observed as a result of testing at 21°C/70°F.

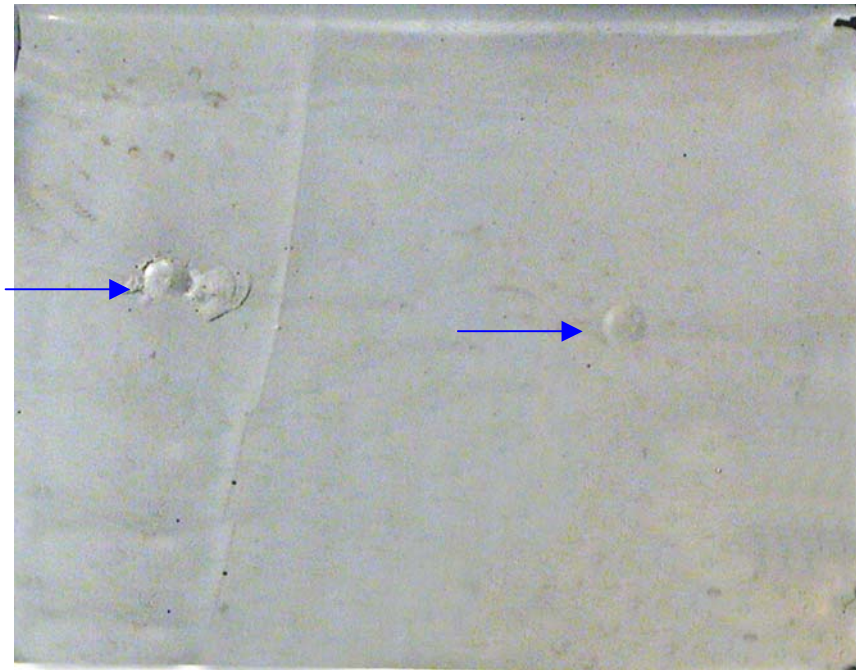


Figure 5 Post-Test Overview - Impact Test at 0°C/32°F

The above shows an overview of one of two tested panels. Seventy-five percent (75%) of the tested panels have passed the 1.5 Joules impact test at 0°C/32°F. No cracking, breaking or adhesion loss was observed as a result of testing. Twenty-five percent (25%) of the tested panels have failed the 1.5 Joules impact test at 0°C/32°F. The blue arrows indicate the locations of where the sample was impacted and failed. Cracks were observed as a result of testing, but the sample was holiday free.

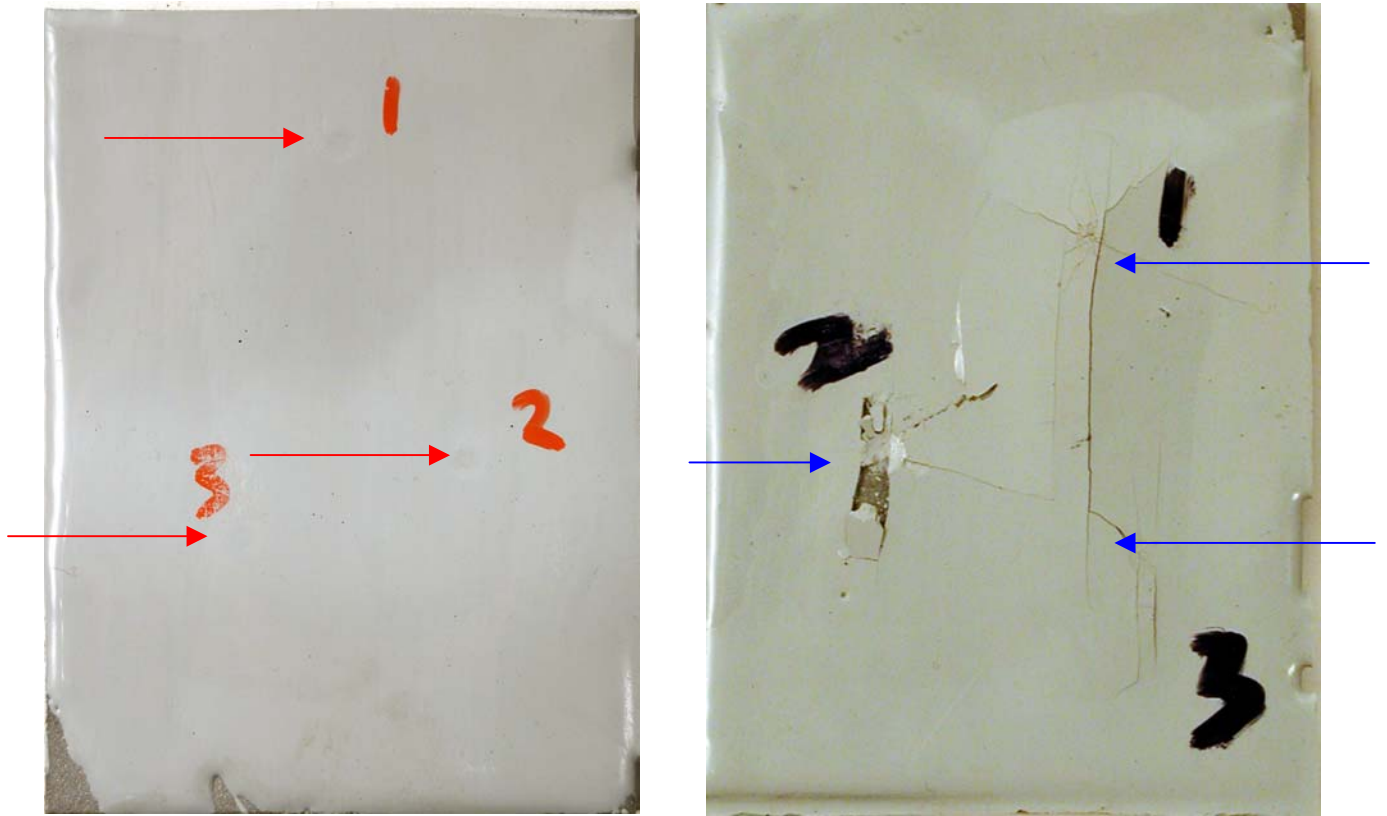


Figure 6 Post-Test Overview - Impact Test at $-30^{\circ}\text{C}/-22^{\circ}\text{F}$

The above shows an overview of one of two tested panels. Only fifty percent (50%) of the tested panels have passed the 1.5 Joules impact test at $-30^{\circ}\text{C}/-22^{\circ}\text{F}$. The blue arrows indicate the locations of where the sample was impacted and failed, while the red arrows indicate the locations where the sample was impacted and passed.

**CHARTER COATING SERVICE LTD.
IMPACT RESISTANCE TEST DATA SHEET
(CAN/CSA Z245.21-98, Clause 12.12)**

WORK ORDER NO.: 154 - 01- 05	DATE: November 20, 2001
TECHNICIAN: J.Hartt / R. Sun	COATING: UN - 2831
HEIGHT OF DROP (CM): 16.5	WEIGHT (KG): 0.927
HOLIDAY DETECTION VOLTAGE: 67.5 V	

Temperature	Film Thickness (mils)	Test No.	Holiday
21°C / 70°F	25 - 30	1	None
		2	None
		3	None
		4	None
		5	None
		6	None
0°C / 32°F	26-30	1	None
		2	None
		3	None
		4	None
		5	None
		6	None
		7	None
		8	None
		9	None
		10	Yes
		11	Yes
		12	Yes
-30°C / -22°F	18 - 28	1	Yes
		2	Yes
		3	Yes
		4	None
		5	None
		6	None

WET ADHESION – KNIFE

INTRODUCTION

Water can be the most detrimental environment to a coating system, especially at elevated temperatures. Water molecules can diffuse through the coating to the substrate, which would cause blistering, and loss of adhesion. If the bond between the coating and the substrate were weakened, the danger of the coating letting go and falling off would leave the substrate unprotected. The hot water soak test examines a coating's ability to adequately protect the steel in immersion conditions.

The objective of the test was to determine the adhesion of the coating SP2831 Low Temperature Cure, after immersion in an aqueous environment. Test panels coated and cured at 0°C/32°F and at 21°C/70°F were used.

CONCLUSIONS

As a result of this test the following can be concluded:

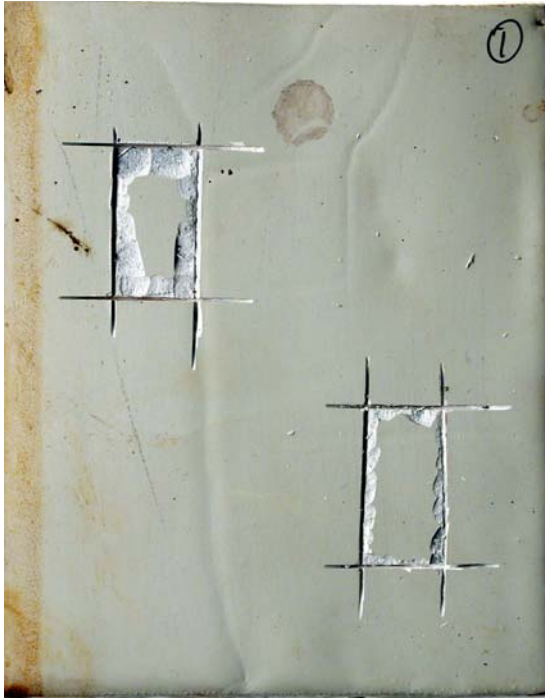
- Test panels coated and cured at 0°C/32°F and at 21°C/70°F maintained excellent to very good adhesion as a result of testing.

METHODOLOGY

The Wet Adhesion – Knife Test was conducted according to the CAN/CSA Z245.20-98 (Section 12.14). In this test, the coated panels were immersed in water at 75°C/167°F for 28 days. Adhesion rating was conducted by cutting a rectangle approximately 30mm x 15mm in the centre of each sample, using a levering action, a knife blade was inserted under the coating and was used to remove the coating from the substrate. This was continued until all of the coating within the rectangle was removed, or until the coating exhibited a definite resistance to the levering action.

RESULTS

Results obtained are shown in Figure 7, and given in the data sheet is attached at the end of this section.



Test Panel Coated and Cured at 0°C/32°F



Test Panel Coated and Cured at 21°C/70°F

Figure 7. Post-Test Wet Adhesion Testing

The above photographs are the post-test adhesion results for the immersion tests conducted at 75°C/167°F for 28 days. The coating exhibited a definite resistance to the levering action applied and maintained excellent to very good adhesion as a result of testing. No blistering or changing in gloss was observed, but there was a slight change in colour.

CHARTER COATING SERVICE LTD.
ADHESION OF COATING TEST DATA SHEET
(CAN/CSA Z245.20-98, Clause 12.14)

WORK ORDER NO.: 0154-01-05

TEMPERATURE: 75°C/167°F

TECHNICIAN: J. Hartt

COATING: SP2831

DATE: OCTOBER 3, 2001

DURATION: 28 days

Application Cure Temperature	Pre-test Film Thickness (mils)	Post test Film Thickness (mils)	Adhesion Rating
20°C / 68°F	24 – 31	26 – 33	1-2
	21 – 27	27 – 32	1-2
	26 – 32	29 – 36	1-2
0°C / 32°F	22 – 51	27 – 58	1
	27 – 51	22 – 55	1
	26 - 56	27 - 61	2

*Pass/Fail criteria - Pass is a rating of 1-3

Rating Key

- 1 Coating cannot be removed cleanly
- 2 Less than 50% of the coating can be removed
- 3 More than 50% of the coating can be removed but the coating demonstrates a definite resistance to the levering action
- 4 The coating can be easily removed in strips or large chips
- 5 The coating can be completely removed as a single piece

CATHODIC DISBONDMENT

INTRODUCTION

Cathodic protection is a technique used to reduce the corrosion of a metal surface by providing it with enough cathodic current to make its anodic dissolution rate become negligible. While preserving the steel, this technique can be detrimental to the performance of the coating applied. Anodes develop at breaks and defects in the coating film (holidays). An aggressive, caustic environment at the substrate/coating interface develops on the edge of the holiday (the cathode) by the electrical stress impressed. Coating disbondment is initiated and propagates around the holiday due to the increase in pH in the immediate environment. The phenomenon is commonly referred to as cathodic disbondment.

The objective of this test was to determine the coatings ability to withstand cathodic protection. Test panels cured at 0°C/32°F and at 21°C/70°F were used.

CONCLUSIONS

- The coating SP2831 Low Temperature Cure applied and cured at 0°C/32°F showed an average radius of disbondment of 9.11mm as a result of testing. This value is considered acceptable as per the CSA Z245.20-M92 standard acceptance criteria.
- The coating SP2831 Low Temperature Cure applied and cured at 21°C/70°F showed an average radius of disbondment of 8.23 mm as a result of testing. This value is considered acceptable as per the CSA Z245.20-M92 standard acceptance criteria.

METHODOLOGY

In this study, the Cathodic Disbondment Test was conducted according to CSA Z245.20-M92, "Cathodic Disbondment of External Fusion Bond Epoxy Coating." An external holiday, 3.2 mm/0.25" diameter was drilled through the coated samples to the steel surface. The experimental set-up consists of making a seal between a cylinder and coated sample using silicone sealant centred on the initial holiday. The cylinder was filled with 3.0% NaCl solution and the samples were polarized cathodically by impressing a stress potential of -1.5V (with respect to Cu|CuSO₄ reference electrode) for a set number of days. To account for water evaporation in the cells, distilled water was added to the system as required. Test panels coated and cured at 0°C/32°F and 21°C/70°F were used.

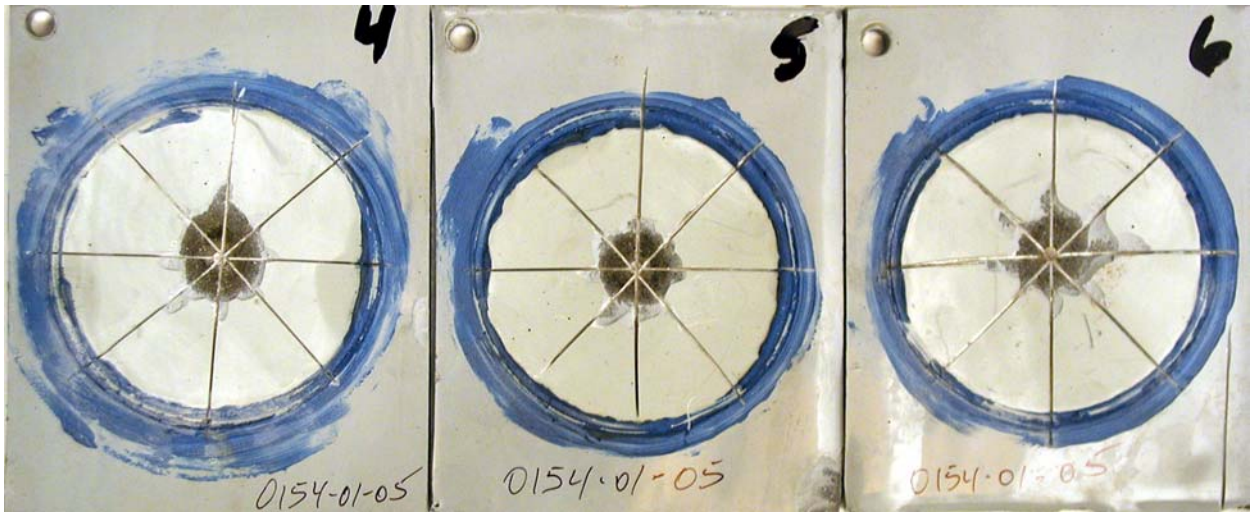
The test conditions were as follows:

Temperature:	65°C/149°F
Electrolyte:	3% NaCl in Distilled Water
Impressed Voltage:	-1.5VDC
Test Duration	28 days

After testing the samples were examined for blisters, and radial cuts were made through the coating to the substrate. The coating was lifted from the substrate adjacent to the initial holiday to measure the extent of any disbondment.

RESULTS

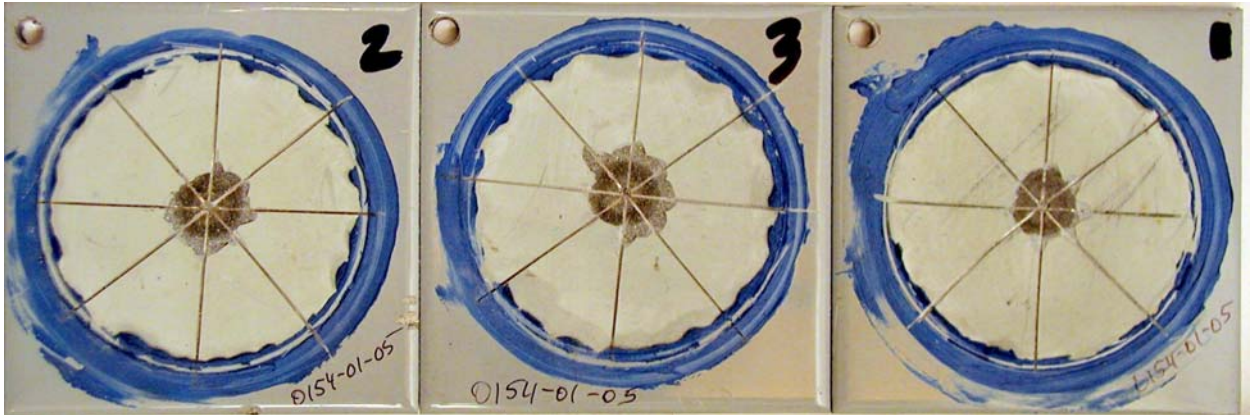
The results are shown in Figure 8 and given in the attached data sheet at the end of this section.



Test Panels coated and Cured at 0°C/32°F

Figure 8. Cathodic Disbondment at 65°C/149°F

The above photographs show test specimens of the Cathodic Disbondment Test with radial cuts intersect the initial holiday. The coating SP2831 Low Temperature Cure applied and cured at 0°C/32°F showed an average radius of disbondment of 9.11mm as a result of testing. This value is considered acceptable as per the CSA Z245.20-M92 standard acceptance criteria.



Test Panels coated and Cured at 21°C/70°F

Figure 8. Cathodic Disbondment at 65°C/149°F

The above photographs show test specimens of the Cathodic Disbondment Test with radial cuts intersect the initial holiday. The coating SP2831 Low Temperature Cure applied and cured at 21°C/70°F showed an average radius of disbondment of 8.23 mm as a result of testing. This value is considered acceptable as per the CSA Z245.20-M92 standard acceptance criteria.

CHARTER COATING SERVICE LTD.
CATHODIC DISBONDMENT OF THE COATING
(CAN/CSA Z245.20 -92, Clause 12.8)

WORK ORDER NO.: 0154-01-05-T	COATING: SP2831 Low Temperature Cure
TECHNICIAN: J. Hartt	TEMPERATURE: 65°C/167°F
DATE: NOVEMBER 1, 2001	VOLTAGE: -1.5 VDC
TEST DURATION: 28 DAYS	

Sample No.	Application & Curing Temperature	Film Thickness (mils)		Diameter of Disbondment (mm) ^A	Average Radius Disbondment (mm) ^B	Average Radius (mm)
		Pre-Test	Post-Test			
1	20°C / 68°F	24 - 32	26 - 32	13.44	6.72	8.23
2		24 - 32	26 - 32	16.48	8.24	
3		21 - 31	27 - 34	19.48	9.74	
4	0°C / 32°F	30 - 42	35 - 43	18.77	9.38	9.11
5		25 - 46	22 - 48	17.59	8.79	
6		30 - 60	21 - 65	18.31	9.16	

^A Excludes initial holiday measurement (3.2 mm diameter)

^B Excludes the initial holiday measurement (1.6mm)

^C Pass/Fail criteria - Pass is 10 mm maximum radius

PULL-OFF STRENGTH TEST

INTRODUCTION

The Pull-Off strength of a coating is determined by the numerical value of perpendicular stresses the coating can withstand. Failure will occur along the weakest plane within the test system. This plane may be at the substrate, within the coating film, at the glue layer, or most commonly a combination of two or more of these sites. The weakest plane in the coating film is the site of failure while in service. The test provides a method for preparing and testing coated surfaces, where a test fixture is adhered to the coating surface. An adhesion tester is used to apply a perpendicular force on the adhered test fixture. This method is most useful on untested coatings (not exposed to chemical environments) since adhesives will typically release from coatings that have been exposed to test environment.

The objective of this test was to determine the Pull-Off strength of the coating applied and cured at 0°C/32°F.

CONCLUSIONS

The following can be concluded as a result of this test:

- SP2831 Low Temperature Cure Coating exhibited mainly cohesive and glue fracturing with an average Pull-Off value of 2022 psi.

METHODOLOGY

The Pull-Off Strength Test was conducted in accordance with ASTM D4541-95 A4, "Pull-Off Strength of Coatings Using Portable Adhesion Testers". The selected test sites and loading fixtures were lightly abraded. Tape was used to remove any residual dust. The adhesive (glue) was prepared in accordance with the manufactures instructions, and applied to the cleaned loading fixture. The loading fixture was placed on the prepared test site on the coating. The glue was allowed to dry for twenty-four (24) hours. A self-aligning piston was attached to the loading fixture. The force applied was gradually increased until the fixture released. Each test site was evaluated for both the force required to remove the fixture and the failure point within the coating.

RESULTS

The results are shown in Figure 9 and given in the attached data sheet at the end of this section.

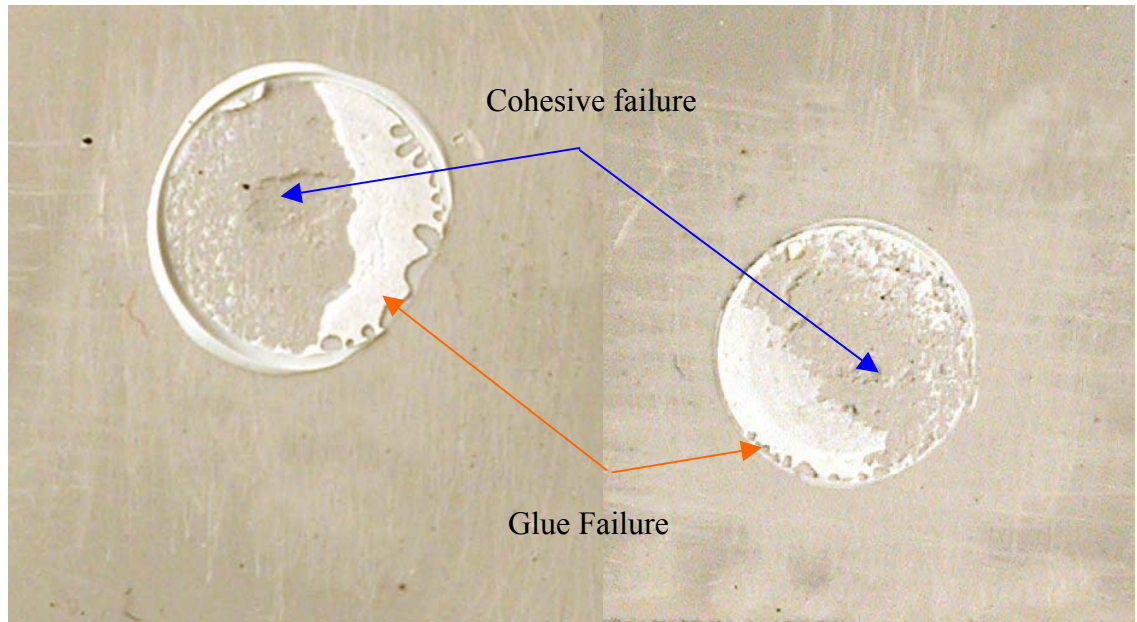


Figure 9. Pull –Off Strength of Coating sample SP2831 Low Temperature Cure

Two of the pull-off test sites are shown above. Abrasion marks are visible where each test site was lightly sanded before gluing the loading fixtures in an effort to promote adhesion of the glue. The test site on the left had a pull value of 2770 psi with a seventy percent (70%) cohesive failure (within the coating film). The test site on the right had a pull value of 2607 psi with a seventy percent (70%) cohesive failure (within the coating film). The blue arrows indicate the failure within the coating film. The red arrows indicate the failure within the glue (fixture) to coating bond.

CHARTER COATING SERVICE LTD.
PULL-OFF STRENGTH OF COATINGS
(ASTM D4541-94 –A4)

WORK ORDER NO.: 0154-01-05	TEMPERATURE: 21°C/69.8°F
TECHNICIAN: J. Hartt	DATE: November 20, 2001
INSTRUMENT: Patti Jr.	COATING: SP2831

Panel/Pull No.	Pull Value (psi)	Description of Failure	Average Pull Value (psi)
A	1631	10% Cohesive/90% Glue	2022
B	1692	10% Cohesive/90% Glue	
C	1835	5% Cohesive/95% Glue	
D	1467	5% Cohesive/95% Glue	
E	1406	15% Cohesive/85% Glue	
F	2770	10% Cohesive/90% Glue	
G	2770	70% Cohesive/30% Glue	
H	2607	70% Cohesive/30% Glue	

Failure Definitions:

Cohesive - Failure is within the coating film.

Adhesive - Failure is within the coating to substrate bond.

Glue - Failure is within the glue (fixture) to coating bond.

HARDNESS

The objective of this test is to determine the coating SP2831 Low Temperature Cure hardness at 0°C/32°F using D type Durometer Hardness.

CONCLUSIONS

- The coating Durometer hardness was 83-85 after seventy-two (72) hours at 0°C/32°F.

METHODOLOGY

The hardness of coating was conducted according to ASTM 2240-86. This test method covers type D shore durometer that is used for hard materials. To account for this property and comply with the specified condition, the sample was prepared and maintained at 0°C/32°F, with the exception of the coating mixing which was done at room temperature. The sample was then tested every twenty-four (24) hours until three (3) consistence hardness readings were obtained.

CHARTER COATING SERVICE LTD.
DUROMETER HARDNESS OF COATING
(ASTM D 2240-86)

DATE: DEC, 3 2001

TEMPERATURE: 0°C/32°F

TECHNICIAN: J.Harrt

DUROMETER TYPE: D

COATING: SP2831

Time (hours)	Hardness Durometer Readings	
	Min	Max
24	80	83
48	80	86
72	83	85