

Evaluation of Bolt Coatings

(File #16-011)

**Infrastructure
Materials Service**

December 2016

Table of Contents

1. PURPOSE.....	3
2. DESCRIPTION.....	3
3. ABRASION TEST.....	4
3.1 METHODOLOGY.....	4
3.2 RESULTS OF ABRASION TESTS.....	4
3.3 CONCLUSIONS for ABRASION TESTS.....	5
4. SALT SPRAY TESTS.....	6
4.1 METHODOLOGY & RESULTS.....	6
4.2 CONCLUSIONS for SALT SPRAY TESTS.....	7
5. OVERALL CONCLUSIONS.....	7
APPENDICES	
APPENDIX 1: PHOTOS of ABRASION RESULTS.....	9
APPENDIX 2: PHOTOS of SALT SPRAY TESTS.....	11
APPENDIX 3: LCL21-102 GRANULATE POLISHING RESISTANCE: METHOD BY PROJECTION.....	12
APPENDIX 4: LCL21-102 AGGREGATES RESISTANCE TO POLISHING: SHOT-BLASTING METHOD.....	13

1. PURPOSE

Our expertise was requested by Mr. Ray Wilcock of the Corrugated Steel Pipe Institute, to assess the abrasion and corrosion performance of certain types of coatings on bolts (ASTM A 449) and nuts (ASTM A 563).

2. DESCRIPTION

We have received from the applicant bolts coated with different types of coatings, as shown in Table 1: Sample Description

No sample	Sample Name	Type of Coating					
		Base Coat (bond coat)		Finishing Coat (top coat)		Sealer	
		Name	Gauge	Name	Gauge	Name	Gauge
1	Phos - Leland	Zintek 300B	0.75 mils	Techdip Black	1.12 mils	Techseal clear SL	0.24 mils
2	Undip AP - Leland	Zintek 300B	0.99 mils	Techdip Black HC	0.99 mils	Techseal clear SL	0.31 mils
4	Undip AP (A) Leland	Zintek 300HP	0.77 mils	Techdip Black HC	0.77 mils	Techseal clear SL	0.16 mils
5	Geomet 321 (ASTM F1136)	G321	24 g/m ²	G321	24 g/m ²	-	-
6	Geomet T321 Plus	G321 Plus	46.8 g/m ²	G321 Plus	4.2 g/m ²	-	-
7	Dacromet (ASTM F1136)	D320	82.6 g/m ²	Dacrolub	0.06 to 0.19 mils	-	-
8	Dacromet Plus	D320 Plus	88.2 g/m ²	Dacrolub	0.14 to 0.20 mils	-	-
9	Part 77717 Stainless Steel ASTM F593	Alloy 316	0.5 mils	Alloy 316	0.3 mils	Clear	0.2 mils
10	Magni Coated Bolts - 2 X B18 RE	B18 RE	0.3 mils	B18 RE	0.3 mils	B18 RE	0.25 mils
11	Magni Coated Bolts - BO6J + P126L	P126L	0.3 mils	BO6J	0.3 mils	-	-
12	Magni Coated Bolts - BO6J + B18	B18	0.5 mils	BO6J	0.3 mils	-	-
13	Hot Dipped Galvanized	Zinc	2.1 mils		No Top	-	-

The 12 samples were subjected to the abrasion test according to LCL21-102 and 12 other samples were subjected to the salt spray test according to ASTM B117.

3. ABRASION TEST

3.1 METHODOLOGY

For the abrasion test in accordance with internal standard LC21-102, we used an Elite Technology type polisher composed of a closed chamber, an abrasive feeding electrical installation with an adjustable flow rate and a pressure compressor, and water supply. The abrasive used is Ottawa sand (chosen according to ASTM C778).

The bolts and the nuts are placed on a steel support and exposed with the abrasive blast front part (see Figure 1, Appendix 1) applied with a pressure of 10,000 kpa, a flow rate of 541 g / min during 7 stages at a duration of 43 min 20 s / 20 cycles.

We measured the overlap thicknesses on the head of the bolts before and after each of our seven tests, and subsequently assessed the percentage loss of thickness. To measure we used a thickness gauge of Elcometer model 456/4.

3.2 RESULTS OF ABRASION TESTS

At the start and after each test, we visually inspected samples and measured the thickness of the coatings. For each sample, we marked the time of the total loss of the coating (recorded by measurement). The total loss of the coating is also visualized and corresponds to the time of occurrence of corrosion over the entire surface of each sample (see Photos 2 to 8, Appendix 1).

No	Sample	1 st cycle	2 nd cycle	3 rd cycle	4 th cycle	5 th cycle	6 th cycle	7 th cycle
1	Phos - Leland		X					
2	Undip AP - Leland		X					
4	Undip AP (A) - Leland		X					
5	Geomet 321 (ASTM F1136)	X						
6	Geomet T321 Plus	X						
7	Dacromet (ASTM F1136)		X					

No	Sample	1 st cycle	2 nd cycle	3 rd cycle	4 th cycle	5 th cycle	6 th cycle	7 th cycle
8	Dacromet Plus		X					
9	Part 77717 Stainless Steel ASTM F593							
10	Magni Coated Bolts - 2 X B18 RE	X						
11	Magni Coated Bolts - BO6J + P126L	X						
12	Magni Coated Bolts - BO6J + B18	X						
13	Hot Dipped Galvanized							O

Table no 2: Loss of coating (marked X)

Note: Total loss of coating (marked X), rust
Partially removed coating (marked O)

3.3 CONCLUSIONS for ABRASION TESTS

The results of the abrasion test presented in Table 2 were obtained by the thickness measurements. Analysis of percentage decrease in coating thickness was not used, because most samples lost their coating after cycle # 1, based upon thickness gauge readings, except sample 9 (316 stainless steel) and sample 13 (hot dip galvanized).

We concluded that the least abrasion resistant are:

- samples **5,6,10,11,12** which lost their coating and rusted after the first cycle
- samples **1,2,4,7,8** which showed some loss of coating after the first cycle and total loss after the 2nd cycle when rust was apparent.

The most abrasion-resistant was sample 13, the Hot Dip Galvanized bolt. At the end of the 7th cycle, the coating was still 85 µm thick

The method for the abrasion test is according to our internal standard LC21-102 and is a comparative method. It augments but does not replace experience and testing that is done in the field.

4. SALT SPRAY TEST

4.1 METHODOLOGY & RESULTS

Twelve additional samples were subjected to salt spray testing in accordance with ASTM B117 - Standard Practice for Operating Salt Spray (fog) Apparatus. The samples are installed on a support so that there is no contact between them.

Periodic observations on the condition of the coating are carried out every 250 hours or so, for a total of 4180 hours. The plates were removed at these intervals, rinsed and cleaned with a nylon brush. Here are the results:

No sample	Sample	300 h	520h	830 h	1000 h	1240 h	1800 h	2050 h	2840 h	3150 h	3375 h	3840 h	4180 h
1	Phos - Leland									RS	RS	RS	RS
2	Undip AP										RS	RS	RS
4	Undip AP (A)									RS	RS	RS	RS
5	Geomet 321 (ASTM F1136)				RS	RS	RS	RS	DC	DC	DC	DC	X
6	Geomet T321 Plus		RS	RS	DC	DC	DC	DC	X	X	X	X	X
7	Dacromet (ASTM F1136)						RS	RS	RS	RS	DC	DC	DC/
8	Dacromet Plus						RS	RS	RS	RS	RS	DC	DC
9	Part 77717 Stainless Steel ASTM F593												
10	Magni Coated Bolts - 2 X B18 RE				RS	RS	RS	RS	DC	DC	DC	DC	X
11	Magni Coated Bolts - BO6J + P126L		RS	RS	DC	DC	DC	DC	X	X	X	X	X
12	Magni Coated Bolts - BO6J + B18		RS	RS	DC	DC	DC	DC	X	X	X	X	X
13	Hot Dipped Galvanized	RS	RS	DC	DC	DC	DC	X	X	X	X	X	X

Table no 3: Evolution of corrosion

Note: Surface coating under attack (marked RS)
Start of corrosion (marked DC)
Total loss of coating (marked X), rust

4.2 CONCLUSIONS for THE SALT SPRAY TEST

The salt spray tests showed that the least resistant coatings in the salt spray test are the following parts:

Number 13 (HDG) which gradually corroded between 830 and 4,180 hours. At 2,050 hours, it was entirely corroded. It is closely followed by **number 6 (Geomet T 321)**, **number 11 (Magni Coated Bolts - BO6J+P126L)** and **number 12 (Magni Coated Bolts - BO6J + B18)**. These bolts were corroded progressively between 1,000 and 2,840 hours. After 4,200 hours, these bolts show 90% corrosion of the total coating.

An average resistance to corrosion is attributed to:

Sample **number 7 (Dacromet -ASTM F1136)**, which started corroding at 3,375 hours in salt spray. At 4,180 hours, the bolt was corroded at 20% of its surface.

Samples **number 5 (Geomet 321 - ASTM F1136)** and **number 10 (Magni Coated Bolts - 2 X B18 RE)** corroded between 2,840-3,840 hours. At 4,180 hours in salt spray, these samples were corroded at 40% of their surface.

Good corrosion resistance is attributed to sample **number 8 (Dacromet Plus)** where the coating is etched at 3,840 hours and the bolt begins with isolated corrosion points ($\text{diam} \leq 05 \text{ mm}$) at the end of the test (4,200 hours).

The **best resistance** to corrosion is attributed to samples **number 1 (Phos – Leland)**, **number 2 (Undip AP – Leland)** and **number 4 (Undip (A) – Leland)**. The coating demonstrated superior resistance to corrosion and the bolts show zero corrosion at the end of the test (4,180 hours).

The visual appearance of sample **number 9, the stainless steel** bolt without covering remained very good and the surface remained shiny.

5. OVERALL CONCLUSIONS

The abrasion and salt spray performance of the customer supplied bolt and nut coatings are summarized in Table 4.

Number	Bolt Sample	Base Coating Bond Coat	Finishing Top coat	Abrasion Resistance	Corrosion Resistance
1	Phos	Zintek 300B	Techdip Black	Low	Very Good
2	Undip AP	Zintek 300B	Techdip Black HC	Low	Very Good
4	Undip AP (A)	Zintek 300HP	Techdip Black HC	Low	Very Good
5	Geomet 321 (ASTM F1136)	G321	G321	Very Weak	Average
6	Geomet T321 Plus	G321 Plus	G321 Plus	Very Weak	Low
7	Dacromet (ASTM F1136)	D320	Dacrolub	Low	Average
8	Dacromet Plus	D320 Plus	Dacrolub	Low	Good
9	Part 77717 Stainless Steel ASTM F593	Alloy 316	Alloy 316		
10	Magni Coated Bolts - 2 X B18 RE	B18 RE	B18 RE	Very Weak	Average
11	Magni Coated Bolts - BO6J + P126L	P126L	BO6J	Very Weak	Low
12	Magni Coated Bolts - BO6J + B18	B18	BO6J	Very Weak	Low
13	Hot Dipped Galvanized	Zinc	galv	Very Good	Low

Table no 4: Summary of the Overall Test Results

Prepared by: **Liana Stepan Stancioi, ing**
Cc: **Donald Villeneuve, ing**
Date: December 9, 2016

APPENDIX 1: PHOTOS of ABRASION RESULTS



Photo no1: Arrangement of samples for the abrasion test



Photo no2: After the 1st Cycle

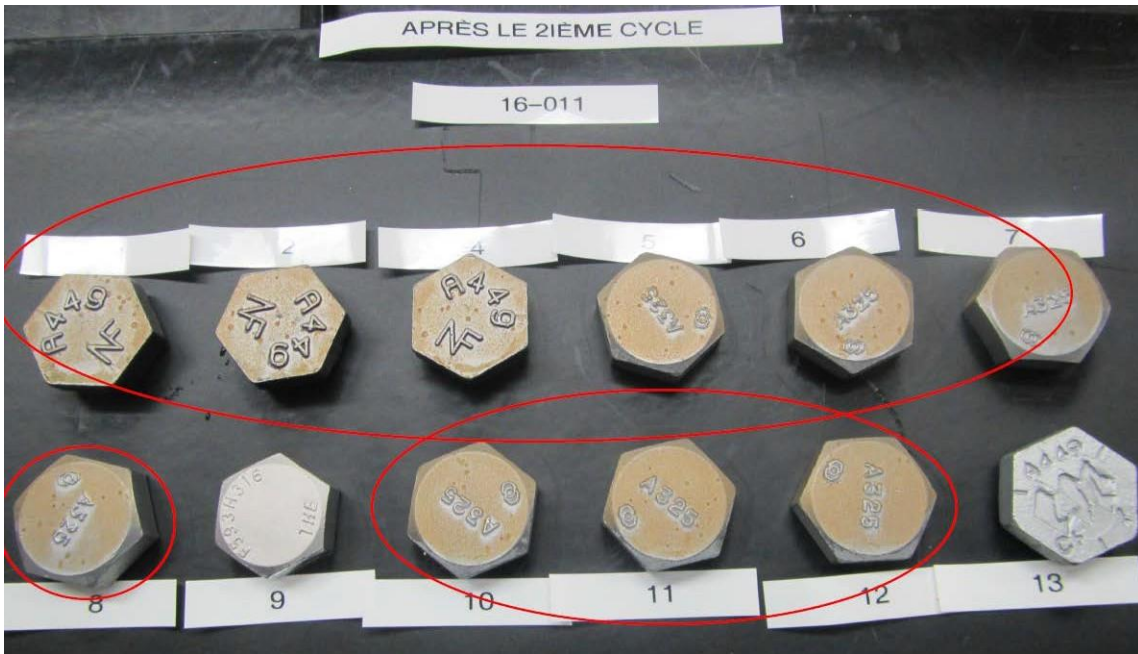


Photo no3: After the 2nd Cycle

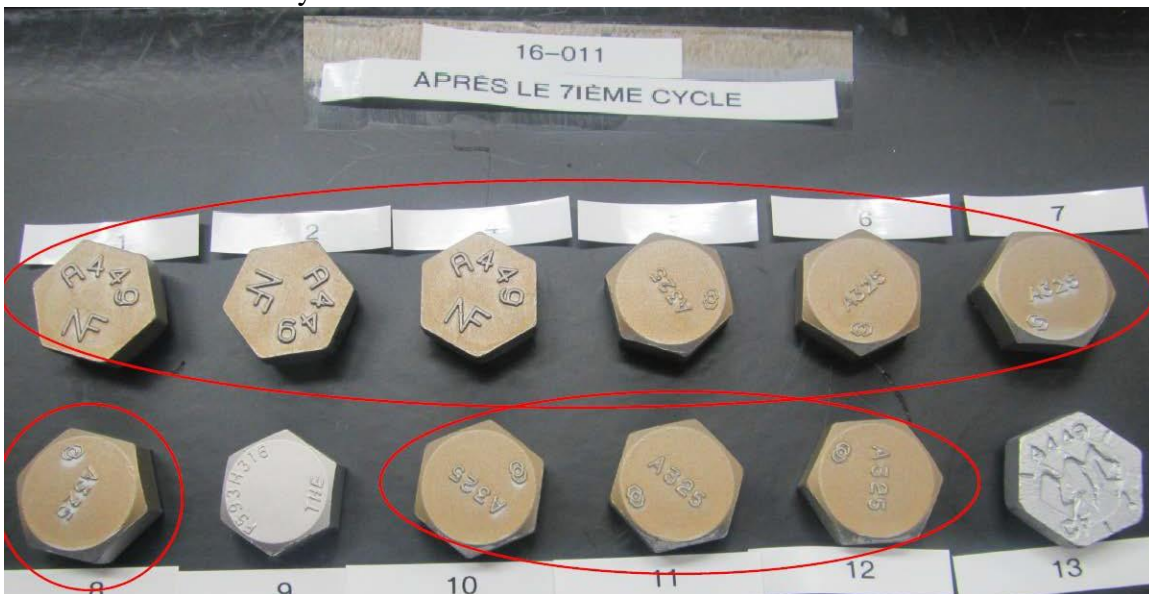


Photo no4: After the 7th Cycle

APPENDIX 2: PHOTOS of SALT SPRAY TESTS



Photo no1: After 300 hours of Salt Spray Test



Photo no 2: After 4,180 hours of Salt Spray Test

APPENDIX 3: LCL21-102 GRANULATE POLISHING RESISTANCE: METHOD BY PROJECTION

Separate document.

APPENDIX 4: LCL21-102 AGGREGATES RESISTANCE TO POLISHING: SHOT-BLASTING METHOD

Separate document.