Assessment of Accelerated Tests Compared to Beachfront Test and Proposed Evaluation Method

September 3, 2009
ASETS Defense Workshop

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
03 SEP 2009		**00-00-2009 to 00-00-2009**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Assessment of Accelerated Tests Compared to Beachfront Test and Proposed Evaluation Method	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Air Warfare Center,Materials Engineering Division,22347 Cedar Point Road,Patuxent River,MD,20670**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
ASETSDefense 2009: Sustainable Surface Engineering for Aerospace and Defense Workshop, August 31 - September 3, 2009, Westminster, CO. Sponsored by SERDP/ESTCP.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**22**	

Outline

- **Background and Test Parameters**
- **Results of Comparison of Accelerated and Beachfront Tests**
- **New NC Systems Testing: Panels and Galvanic Assemblies**
- **Conclusions and Plans**

Background

- **Environmental Security Technology Certification Program (ESTCP) funded project entitled "Non-Chromate Aluminum Pretreatments" (NCAP)**
  - Funding began in 2000, ended 2004 for Phase I assessment
  - Panels prepared 2000/2001
  - Accelerated tests completed in 2001
  - Beachfront test began in November 2001 and is continuing
- **Original Intent: compare the performance of 8 candidate non-chromate aluminum conversion coatings compared to chromated control using a variety of DoD aluminum substrates, paint systems, and standard tests**
  - Joint Test Protocol: defines all tests and materials
  - Phase I and Interim Reports document all test data as of 2004
  - Beachfront data continues to be collected for surviving coatings
- **Current Intent: Compare performance of all coatings in accelerated corrosion tests to beachfront test**

NCAP Data Assessment

Data set includes:

- 4 aluminum alloys: 2024, 7075, 2219, 5083
- 9 conversion coatings/pretreatments (including one chromate control)
- 5 paint systems
  - MIL-PRF-23377 Class C primer w/MIL-PRF-85285 topcoat (chromate, high-solids)
  - MIL-PRF-85582 Class C primer w/MIL-PRF-85285 topcoat (chromate, water)
  - MIL-PRF-85582 Class N primer w/MIL-PRF-85285 topcoat (non-chromate, water)
  - MIL-C-53022 primer w/MIL-C-53039 topcoat (non-chromate, high-solids)
  - MIL-C-53030 primer w/MIL-C-53039 topcoat (non-chromate, water)
- 4 corrosion tests (with 5 replicates per coating system)
  - ASTM B 117 for 3000 hours (completed by ARL)
  - GM9540P for 120 cycles (completed by ARL)
  - ASTM G85 Annex 4 (SO2) for 500 hours (completed by NAVAIR-PR)
  - Beach front at Kennedy Space Center for 5 years (completed by NASA)

Analysis of Data

- **Excel software used to analyze and plot data**
- **Initial focus on comparing end points of tests**
- **A variety of combinations of variables was studied**
  - All alloys and coatings
  - All alloys for each primer
  - 7075 and 2024 for all coatings
  - 2024 for all coatings
  - Beach vs ASTM B117, ASTM G85 Annex 4 (SO2), GM9540P, B117/SO2, B117/9540P,


2-183
85582c1/85285


2-188
85582nc/85285


2-283
85582c1/85285


2-288
85582nc/85285

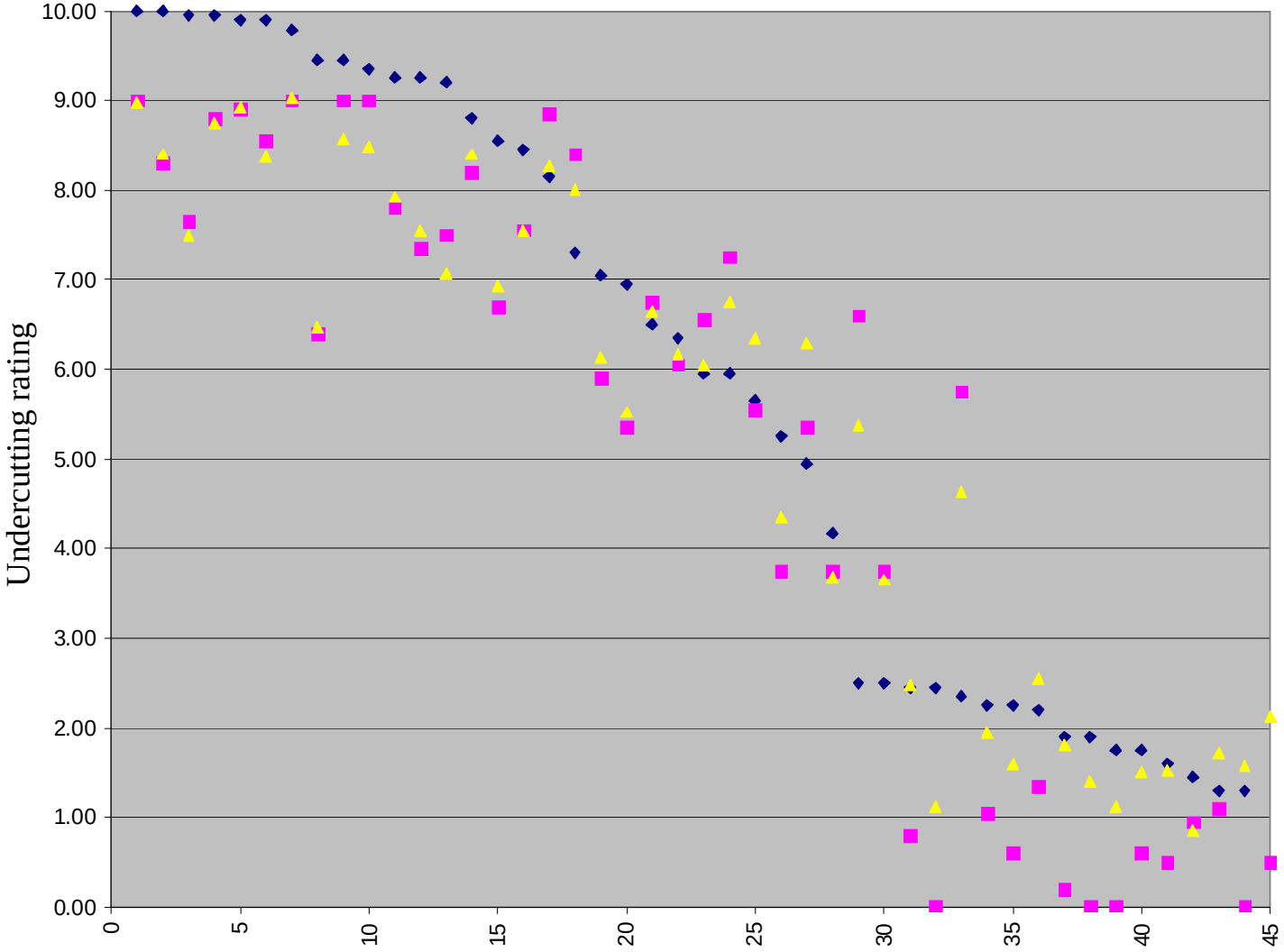

2-483
85582c1/85285


2-488
85582nc/85285


2-883A
85582c1/85285

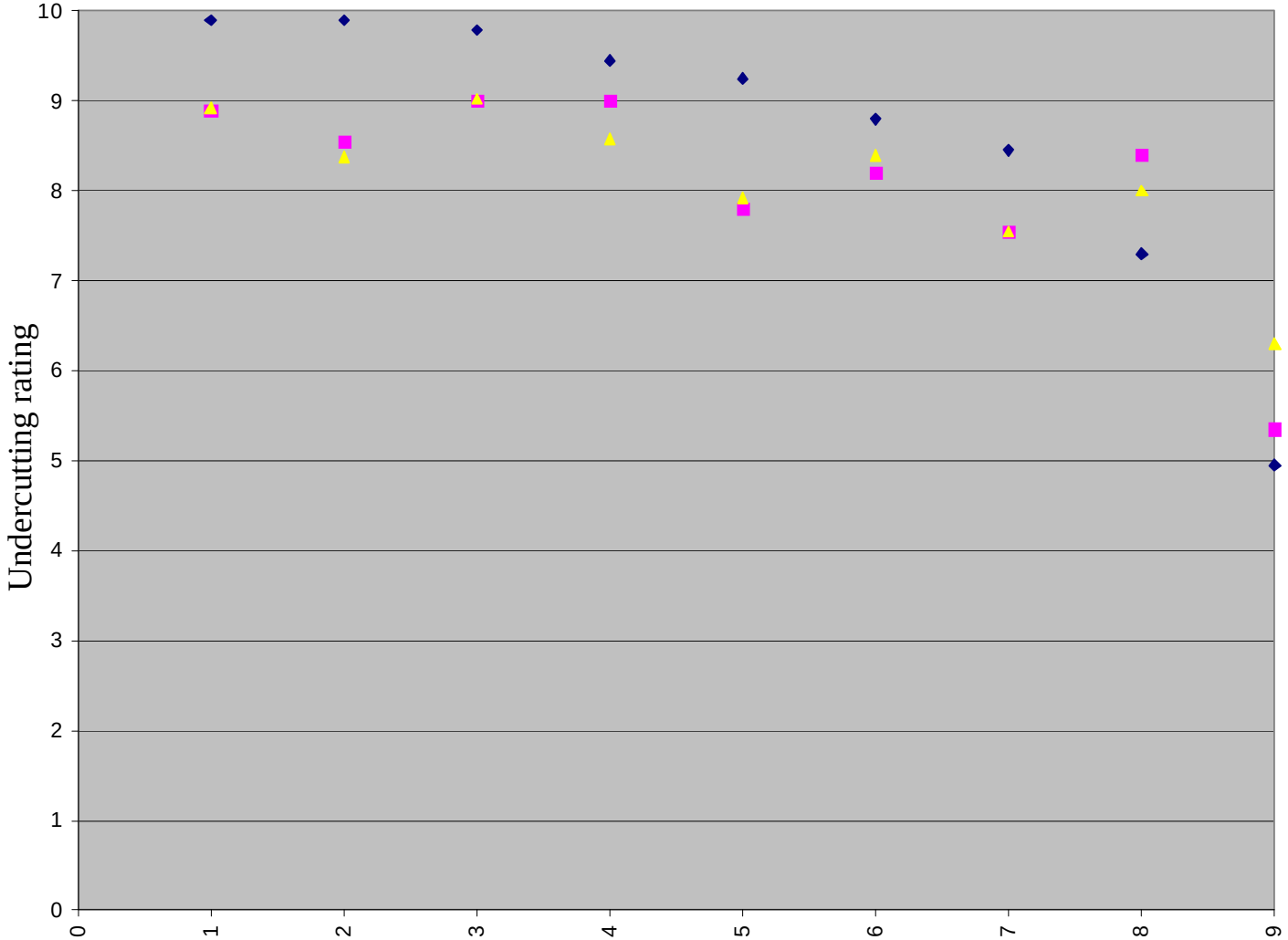

2-888
85582nc/85285

All Alloys and Coatings



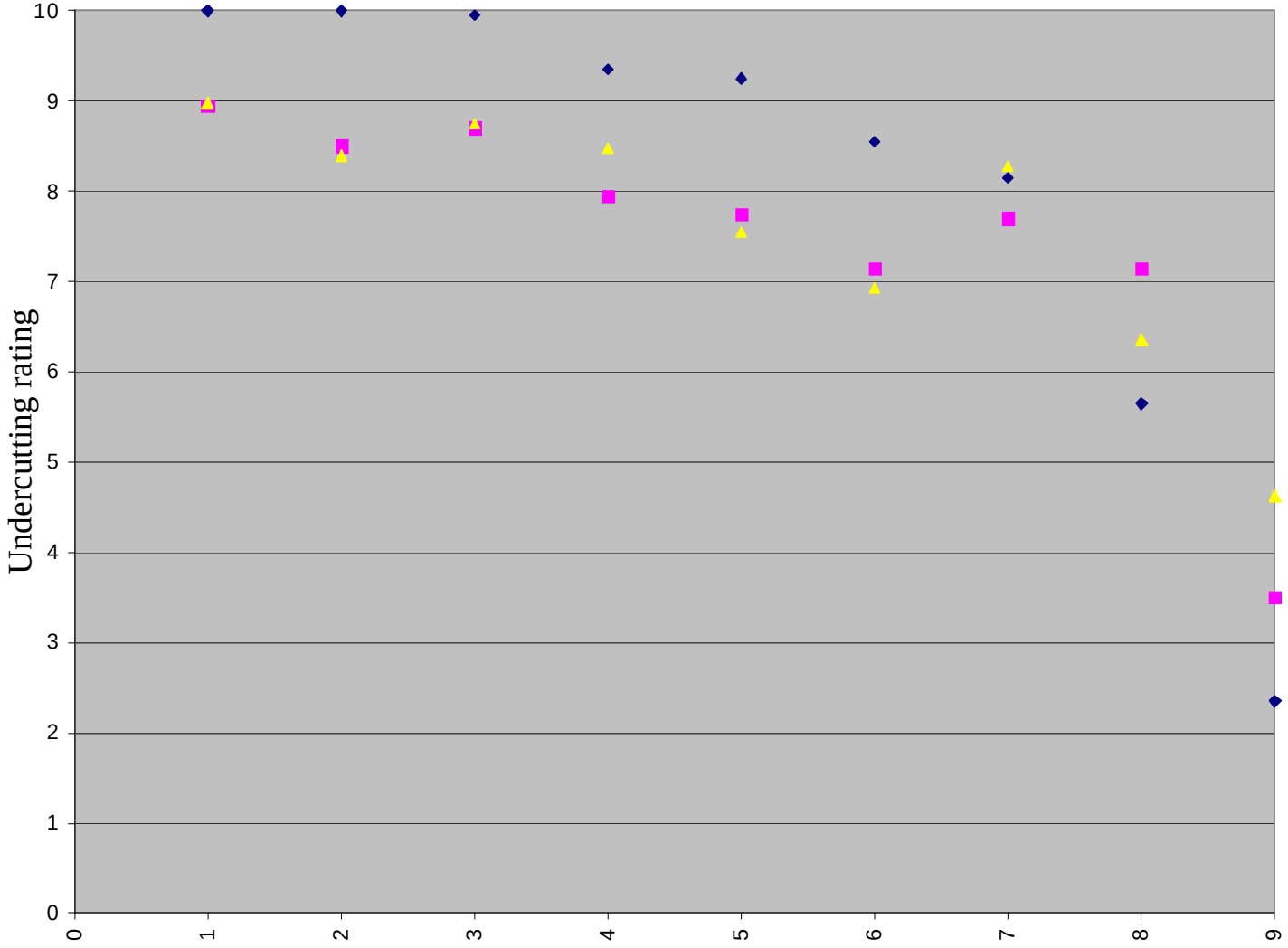
Tests	Correlation
Beach vs B117	0.915
Beach vs 9540P	0.94
Beach vs SO2	0.825
Beach vs B117/SO2	0.908
Beach vs B117/9540P	0.943

All Alloys with MIL-PRF-23377 C2



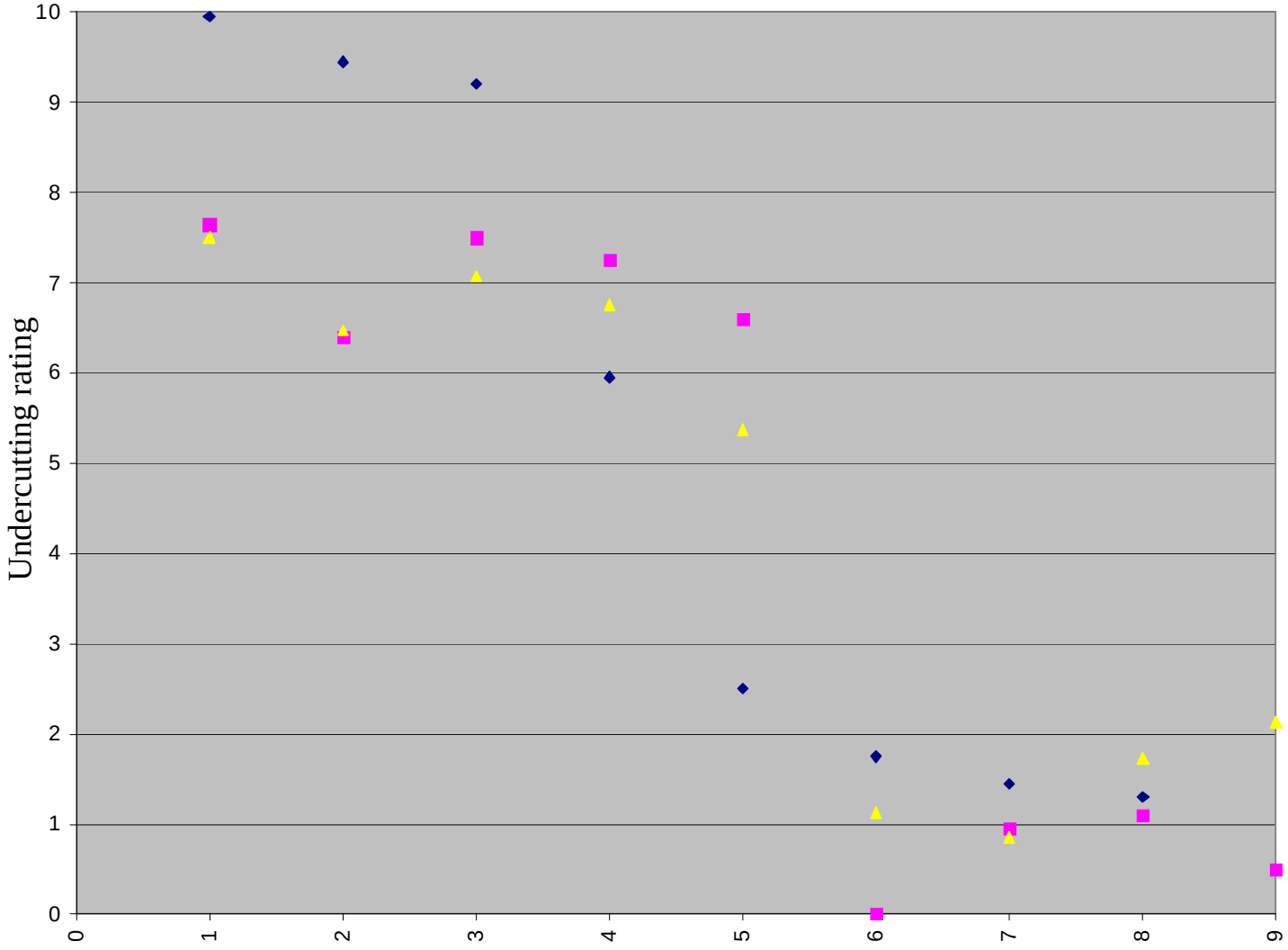
Tests	Correlation
Beach vs B117	0.876
Beach vs 9540P	0.775
Beach vs SO2	0.621
Beach vs B117/SO2	0.864
Beach vs B117/9540P	0.898

All Alloys with MIL-PRF-85582 C1



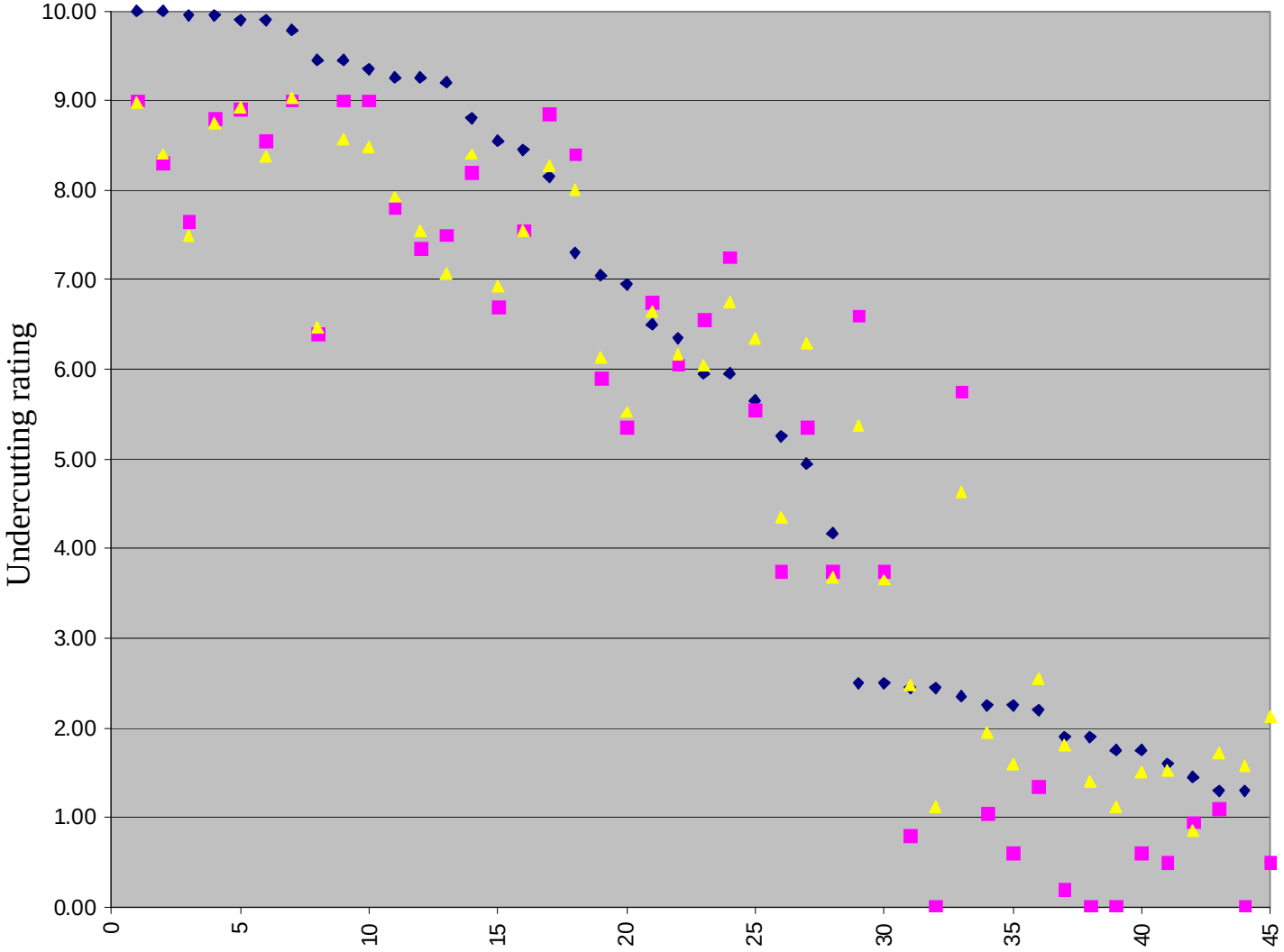
Tests	Correlation
Beach vs B117	0.794
Beach vs 9540P	0.942
Beach vs SO2	0.859
Beach vs B117/SO2	0.887
Beach vs B117/9540P	0.938

All Alloys with MIL-PRF-85582 N



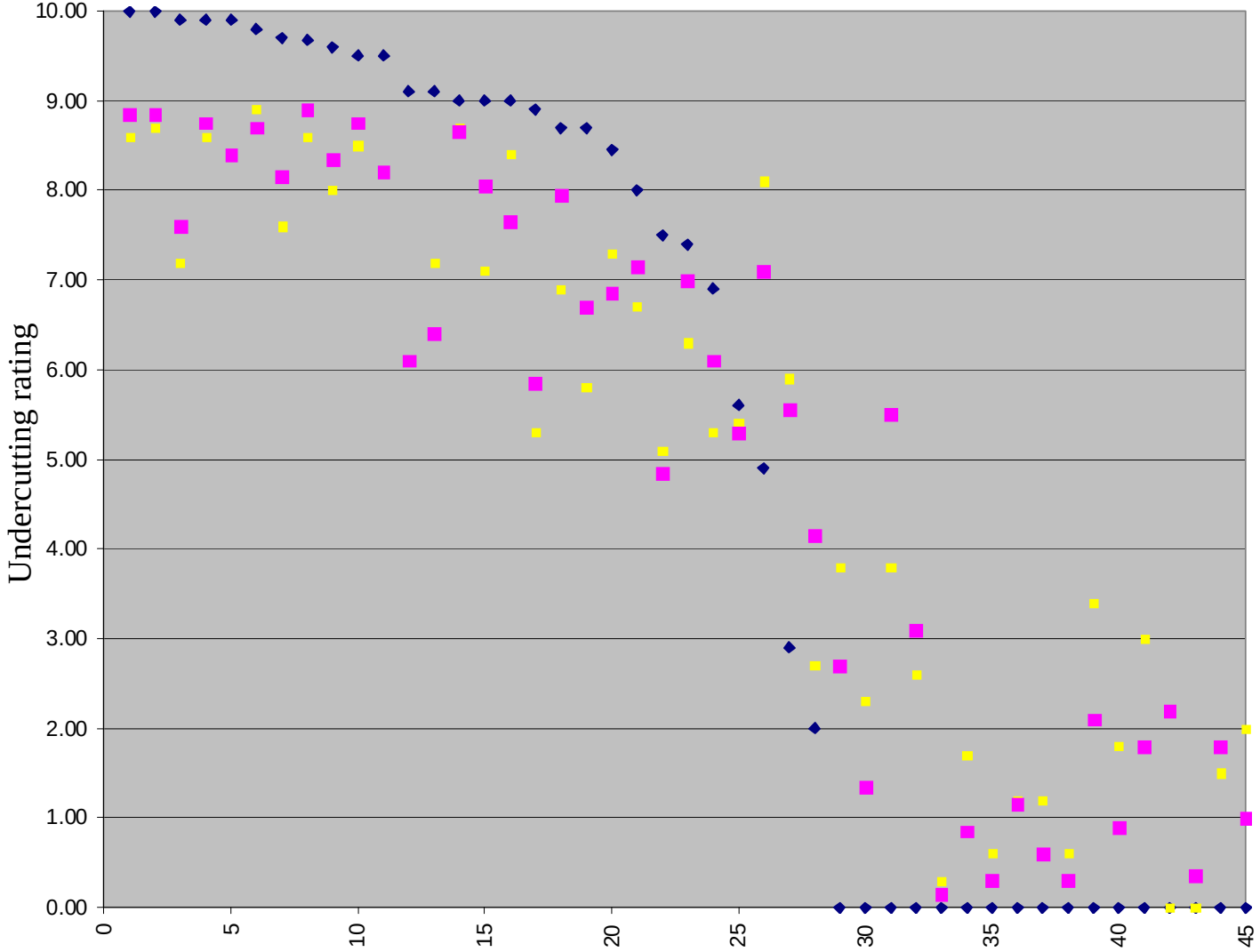
Tests	Correlation
Beach vs B117	0.838
Beach vs 9540P	0.893
Beach vs SO2	0.837
Beach vs B117/SO2	0.854
Beach vs B117/9540P	0.886

All Alloys and Coatings



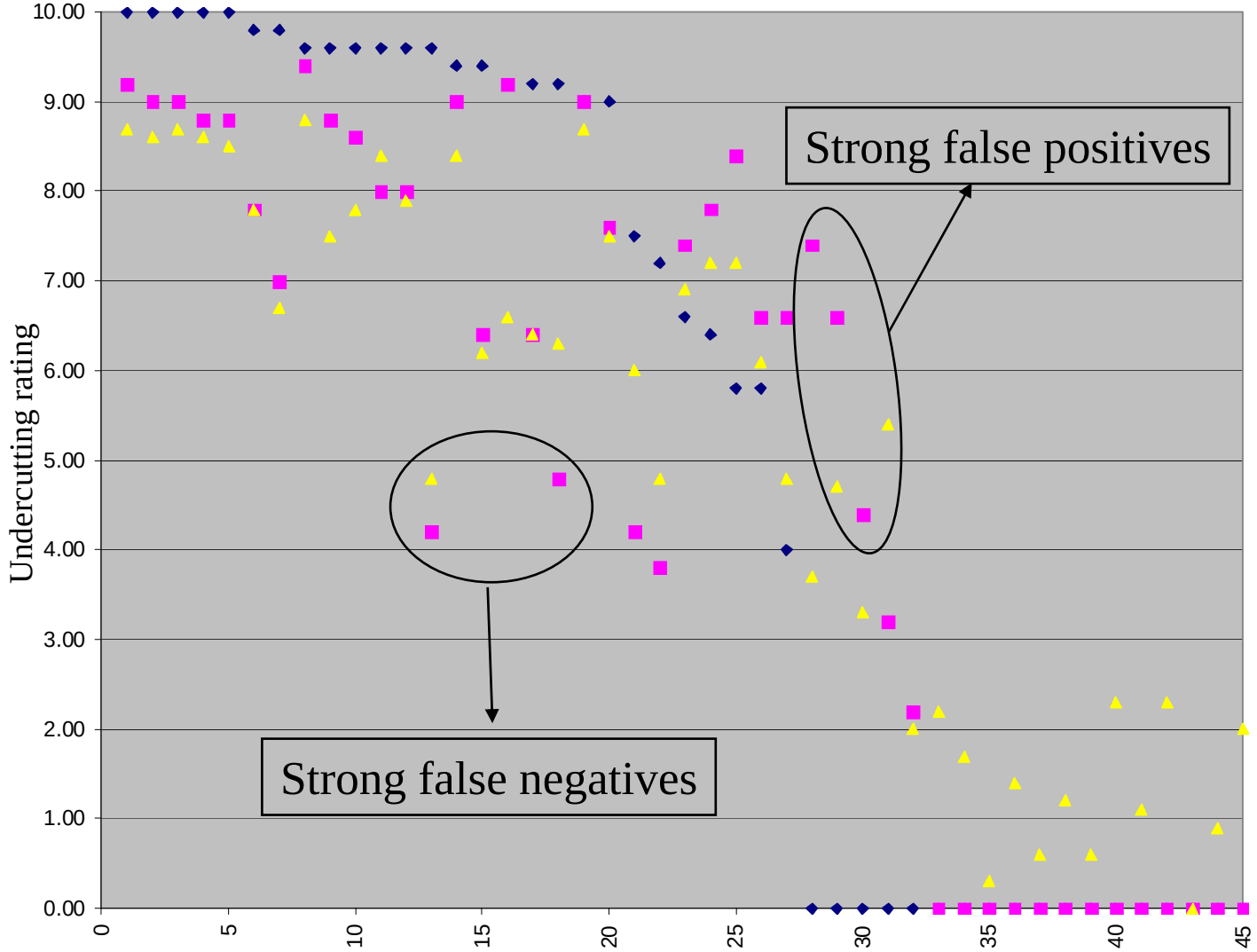
Tests	Correlation
Beach vs B117	0.915
Beach vs 9540P	0.94
Beach vs SO2	0.825
Beach vs B117/SO2	0.908
Beach vs B117/9540P	0.943

2024 and 7075 with All Coatings

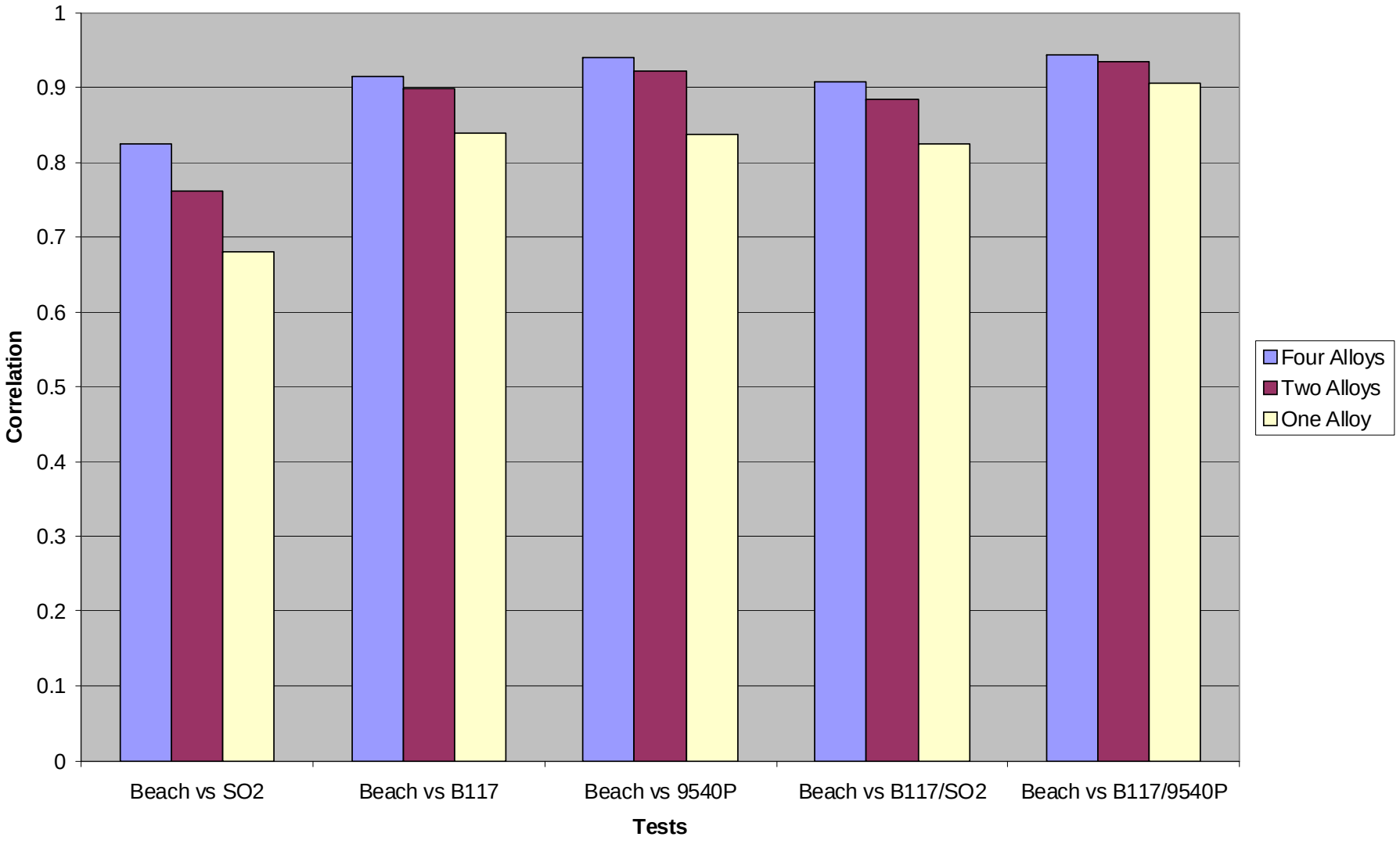


Tests	Correlation
Beach vs B117	0.898
Beach vs 9540P	0.922
Beach vs SO2	0.762
Beach vs B117/SO2	0.885
Beach vs B117/9540P	0.934

2024 with All Coatings



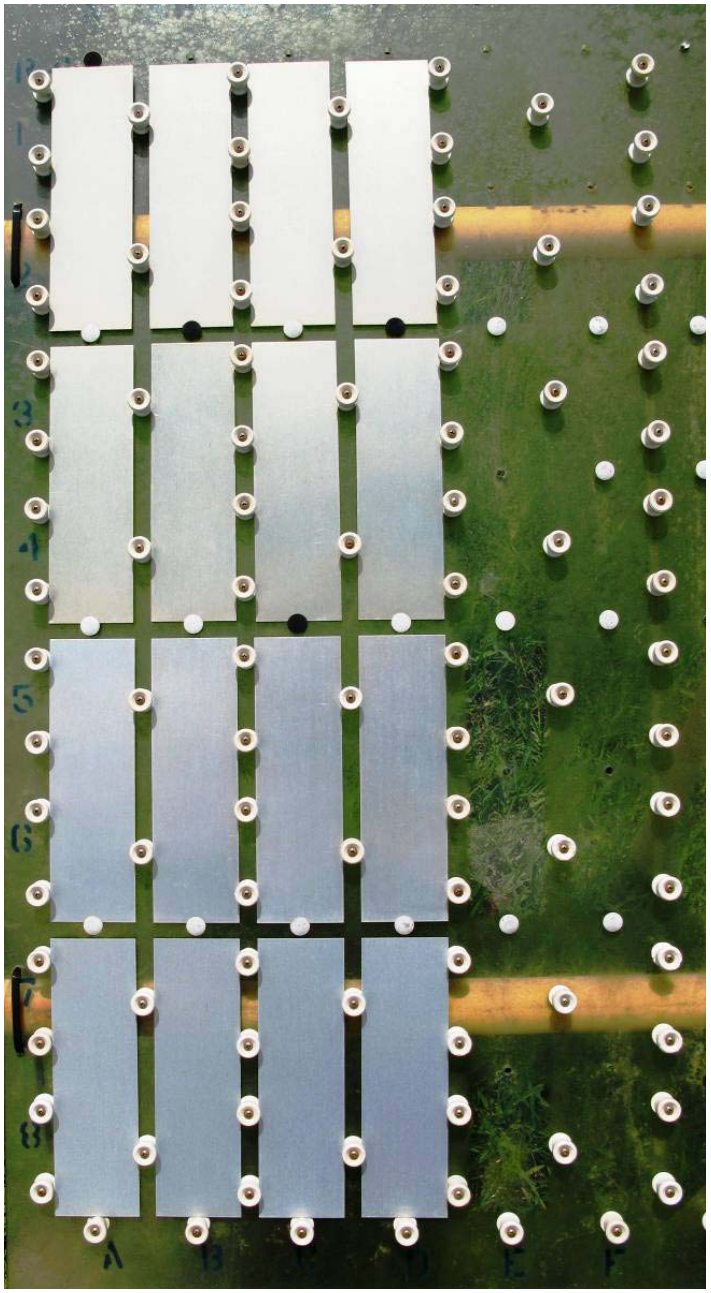
Tests	Correlation
Beach vs B117	0.839
Beach vs 9540P	0.837
Beach vs SO2	0.68
Beach vs B117/SO2	0.824
Beach vs B117/9540P	0.906


Effect of Number of Alloys on Data Correlation
Correlation
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Beach vs SO2
Beach vs B117
Beach vs 9540P
Beach vs B117/SO2
Beach vs B117/9540P
Tests
Four Alloys
Two Alloys
One Alloy

Beachfront Exposure of Unpainted Conversion Coatings

- 2024-T3 and 7075-T6
- 5 each alloy and coating
- Alodine 1600 (chromate control)
- TCP-IC (developmental)
- Started 11/07

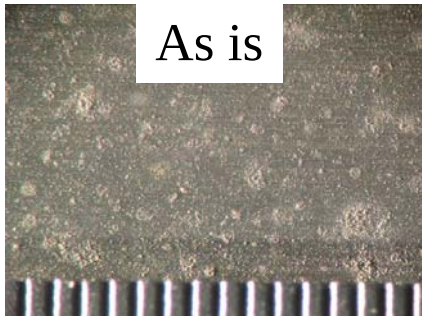
18 Months Exposure at KSC

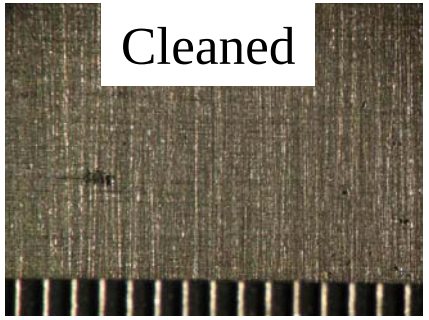


20X view of surface

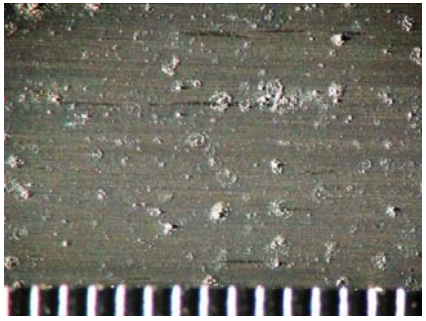
As is

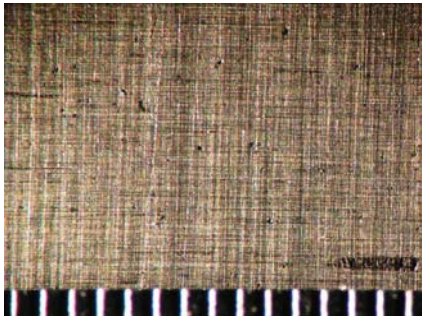
Cleaned



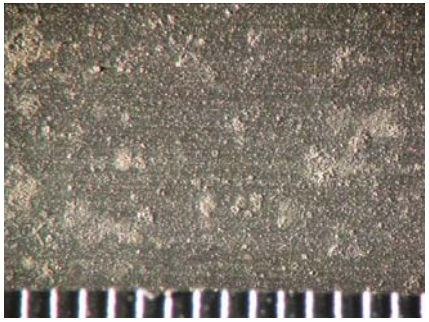


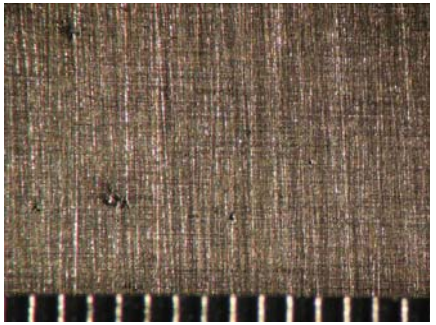
2024-T3
Alodine 1600



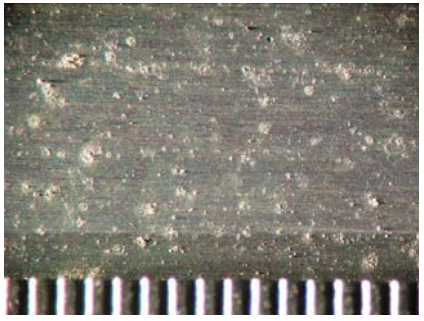


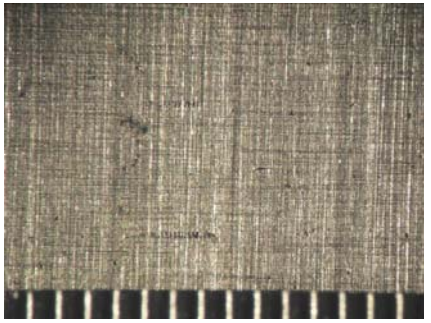
2024-T3
TCP-IC





7075-T6
Alodine 1600



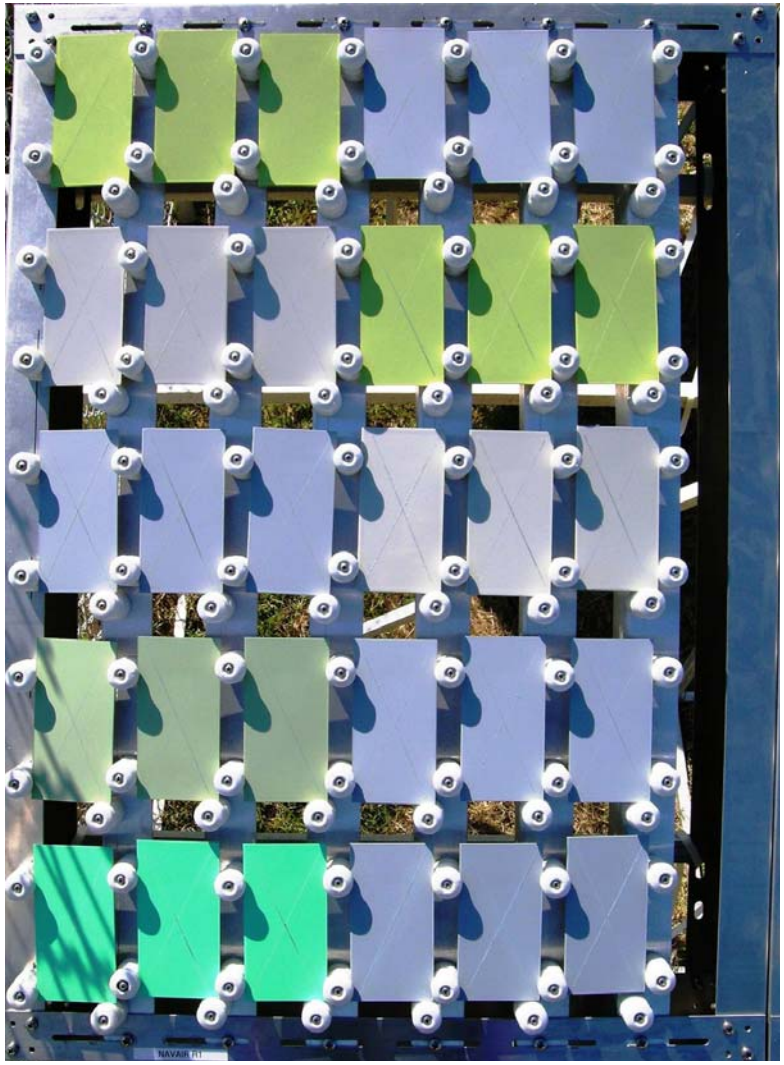


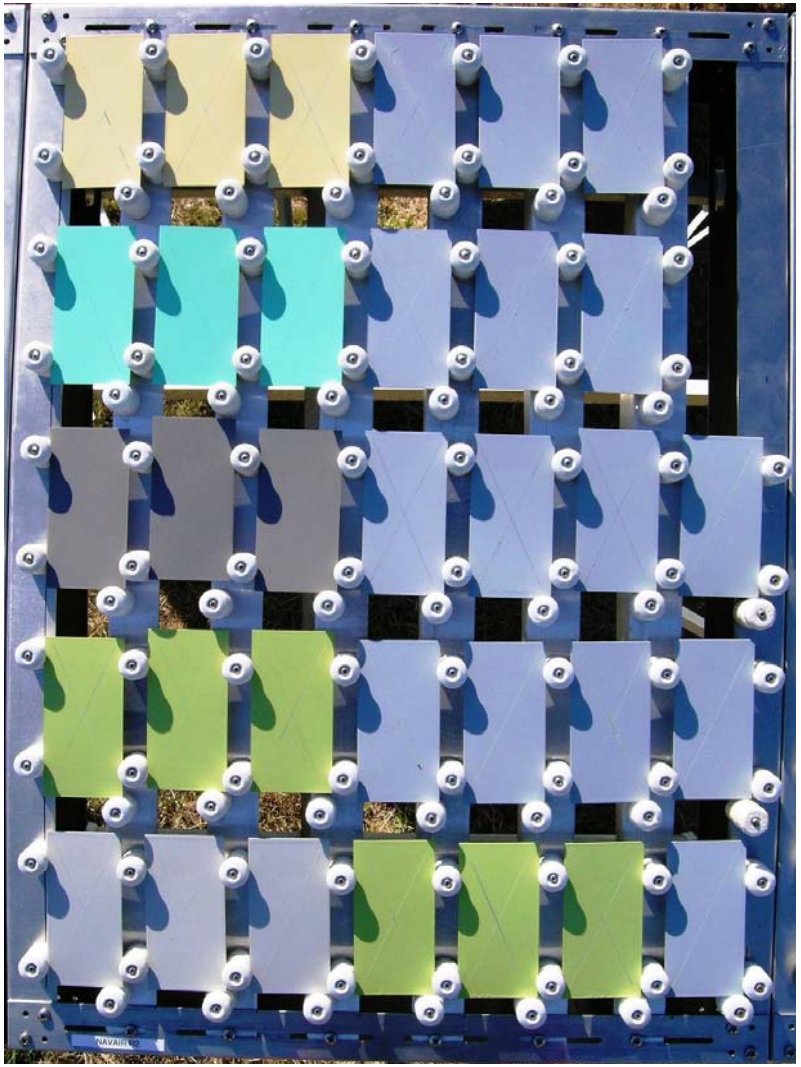
7075-T6
TCP-IC

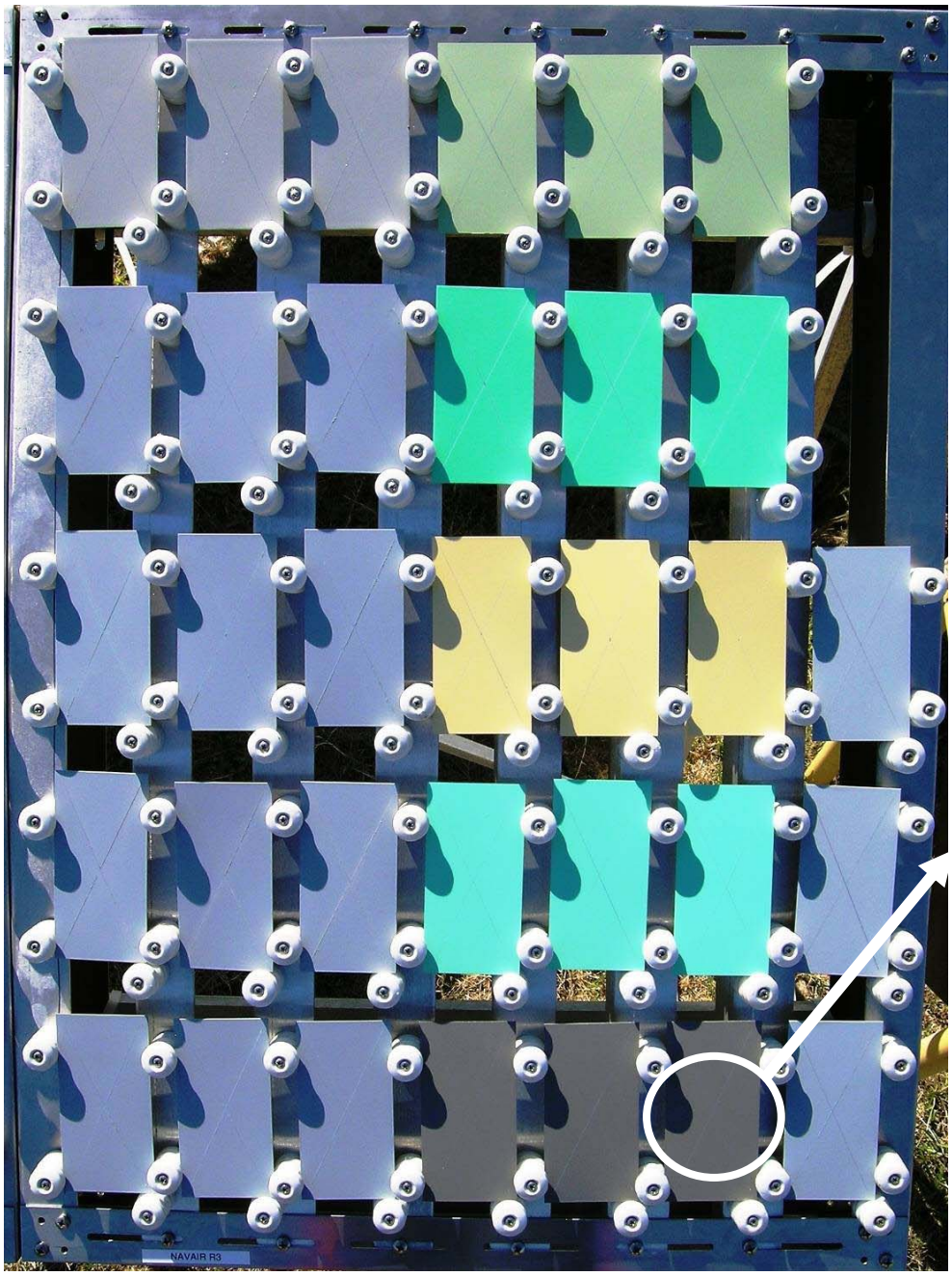
Unpainted Corrosion Results for ASTM B117 and ASTM G85 A4

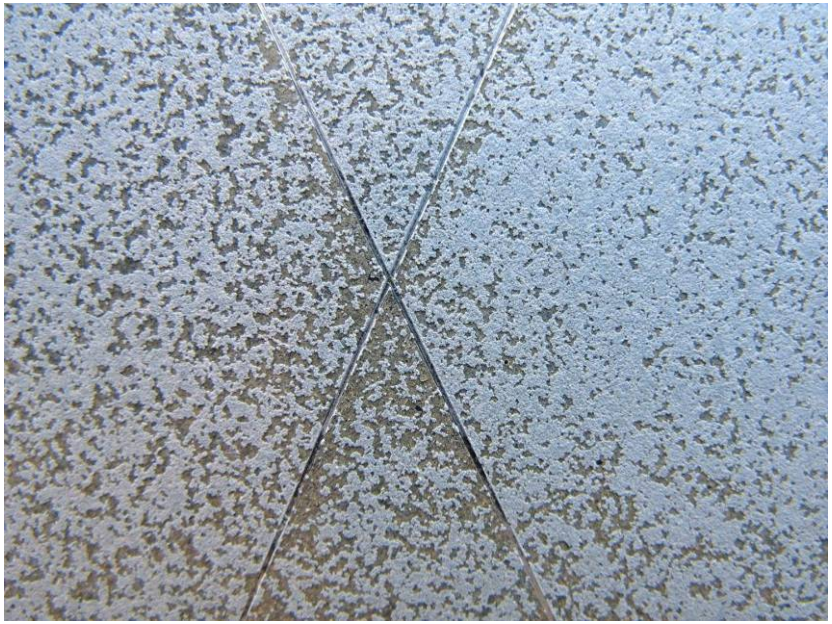
B117 Number	Rating 168 hr	696 hr	1344 hr	2500 hr	G85 Number	Rating 24 hr	168 hr	504 hr		
7-3-412	10	10	8	4	7-3-417	6	5	5	Alodine 1600	2024
7-3-413	10	10	7	4	7-3-418	6	5	5		
7-3-414	10	8	9	4	7-3-419	6	5	4		
7-3-415	10	9	7	5	7-3-420	6	5	5		
7-3-416	10	8	4	5	7-3-421	6	5	5		
7-3-427	10	10	10	8	7-3-432	7	5	5	TCP-IC	
7-3-428	10	10	10	8	7-3-433	7	5	5		
7-3-429	10	10	10	8	7-3-434	7	5	5		
7-3-430	10	9	9	8	7-3-435	7	4	4		
7-3-431	10	10	10	8	7-3-436	7	4	4		
7-3-442	9	7	6	5	7-3-447	10	8	7	Alodine 1600	7075
7-3-443	9	7	6	5	7-3-448	10	8	7		
7-3-444	9	7	6	5	7-3-449	10	8	7		
7-3-445	9	7	6	5	7-3-450	10	8	7		
7-3-446	9	7	7	6	7-3-451	10	8	7		
7-3-457	10	8	8	7	7-3-462	7	6	5	TCP-IC	
7-3-458	10	9	8	7	7-3-463	7	6	6		
7-3-459	10	10	8	7	7-3-464	7	6	6		
7-3-460	10	10	8	7	7-3-465	8	6	6		
7-3-461	9	9	8	7	7-3-466	7	6	6		

NC Coating Systems: Corrosion Assessment at KSC - panels as installed 11/07









Surface after 15-month exposure (April 2009)

As installed- April 2008

After 5 months- September 2008

Conclusions and Plans

- **The best correlations to beachfront with lowest risk of false positives and negatives were achieved by using multiple alloys and multiple tests- at least two for each.**
- **Maximum correlations to beachfront achieved using average of B117 and GM9540P data**
  - GM9540P and B117 showed similar correlations to beachfront
  - These tests show large drop in correlation when only one alloy was used
- **SO_2 correlation to beachfront clearly the worst**
  - Future work will attempt to gather on-ship data to investigate correlation with SO_2 and beachfront
- **Performance of Type I and Type II conversion coatings on beach very different than in salt fog- very little or no difference in performance between alloys and coatings at each rating interval up to 15 months**
- **Galvanic assemblies accelerate degradation of all coatings**
  - Method being pursued as rapid (3-6 month) validation of “plain” scribed panel performance which is expected to take 10+ years at KSC to yield failures of best coating systems