Introducing the Corrosion Accelerated Test with Controlled Humidity (CATCH) for aluminum materials in automotive applications

汽车用铝材的控制湿度腐蚀加速试验 (CATCH)

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Content 内容

- Background and participants 背景介绍与参与单位
- Specimens & Evaluations 试样&评估
- Steel Substrate Results 钢基材试验结果
- Second Study—Aluminum Substrates 第二项研究- 铝基材

Background 背景

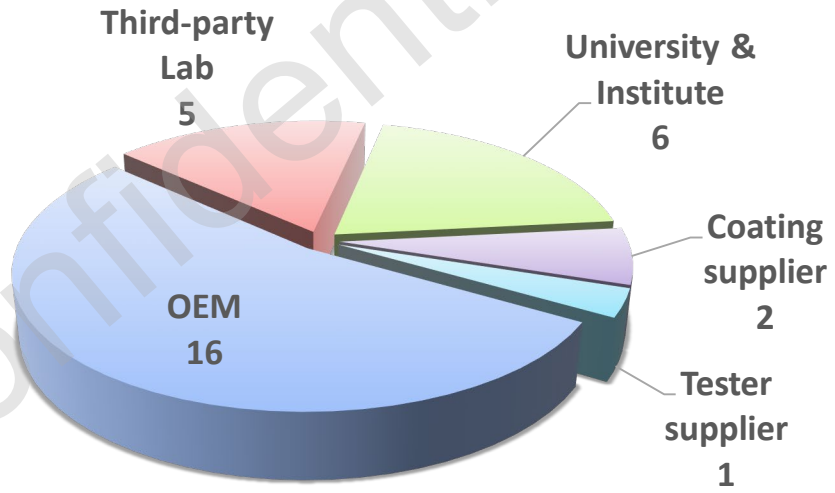
SAE China (CSAE) began a project in 2016 to develop a new corrosion test method for domestic manufacturers

SAE中国于2016年开始研发一种新的腐蚀试验方法

- Reduce redundant testing within domestic market 减少冗余测试
- Observe best practices from global OEM testing 关注全球OEM测试的最佳实践
- Test could be used for validation and QC 试验可用于验证和质量控制
- Method development would start with steel substrates 方法开发从钢基材开始

Participants 参与单位

Q-Lab China (Lead Company)	Chery Auto - Shanghai
FAW	FAW - Tianjin
Changan Auto	Guanzhi Auto
BYD Auto	Institute of Metal Research, CAS
Dongfeng Auto	Hainan Institute
Jianghuai Auto	725 Institute
FAW-VW	59 Institute
Shenlong Auto	SGS - Shanghai
Shanghai Auto	CTI - Shanghai
Nanjing Auto	Intertek - Shanghai
Guangzhou Auto	Emtek - Suzhou
Changan Ford	Shanghai Hanhai
PATAC	AkzoNobel - Shanghai
Wuhu Kaiyi Auto	Kmtehx - Shanghai
Wuhan University of Science & Technology	University of Science & Technology Beijing



Types of Accelerated Tests 加速测试类型

Accelerated Test Type 加速测试类型	Result 结果表示	Test Time 试验时间	Results compared to 试验结果用于比较	Research? 研究? Development? 开发? Certification? 认证?
Quality Control 质量控制	Pass / fail 通过 / 失效	• Defined 确定的 • Short 较短时间	Material specification 材料规范	Certification 认证 & Research 研究
Qualification / validation 鉴定 / 验证	Pass / fail 通过 / 失效	• Defined 确定的 • Medium-long 中长时间	Reference material or specification 参照材料或规范	Certification 认证 & Development 开发
Correlative 相关性	Rank-ordered data 排序数据	• Open-ended 不确定 • Medium 中等时间	Natural exposure (Benchmark site) 自然曝晒（基准曝晒地点）	Development 开发
Predictive 预测	Service life Acceleration factor 使用寿命 加速因子	• Open-ended 不确定 • Long 较长时间	Natural exposure (Service environment) 自然曝晒（使用环境）	Development 开发 & Warranty Contracts 保修合同

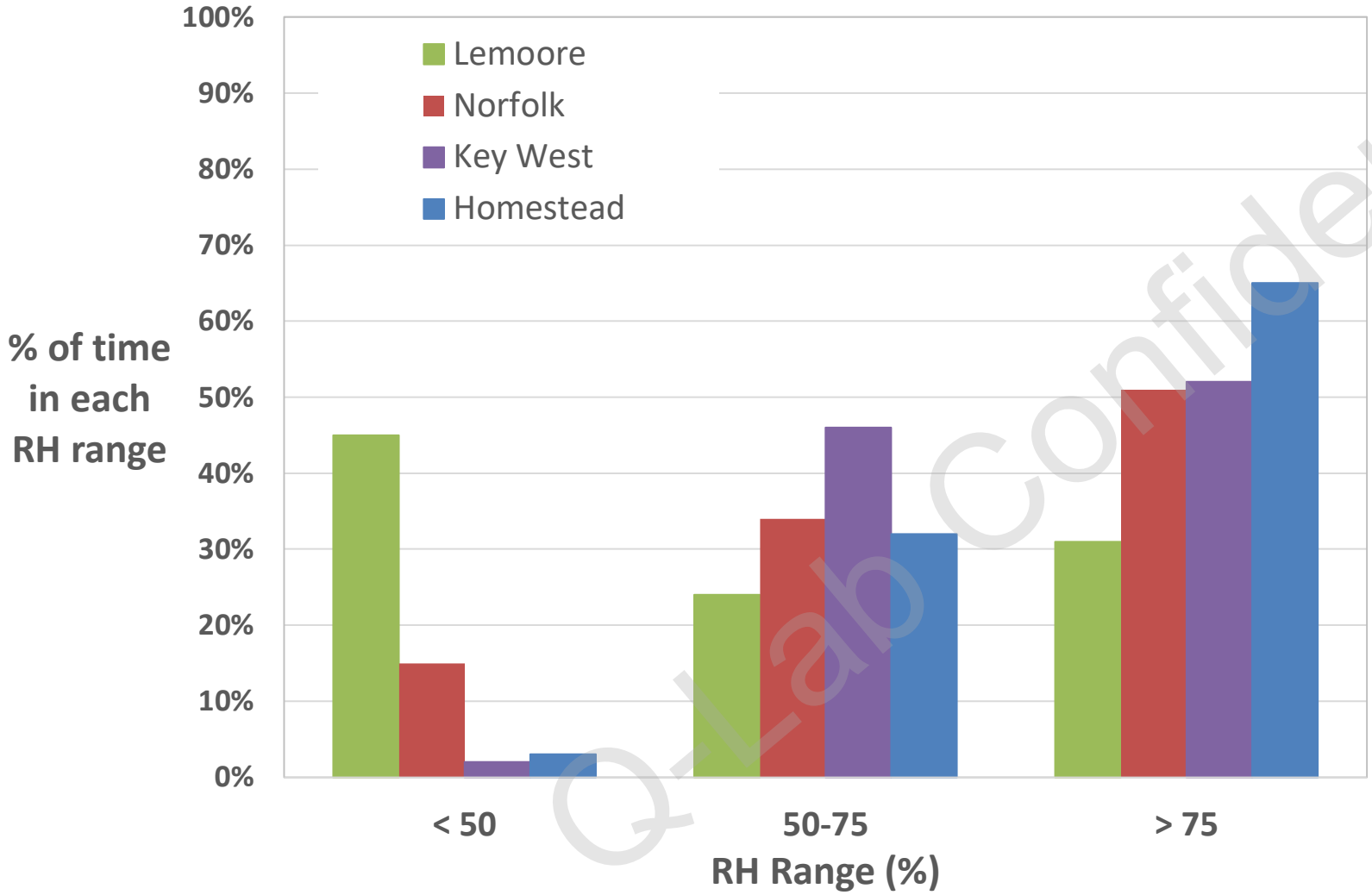
Technical Background 技术背景

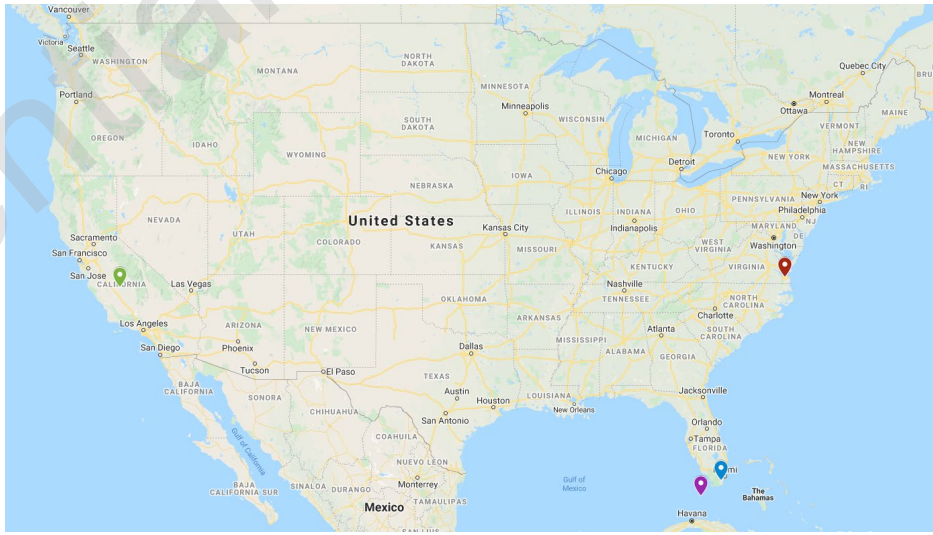
- Relative humidity control is key to laboratory repeatability
- 相对湿度控制是实验室测试重复性的关键
  - It's also a key driver for corrosion
  - 也是引起腐蚀的关键因素
  - Different RH levels can produce different corrosion mechanisms
  - 不同的相对湿度水平会产生不同的腐蚀机制
- During last 10-15 years, automotive methods with precise RH control have become popular
- 在过去的10-15年中，带精确相对湿度控制的汽车试验方法已常见

Relative Humidity and Corrosion 相对湿度与腐蚀

Condition 条件	RH Range 相对湿度范围	Result 结果
Dry 干燥	**≤ 50%**	Very little corrosion from NaCl 几乎不发生腐蚀
Electrolytic cells around salt crystals; film formation as RH increases **盐开始潮解，但未形成连续的薄液层**	**50-76%**	• AL-Steel galvanic couple broken • 未形成铝-铁电偶腐蚀 Both metals in galvanic couples can corrosion in this RH range 在该相对湿度范围内，电偶中的两种金属都可能发生腐蚀
Uniform Electrolytic Film formation **均匀的电解液形成**	**≥76%**	• **Al corrosion** in galvanic couple with steel • 铝-铁电偶腐蚀形成，铝发生腐蚀

RH Conditions in the Natural Environment
自然环境中的相对湿度





Summary of Environmental Conditions of First Generation Cyclic Automotive Standards
第一代循环汽车标准中的环境条件概述

Cycle	Solution	Spray Type	RH < 50%	50%≤RH<76%	RH ≥76%
ISO 11997-1 Cycle A	NaCl 5.0% pH = 7	Fog	48%	3%	49%
VW PV1210	NaCl 5.0% pH = 7	Fog	9%*	7%	85%

Summary of Environmental Conditions in Modern Automotive Corrosion Standards
现代汽车腐蚀标准中的环境条件概述

Cycle	Solution	Spray Type	RH < 55%	55%≤RH<76%	RH≥76%
Ford L-467 Volvo ACT2	NaCl 0.5% pH uncontrolled	Shower	0%	**66%**	34%
GMW 14872	NaCl 0.9% **$CaCl_2$ 0.1%** $NaHCO_3$ 0.075% pH uncontrolled	Shower	47% (22% below RH30%)	**15% (40% of cycle 30%-76% RH)**	38%
Renault D17 2028 (ECC1)	NaCl 1.0% pH =4.0 (H_2SO_4)	Fog	8%	**62%**	30%
VDA 233-102	NaCl 5.0% pH neutral	Fog	23%	**17%**	60%
Volvo ACT 1	NaCl 1.0% pH =4.2 (H_2SO_4)	Shower	33%	**15%**	52%
CATCH	NaCl 1.0% pH =4.0-4.2 (H_2SO_4)	Shower	19%	**33%**	48%

Test Methods & Specimens 试验方法与试样
Steel Substrate Study 钢基材研究

ASTM B117

ISO 11997-1 Cycle A

GMW 14872

Ford L-467

VW PV1210

Outdoor multiple sites (natural)

Outdoor 2 sites (salt spray enhanced)

CATCH

5000 specimens total 样板数量5000片

Substrate 底材

- CRS (various OEM specifications) 冷轧钢
- Galvanized sheets 镀锌板

Pretreatment 前处理

- 6 Types 6种不同前处理

Primer 底漆

- 3 types or omitted 3种底漆或不涂底漆

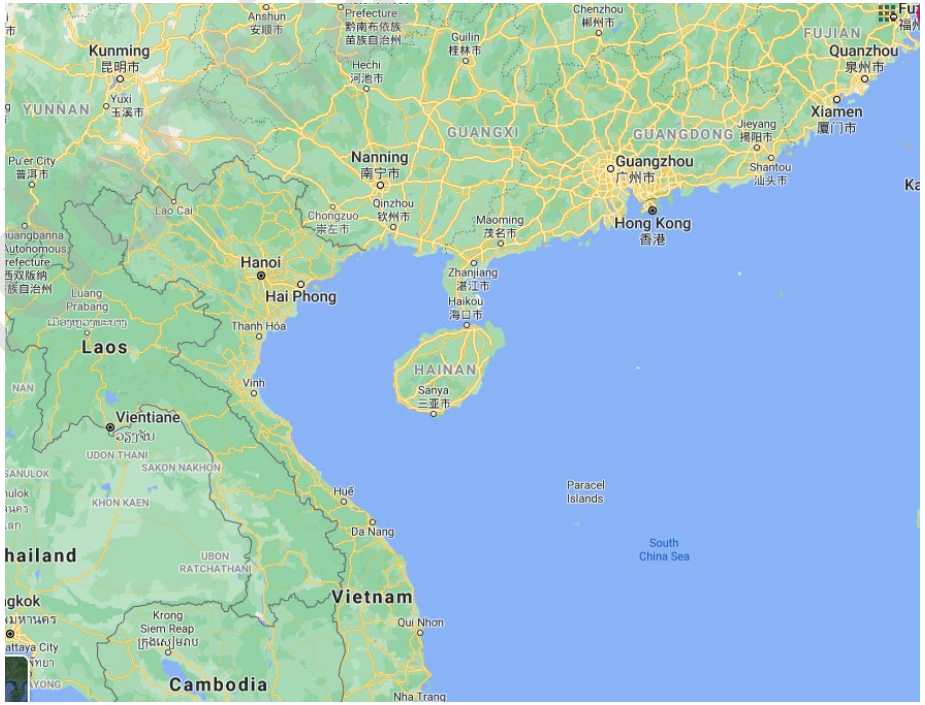
Basecoat/clearcoat (several varieties)
色漆/清漆（几种）

Test Methods Evaluated 试验方法

Test Method 试验方法	ASTM B117	ISO 11997-1 Cycle A	GMW 14872	Ford L-467	PV 1210	CATCH
Total test duration 总试验时间	2016h 84 Days	2016h 84 Days	72 cycles 72 Days	72 cycles 72 days (no weekends)	60 cycles 84 Days (include weekends)	72 cycles 72 days

Outdoor Tests 户外试验

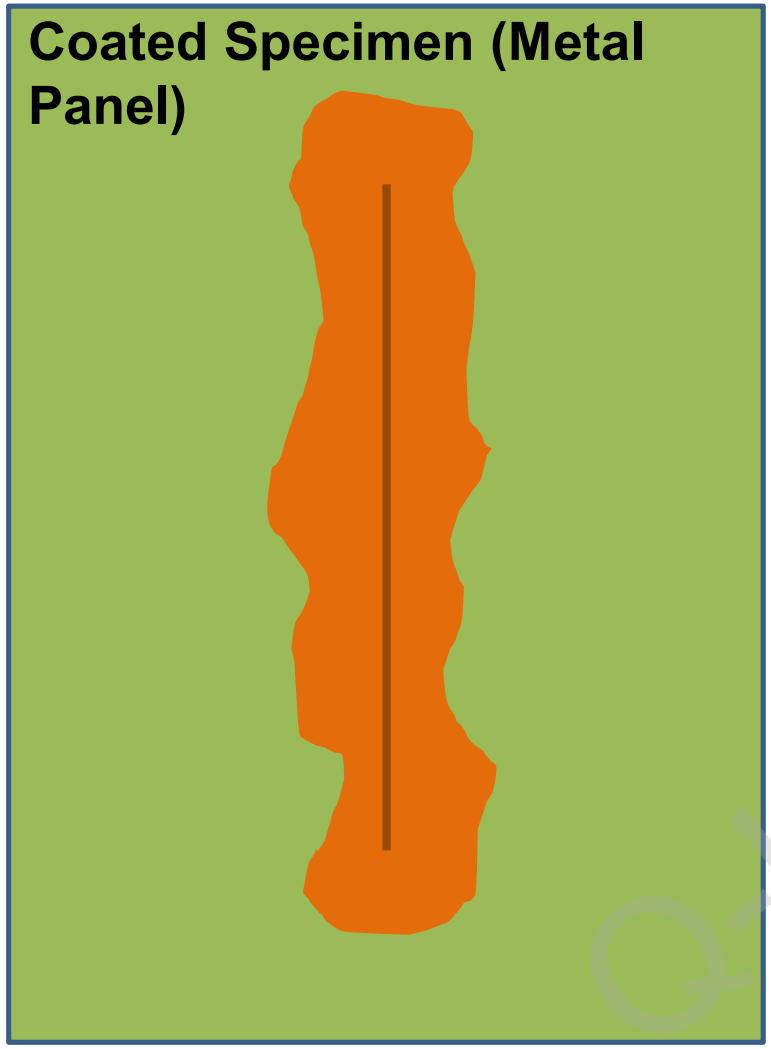
Xiamen, China Oceanfront Racks, 12 months natural exposure



Hainan Island, China

12 months, natural
21 months, natural
12 months, salt spray enhanced

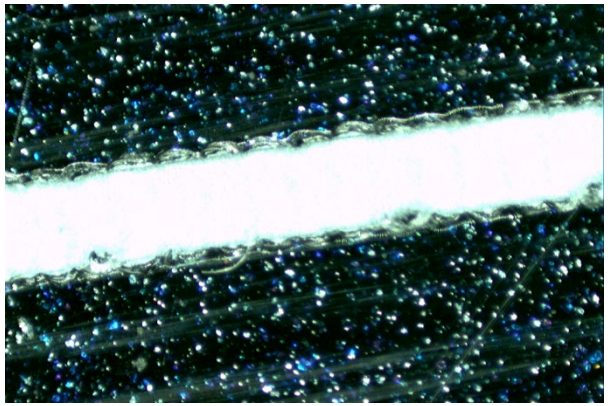
Corrosion Along a Scribe 划痕处的腐蚀



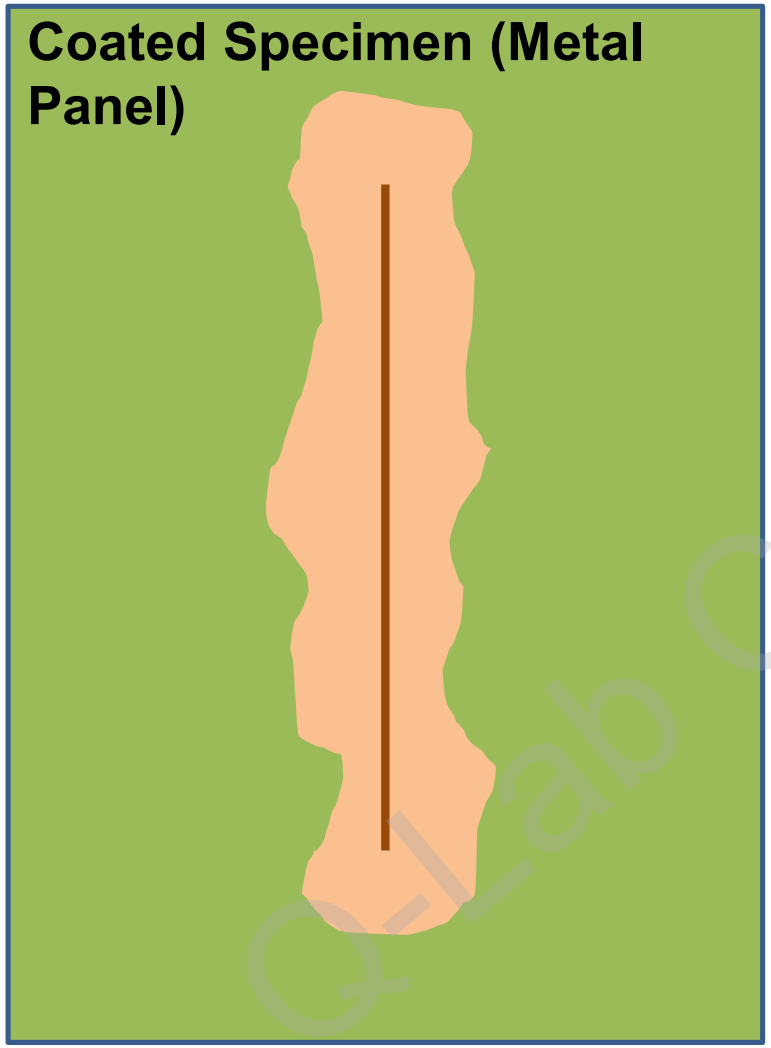
Scribing Tool

Scribe (cut) through the coating to the metal substrate

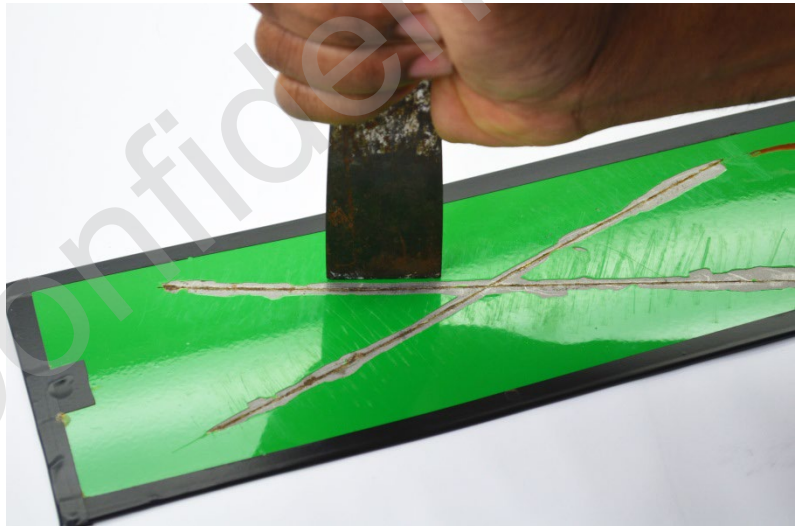
Expose the panel and allow corrosion to “creep” from the scribe



Corrosion Along a Scribe 划痕处的腐蚀

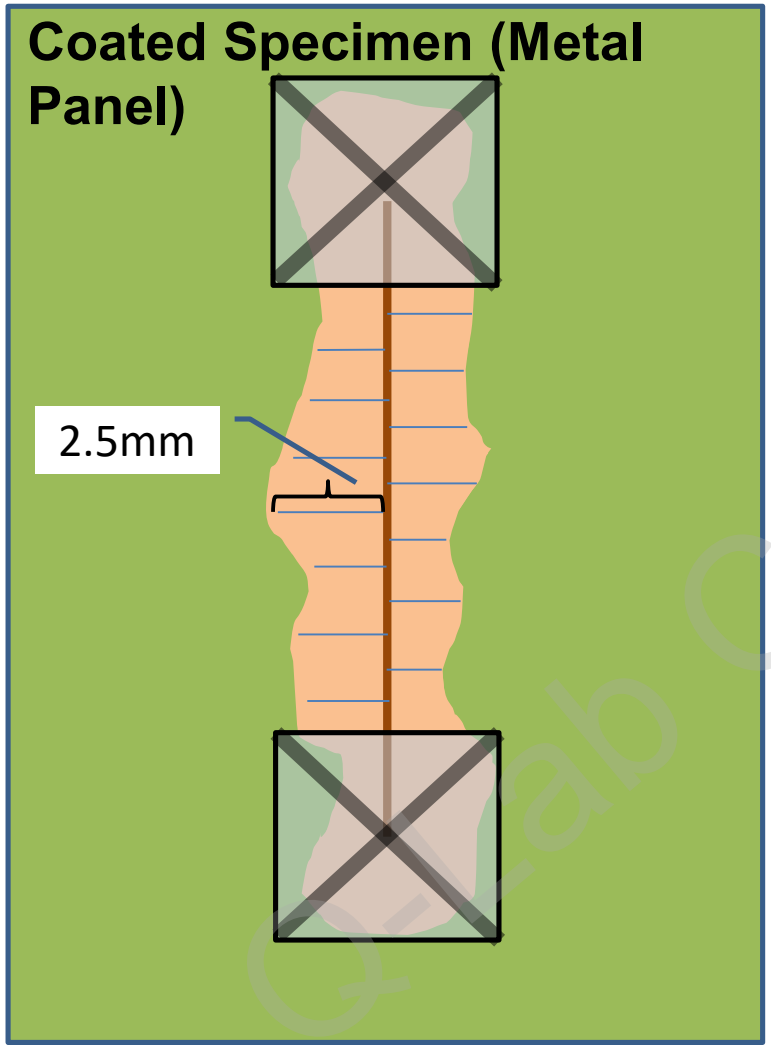


Remove rust “scab” with dull blade



Now the panel is ready for evaluation

Corrosion Along a Scribe 划痕处的腐蚀



Ignore corrosion areas near ends of scribe (approximately 6-12 mm)

Create grid lines (minimum of 6) from scribe perpendicular to edge of corroded areas—transparency can be placed over panel for this purpose

Measure distance between scribe and edge of corrosion

Paint removed due to loss of adhesion is a separate measurement

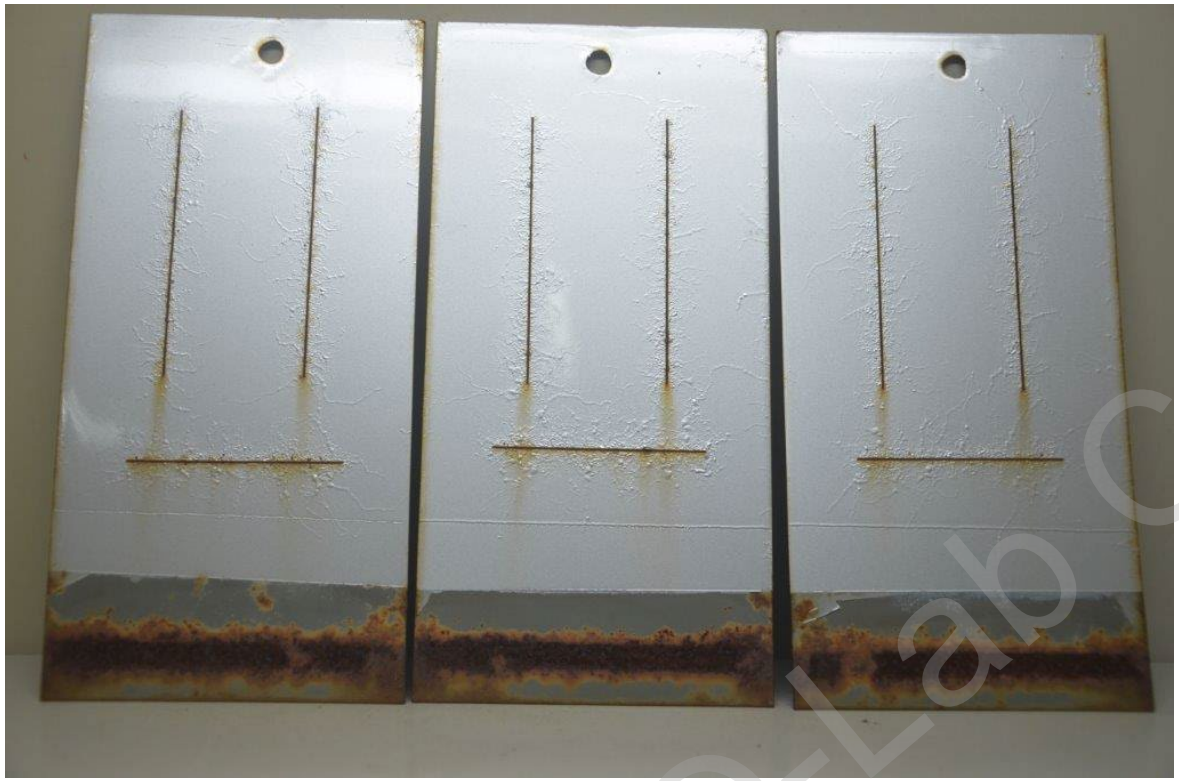
Corrosion creep
腐蚀

Vs

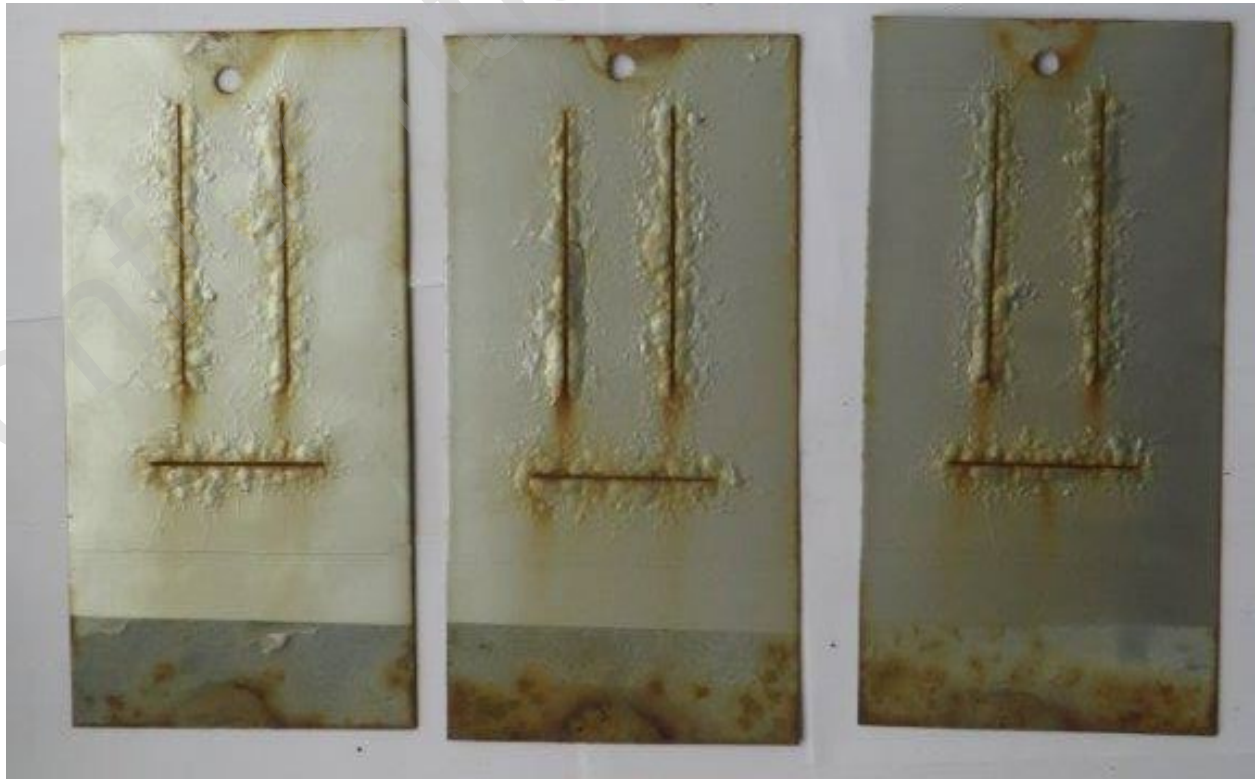
Loss of adhesion
附着力丧失
(cathodic delamination)
（层离）

In this study, delamination data from laboratory tests correlated best to outdoor data

Filiform Corrosion on Steel Panels
钢板上的丝状腐蚀

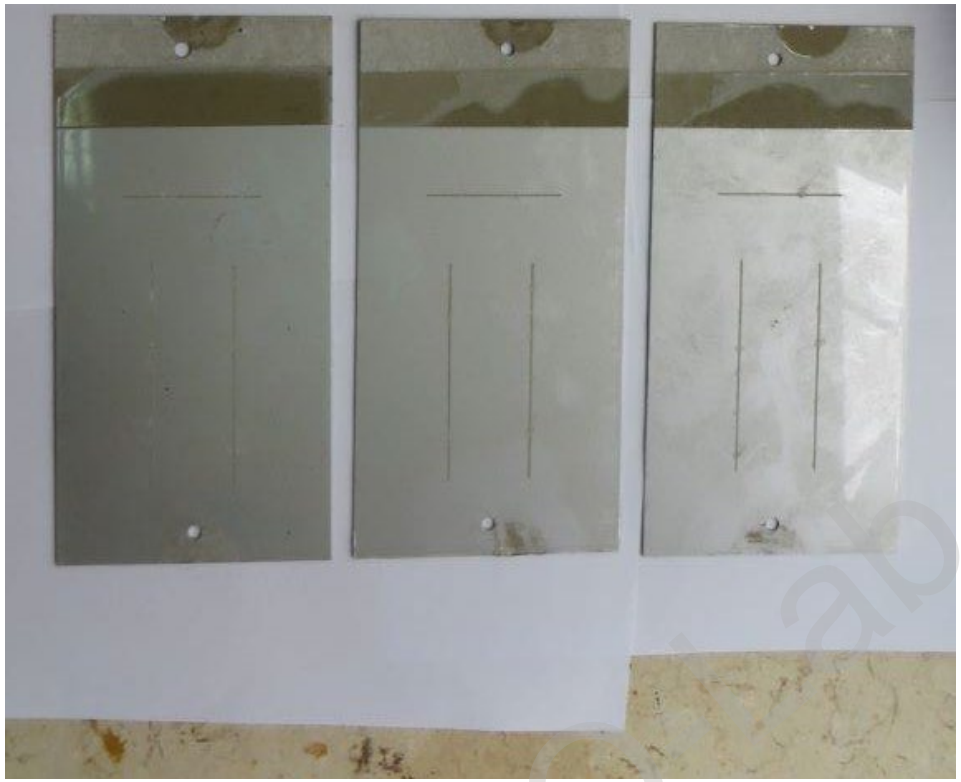


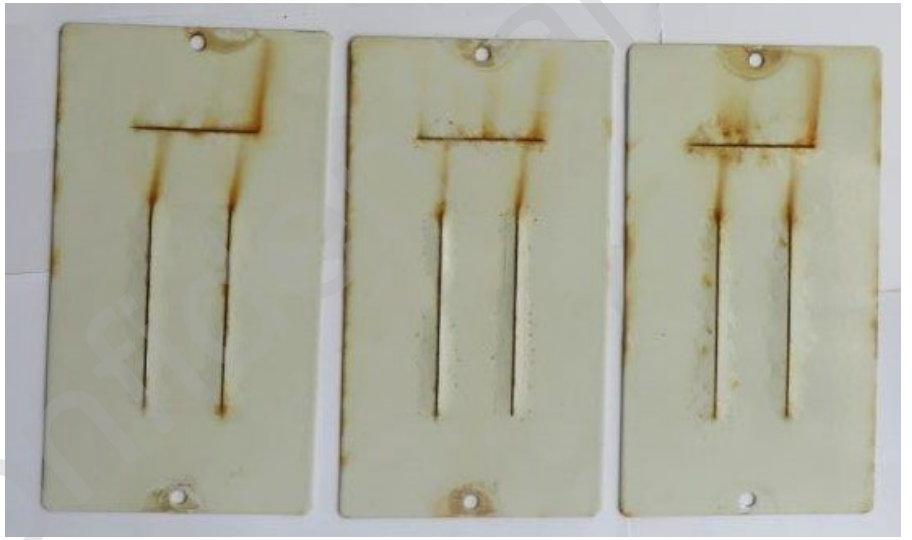
Subtropical Site (not near ocean)



Oceanfront Site

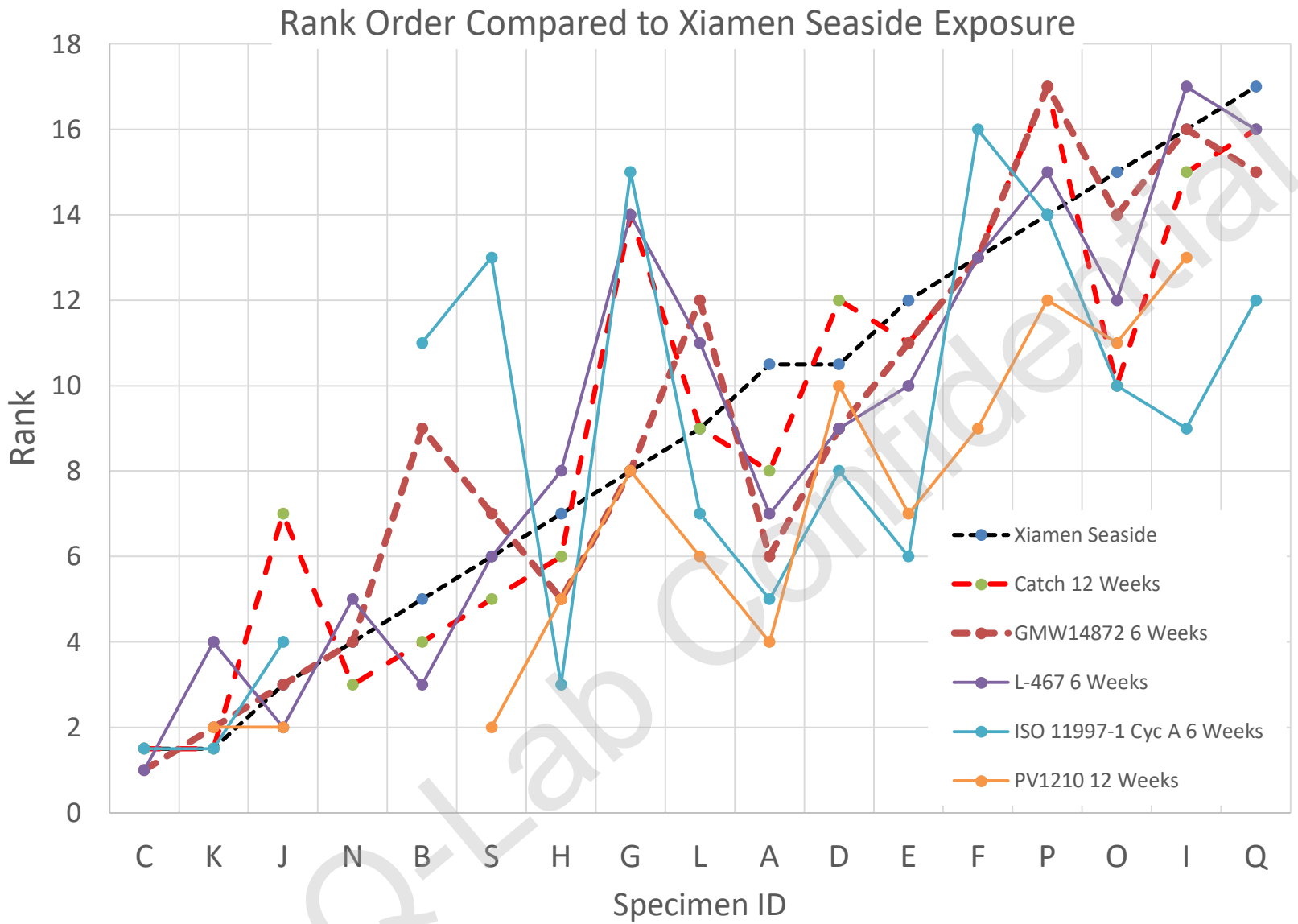
Wide Range of Durability 耐腐蚀性不同





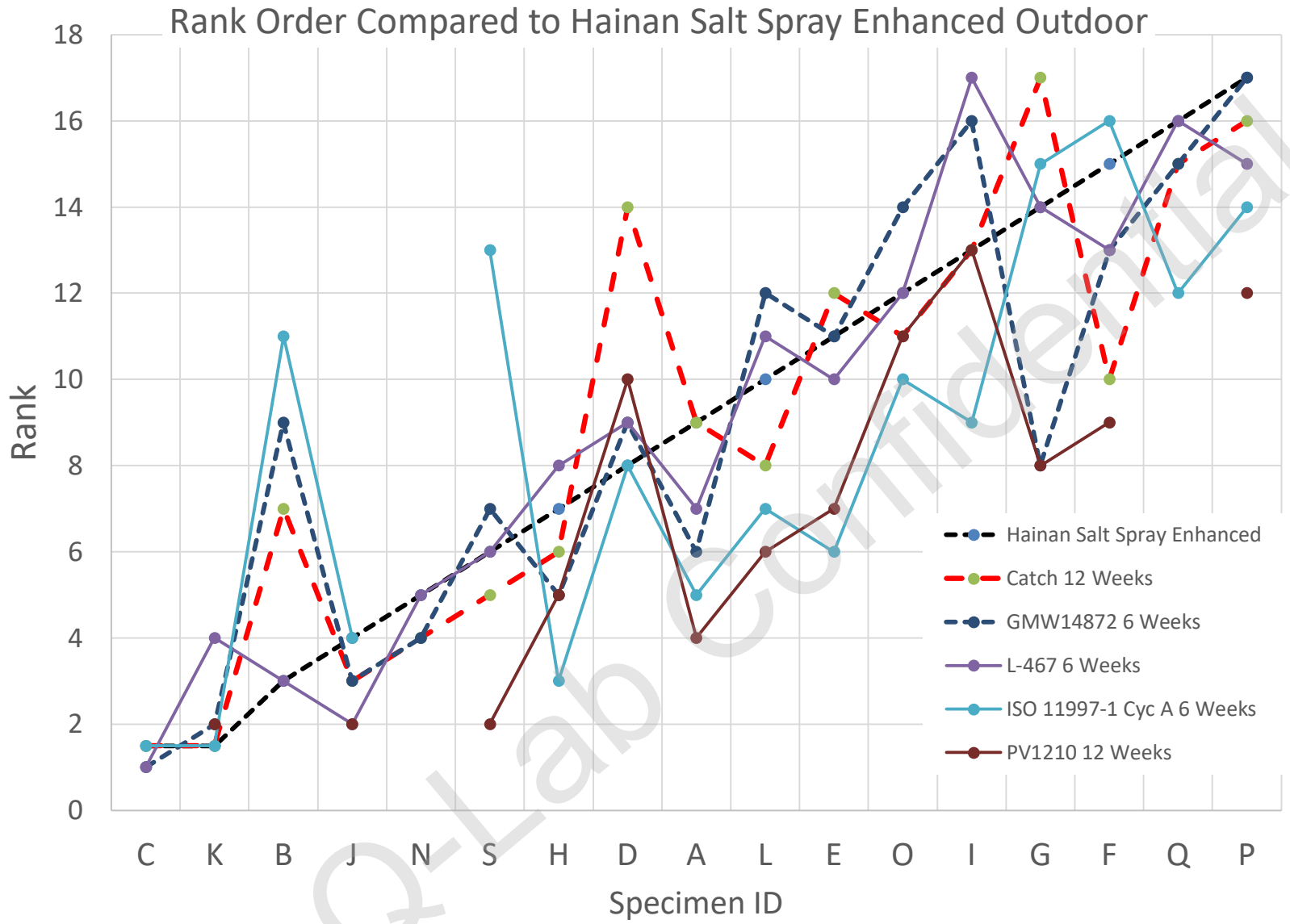
Spearman Rank—Laboratory versus Outdoor Tests
相关性 – 实验室与户外

Laboratory Test	CATCH		GMW14872		L-467		ISO 11997-1 Cyc A		PV1210
Outdoor Test	6 Weeks	12 Weeks	6 Weeks	12 Weeks	6 Weeks	12 Weeks	6 Weeks	12 Weeks	12 Weeks
Hainan, 12 months	0.82	0.83	0.82	0.72	0.90	0.85	0.45	0.61	0.58
Hainan, 21 months	0.83	0.83	0.77	0.72	0.87	0.84	0.39	0.55	0.53
Hainan salt spray enhanced, 12 months	0.81	0.84	0.84	0.76	0.90	0.83	0.53	0.71	0.65
Xiamen (seaside), 12 months	0.79	0.89	0.82	0.67	0.95	0.94	0.71	0.78	0.66



Dotted black line represents the rank orders of specimens in the reference test, the Xiamen natural seaside exposure in this case.

黑色虚线代表参考试验中样品的评级顺序，本例中为厦门海边暴露



Dotted black line represents the rank orders of specimens in the reference test, the Hainan salt spray enhanced natural exposure in this case.

黑色虚线代表参考试验中样品的评级顺序，本例中为海南喷洒盐水试验

Second Study—Aluminum Substrates
第二项研究 – 铝基材

- Automotive lightweighting efforts 汽车轻量化要求
- In the market there was no clear standard for aluminum body panels
- 在市场上，铝车身板没有明确的标准
- Conduct comparison tests between laboratory and outdoor methods in order to achieve:
- 进行实验室与户外比对试验，以实现：
  - Verification of corrosion resistance of aluminum alloy coatings
  - 铝合金涂层耐腐蚀性的验证
  - Performance verification of coatings developed and applied to aluminum alloy substrates
  - 开发并应用于铝合金基材的涂层的性能验证
  - Quality control of anti-corrosion performance for aluminum alloy coating
  - 铝合金涂层防腐性能的质量控制

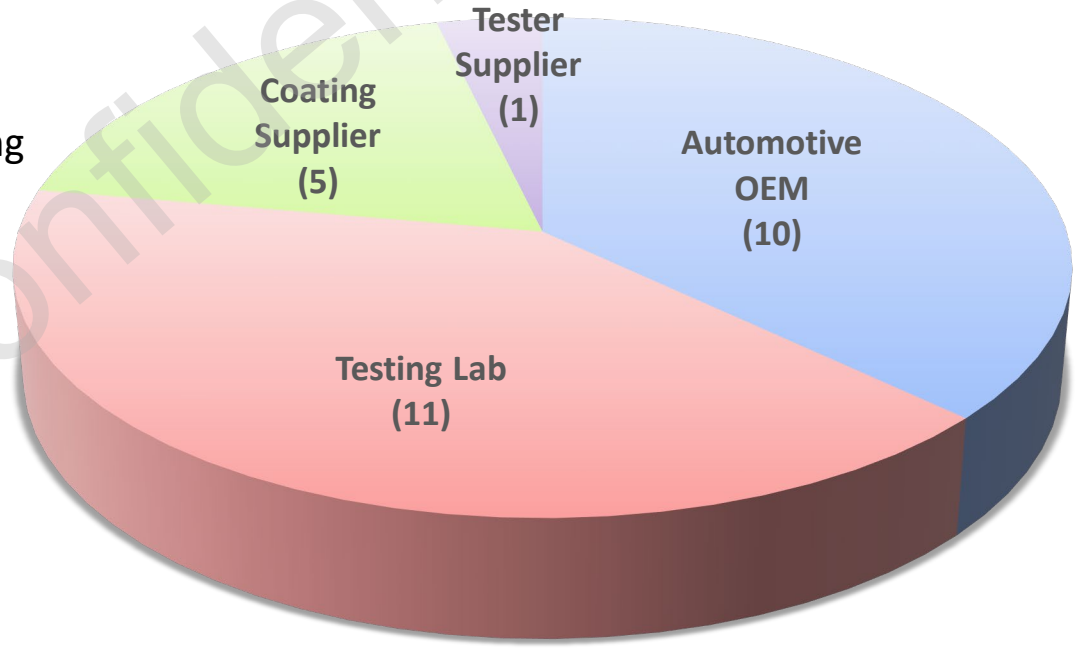
Participants in This Study 参与单位

Lead company: JAC Auto

Participant companies:

- Q-Lab China
- Zhongtai Auto
- Beijing Benz
- AkzoNobel
- Weikai Lab
- Meixin Lab
- Hainan automotive research institute
- Liaoning Zhongwang
- BYD Auto
- Xince Lab
- CTI Lab
- Nannan aluminum processing
- Empirechem
- ……

Total: 27 participants



Comparison test 比对试验

- Two rounds of tests 一共两轮试验
  - First goal to achieve acceptable correlation to outdoor tests and pass/fail QC results with good agreement
  - 第一轮试验的目标是实现与户外试验的可接受的相关性， 且“通过/失效”质量控制结果具有良好的一致性
  - Second round: Can we speed up the test?
  - 第二轮试验：我们能快速得到试验结果吗？

Test specimens 试样

- 53 different specimens, 1033 panels
- 53种不同试样，一共1033片
- The difference of the specimens:
- 试样的差异：
  - Substrate: 5000 series, 6000 series, profiles
  - 底材：5000系列，6000系列
  - Pre-processing: silane, phosphating, zirconium
  - 前处理：硅烷、磷化、锆化
  - Electrophoretic coating: 3 types 电泳：3种
  - Finish: 2 types 面漆：2种

Corrosion test methods 腐蚀试验方法

Test method	CASS	AASS	Filiform	CATCH*	Outdoor - Spray salt water	Road enhanced corrosion
Reference standard	ISO 9227	ISO 9227	SAE J2635	T/CSAE 71	ASTM D6675	QC/T 732
Salt solution, pH value and deposition rate	sodium chloride: 50g/L copper chloride dehydrate: 0.26g/L pH = 3.1~3.3 1～2mL/h @80cm2	sodium chloride: 50g/L pH = 3.1~3.3 1～2mL/h @80cm2	Same as CASS	1% sodium chloride pH = 4.0 39～79mL/h @80cm2 (16min/day)	sodium chloride: 50g/L, twice per week	sodium chloride: 50g/L
Temperature and RH	50°C	35°C	6 hours CASS + 60°C, 85%RH, Wind speed: 6-24 m/min		-	-
Total test duration	240 h	1980 h	6 h CASS + 672 h	2980 h	12 month	120 days

*CATCH： Corrosion Acceleration Test with Controlled Humidity

CATCH test method CATCH试验方法

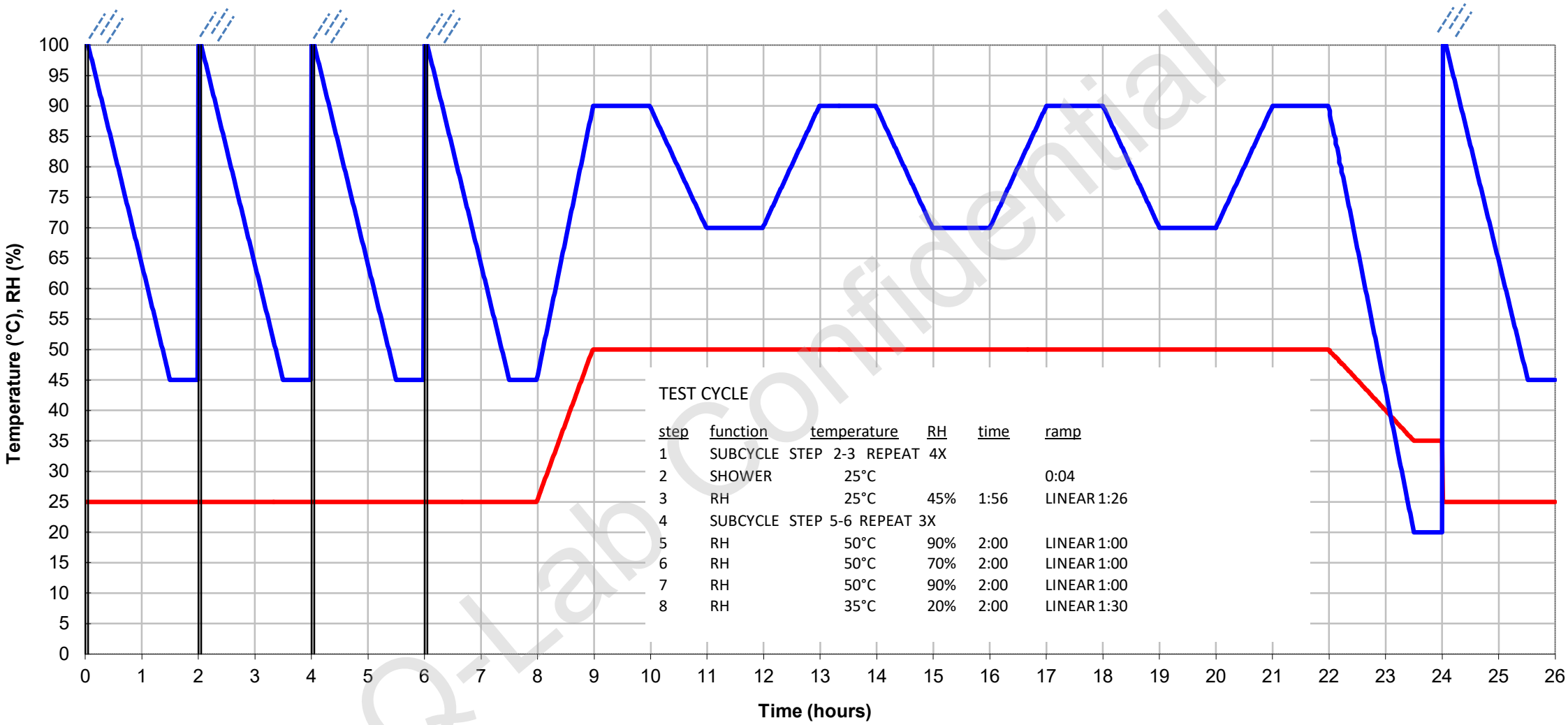
Step	Function	Chamber air temp (℃)	RH (%)	Step time (hh:mm)	Ramp	Ramp time (hh:mm)
1	Subcycle: repeat steps 2-3 4x					
2	Shower	25		0:04		
3	RH	25	45	1:56	Linear	1:26
4	Subcycle: repeat steps 5-6 3x					
5	RH	50	90	2:00	Linear	1:00
6	RH	50	70	2:00	Linear	1:00
7	RH	50	90	2:00	Linear	1:00
8	RH	35	20	2:00	Linear	1:30
9	Final step – go to step 1					

Note: solution: Sodium Chloride (NaCl): 1%, pH = 4.0,
Shower deposition: 39 ml ~ 79 ml @ 80 cm^2。

CATCH Cycle

Color Code
Chamber Temperature
Chamber Relative Humidity

Test Solution:
1% NaCl, pH = 4.0 or 3.0 by addition of sulfuric acid (H_2SO_4), 0.5M



TEST CYCLE

step	function	temperature	RH	time	ramp
1	SUBCYCLE STEP 2-3 REPEAT 4X				
2	SHOWER	25°C			0:04
3	RH	25°C	45%	1:56	LINEAR 1:26
4	SUBCYCLE STEP 5-6 REPEAT 3X				
5	RH	50°C	90%	2:00	LINEAR 1:00
6	RH	50°C	70%	2:00	LINEAR 1:00
7	RH	50°C	90%	2:00	LINEAR 1:00
8	RH	35°C	20%	2:00	LINEAR 1:30

Q-FOG CRH cyclic corrosion chamber

Outdoor accelerated corrosion 户外加速腐蚀

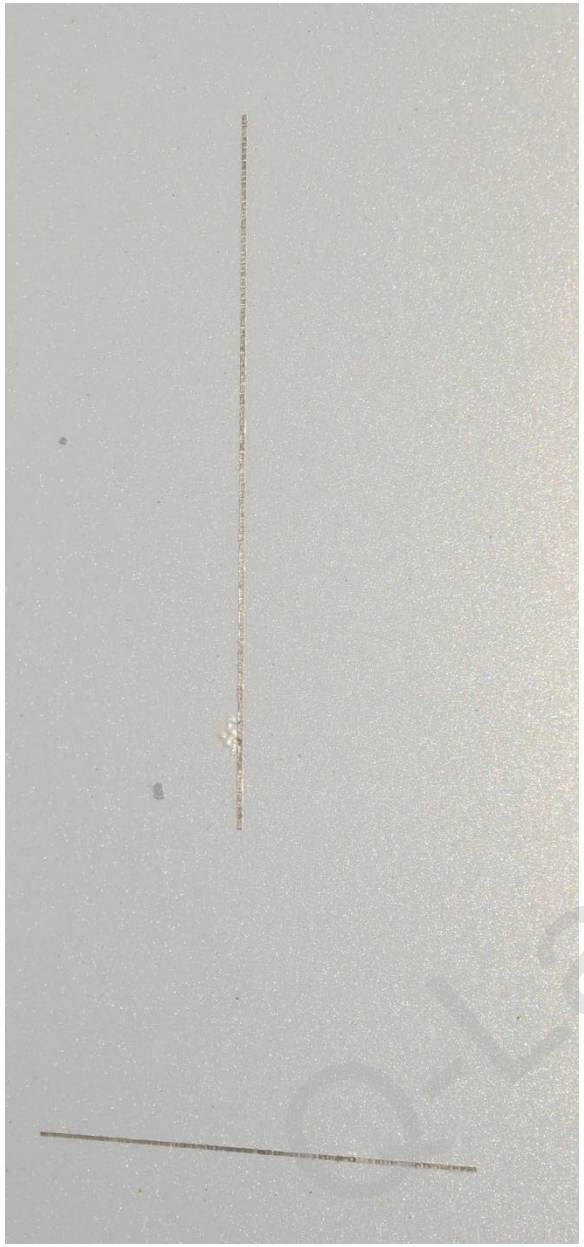
Spray salt water 人工喷洒盐水

Test specimen – spray salt water
试样 – 喷洒盐水

Filiform corrosion
丝状腐蚀

Outdoor accelerated corrosion 户外加速腐蚀

Road enhanced corrosion 道路强化腐蚀

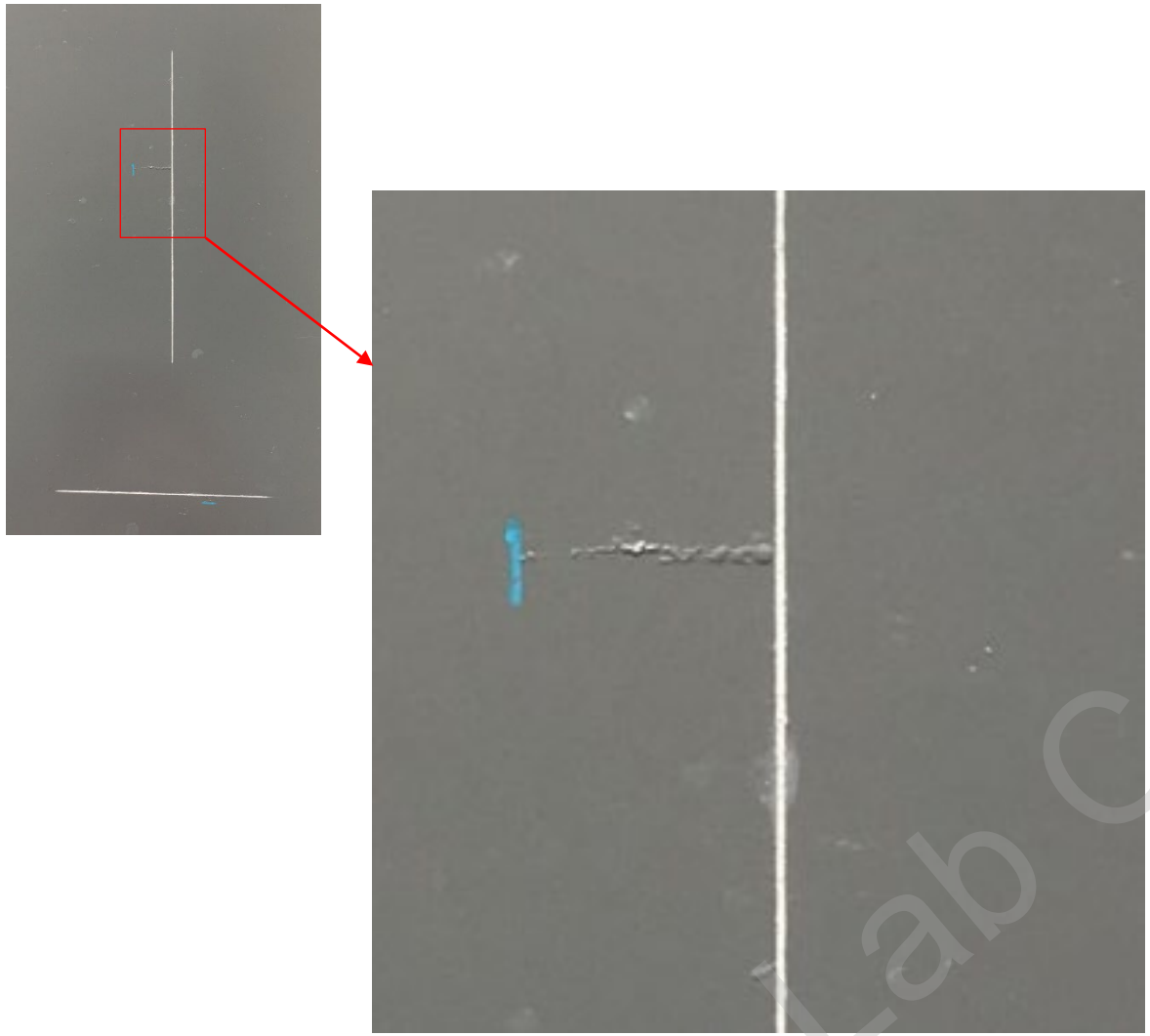


Test specimen -
Road enhanced corrosion
试样 – 道路强化腐蚀

Good performer
腐蚀很小

Typical corrosion morphology of aluminum alloy composite coating
铝板几种常见的腐蚀形貌

Type 类型	Description 描述
A	Filiform corrosion—individual filaments 丝状腐蚀 – 单根丝状腐蚀
B	Filiform corrosion -- Multiple filaments which form a network and spread out from the scribed line 丝状腐蚀 – 多根丝状腐蚀，形成网状，从划痕处向外扩散
C	Single or multiple corrosion blisters from the scribed line 从划痕处长出单个或多个泡状腐蚀
D	Other forms of corrosion, usually a combination of the above three types 其它形式的腐蚀，通常是上述三种类型的组合



Corrosion morphology – Type A
腐蚀形貌 – 类型A

Corrosion morphology – Type B
腐蚀形貌 – 类型B

Corrosion morphology – Type C
腐蚀形貌 – 类型C

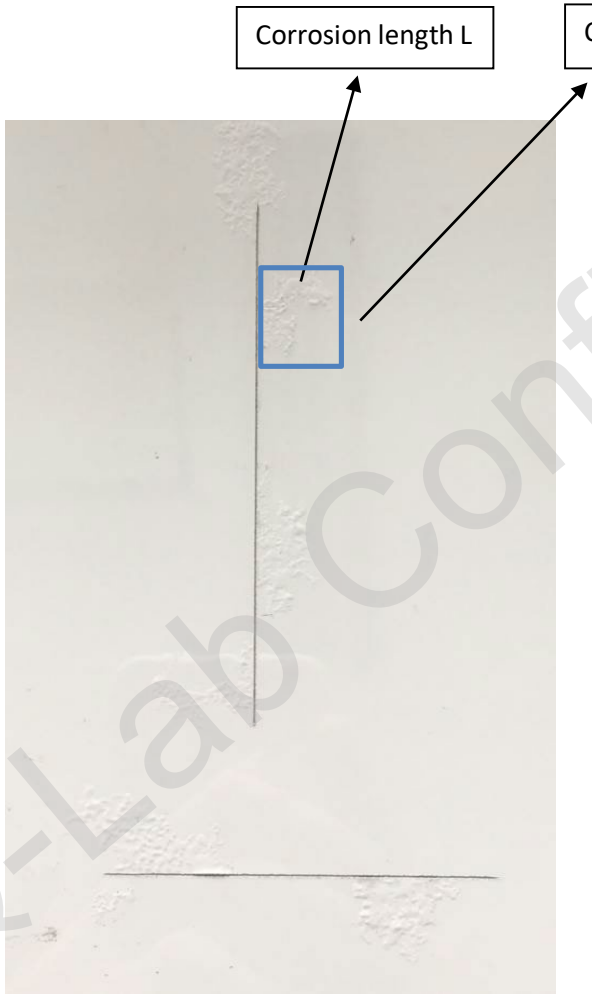
Corrosion morphology – Type D
腐蚀形貌 – 类型D

Test results 试验结果

- One set of specimens tested by road enhanced corrosion
- 一组试样进行道路强化腐蚀
  - 120 cycles (120 days) 120个循环
  - Compared with lab accelerated corrosion test methods
  - 与实验室加速腐蚀试验方法比较

- A different set exposed to salt spray enhanced natural test
- 另一组试样进行户外人工喷洒盐水试验
  - 12 months 12个月
  - Compared with lab accelerated corrosion test methods
  - 与实验室加速腐蚀试验方法比较

Test results 试验结果



Calculate the corrosion area:
计算腐蚀面积：
Corrosion area = L * W
腐蚀面积=腐蚀长度 * 腐蚀宽度

Manually or using photography and CAD software
手动测量或使用摄影和CAD软件

First round test 第一轮试验

Example Test results – corrosion area

试验结果 – 腐蚀面积

Specimen no.	Road enhanced corrosion	CASS	AASS	Filiform	CATCH
12	0	9.83	1.89	2.00	0.50
24	0	4.90	2.23	0.50	0.00
5	0.4	42.30	14.25	3.50	1.00
2	0.5	18.90	7.75	0.00	1.00
14	1	157.70	7.00	5.00	1.50
18	1.4	79.55	3.75	4.50	11.00
16	1.5	59.80	18.33	7.50	13.50
20	3.5	44.50	5.25	3.00	10.50
23	14.25	62.40	15.50	325.00	29.00
21	28.85	59.50	9.50	7.00	17.00

Note: the unit of corrosion area is mm^2

Example Test results – corrosion area

试验结果 – 腐蚀面积

Specimen no.	Spray salt water	CASS	AASS	Filiform	CATCH
35	0.00	3.27	0.00	2.50	0.00
45	10.67	31.57	12.00	9.38	2.33
44	20.00	28.00	10.58	5.12	4.67
50	31.00	33.20	8.25	17.73	9.33
47	73.67	65.93	171.08	10.32	108.67
46	53.67	356.00	392.33	35.87	102.00
42	133.00	362.53	2104.58	193.95	194.33
41	718.33	1507.67	3554.25	30.13	516.33
37	1750.67	615.00	2698.00	5.17	316.33

Note: the unit of corrosion area is mm^2

Correlation 相关性

- Comparison of pass/fail results
- 通过/失效
  - True pass and fail results, chamber versus outdoor tests
  - False pass and fail results, chamber versus outdoor tests

- Spearman Rank Correlation Coefficient
- Spearman相关系数
  - Pearson correlation inappropriate due to non-linearity of dataset (2-3 orders of magnitude between best and worst performers)
  - 由于数据的非线性，Pearson相关性不合适
  - Complete data and subsets examined

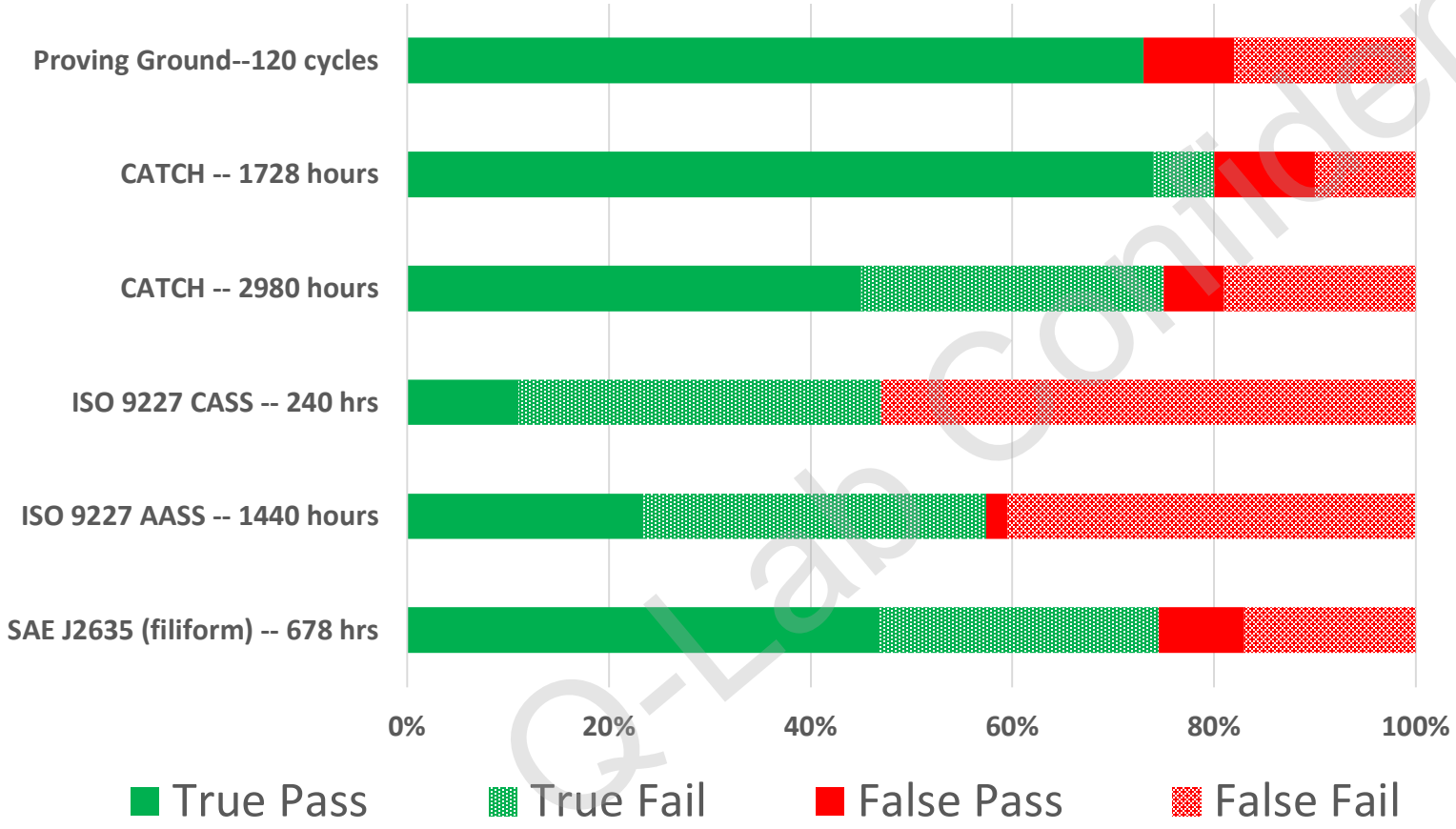
Spearman Rank Spearman排序

Test Method 试验方法	Correlation vs Outdoor Salt Spray	Correlation vs Proving Ground
Outdoor Salt Spray	1.0	0.58
Proving Ground	0.58	1.0
CATCH 1728 hours	0.71	0.56
CATCH 2980 hours	0.79	0.52
CASS (ISO 9227) 240 hours	0.69	0.30
AASS (ISO 9227) 1440 hours	0.66	0.07
SAE J26353 (filiform) 678 hours	0.48	0.05

CATCH is best, but why not use simpler and faster CASS and AASS tests?

Pass/Fail Correlation 通过/失效相关性

Pass/Fail Compared to Salt Accelerated Outdoor



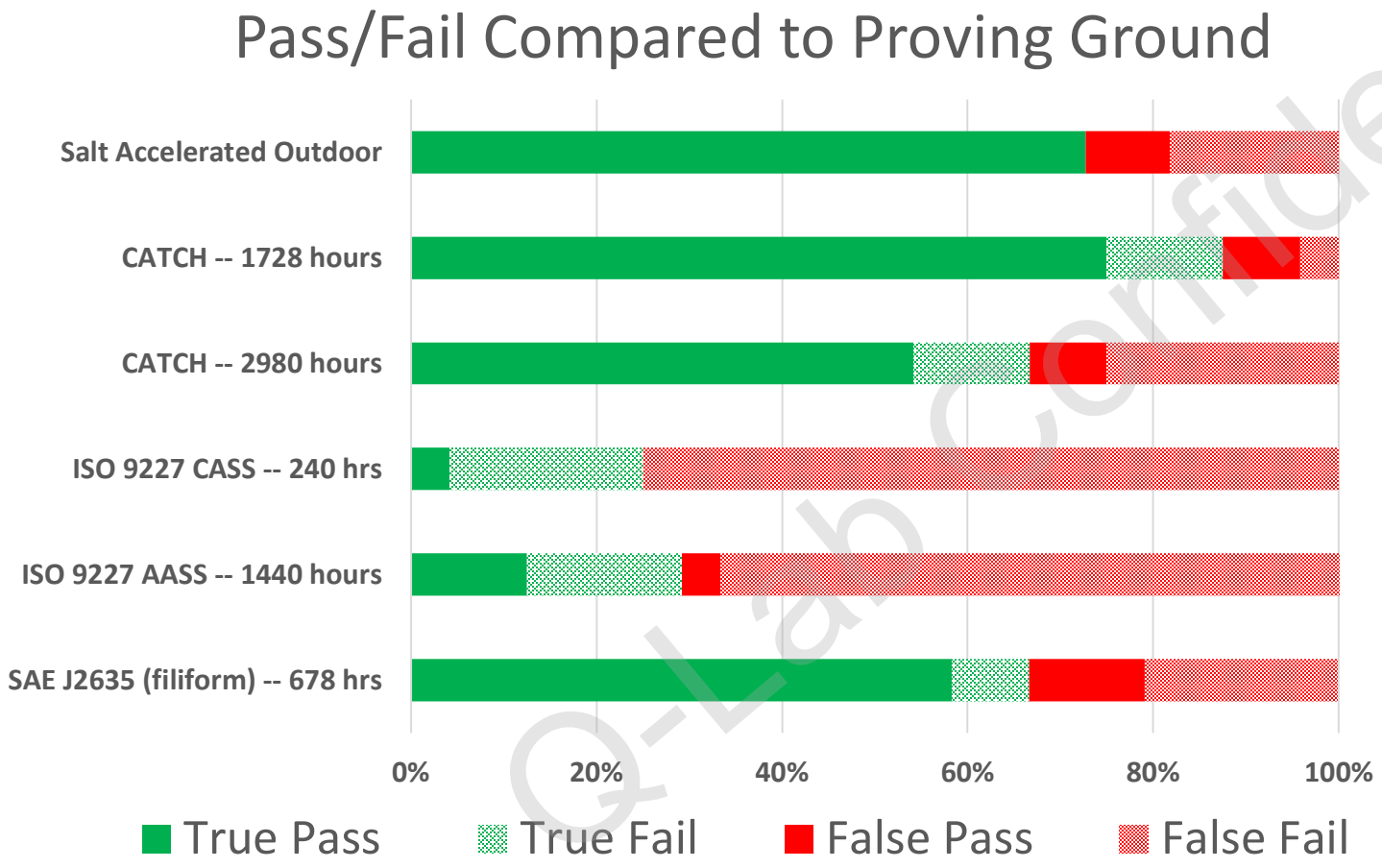
Green means agreement between outdoor test and chamber test

Red means that outdoor test and chamber test do not give same pass/fail results

Solid colors refer to specimens that passed the chamber test

Textured colors refer to specimens that failed the chamber test

Pass/Fail Correlation 通过/失效相关性



Green means agreement between outdoor test and chamber test

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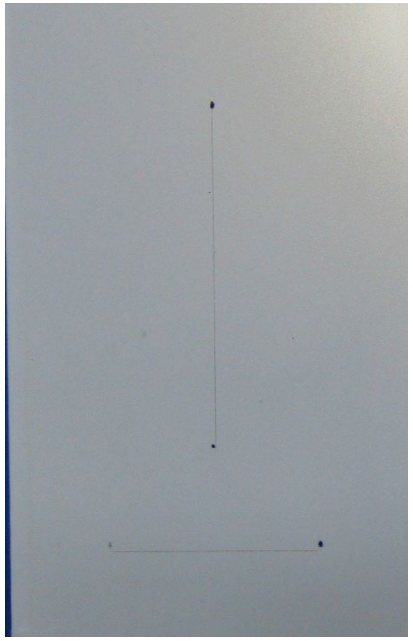
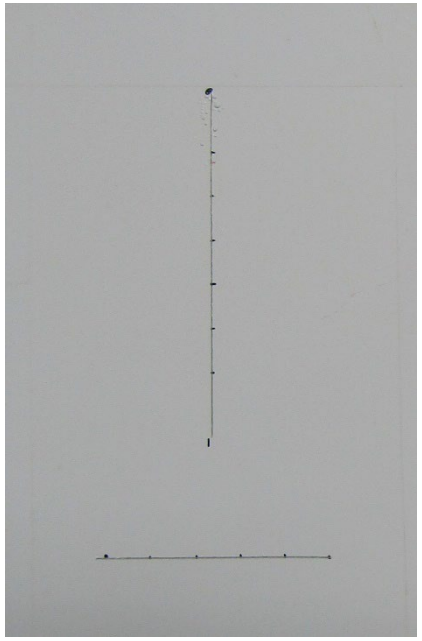
Solid colors refer to specimens that passed the chamber test

Textured colors refer to specimens that failed the chamber test


Aluminum panels:
CATCH - 2980 h

(from left to right:
good, middle, bad)

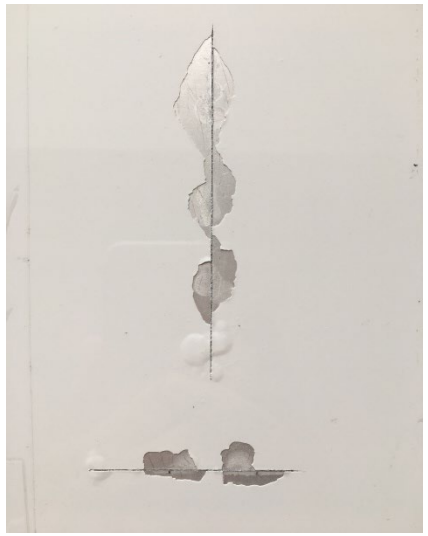


Steel panels:
CATCH - 1728 h

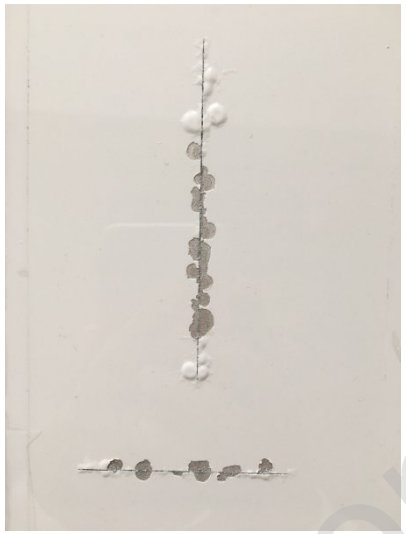
(from left to right:
good, middle, bad)

Corrosion morphology comparison 腐蚀形貌比较

Specimen 41



Specimen 46



Specimen 44

CASS
240 hours

Spray salt water
12 months

Corrosion morphology comparison

Specimen 41 **Specimen 46** **Specimen 44**



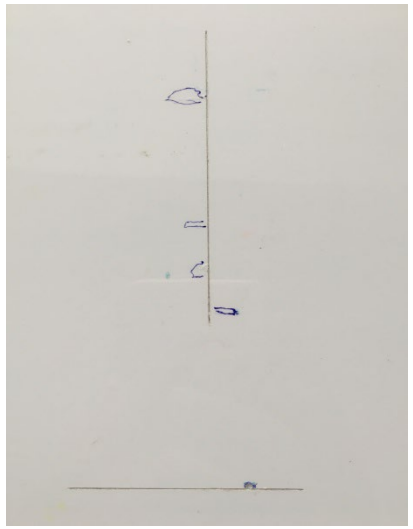
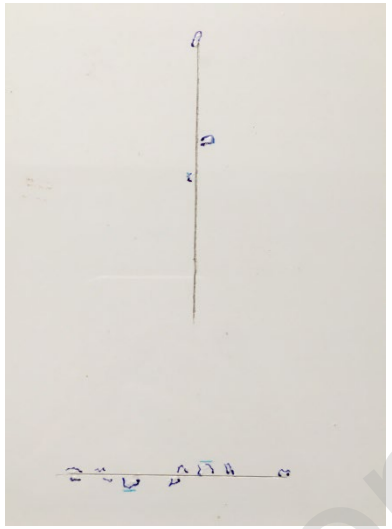
AASS
1980 hours



Spray salt water
12 months

Corrosion morphology comparison

Specimen 41 **Specimen 46** **Specimen 44**

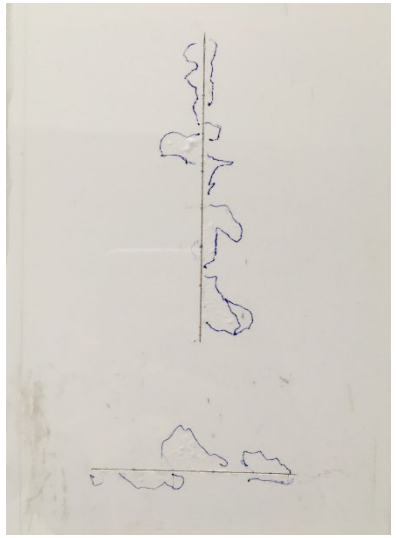

Filiform
678 hours



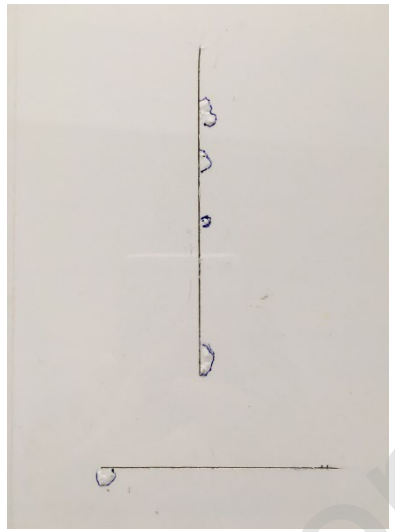
Spray salt water
12 months

Corrosion morphology comparison

Specimen 41



Specimen 46



Specimen 44

CATCH
2980 hours

Spray salt water
12 months

Summary of first round test 第一轮试验总结

- From the test results of CATCH, we can see that the anti-corrosion performance of aluminum panels is better than that of steel panels.
- 铝板耐腐蚀性能比钢板好
- CATCH test method produces similar corrosion morphology to outdoor spray salt water, and the correlation is good.
- 腐蚀形貌相似，相关性好
- The anti-corrosion performance of coated aluminum panels is closely related to electrophoresis, surface treatment and substrate, but not finish type.
- 涂层铝板的防腐性能与电泳、表面处理和底材密切相关，而与面漆关系不大
- The corrosion morphology of aluminum panels is quite different from that of steel panels. Evaluation method of aluminum panels is calculating corrosion area.
- 铝板的腐蚀形貌与钢板有很大不同，铝板的评价方法是计算腐蚀面积

Analysis of first round test results
第一轮试验结果分析

- There are differences of corrosion morphology between different test methods
- 不同试验方法的腐蚀形貌不同
- CATCH test method is consistent with the test design
- CATCH试验方法与试验设计一致
- CATCH test method delivers similar corrosion morphology with outdoor spray salt water, and the correlation is good
- CATCH试验方法与户外喷洒盐水的腐蚀形貌相似，相关性好
- CATCH test method has good correlation with road enhanced corrosion, too
- CATCH试验方法与道路强化腐蚀的相关性也好

Pressure Cooker as Screening Tool
压力锅测试作为筛选工具

Test Method	Correlation vs Outdoor Salt Spray	Correlation vs Proving Ground
Outdoor Salt Spray	1.0	0.56
Proving Ground	0.56	1.0
CATCH 1728 hours	**0.70**	**0.55**
CATCH 2980 hours	0.65	0.50
CASS (ISO 9227) 240 hours	0.52	0.30
AASS (ISO 9227) 1440 hours	0.45	0.08
SAE J26353 (filiform) 678 hours	0.29	0.04

- 1 hour screening test eliminates worst performers and reduces need for the other screening tests
- With remaining specimens, Spearman values remain high for CATCH but decrease for other methods

Second round test 第二轮试验

- The correlation between CATCH and outdoor spray salt water, road enhanced corrosion is good, but the CATCH test method is slow
- CATCH试验方法测试慢
  - CATCH 1728 h (2.4 months) or 2980h (4.1 months)
  - Outdoor spray salt water 12 months
- CASS, AASS, and J2635 tests suggest reduction of pH to accelerate corrosion (3.0 instead of 4.0)
- CASS, AASS, and J2635试验建议降低溶液pH值以加速腐蚀

CATCH pH3.0 vs. CATCH pH4.0

Specimen no.	pH3.0 - 336h	pH3.0 - 600h	pH3.0 - 864h	pH3.0 - 1296h	pH3.0 - 1728h	pH4.0 - 864h	pH4.0 - 1296h	pH4.0 - 1728h
A	0.00	0.45	0.72	1.67	2.65	0.13	0.65	0.99
B	0.00	0.05	0.16	0.29	0.49	0.00	0.00	0.00
C	0.00	0.50	1.11	1.60	2.49	0.00	0.00	0.06
D	0.00	0.09	0.18	0.20	0.80	0.00	0.00	0.00
E	0.17	0.23	0.59	0.98	1.56	0.17	0.35	0.56
F	0.43	0.72	0.98	1.05	2.22	0.21	0.50	0.88
G	1.18	1.63	1.92	2.40	4.11	0.50	0.98	1.76
H	2.67	7.48	9.51	14.55	20.77	2.53	4.84	6.76
I	0.00	0.59	0.92	1.43	3.24	0.00	0.26	0.29
J	0.72	1.66	2.88	5.30	7.80	0.48	0.79	1.02
Total	5.17	13.40	18.99	29.45	46.12	4.02	8.39	12.33

Note: the unit of corrosion area is mm^2

CATCH pH3.0 vs. CATCH pH4.0

- The corrosion area of CATCH pH3.0 600h matches CATCH pH4.0 at 1728h
- pH值为3.0的CATCH试验方法测试600h与pH值为4.0的CATCH试验方法测试1728h腐蚀相当
- The correlation coefficient between CATCH pH3.0 600h and CATCH pH4.0 1728h is 0.87
- CATCH pH3.0 600h与CATCH pH4.0 1728h的相关系数为0.87

CATCH 3.0 Correlation

Spearman Rank Coefficient	CATCH 3.0 - 600h	CATCH 3.0 - 864h	CATCH 3.0 - 1296h	CATCH 3.0 - 1728h
Proving Ground	0.73	0.72	0.82	0.8
CATCH 4.0 -- 1728 hrs	0.87	0.77	0.84	0.84

Conclusion 总结

SAE China published CATCH 3.0 as a new standard,

T/CSAE 130-2020

此方法写在新标准T/CSAE 130-2020中

672 hours exposure recommended

推荐测试672h

1 hour “pressure cooker” test for pre-screening

1h的压力锅测试作为预筛选

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