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IKA Report No. 22-1340

## Salt Spray and Weight Loss Tests

Ordered by Roi Peretz

Green I.C.P.S

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06.06.2022

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## 1. Introduction

Six groups of different types of metal coupons were received for examination. The groups consist of 12 coupons each with approximate dimensions of 99mm /50mm / 2mm. According to the customer, six samples from each group underwent "Corrizon Base" treatment. In every group, six coupons were treated with "Corrizon Base" and six remained untreated. We were requested to evaluate the effect of the "Corrizon Base" treatment on the corrosion resistance of the steel samples by performing salt spray test (SST) followed by weight loss test. The weight loss should be measured after 500, 1000, 1500, 2000, 2500, 3000, 4000, 5000 and 10,000 hours of SST. The mass loss test shall be performed for two coupons of each group (one treated with "Corrizon Base" and the second without treatment) for each time period of SST. The details of the coupons as received from the customers are listed in Table No. 1 and Table No. 2.

*Table 1 –Designation of Coupons for Mass Loss Test*

Group	Material	Thickness (mm)	Sample Designation	Coating
I	Steel St 37	2	101 - 109	No coating
			201 – 209	"Corrizon Base" treatment on 2 sides
II	Steel St 37- painted	2	301 – 309	"Corrizon Base" treatment on 2 sides
			401 – 409	No treatment
III	Steel St 37 galvanized	2	501 – 509	No coating
			601 – 609	"Corrizon Base" treatment on 2 sides
IV	Stainless Steel SS304, annealed	2	701 – 709	No coating
			801 – 809	"Corrizon Base" treatment on 2 sides
V	Aluminum Al5083	2	901 – 909	No coating
			1001 – 1009	"Corrizon Base" treatment on 2 sides
VI	Aluminum Al6061-T6	2	1101 – 1109	No coating
			1201 – 1209	"Corrizon Base" treatment on 2 sides

***Table 2–Designation of coupons for testing after 10 000 hr. of SST***

Group	Sample Designation	Thickness (mm)	Coating	Remarks
I	114	2	No treatment	st 37 Steel coupons
	218	2	"Corrizon Base" treatment on 2 sides	
II	318	2	Corrizon Base treatment on 2 sides	st 37 painted Steel coupons
III	714	2	No treatment	Stainless Steel SS304 annealed coupons
	818	2	Corrizon Base treatment on 2 sides	
IV	914	2	No treatment	Al 5083 coupons
	1019	2	Corrizon Base treatment on 2 sides	
V	1114	2	No treatment	Al 6061 T6 coupons
	1232	2	Corrizon Base treatment on 2 sides	

***Table 3–Designation of coupons for tensile testing after 10 000 hr. of SST***

Group	Sample Designation	Thickness (mm)	Coating	Remarks
I	118	2	No treatment	st 37 Steel coupons
	241	2	"Corrizon Base" treatment on 2 sides	
III	718	2	No treatment	Stainless Steel SS304 annealed coupons
	841	2	Corrizon Base treatment on 2 sides	
IV	918	2	No treatment	Al 5083 coupons
	1028	2	Corrizon Base treatment on 2 sides	
	1241	2	Corrizon Base treatment on 2 sides	



## 2. Test Results

### 2.1 Salt Spray Test

We performed a salt spray test in accordance with ASTM B 117-19, at  $35\pm 2^{\circ}\text{C}$  and pH levels of  $6.5\div 7.2$ , for 10 000 hours. Afterwards, mass loss of the metal coupons of each six groups was measured. Signs of corrosion were observed on the surface of all samples.

### 2.2 Mass Loss of Steel, Stainless Steel and Aluminum Coupons

The mass loss test was performed according to ASTM G1-03(2017) standard.

After the completion of the SST, the coupons were washed with tap water and loose corrosion products were mechanically removed. Afterwards, the coupons were immersed in a chemical cleaning solution to dissolve the corrosion products. The chemical solutions are detailed in Table 2.

*Table 3 – Composition of chemical cleaning solutions*

Solution No.	Coupon type	Composition
1	- Steel St37 - Galvanized St 37	HCl $\sim 1.18 \text{ g/cm}^3$ , $\text{Sb}_2\text{O}_3$ 20g/L, room temp.
2	- Aluminum 5083 - Aluminum 6061	Nitric acid, $\sim 1.42 \text{ g/cm}^3$ , room temp.
3	- Stainless steel SS304	Nitric acid $\sim 1.42 \text{ g/L}$ 100ml/1000L distilled water, $60^{\circ}\text{C}$
4	- Painted St37 coupons	Paint remover follows with solution No. 1, room temp.

Afterwards, the coupons were immersed, dried and weighed for 4 time, until the mass loss was 0.05gr or less. Figures No. 1-7 present the coupons after the mass loss test. Carbon steel and galvanized coupons "CB" remain flat with dull gray appearance, similar to the appearance of the reference coupons "Ref". Coupons " Untreated " exhibits rough surface with concaves and pits due to corrosive attack (general corrosion). Table No. 3 summarizes the results of the mass loss test.

***Table 4 -Results of the mass loss test***

Coupon	Treatment	Initial mass (gr)	Mass after 10000hr SST (gr)	Final mass (after removal of corrosion products)	Mass loss (gr)	Mass loss (%)	Effective mass loss*, approximate (%)
109	No treatment	76.34	107.15	19.33	57.01	74.68	73.99
209	"Corrizzon Base"	76.29	92.13	46.22	30.07	39.42	26.89
Ref	No treatment	75.72	-	75.20	0.52	0.69	
309	"Corrizzon Base"	77.39	84.36	67.70	9.69	12.52	11.83
409	No treatment	77.82	87.80	56.74	21.08	27.09	26.40
Ref	No treatment	75.72	-	75.20	0.52	0.69	
509	No treatment	76.94	92.18	21.67	55.27	71.84	70.73
609	Corrizzon Base""	77.03	89.11	42.28	34.75	45.11	40.39
Ref	No treatment	75.84	-	75.00	0.84	1.11	
709	No treatment "	78.22	77.26	76.06	3.69	4.72	4.52
809	Corrizzon Base"	78.10	74.66	74.53	2.04	2.61	1.41
Ref	No treatment	72.12	-	71.98	0.14	0.19	
909	"No treatment	25.88	25.97	25.57	0.31	1.20	1.12
1009	Corrizzon Base"	25.87	25.98	25.85	0.02	0.08	0.00
Ref	No treatment	25.87	-	25.85	0.02	0.08	
1109	No treatmen	26.35	26.40	25.75	0.6	2.28	1.31
1209	"Corrizzon Base"	26.32	26.82	26.31	0.01	0.04	-0.93
Ref	No treatment	26.93	-	26.67	0.26	0.97	

\* The effective mass loss was calculated with the following assumption:

a) The mass loss due to the chemical dissolution method is about original loss rate factor

\*\*Mass after 10000hr SST (gr) after removal of painted coating for Coupon No. 309 – 81.22 gr., Coupon No. 409 – 83.92 gr.



**2.3 Microhardness Tests**

The microhardness measurements were carried out using the Vickers method with 500g load on the polished longitudinal metallographic specimen in accordance with ASTM E 384 – 17. The results are presented in Table No. 4.

**Table 5. Results of the microhardness tests.**

Coupon No.	Base metal	Hardness HV <sub>0.5</sub>	
		Individual measurements	Average
114	St 37	134,133,137	135
218	St 37 +CB	140,148,132	140
318	St37 + paint	132,138,130	133
714	SS304	212,214,213	213
818	SS304	201,230,240	224
914	Al5083	110,109,111	110
1019	Al5083	110,109,112	109
1114	Al6061	77,78,79	78
1232	Al6061	113,116,111	113




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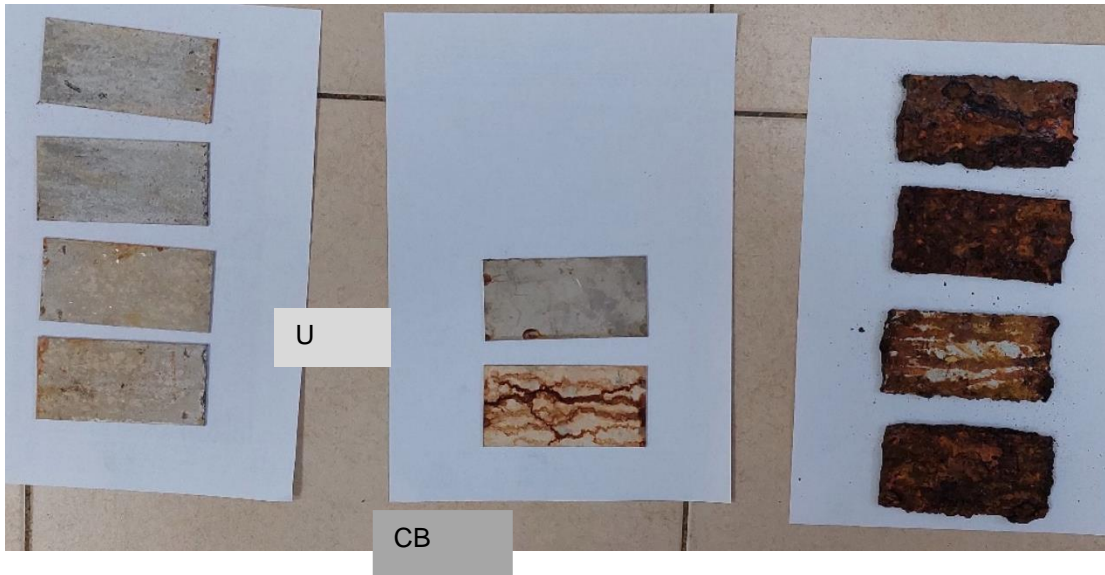
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Ref



Figure 2

Group I – coupons after 10000 hours of SST and mass loss test  
(CB) "Corrizon Base" treated  
(U) Untreatment  
(Ref) Not treated - reference

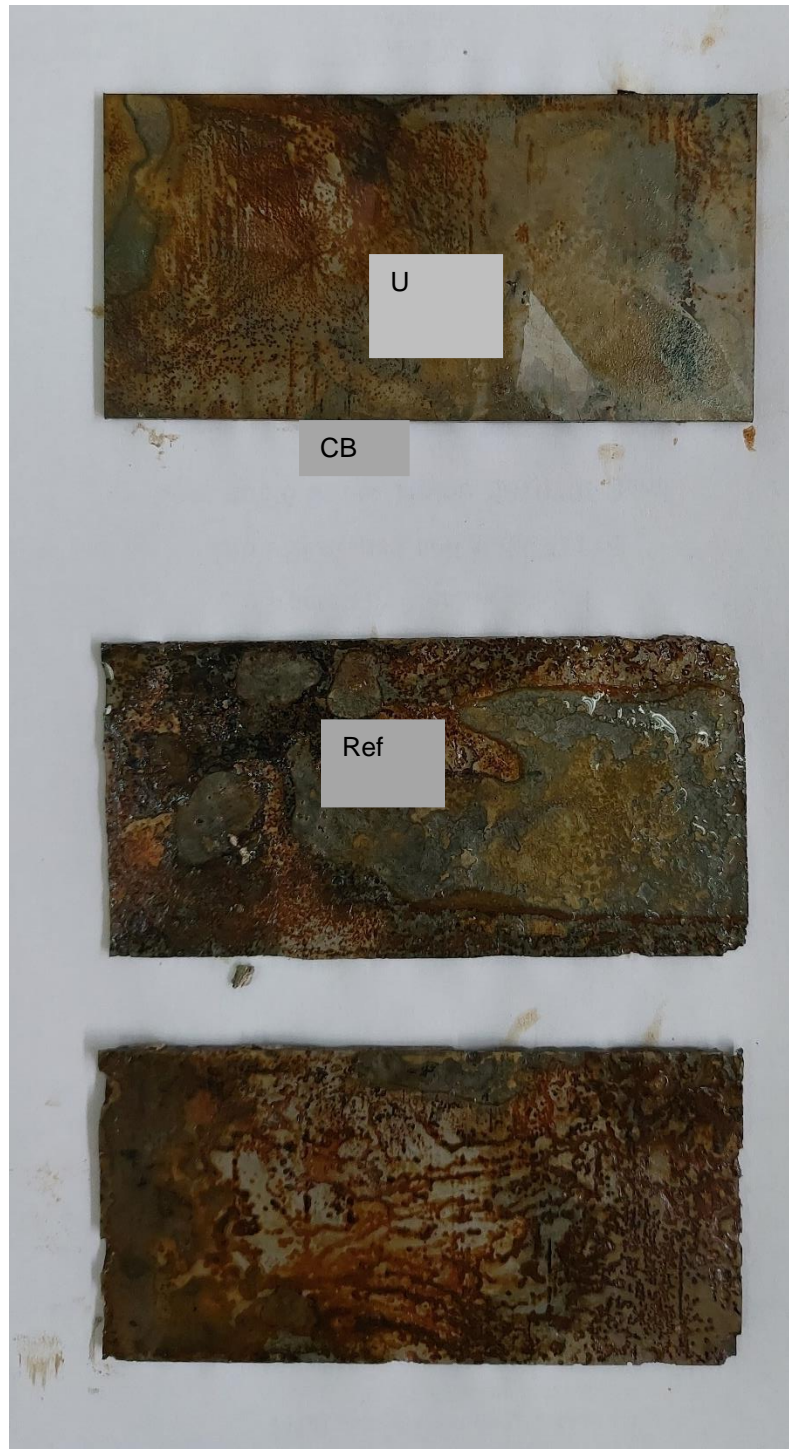


Figure 3

Group II – coupons after 10000 hours of SST and mass loss test

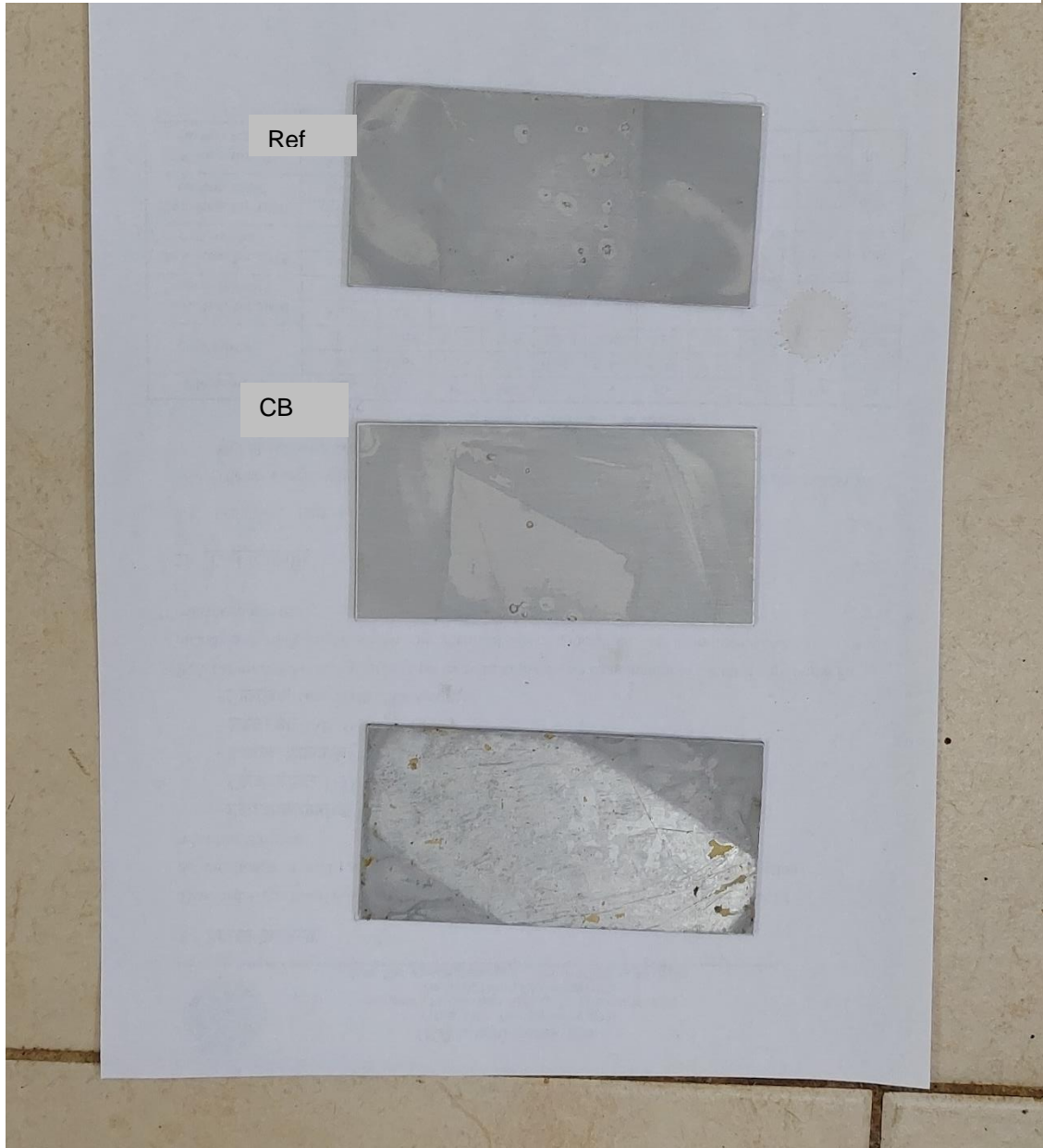
(CB)"Corrizon Base" treated

(U) Untreatment

(Ref) Not treated - reference



**Figure 4**  
Group IV – U after 10000 hours of SST and mass loss test  
(CB)"Corrizon Base" treated  
(U) Untreatment  
(Ref) Not treated - reference



**Figure 5**  
Group V – coupons after 10000 hours of SST and mass loss test  
(CB)"Corrizon Base" treated  
(U) Untreatment  
(Ref) Not treated - reference

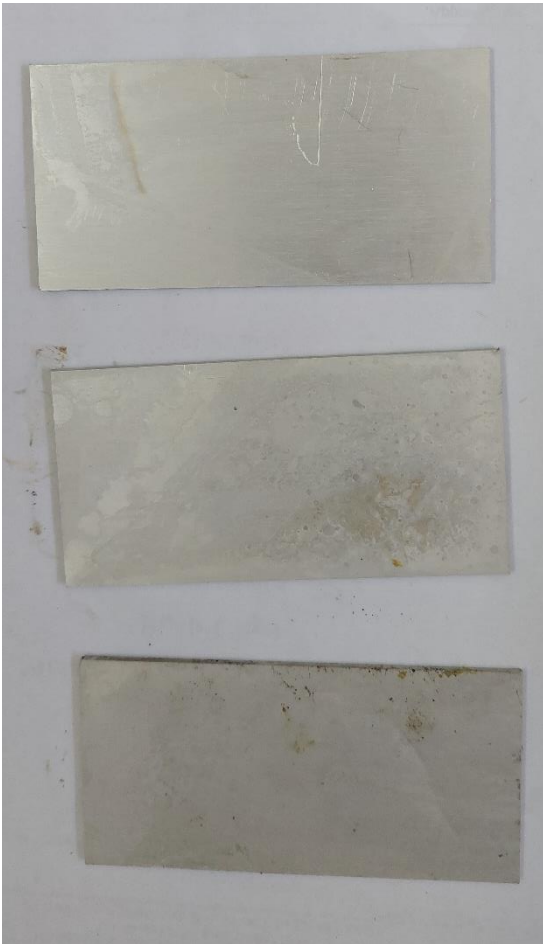


Figure 4

Group III – coupons after 10000 hours of SST and mass loss test

(CB) "Corrizon Base" treated

(U) Untreatment

(Ref) Not treated - reference

CB

U



Figure 6

Group VI – coupons after 10000 hours of SST and mass loss test  
(CB) "Corrizon Base" treated  
(U) Untreatment  
(Ref) Not treated - reference

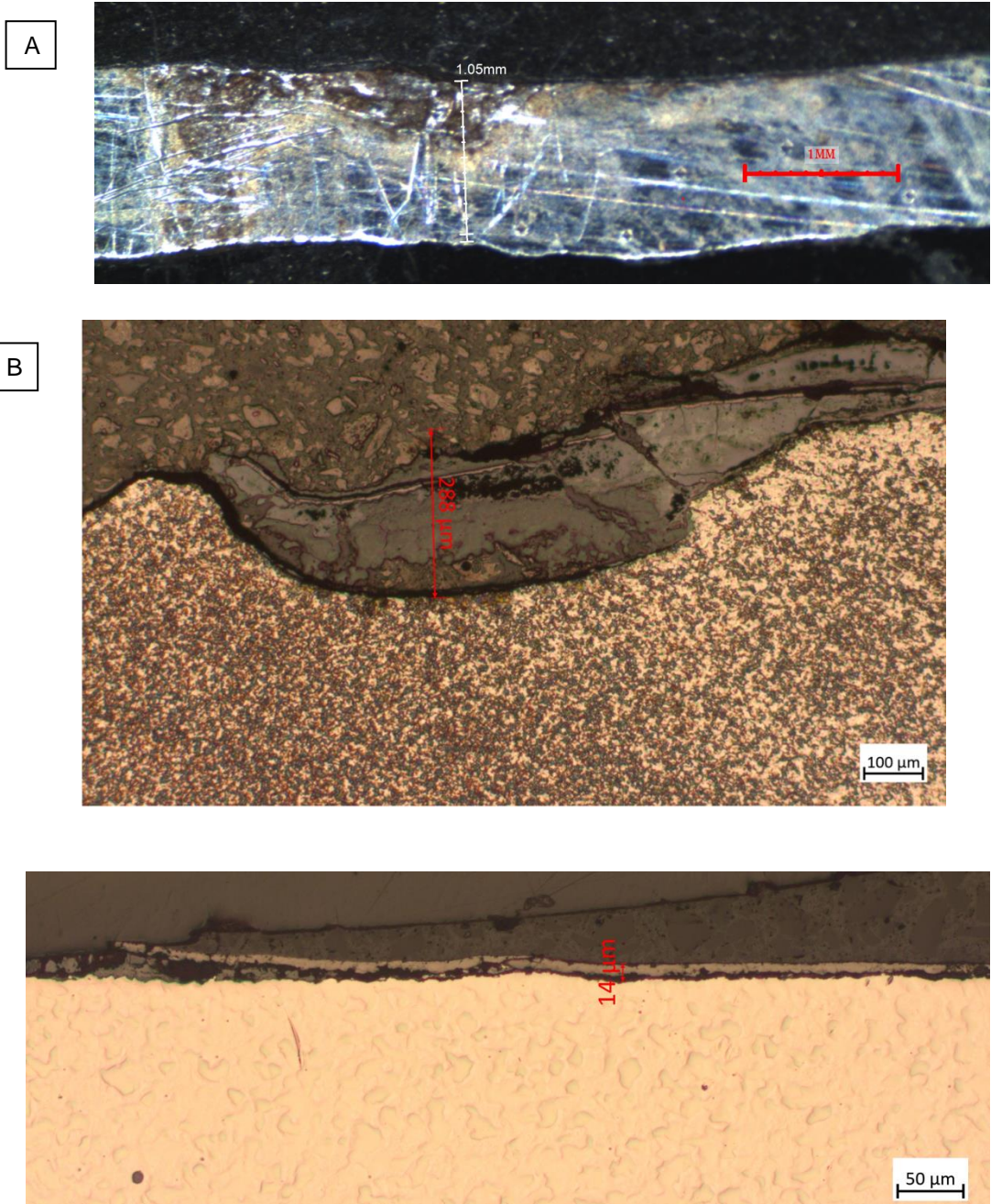


Figure 7. Optical microscope images of metallographic section of the coupons after 10000 hr. in SST

(A) Coupon 114 (St37, not treated)

(B) Coupon 218 (St37 +CB)

(C) Coupon 318 ( St37, galvanized)



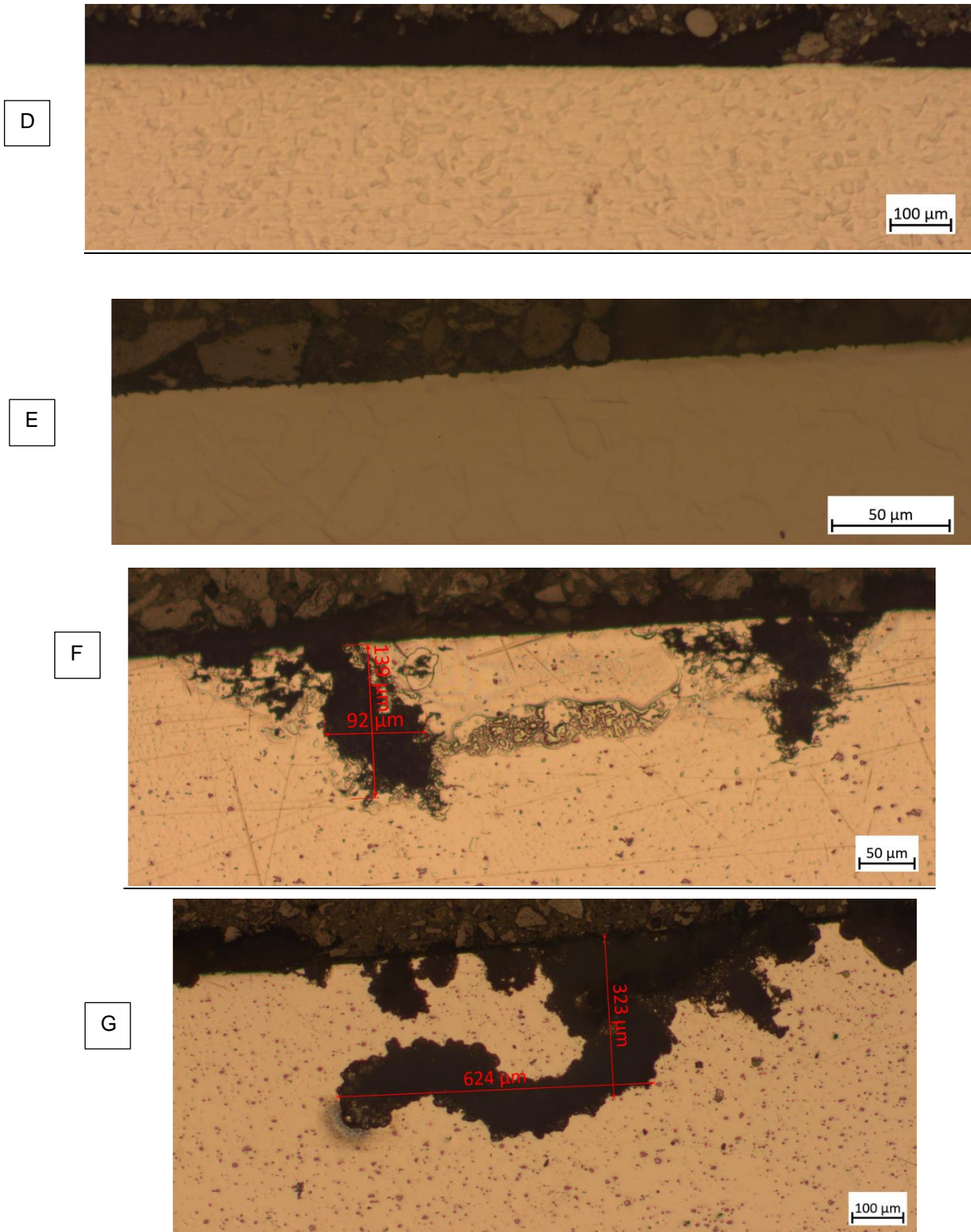
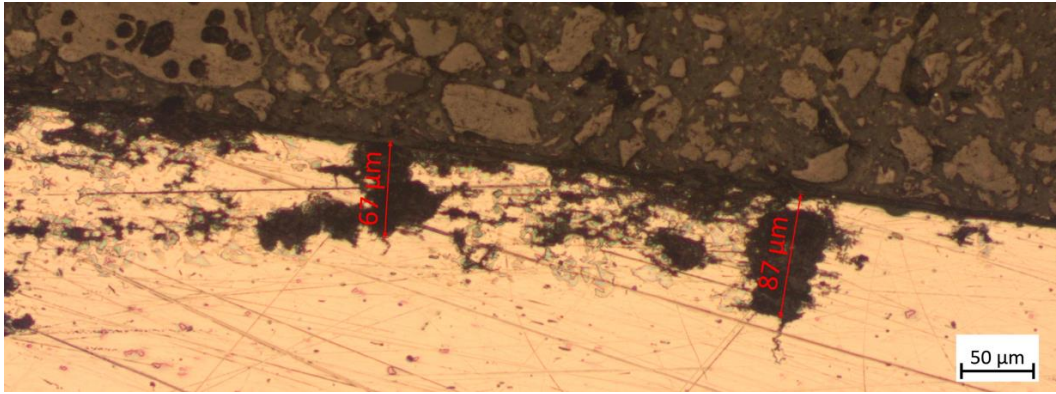


Figure 7(continue).Optical microscope images of metallographic section of the coupons after 10000 hr. in SST  
(D) Coupon 714 (SS304)



- (E) Coupon 832(SS304 +CB)
- (F) Coupon 914 (Al5083)
- (G) Coupon 1014 (Al5083+CB)

H



I

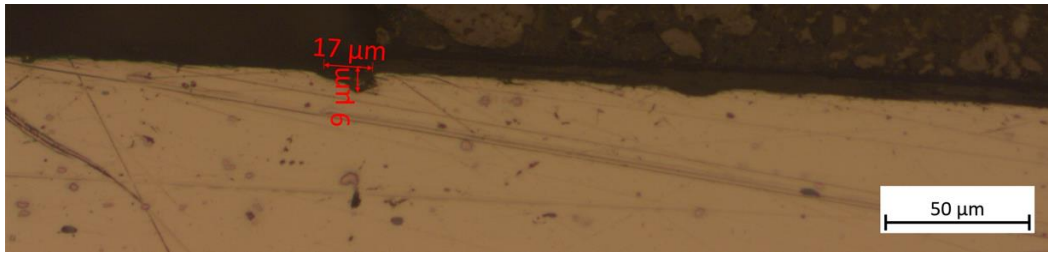
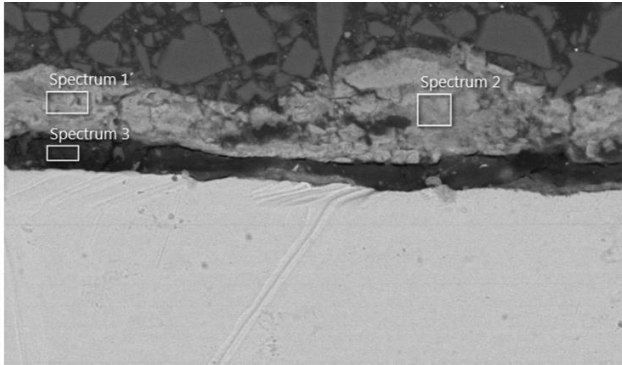


Figure 7(continue). Optical microscope images of metallographic section of the coupons after 10000 hr. in SST

- (H) Coupon 1114 (Al6061-T6 )
- (I) Coupon 1218 (Al6061-T6 +CB)

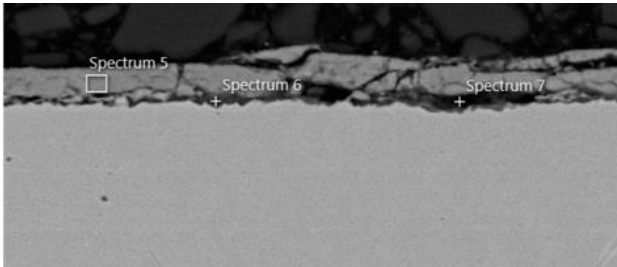


Spectrum 1				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
O	K series	27.67	0.95	56.60
Fe	K series	70.24	0.95	41.16
Si	K series	1.29	0.22	1.50
Cl	K series	0.79	0.16	0.73
Total		100.00		100.00

Spectrum 2				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
O	K series	28.00	0.92	57.17
Fe	K series	70.60	0.93	41.30
Si	K series	0.92	0.22	1.07
Cl	K series	0.49	0.16	0.45
Total		100.00		100.00

Spectrum 3				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
Fe	K series	5.63	0.39	1.44
O	K series	45.81	2.68	41.03
Cl	K series	0.34	0.07	0.14
C	K series	48.00	2.87	57.27
Si	K series	0.22	0.08	0.11
Total		100.00		100.00

**Figure 8. SEM+EDS analysis of metallographic section of the coupons after 10000 hr. in SST  
 (A) Coupon 218 (St37 +CB)**

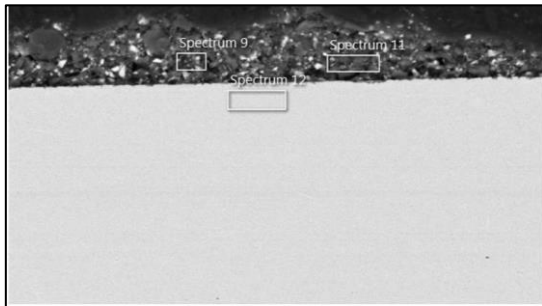


Spectrum 5				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
O	K series	24.60	0.72	53.25
Fe	K series	75.40	0.72	46.75
Total		100.00		100.00

Spectrum 6				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
O	K series	21.57	0.92	47.65
Fe	K series	73.10	0.97	46.26
Si	K series	1.58	0.19	1.99
Ca	K series	0.67	0.10	0.59
Cl	K series	0.35	0.10	0.35
Ba	L series	0.80	0.23	0.20
Na	K series	1.92	0.52	2.95
Total		100.00		100.00

Spectrum 7				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
Fe	K series	84.31	1.27	71.98
Si	K series	10.32	0.58	17.52
Na	K series	4.65	1.28	9.65
Ca	K series	0.71	0.20	0.85
Total		100.00		100.00

**Figure 8 (continue). SEM+EDS analysis of metallographic section of the coupons after 10000 hr. in SST  
 (B) Coupon 318 (St37, Galvanized)**



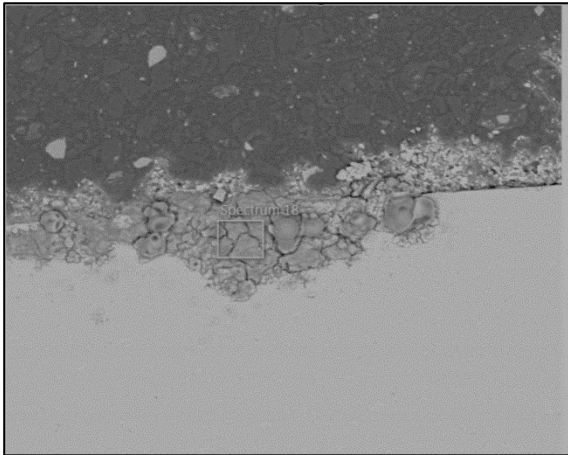
Spectrum 9				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
Al	K series	16.07	0.87	14.49
Si	K series	10.04	0.64	8.70
Ba	L series	21.02	1.09	3.72
O	K series	44.98	2.41	68.39
Fe	K series	2.94	0.34	1.28
S	K series	3.82	0.43	2.90
Cr	K series	1.11	0.25	0.52
Total		100.00		100.00

Spectrum 11				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
O	K series	54.77	0.88	72.70
Al	K series	22.74	0.53	17.89
Si	K series	7.07	0.32	5.35
Ba	L series	10.21	0.39	1.58
Fe	K series	1.90	0.16	0.72
S	K series	2.38	0.23	1.57
Pd	L series	0.92	0.30	0.18
Total		100.00		100.00



Spectrum 12				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
Cr	K series	19.21	0.30	20.18
Fe	K series	70.39	0.45	68.85
Ni	K series	7.72	0.32	7.18
Mn	K series	1.60	0.22	1.59
Al	K series	1.09	0.26	2.20
Total		100.00		100.00

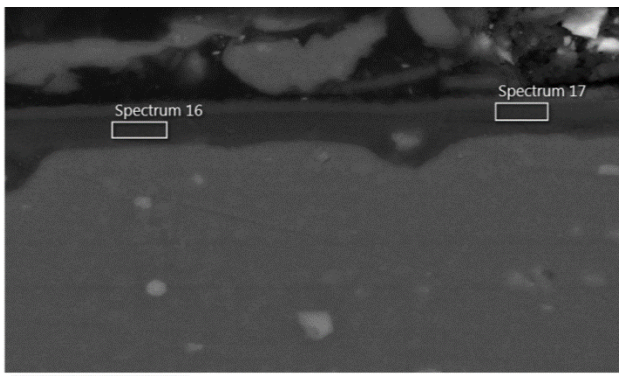
Figure 8 (continue). SEM+EDS analysis of metallographic section of the coupons after 10000 hr. in SST  
(C) Coupon 818 (SS304 +CB)



Spectrum 18				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
O	K series	59.10	0.95	71.39
Al	K series	29.54	0.73	21.16
Cl	K series	5.17	0.28	2.82
Si	K series	3.18	0.30	2.19
Mg	K series	1.76	0.28	1.40
Na	K series	1.25	0.37	1.05
Total		100.00		100.00

8 (continue). SEM+EDS analysis of metallographic section of the coupons after 10000 hr. in SST  
(D) Coupon 1019(A15083 + CB)

b



Spectrum 16				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
O	K series	50.24	0.93	62.88
Al	K series	44.60	0.85	33.09
Cl	K series	1.33	0.15	0.75
Na	K series	2.64	0.32	2.29
Mg	K series	1.20	0.23	0.99
Total		100.00		100.00

Spectrum 17				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
O	K series	54.17	0.92	66.47
Al	K series	42.02	0.86	30.57
Cl	K series	0.83	0.14	0.46
Na	K series	2.06	0.33	1.76
Mg	K series	0.92	0.23	0.74
Total		100.00		100.00

Figure 8 (continue). SEM+EDS analysis of metallographic section of the coupons after 10000 hr. in SST  
(E) Coupon 1218 (Al6061 – T6)