No.KKEA9008

Report on Applicability of Model SSM-21P to the Measurement of Soluble Salts on Steel Surfaces

Feb. 2011

Sumitomo Heavy Industries Environment Co.,Ltd.
Development and Analysis Center

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1. Introduction

SSM-21P is a portable surface salinity meter manufactured by DKK-TOA Corporation. The aim of this test was to evaluate equivalence of SSM-21P for measuring the level of contamination of soluble salts on surfaces to Bresle method as defined by ISO 8502-9 under NACE Standard SP0508-2010.

Dates of Performance Test

From 19th January to 10th February 2011

Location of Testing

Sumitomo Heavy Industries Environment Co.,Ltd.
Development and Analysis Center

2. Materials Used During Test

Steel Panels

Surface Condition A: zinc shop-primer-coated new steel (200x300 mm)
Surface Condition B: non-shop-primed steel rusted to rust grade C in accordance with ISO 8501-1 (200x300 mm)
Surface Condition C: new steel blasted to Sa2.5 in accordance with ISO 8501-1, using aluminum oxide to achieve a surface profile of 50 to 75 μ m (200x300 mm)

Salt Solution

Salt Solution with the following mass ratio of salts was used :
24.3% Na_2SO_4, 22.1% $NaNO_3$, 53.6% NaCl

Glass Panel

A clean flat glass panel was used for the determination of the Bresle patch background contamination.

Ultra Pure Water

RO/de-ionized water which electrical conductivity 0.4 μ S/cm produced using

MILLIOPER Elix and MilliQ, was used for extraction solution.

3. Apparatus

Surface Salinity Meter

Model SSM-21P(S/N 618710) with measurement cell ELC-006(S/N 811K006) manufactured by DKK-TOA Corporation.

ISO 8502-9 Tests

Bresle patch provided by SP Technical Research Center of Sweden

Electrical conductivity meter B-173(S/N 733039) manufactured by HORIBA

4. Procedure

Bresle Patch Background Contamination

The average background Bresle patch contamination was determined by following the test method described in NACE SP0508-2010 Appendix A.

$$\gamma \text{ (patch contamination)} = \gamma \text{ (sample)}_A - \gamma \text{ (extraction solution)}$$

where

γ (patch contamination) = conductivity attributable to patch contamination in μ S/cm

γ (sample)$_A$ = conductivity of the sample solution in μ S/cm

γ (extraction solution) = conductivity of the extraction solution in μ S/cm

Test Condition

The tests were performed at the five conditions listed in table 1.

Table 1 Test conditions

Test Condition	Surface Condition	Target Salt Level (mg/m^2)
1	A	50
2	B	50
3	C	50
4	C	30
5	C	85

Preparation of Steel Panels

50 μ L of Salt solution was dropped at 11 points on each panel using a micro pipet (Eppendorf) and the panels were dried at 55℃ for 30 minutes.

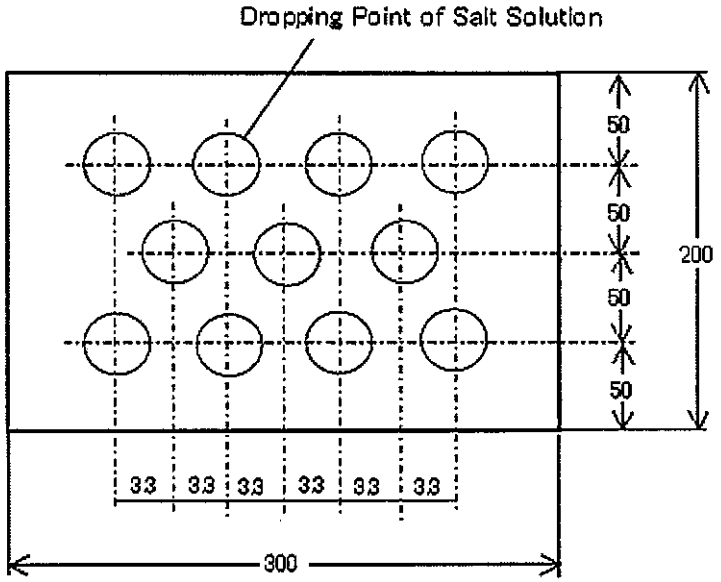

Fig.1 Dropping points of salt solution

Calibration

The Model SSM-21P was calibrated to zero using extraction solution every day and was checked occasionally using standard solution(1.409 mS/cm KCl at 25℃).

The electrical conductivity meter was calibrated every 4 hours using standard solution(1.41 mS/cm KCl at 25℃).

Measuring Method

Model SSM-21P

Set the measurement cell of the Model SSM-21P onto the steel panel to be measured and fill the cell with ultra pure water.

One minutes after, read conductivity and surface salt density.

$\Delta\gamma_c = \gamma(\text{sample})_c - \gamma(\text{extraction solution})$

$\rho_c = 4 \times \Delta\gamma_c + 4$

where

$\gamma(\text{sample})_c$ = conductivity of the sample solution in μ S/cm

γ (extraction solution) = conductivity of the extraction solution in μ S/cm

$\Delta\gamma_c$ is the increase in conductivity in the test solution in μ S/cm

ρ_c is the surface salt density of the salt in mg/m^2

ISO 8502-9 tests

Follow the test method described in NACE SP0508-2010 Appendix A.

$\Delta\gamma_A = \gamma(\text{sample})_A - \gamma(\text{extraction solution}) - \gamma(\text{patch contamination average}) + 6\ \mu$ S/cm

where

$\gamma(\text{sample})_A$ = conductivity of the sample solution in μ S/cm

γ (extraction solution) = conductivity of the extraction solution in μ S/cm

γ (patch contamination average) = conductivity attributable to the average patch contamination in μ S/cm

$$\rho_A = C \times V/A \times \Delta\gamma_A$$

where

ρ_A is the surface salt density of the salt in mg/m^2

C=5.0 kg/m^{2}S (constant)

A=1,250 mm^2 (surface area)

V=3.0 mL (volume of test solution)

$\Delta\gamma_A$ is the increase in conductivity in the test solution in μ S/cm

then

$$\rho_A = 1.2 \times \Delta\gamma_A$$

Test Measurements

Select 2 of 11 points on the panel randomly and measure surface salt density by ISO 8502-9.

Select 5 of remaining 9 points on the panel randomly and measure surface salt density by the Model SSM-21P.

Select 1 of last 4 points on the panel randomly and measure surface salt density by ISO 8502-9.

5. Results

Bresle patch background contamination

Table 2 Bresle patch background contamination

Date	No.	Package No.	Patch contamination [μS/cm]
19th January	1	2	2.0
	2	2	2.0
	3	6	4.0
	4	6	3.0
	5	5	4.0
20th January	6	5	3.0
	7	5	3.0
	8	4	0.0
	9	1	4.0
	10	3	2.0
Average background contamination			2.7

Background contamination of steel panels

Table 3 Contamination Level of Steel Panels (ISO 8502-9)

[μS/cm]

Test condition		1	2	3	4	5
Surface condition		A	B	C	C	C
Panel No.	①	2	7	3	6	6
	②	3	14	5	4	5
	③	5	8	5	2	4
	④	5 , 4	12, 9	5 , 6	3 , 5	4 , 5
Maximum value		14				

The maximum value was 14 μS/cm (i.e. 16.8 mg/m²). Then the maximum contamination level of steel panels was 16.8 mg/m² and was less than 18 mg/m².

Calibration log

Table 4 Calibration log of the electrical conductivity meter B-173

Date	Time	Conductivity before calibration [mS/cm]	Conductivity after calibration [mS/cm]
19th Jan.	17:30	1.40	1.41
20th Jan.	9:05	1.42	1.41
	13:50	1.42	1.41
21st Jan.	9:05	1.42	1.41
	13:30	1.41	1.42
24th Jan.	10:10	1.42	1.41
	14:15	1.43	1.40
3rd Feb.	11:55	1.38	1.41
	13:40	1.41	1.41
7th Feb.	10:45	1.40	1.41
	14:10	1.42	1.41
8th Feb.	9:25	1.38	1.41
	13:30	1.42	1.41
9th Feb.	9:40	1.40	1.41
	13:20	1.42	1.41
10th Feb.	9:20	1.41	1.41
	13:10	1.41	1.41

Table 5 Checking Log of the Model SSM-21P

Date	Time	Conductivity [mS/cm]
19th Jan.	9:05	1.422 at 21.3℃
24th Jan.	10:15	1.404 at 20.5℃
3rd Feb.	11:50	1.413 at 22.0℃
7th Feb.	10:40	1.402 at 23.9℃

The Model SSM-21P should indicate conductivity of standard salt solution ±5% (i.e. between 1.339 and 1.480).

Test Results

Table 6 Test results of Test Condition 1 (Surface Condition A, Target Level 50mg/m²)

Date	Panel	No.	ISO 8502-9		SSM-21P		Bias
			Conductivity [μ S/cm]	Salt Density [mg/m²]	Conductivity [μ S/cm]	Salt Density [mg/m²]	[mg/m²]
20th Jan.	①	1	36.0	47.2	11.1	48.6	
		2	37.0	48.4	11.2	48.7	
		3	37.0	48.4	10.9	47.8	
		4			11.2	48.7	
		5			11.0	48.0	
		R		(1.2)			
		Av.		(48.0)			
21st Jan.	②	6	38.0	49.6	11.1	48.4	
		7	37.0	48.4	11.1	48.4	
		8	36.0	47.2	10.4	45.6	
		9			11.0	48.1	
		10			11.0	47.9	
		R		(1.6)			
		Av.		(48.4)			
	③	11	35.0	46.0	11.1	48.4	
		12	38.0	49.6	11.2	48.8	
		13	37.0	48.4	11.0	47.8	
		14			11.2	48.6	
		15			11.1	48.5	
		R		(2.4)			
		Av.		(48.0)			
24th Jan.	④	16	37.0	48.4	11.1	48.4	
		17	37.0	48.4	11.1	48.3	
		18	36.0	47.2	11.4	49.5	
		19			11.3	49.3	
		20			11.2	48.9	
		R		(1.2)			
		Av.		(48.0)			
Average				48.1		48.3	-0.3
Standard Dev.				1.04		0.78	

Table 7 Test results of Test Condition 2 (Surface Condition B, Target Level 50mg/m²)

Date	Panel	No.	ISO 8502-9		SSM-21P		Bias
			Conductivity [μ S/cm]	Salt Density [mg/m²]	Conductivity [μ S/cm]	Salt Density [mg/m²]	[mg/m²]
20th Jan.	①	21	36	47.2	11.4	49.6	
		22	38	49.6	11.4	49.7	
		23	40	52.0	11.3	49.3	
		24			11.0	48.0	
		25			11.5	49.9	
		R		(4.8)			
		Av.		(49.6)			
21st Jan.	②	26	37	48.4	11.5	49.8	
		27	38	49.6	10.9	47.7	
		28	39	50.8	11.4	49.6	
		29			10.6	46.2	
		30			11.7	50.8	
		R		(2.4)			
		Av.		(49.6)			
24th Jan.	③	31	37	48.4	11.5	49.9	
		32	38	49.6	11.2	48.7	
		33	37	48.4	11.6	50.4	
		34			11.1	48.4	
		35			11.3	49.2	
		R		(1.2)			
		Av.		(48.8)			
	④	36	36	47.2	11.4	49.5	
		37	38	49.6	11.5	49.8	
		38	36	47.2	11.1	47.8	
		39			10.7	46.6	
		40			11.3	49.1	
		R		(2.4)			
		Av.		(48.0)			
Average				49.0		49.0	0.0
Standard Dev.				1.49		1.21	

Table 8 Test results of Test Condition 3 (Surface Condition C, Target Level 50mg/m²)

Date	Panel	No.	ISO 8502-9		SSM-21P		Bias
			Conductivity [μ S/cm]	Salt Density [mg/m²]	Conductivity [μ S/cm]	Salt Density [mg/m²]	[mg/m²]
3rd Feb.	①	41	38	49.6	11.3	49.3	
		42	37	48.4	11.7	50.8	
		43	38	49.6	11.7	50.8	
		44			11.6	50.2	
		45			11.6	50.2	
		R		(1.2)			
		Av.		(49.2)			
7th Feb.	②	46	37	48.4	11.4	49.4	
		47	38	49.6	11.4	49.4	
		48	38	49.6	11.3	49.3	
		49			11.1	48.6	
		50			11.5	50.1	
		R		(1.2)			
		Av.		(49.2)			
	③	51	39	50.8	11.3	49.1	
		52	37	48.4	11.2	48.7	
		53	37	48.4	11.2	49.0	
		54			11.4	49.6	
		55			11.2	49.0	
		R		(2.4)			
		Av.		(49.2)			
8th Feb.	④	56	39	50.8	11.3	49.2	
		57	36	47.2	11.3	49.2	
		58	36	47.2	11.2	48.8	
		59			11.2	48.6	
		60			11.2	48.7	
		R		(3.6)			
		Av.		(48.4)			
Average				49.0		49.4	-0.4
Standard Dev.				1.20		0.68	

Table 9 Test results of Test Condition 4 (Surface Condition C, Target Level 30mg/m²)

Date	Panel	No.	ISO 8502-9		SSM-21P		Bias
			Conductivity [μ S/cm]	Salt Density [mg/m²]	Conductivity [μ S/cm]	Salt Density [mg/m²]	[mg/m²]
8th Feb.	①	61	21	29.2	6.3	29.1	
		62	23	31.6	6.3	29.0	
		63	22	30.4	6.3	29.2	
		64			6.3	29.3	
		65			6.1	28.3	
		R		(2.4)			
		Av.		(30.4)			
	②	66	22	30.4	6.1	28.5	
		67	22	30.4	6.1	28.2	
		68	21	29.2	6.0	28.0	
		69			6.2	28.7	
		70			6.1	28.4	
		R		(1.2)			
		Av.		(30.0)			
9th Feb.	③	71	24	32.8	6.2	28.9	
		72	22	30.4	6.1	28.4	
		73	22	30.4	6.1	28.5	
		74			5.9	27.8	
		75			6.0	28.0	
		R		(2.4)			
		Av.		(31.2)			
10th Feb.	④	76	24	32.8	6.2	28.9	
		77	22	30.4	6.2	29.5	
		78	22	30.4	6.4	29.7	
		79			6.3	29.0	
		80			6.3	29.2	
		R		(2.4)			
		Av.		(31.2)			
Average				30.7		28.7	1.9
Standard Dev.				1.16		0.53	

Table 10 Test results of Test Condition 5 (Surface Condition C, Target Level 85mg/m²)

Date	Panel	No.	ISO 8502-9		SSM-21P		Bias [mg/m²]
			Conductivity [μ S/cm]	Salt Density [mg/m²]	Conductivity [μ S/cm]	Salt Density [mg/m²]	
8th Feb.	①	81	64	80.8	20.7	86.7	
		82	66	83.2	20.6	86.2	
		83	68	85.6	20.9	87.5	
		84			20.9	87.7	
		85			20.5	86.2	
		R		(4.8)			
		Av.		(83.2)			
	②	86	67	84.4	21.0	88.1	
		87	66	83.2	20.9	87.6	
		88	67	84.4	20.8	87.1	
		89			20.9	87.4	
		90			20.9	87.8	
		R		(1.2)			
		Av.		(84.0)			
9th Feb.	③	91	66	83.2	20.8	87.1	
		92	67	84.4	20.6	86.3	
		93	66	83.2	20.7	86.7	
		94			20.7	86.8	
		95			20.6	86.3	
		R		(1.2)			
		Av.		(83.6)			
10th Feb.	④	96	65	82.0	20.9	87.7	
		97	68	85.6	20.8	87.1	
		98	68	85.6	20.7	86.7	
		99			20.4	85.5	
		100			20.7	86.7	
		R		(3.6)			
		Av.		(84.4)			
Average				83.8		87.0	-3.2
Standard Dev.				1.49		0.67	

Table 11 Summary of Test Results

Test Condition	Surface Condition	Target Salt Level [mg/m2]	Item	ISO 8502-9 [mg/m²]	SSM-21P [mg/m²]	Bias [mg/m²]
1	A	50	Range	3.6	3.9	-0.3
			Average	48.1	48.3	
			Std. Dev.	1.04	0.78	
2	B	50	Range	2.8	4.6	0.0
			Average	49.0	49.0	
			Std. Dev.	1.49	1.21	
3	C	50	Range	3.6	2.2	-0.4
			Average	49.0	49.4	
			Std. Dev.	1.20	0.68	
1,2,3	A,B,C	50	Combined Std. Dev.	1.29	1.01	
4	C	30	Range	3.1	1.9	1.9
			Average	30.7	28.7	
			Std. Dev.	1.16	0.53	
5	C	85	Range	4.8	2.6	-3.2
			Average	83.8	87.0	
			Std. Dev.	1.49	0.67	

In the ISO 8502-9 test results of each panel,

the difference between the highest and lowest test results was less than 12 mg/m², the average of the test results was within ±5 mg/m² of the target salt level.

So the ISO 8502-9 measurement was capable and the salt distribution was uniform for each panel.

In the ISO 8502-9 test results of the test conditions,

the standard deviation at 50 mg/m² which was combined test conditions 1,2,3 was less than 5.1 mg/m²,

the standard deviation at 30 mg/m² was less than 5.3 mg.m²,

the standard deviation at 85 mg/m² was less than 5.3 mg/m².

So the ISO 8502-9 measurement was capable and the salt distribution was uniform for the data set.

In the Model SSM-21P test results,

the standard deviation at 50 mg/m^2 which was combined test conditions 1,2,3, was less than 4.8 mg/m^2,

the standard deviation at 30 mg/m^2 was less than 5.3 mg.m^2,

the standard deviation at 85 mg/m^2 was less than 5.3 mg/m^2.

and the bias at each test condition was less than $\pm$4.2 mg/m^2.

So the Model SSM-21P method was deemed equivalent to ISO 8502-9.

6. Conclusion

The Model SSM-21P manufactured by DKK-TOA Corporation was tested to evaluate equivalence for measuring the level of contamination of soluble salts on surfaces in comparison to Bresle method as defined by ISO 8502-9 under NACE Standard SP0508-2010.

The measurement results obtained from the Model SSM-21P were deemed equivalent to those obtained by using the Bresle method.

Hence use of the Model SSM-21P is equivalent to ISO 8502-9.

Tested by Yuko, Yamanouchi

Yuko Yamanouchi

Approved by N. Nakashima

Nobuaki Nakashima

(Certified Environmental Measurer)