Midland Corrosion Services Ltd.

Report Number: 0920

Performance of Hydromix-PG
as tested in accordance to NSF CIAS
Standard Specification
Ref: NSF 2102

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1. Introduction

Midland Corrosion Services Ltd. has been certified by NSF Wales as an approved laboratory for carrying out the NSF CIAS Performance test for chemical inhibitors for use in central heating systems.

NSF Wales has supplied two 5 Litre plastic containers of Hydromix (ref: NSF 2102) for evaluation of its performance according to the NSF CIAS Performance Test for the performance of chemical inhibitors for use in domestic hot water central heating systems (version February 2017). The requested in-use concentration was 50% v/v (500ml) to 1 litre.

2. Tests Carried out

2.1 Corrosion Rate Determination

The corrosion test in both modified standard hard and modified standard soft water were carried out according to the NSF CIAS test – Section 1. Metal coupons were obtained from European Corrosion Supplies Ltd together with analysis certificates.

The NSA CIAS modified standard hard water was made using Evian bottled water together with added analytical grade reagents. The NSF CIAS modified standard soft water was made using AquaPura together with an added analytical reagent.

Monitoring of stirrer speeds (Vos 14 overhead stirrers), gas bubbling and cell temperature was carried regularly during the test. No interruptions or deviations from the test method were noted during either of the 14 day test.

The test was run for 336 hours in modified Hard and Soft Water (02/01/2019 – 16/01/2019) in 8 cells.

2.2 Scaling Determination

A recommended in-use concentration of Hydromix was made up in NSF CIAS standard hard water (bottled Evian water). Six glass cells were filled with 1 litre of this solution each and a freshly prepared stainless steel heater sheath and assembly was fitted to each cell. The solution was heated to 82°C +/- 2.0°C using the internal 150W heating elements for 168 hours (1 week). The temperature control box and platinum resistance thermometers were calibrated using a reference thermometer immediately before the start of the test.

After the end of the test, the heater sheaths were dried and photographed. The solution was allowed to stand for at least 30 minutes, before following the procedure as laid down in the February 2017 standard for the determination of the calcium concentration and Calcium Balance in the solution. All required samples were sent to DETS (UKAS accredited analysis laboratory) for calcium analysis (see Appendix 2).

2.3 Compatibility with Non-Metallic Materials

Rubber test pieces were cut from certified test sheets obtained from Clywd Compounders Ltd. The volume of each rubber test piece was determined before and after immersion in the test solution by weighing the pieces in air and in demineralised water using the Mettler Toledo analytical balance.

The eight rubber test pieces (4 of each rubber) were immersed individually in glass bottles containing 100ml of double the suggested concentration (i.e. 100%) of the product provided. The bottles were placed in a calibrated Genlab recirculating oven at 82 +/- 1°C for 336 hours. At the end of the test, the rubbers were inspected for any signs of deterioration, using a stereo zoom microscope.

3. Results

3.1 Corrosion Rate Determination

Each coupon was weighed after the test and after cleaning in the recommended acidic cleaning solutions using the 5-figure Mettler Toledo analytical balance. By plotting the results on a graph, corrected weight losses adjusting for any metal losses due to cleaning were obtained.

The corrosion rates derived from the corrected weight losses are shown in Appendix 1. The mean corrosion rates for all five metals were below the corrosion rate limits as specified in the NFS CIAS standard in both hard and soft water.

The appearance of the coupons after testing is shown in the plates at the end of the report.

3.2 Scaling Tendency

The photographs of the heater sheaths with any scale deposited taken after the seven day test are shown at the end of the report. The scaling tendency data was collected from the Scaling Tendency Calculation Spreadsheet (Appendix 2). The spreadsheet will work out the required results of calcium concentration. The reduction in calcium ion concentration is shown in the Appendix 2. Hydromix had achieved the arithmetic mean (M4) of -1.62 % calcium ion reduction which is within the 15% limit set in the standard.

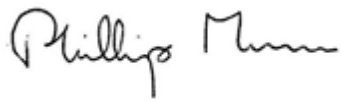
3.3 Compatibility with Non-Metallic Materials

The results given in Appendix 3 show the volume swells on all EPDM rubbers and NBR rubber after immersion in double the concentration of HYDROMIX in ‘standard soft water’ e.g. 100% Hydro-mx-PG. The change in volume on any of the 4 rubbers in the Hydromix solution was between +0.97% and – 1.89% and was therefore well within the limits set in the standard. Therefore, the Hydromix sample submitted passed the rubber swell part of the test.

4. Conclusions

Hydromix inhibitor (formulation ref. NSF 2102), has been tested at the recommended in-use strength of 50% v/v and at 2 x this concentration for rubber compatibility testing, in the NSF CIAS industry standard specification for the performance of chemical inhibitors for the use in domestic hot water central heating system.

The mean corrosion rates were below the limits for all five metals in both hard and soft water. The product also passed on the requirements for both scaling tendency and rubber swell. Therefore, the product supplied meets the requirements of the NSF-CIAS test.



Signed

Date: 30 January 2019

Images of Coupons after Testing

Inhibitor: Hydromx PG

Natural aeration, 50 % v/v in mod.HW

Tested: 02/01/2019 – 16/01/2019

Bundles 3 and 4

Midland Corrosion Services Ltd.

Inhibitor: Hydromx PG

Forced aeration, 50 % v/v in mod.SW

Tested: 02/01/2019 – 16/01/2019

Bundles 5 and 6

Midland Corrosion Services Ltd.

Inhibitor: Hydromx PG

Natural aeration, 50 % v/v in mod.SW

Tested: 02/01/2019 - 16/01/2019

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Bundles 7 and 8

Section 1. General Corrosion Rate

- **Appendix 1**
- Batch Reference: L31 19:05 and LX 8152
- Supplier of coupons: European Corrosion Supplies
- Water Analysis: DETS 19-00236
- Water Source: Evian bottled water and AquaPura bottled water
    - made up: 02/01/2019
- Water Dilution: 50% v/v
- Test Dates: 02/01/2019 – 16/01/2019

- **Absolute Corrosion Rate**

Section 1 - Corrosion Rate Determination

Product: Hydromix PG
Concentration: 50% v/v

Metal	Absolute corrosion rate (mm/yr) Hard Water Air Sparging		Hard Water Natural aeration		Soft Water Air Sparging		Soft Water Natural aeration	
	Bundle 1	Bundle 2	Bundle 3	Bundle 4	Bundle 5	Bundle 6	Bundle 7	Bundle 8
Stainless Steel	0.0007	0.0004	0.0008	0.0007	0.0009	0.0010	0.0010	0.0009
	Average:	**0.0005**	**Average:**	**0.0007**	**Average:**	**0.0009**	**Average:**	**0.0009**
Copper	0.0039	0.0043	0.0046	0.0038	0.0050	0.0039	0.0039	0.0039
	Average:	**0.0041**	**Average:**	**0.0042**	**Average:**	**0.0044**	**Average:**	**0.0039**
Extruded aluminium	0.0090	0.0499	0.0036	0.0050	0.0284	0.0323	0.0276	0.0205
	Average:	**0.029**	**Average:**	**0.004**	**Average:**	**0.030**	**Average:**	**0.024**
Brass	0.0037	0.0040	0.0044	0.0033	0.0043	0.0036	0.0041	0.0042
	Average:	**0.0038**	**Average:**	**0.0039**	**Average:**	**0.0040**	**Average:**	**0.0042**
Mild Steel 1/	0.0019	0.0022	0.0038	0.0050	0.0026	0.0347	0.0030	0.0029
2/	0.0043	0.0067	0.0036	0.0031	0.0029	0.0099	0.0029	0.0029
	Average:	**0.004**	**Average:**	0.004	**Average:**	**0.013**	**Average:**	0.003

Taken from NSF CIAS Test Standard - Feb 2017

1.7.1 Absolute Corrosion Rate

The absolute corrosion rate of the metals shall not exceed those specified in Table 4.

Metal	Corrosion Rate mm/year			
	Modified Standard Hard Water, air sparging	Modified Standard Hard Water, natural aeration	Modified Standard Soft Water, air sparging	Modified Standard Soft Water, natural aeration
Mild steel	0.040	0.040	0.040	0.040
Copper	0.005	0.005	0.005	0.005
Extruded Aluminium	0.100	0.100	0.100	0.100
Brass	0.005	0.005	0.005	0.005
Stainless steel	0.002	0.002	0.002	0.002

Table 4. Maximum corrosion rates for metal coupons

Pitting Density

Additional notes:	
Disruptions / equipment failure? **None**	Date: 16/01/2019
Detail:	

	Number of Pits: none							
	Hard water, air sparging		Hard water, natural aeration		Soft water, air sparging		Soft water, natural aeration	
Metal	Coupon bundle 1	Coupon bundle 2	Coupon bundle 3	Coupon bundle 4	Coupon bundle 1	Coupon bundle 2	Coupon bundle 3	Coupon bundle 4
Mild steel (1) (2)	none	none	none	none	none	none	none	none
	none	none	none	none	none	none	none	none
	Average: none		Average: none		Average: none		Average: none	
Copper	none	none	none	none	none	none	none	none
	Average:		Average:		Average:		Average:	
Extruded aluminium	none	none	none	none	none	none	none	none
	Average: none		Average: none		Average: none		Average: none	
Brass	none	none	none	none	none	none	none	none
	Average: none		Average: none		Average: none		Average: none	
Stainless steel	none	none	none	none	none	none	none	none
	Average: none		Average: none		Average: none		Average: none	

Appendix 2 NSF CIAS Scaling Tendency
Laboratory Reference of Heater Sheath Used: '/', '//', '/// ', ' , '' and '''
Water Analysis: DETS 19-00236
Water Source: Evian Bottled L31 09:05
Water Dilution Required: 50% v/v
Test Start: 11/12/2018
Test End: 18/12/2018

Scaling Tendency

Inhibitor:
HydromixPG

Sample Prep Dosage (%)	**50**					
Evian Water Batch Code	**L31 09:05**	**Evian Batch Ca Concentration**		**80.0**	**mg L^{-1}**	

	C1	***C2***	***C3***	**Calcium Ion Reduction *C1-C2*** (Corrected)	**% Calcium Ion Reduction**	**Balance** ***C3*+0.1*(C2)** (Corrected)	**Calcium Balance % Change**
	Initial Calcium Conc	**Final Calcium Conc**	**Total Calcium Conc**				
Cell	**mg L^{-1}**	**mg L^{-1}**	**mg L^{-1}**	**mg L^{-1}**	**%**	**mg L^{-1}**	**%**
1		22.0	26.0	9.18	29.14	28.8	-7.2
2		33.0	33.0	-2.04	-6.48	37.0	19.4
3	31.0	31.0	31.0	0.00	0.00	34.8	12.2
4		31.0	33.0	1.02	3.24	36.8	15.1
5		33.0	30.0	-1.02	-3.24	34.0	6.1
6	32.0	36.0	36.0	-4.08	-12.95	40.4	26.2
Average *C1*	**31.5**			Arithmetic Mean *(M6)*	1.62		**12.0**
				Arithmetic Mean *(M4)*	**-1.62**		
					PASS		

	Analysis Result 1	Analysis Result 2	Average	Average *C1* Value (corrected)	Confidence %
Evian Raw Water (mg L^{-1} Ca)	79.8	78.8	79.3	47.3	59.6

Analysis QC Check	**99.1**	PASS

Appearance of Heater Sheaths after scaling test Cells 1-6

Compatibility with non-metallic materials

Appendix 3
Supplier of Rubber, batch ref: Clwyd Compounders, Ref: 147445

Water Analysis: DETS

Test Start: 18/12/2018
Test End: 02/01/2019

Non-metallic material	% change in volume of samples in control test (synthetic soft water)		% change in volume of samples in test solution, with Hydromx PG		% change in volume – control vs. Hydromx PG	Visual inspection notes
	Set 1	Set 2	Set 1	Set2		
EPDM 70, resin-cured	2.67	2.82	-7.25	3.47	-4.63	OK
	Average: 2.74		Average: -1.89			
EPDM 70, peroxide-cured	1.47	1.48	0.89	0.97	-0.55	OK
	Average: 1.47		Average: 0.93			
EPDM 70, sulphur-cured	0.57	0.60	-0.42	-0.35	-0.97	OK
	Average: 0.58		Average: -0.38			
NBR 70, peroxide-cured	11.8	12.1	3.53	-7.2	-13.79	OK
	Average: 11.95		Average: -1.83			

Images of received container (sealed)