

Detection of Trace Elements in Steel Piping and Components Susceptible to FAC Using HH XRF

Introduction

Flow Accelerated Corrosion (FAC) is primarily an electrochemical process that causes wall thinning of carbon steel components exposed to flowing water or wet steam. FAC has caused several failures in piping systems in nuclear power plants and other types of fossil and industrial steam applications. Studies have shown that increasing the chromium content in carbon steel to the allowable ASTM/ASME limit can reduce FAC rates as much as 50 percent. Systems susceptible to FAC (ex. A106 Gr. B) when replaced with materials of higher levels of Cr & Mo show an even greater reduction in corrosion rate (ex. ASTM A335 Gr. P11/P22).



Test Method & Results

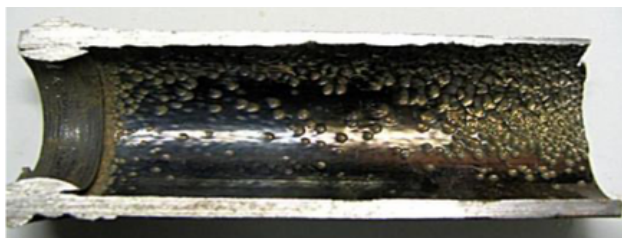
Certified reference standards that represent trace elements commonly found in carbon steels were selected, analyzed, and evaluated against the known values respectively. Figure 1 offers the correlation between the certified results and the measured results for the SciAps X-550 analyzer. The coefficient of determination (R^2) value is a measure of how closely the data sets correlate with each other. The given data would suggest the agreement between the X-550 test results and the certified NIST traceable values for each reference sample to be in excellent agreement with $R^2 = 0.99$. Measurements were taken at 10 seconds for each consecutive test, and increasing measurement time could further improve performance in terms of sensitivity and precision.



Effect of alloy composition on relative FAC rate

Type		Cr	Cu	Mo	FAC Rate
Carbon Steel	ASTM A106	0.02	0.13	0.005	100
Carbon Steel	ASTM A106	0.04	0.13	0.005	54
Carbon Steel	ASTM A106	0.02	0.26	0.005	84
Carbon Steel	ASTM A106	0.02	0.13	0.01	87
Carbon Steel	ASTM A106	0.2	0.13	0.005	13
Cr-Mo Steel	ASTM 335 - P11	1.2	0.05	0.65	1.3
Cr-Mo Steel	ASTM 335 - P22	2.45	0.05	1.13	0.6
Stainless Steel	ASTM A312 - 304	18.3	0.07	0.12	0.14

Effective sample preparation is critical to achieving reliable results. It is important that any scale, rust, paint, etc. be removed from the surface of the sample exposing the XRF to clean bare metal for a proper analysis. It is also important to note that if performing analyses at elevated temperatures, the surface of the metal will oxide at a rate proportional to the surface temperature. Periodic checks of certified reference standards is a good engineering practice.



Measurement	Chromium	Molybdenum	Copper
1	0.034	0.043	0.049
2	0.032	0.045	0.050
3	0.033	0.044	0.050
4	0.031	0.044	0.048
5	0.032	0.043	0.052
6	0.031	0.045	0.051
7	0.031	0.044	0.051
8	0.034	0.044	0.049
9	0.030	0.045	0.050
10	0.032	0.044	0.051
Average	0.032	0.044	0.050
Certified Value	0.034	0.043	0.055
STDEV	0.001	0.001	0.001

Conclusion

SciAps X-505/X-550 handheld portable X-ray fluorescence (XRF) analyzer with its lower detection limits and fast analysis time is an ideal tool to accurately measure the trace levels of specific elements such as chromium, molybdenum, copper, etc. that may be significant corrosion indicators. The X-505/X-550 analyzers provide reliable performance and sensitivity for FAC and other applications in nuclear power and fossil fuel facilities. Given appropriate sample preparation, these analyzers can accurately measure Cr levels <0.01% in Fe matrix. Extending measurement time will reduce the detection limits by the square root of the increased analysis time.

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