Stainless Steel Performance Characteristics

Using the Niton Apollo Handheld LIBS Analyzer

Introduction

The Thermo Scientific™ Niton™ Apollo™ handheld LIBS analyzer is built for your most demanding applications. When low detection limits and high sample throughput are critical, the Niton Apollo's combination of hardware and software provides you with solutions designed to meet your most difficult analytical requirements. Featuring an effective laser and high purity argon purge, the Niton Apollo accurately measures carbon in about 10 seconds. Weighing just 6.4 lbs. (2.9 kg.), the Niton Apollo transforms a traditional laboratory, or cart mounted Optical Emission Spectroscopy (OES) system, into a highly portable handheld analyzer.

The Importance of Sample Preparation

Good sample preparation is essential to obtaining reliable results when using the Niton Apollo. Trace amounts of contaminants, such as paint, grease or scale may yield unreliable outcomes. This is because the Niton Apollo uses a laser to ablate the surface of the sample. When this occurs, only a small portion of the sample (a few nanograms) is removed. If the surface is diluted, then there is not a representative sample of the metal to provide accurate results.

Instrument Performance

The results listed are obtained from well-prepared samples and are an indication of the best performance to be expected from the Niton Apollo. Accuracy and precision are typical ways of determining instrument performance. Accuracy describes how close the read values (concentration) are to the certified or true value. Precision is an indication of how close multiple readings are to one another on any given sample.

Accuracy is dependent on the calibration of the instrument and sample preparation. Precision is dependent on both the instrument performance in terms of stability and equally on the homogeneity of the sample analyzed. Due to the small amount of material being ablated, spot to spot variation can occur increasing (worsening) the measured precision. It is highly recommended to perform at least three (3) or more analysis and average the results. Users may also delete questionable burns if they occur.

The Niton Apollo in use, verifying incoming materials.

Accuracy and Reproducibility

Instrument performance has been assessed using a multiple instrument comparison method (average of six (6) readings from sixteen (16) instruments) demonstrating typical accuracy and average recovery (an indication of closeness to true value). Table 1 illustrates that the Niton Apollo provides excellent accuracy and high reproducibility across each analyzer for elements of interest in stainless steels.

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Sample SPL-LA-2d										
Instrument	**C**	**Mn**	**Cr**	**Ni**	**Mo**	**Cu**	**Si**	**Ti**	**V**	**W**
1	0.563	0.912	24.725	4.183	2.427	0.340	0.321	0.022	0.201	0.217
2	0.556	0.927	23.301	5.237	2.449	0.323	0.317	0.089	0.240	0.205
3	0.548	1.016	22.575	4.970	2.405	0.341	0.344	0.028	0.223	0.275
4	0.482	0.906	24.344	4.624	2.496	0.320	0.325	0.037	0.260	0.191
5	0.587	0.899	24.679	4.551	2.491	0.347	0.326	0.038	0.269	0.231
6	0.491	0.935	23.768	5.135	2.540	0.342	0.297	0.023	0.248	0.216
7	0.486	1.045	23.990	4.814	2.380	0.362	0.303	0.021	0.220	0.223
8	0.521	0.966	24.685	4.352	2.573	0.348	0.295	0.024	0.204	0.210
9	0.501	1.019	23.438	4.640	2.509	0.359	0.318	0.029	0.231	0.197
10	0.554	1.009	22.850	4.543	2.512	0.343	0.313	0.080	0.261	0.237
11	0.427	0.992	24.121	4.443	2.473	0.347	0.295	0.015	0.237	0.241
12	0.496	1.015	24.192	4.808	2.376	0.373	0.318	0.060	0.232	0.080
13	0.579	0.979	22.147	4.712	2.577	0.361	0.319	0.014	0.259	0.234
14	0.539	0.927	23.816	4.594	2.451	0.352	0.325	0.049	0.239	0.244
15	0.509	0.995	23.928	5.115	2.461	0.364	0.313	0.067	0.241	0.210
16	0.513	0.919	23.916	4.414	2.388	0.333	0.303	0.040	0.256	0.231
Average	0.522	0.966	23.780	4.696	2.469	0.347	0.314	0.040	0.239	0.215
Certified Value	0.480	0.990	23.40	4.260	2.410	0.388	0.292	0.039	0.264	0.210
Avg. % Recovery	108.7	97.6	101.6	110.2	102.5	89.5	107.7	101.8	90.4	102.4

Table 1

Stability

Challenging to stainless steel analysis is the wide variability in elemental concentrations when compared to the low alloy family of steels. Low alloy steels have at least 90% iron and are alloyed with 10% other elements, such as carbon, chromium, nickel, molybdenum, silicon and aluminum. By comparison, stainless steel compositions vary broadly, with iron compositions of as little as 50% and alloying elements such as chromium and nickel (for example) ranging from nearly zero to about 30%.

The Niton Apollo has been designed to accommodate the demanding needs for stainless steel analysis with excellent accuracy and precision (variability) at low and high concentrations of alloying elements. Shown to the right in Charts 1 & 2 are stability graphs for chromium at concentrations of 0.745% and 23.4%, respectively. Data for each was collected on two (2) Niton Apollo analyzers for approximately 1.5 hours using certified stainless steel materials.

Detection Limits

Typical maximum limits of detection (LODs) in ppm for stainless steel samples (Table 2). Results may vary from alloy to alloy.

Stainless Steel Differentiation – L and H Grade

Carbon is the most important alloy ingredient in all families of stainless steels. Carbon in steels controls many physical properties, including hardness, strength, weldability and

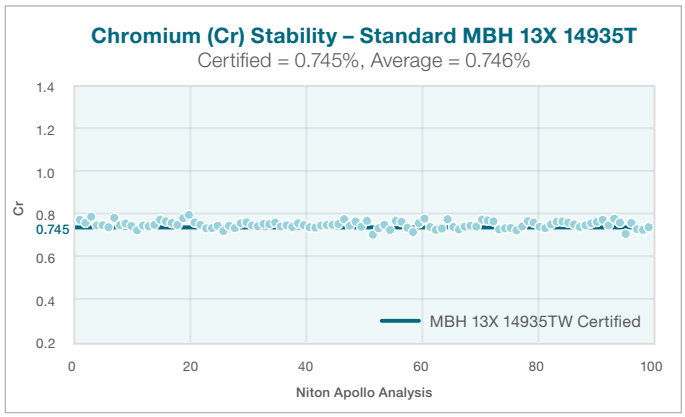

Chart 1

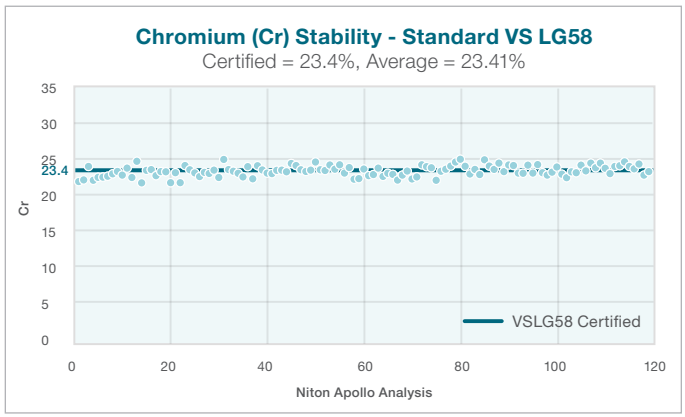

Chart 2

brittleness. Correct identification of stainless steels in the field can indicate the appropriate grade to be used for your specific application or for design remediation. Of great importance in stainless steel analysis is the ability to differentiate between L and H grades. Low grade stainless steels contain < 0.03% carbon, while those with concentrations above this are considered High grade stainless steels.

The Niton Apollo accurately separates L and H grade stainless steels. Chart 3 shows typical carbon readings from the Niton Apollo for several L-Grade and H-Grade stainless steels. For each steel sample, 20 readings were taken. The mean of the readings are shown as solid dots with certified values displayed in parenthesis beside the name of each sample on the x-axis. The data indicates good accuracy above and below the L and H grade boundary, shown as 0.03% on Chart 3.

Summary

The Niton Apollo handheld LIBS analyzer rapidly and accurately determines major and minor alloy elements in stainless steel across a wide range of concentrations. The Niton Apollo is capable of accurately differentiating between L and H grade stainless steels, critical to safety and material compatibility considerations in manufacturing environments. Field users can safely and easily analyze pipes in situ without heavy equipment, using the real-time data display for accurate decision making.

Element	LOD
C	150
Mn	1320
Cr	70
Ni	800
Mo	1150
Cu	200
Si	275
Ti	175
V	65
W	800
Al	700
Co	1120
Nb	650

Table 2

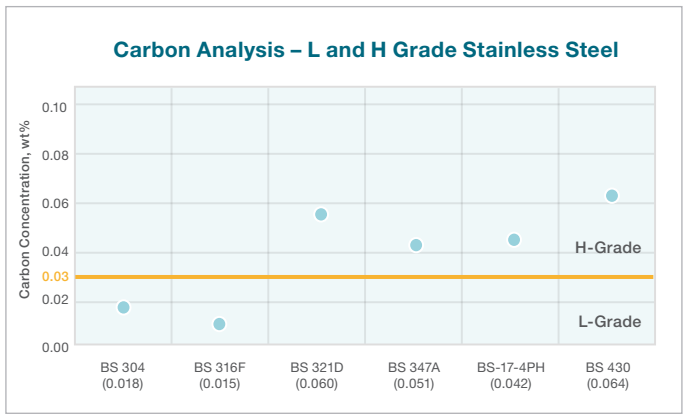

Chart 3

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