Application Note

Instrument: GDS900

Bulk Analysis of Stainless Steels (Corrosion and Heat-Resistant Steels)

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Key Words: Stainless Steels, Corrosion, Heat-Resistant, Steels, GDS900 Atomic Emission Spectrometer

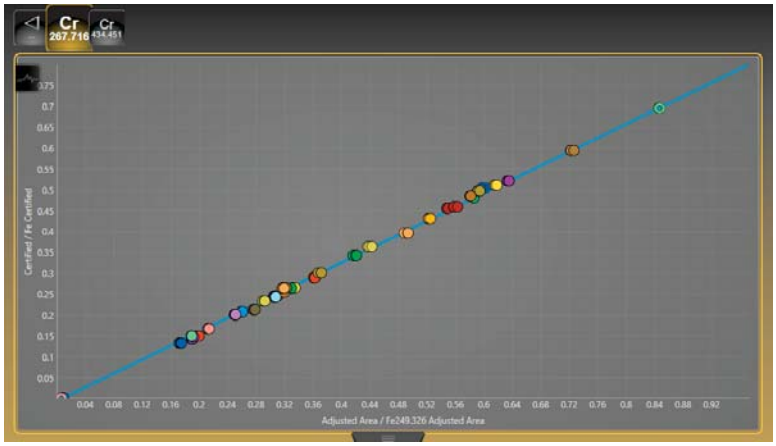
Introduction

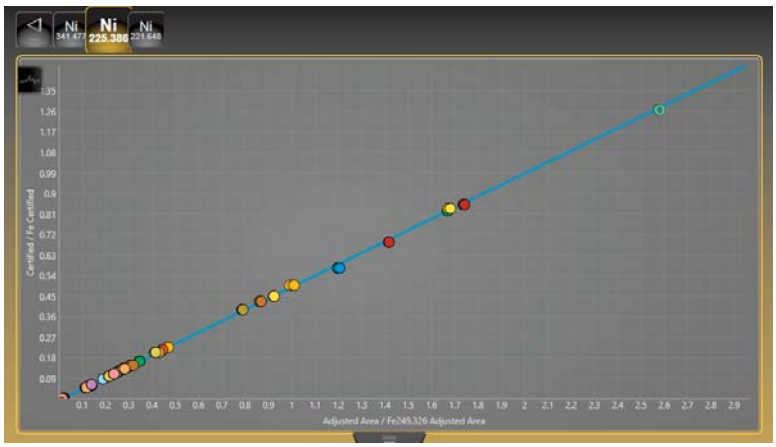
Stainless steels comprise a large group of ferrous-based alloys offering a wide range of corrosion- and heat-resistant properties. This wide range of properties makes stainless steels very versatile. Each grade of stainless steel has a known set of physical characteristics that are directly related to the levels of alloying constituents present in the material. The two defining alloying elements are Cr and Ni, but components such as C, Mn, Mo, and Cu are also relevant.

Chemical composition can be used as a basis for classifying stainless steels. The stainless steel producer must control alloying composition of the heat to be sure it meets specification, and thereby have the desired corrosion- and heat-resistant properties of the target grade. Expensive alloying ingredients are added to bring the heat into grade based upon the chemical analysis of the raw material. Control of the composition therefore offers a way of controlling cost. Manufacturers that use stainless steel in their products should also verify the material before it is used in the final product. If the stainless material is out of specification then it will not hold up under the specific environment that it was intended for, and premature failure of the product could result.

The LECO GDS900 is an atomic emission spectrometer that determines the elemental content of solid conductive materials by measuring the intensity of characteristic light emitted from the sample when excited. The glow discharge source uniformly removes (sputters) material from the sample surface, outperforming other excitation sources. Excitation of the atoms occurs in the glow discharge plasma discretely apart from the sample surface thereby reducing the metallurgical and chemical history inherent in all samples. Neutral atomic emission lines predominate the glow discharge spectra. While singly ionized transitions are observed in the glow discharge, the spectra are notably less complex than those produced by most other atomic emission techniques, resulting in few spectral interferences. In addition, the response of the typical glow discharge analytical line is linear and thus fewer wavelengths are required to determine the full range of concentrations.

The GDS900 offers you state-of-the-art technology designed specifically for routine elemental determination in most ferrous and nonferrous materials. LECO's exclusive CCD-based design ensures measurement stability, flexibility, and analytical performance in a production environment.





Sample Preparation

Stainless steels are prepared using a 120-grit zirconium oxide belt or wet disk.

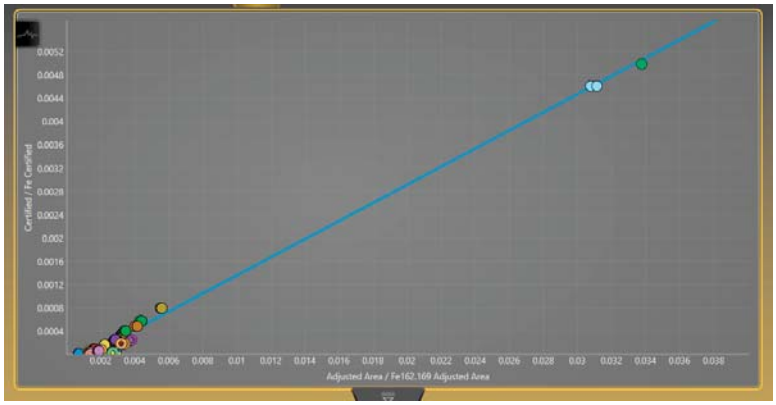
Accessories

Sample surface preparation: Belt Grinder (LECO BG) or polisher (LECO PX).

Calibration Curves

GDS calibration curves are inherently linear over a large concentration range. The chromium and nickel curves show a very good fit through all the various grades of stainless.

The sulfur curve demonstrates the glow discharge lamp's advantage over other sources when analyzing volatile species. The GDS source does not melt the sample surface. Another significant advantage over other spectrographic sources is that the lamp is not contaminated, resulting in no carry-over from one sample type to another.



Calibration Standards

A factory-installed stainless steel calibration is offered based upon specific customer requirements. Working curves are comprised of Certified Reference Materials (CRM's) and Reference Materials (RM's), and may include standards from the following manufacturers: Brammer, ARMI, NIST, and MBH. Customer-supplied calibration pieces are useful to complement the calibration.

Drift Control of Calibration

Homogenous non-certified set-up standards (SUS's) are used to drift correct calibration curves. When necessitated by customer ranges or lack of suitable SUS material, RM's and CRM's can be substituted.

Analysis Times

The LECO GDS900 has the ability to perform multiple analyses without dropping the sample. This is possible due to the sputtering away of material constantly revealing new untouched sample for each analysis. Three analyses can be completed in ninety seconds (compared to seventy seconds for one analysis) when using the "analyze all in one spot" option in the software.

	Single Burn	Three Burns w/o Dropping
Start-up and Pre-burn	60 s	60 s
Analyze	10 s	10 s
Analyze		10 s
Analyze		10 s
Total	**70 s**	**90 s**

Typical Analysis Results

PRECIPITATION HARDENED STAINLESS STEEL GRADE 17-4PH: BRAMMER BS 17-4PHB

ELEMENT	CERT	AVG	STDEV	RSD	Run #1	Run #2	Run #3
Fe	74.81	74.94			74.93	74.96	74.92
Al	0.035	0.033	0.0001	0.2	0.0326	0.0325	0.0327
B	0.0036	0.0039	0.0002	4.4	0.0040	0.0037	0.0040
C	0.042	0.039	0.0005	1.4	0.0397	0.0386	0.0389
Co	0.040	0.043	0.001	1.6	0.043	0.042	0.043
Cr	15.60	15.68	0.05	0.3	15.66	15.65	15.74
Cu	3.35	3.30	0.02	0.5	3.31	3.30	3.28
Mn	0.56	0.54	0.003	0.6	0.542	0.537	0.543
Mo	0.11	0.11	0.0004	0.3	0.1143	0.1136	0.1139
Nb	0.31	0.31	0.002	0.6	0.314	0.312	0.310
Ni	4.53	4.47	0.02	0.4	4.48	4.47	4.45
P	0.021	0.021	0.0002	1.0	0.0210	0.0209	0.0213
S	0.024	0.021	0.0002	0.9	0.0210	0.0213	0.0214
Si	0.42	0.41	0.001	0.3	0.407	0.407	0.409
V	0.059	0.063	0.001	1.3	0.064	0.064	0.063

AUSTENITIC STAINLESS STEEL GRADE 347: BRAMMER BS 347B

ELEMENT	CERT	AVG	STDEV	RSD	Run #1	Run #2	Run #3
Fe	69.99	69.66			69.70	69.79	69.48
B	0.0036	0.0044	0.0002	5.5	0.0044	0.0042	0.0047
C	0.051	0.055	0.001	2.0	0.055	0.054	0.056
Co	0.050	0.056	0.001	1.7	0.055	0.056	0.057
Cr	17.24	17.42	0.06	0.3	17.37	17.41	17.48
Cu	0.15	0.15	0.002	1.1	0.155	0.153	0.156
Mn	1.57	1.59	0.01	0.9	1.60	1.57	1.59
Mo	0.38	0.38	0.002	0.6	0.384	0.380	0.384
Nb	0.71	0.77	0.03	3.7	0.77	0.73	0.79
Ni	9.16	9.30	0.07	0.8	9.30	9.24	9.38
P	0.028	0.029	0.001	5.1	0.029	0.028	0.031
S	0.026	0.024	0.002	6.8	0.024	0.022	0.026
Si	0.51	0.50	0.003	0.6	0.496	0.499	0.502
V	0.040	0.042	0.0002	0.5	0.0420	0.0419	0.0423

FERRITIC STAINLESS STEEL GRADE 410: BRAMMER BS 410B

ELEMENT	CERT	AVG	STDEV	RSD	Run #1	Run #2	Run #3
Fe	87.07	86.89			86.93	86.88	86.85
C	0.13	0.14	0.001	0.4	0.139	0.140	0.138
Cr	11.58	11.78	0.04	0.3	11.74	11.79	11.82
Cu	0.090	0.084	0.001	0.8	0.084	0.084	0.085
Mn	0.38	0.37	0.002	0.5	0.376	0.375	0.372
Mo	0.077	0.072	0.0004	0.5	0.0724	0.0717	0.0722
Ni	0.26	0.27	0.001	0.5	0.266	0.264	0.265
P	0.018	0.016	0.0001	0.7	0.0156	0.0157	0.0158
S	0.0030	0.0043	0.0001	1.6	0.0042	0.0043	0.0043
Si	0.30	0.30	0.002	0.6	0.298	0.301	0.298
V	0.038	0.040	0.001	1.4	0.039	0.039	0.040

AUSTENITIC STAINLESS STEEL GRADE 316L: BRAMMER BS Ca316-4

ELEMENT	CERT	AVG	STDEV	RSD	Run #1	Run #2	Run #3
Fe	66.49	66.28			66.37	66.27	66.21
C	0.018	0.019	0.0003	1.8	0.0188	0.0191	0.0195
Co	0.24	0.23	0.002	0.7	0.225	0.226	0.228
Cr	17.60	17.77	0.09	0.5	17.73	17.71	17.87
Cu	0.42	0.44	0.003	0.6	0.437	0.441	0.436
Mn	1.43	1.44	0.006	0.4	1.446	1.441	1.435
Mo	2.03	2.00	0.005	0.2	2.002	2.005	1.996
Ni	11.00	11.13	0.06	0.6	11.08	11.20	11.11
P	0.028	0.030	0.0005	1.5	0.0294	0.0303	0.0301
S	0.027	0.023	0.0004	1.9	0.0229	0.0238	0.0234
Si	0.46	0.47	0.003	0.5	0.472	0.477	0.476
V	0.054	0.056	0.001	1.9	0.057	0.057	0.055
W	0.060	0.056	0.002	3.0	0.058	0.055	0.055

AUSTENITIC FREE MACHINING STAINLESS STEEL GRADE 303: BRAMMER BS303

ELEMENT	CERT	AVG	STDEV	RSD	Run #1	Run #2	Run #3
Fe	70.73	70.27			70.23	70.27	70.30
C	0.044	0.051	0.0004	0.9	0.0510	0.0504	0.0502
Co	0.071	0.074	0.0005	0.7	0.0740	0.0744	0.0734
Cr	17.23	17.49	0.04	0.2	17.53	17.49	17.45
Cu	0.63	0.66	0.0005	0.1	0.6591	0.6599	0.6599
Mn	1.80	1.90	0.002	0.1	1.899	1.898	1.902
Mo	0.41	0.41	0.0002	0.0	0.4096	0.4099	0.4096
Ni	8.17	8.27	0.001	0.0	8.264	8.266	8.265
P	0.028	0.027	0.0001	0.4	0.0272	0.0271	0.0273
S	0.33	0.33	0.001	0.4	0.331	0.329	0.328
Si	0.42	0.42	0.001	0.2	0.417	0.418	0.419
Ti	0.017	0.015	0.0001	0.7	0.0150	0.0149	0.0148
V	0.056	0.055	0.0001	0.2	0.0549	0.0552	0.0550
W	0.023	0.023	0.0005	2.0	0.0229	0.0236	0.0237

PRECIPITATION HARDENED STAINLESS STEEL GRADE 17-7PH: IARM 152C

ELEMENT	CERT	AVG	STDEV	RSD	Run #1	Run #2	Run #3
Fe	72.64	72.61			72.60	72.62	72.61
Al	0.94	0.93	0.002	0.2	0.931	0.932	0.935
B	0.0029	0.0034	0.0001	2.3	0.0034	0.0035	0.0033
C	0.072	0.075	0.0001	0.1	0.0747	0.0749	0.0749
Co	0.11	0.11	0.001	0.8	0.107	0.109	0.108
Cr	16.99	16.95	0.01	0.1	16.97	16.95	16.94
Cu	0.32	0.33	0.001	0.2	0.326	0.327	0.327
Mn	0.74	0.75	0.0005	0.1	0.7452	0.7454	0.7461
Mo	0.36	0.36	0.0004	0.1	0.3639	0.3638	0.3631
Ni	7.30	7.40	0.002	0.0	7.396	7.394	7.398
P	0.024	0.022	0.0001	0.7	0.0220	0.0222	0.0222
S	0.0006	<0.002			<0.002	<0.002	<0.002
Si	0.26	0.25	0.001	0.4	0.252	0.254	0.254
Ti	0.098	0.094	0.001	1.4	0.092	0.094	0.095
V	0.072	0.077	0.001	0.9	0.077	0.078	0.077
W	0.026	0.031	0.001	2.3	0.031	0.030	0.030

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