Spectroscopy Performance Note

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

Preface

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 GDS500A is an atomic emission spectrometer that records the spectra of each analysis; all elements can be defined within the wavelength range of the spectrometer. The glow discharge source uniformly removes (sputters) material from the sample surface, and separates sampling from excitation, therefore reducing the effect of metallurgical history inherent in all samples. The excitation of primarily ground state atom lines means less complex spectra and reduced interference, which is extremely important when analyzing high-alloy materials such as stainless steels. Calibration curves are inherently linear and cover a wide dynamic range. For these reasons, GDS is an excellent way to perform compositional analysis on stainless steels.

Typical Analysis Results

RESULTS OF ANALYSIS FOR BRAMMER STANDARD BS316A • MATERIAL: STAINLESS STEEL GRADE 316

ELEMENT	RUN#1	RUN#2	RUN#3	AVERAGE	CERT	% REL	STDEV	RSD
Al %	0.004	0.004	0.004	0.004	0.004	2.50	0.0001	2.56
C %	0.064	0.063	0.062	0.063	0.065	3.23	0.001	1.57
Co %	0.16	0.16	0.16	0.16	0.16	0.94	0.003	2.14
Cr %	17.44	17.32	17.47	17.41	17.25	0.93	0.079	0.46
Cu %	0.36	0.35	0.36	0.35	0.35	1.20	0.006	1.60
Mn %	1.49	1.47	1.47	1.47	1.48	0.43	0.010	0.68
Mo %	2.12	2.06	2.09	2.09	2.05	1.90	0.031	1.47
Nb %	0.033	0.029	0.026	0.030	0.029	1.84	0.004	11.9
Ni %	10.27	10.03	10.26	10.19	10.15	0.36	0.14	1.33
P %	0.028	0.027	0.029	0.028	0.029	3.68	0.001	2.64
S %	0.025	0.026	0.025	0.026	0.026	1.79	0.0004	1.58
Si %	0.75	0.75	0.74	0.75	0.74	0.80	0.001	0.15
Ti %	<0.003	<0.003	<0.003	<0.003	0.003	—	—	—
V %	0.13	0.13	0.13	0.13	0.13	1.46	0.002	1.70
W %	0.10	0.11	0.10	0.10	0.10	1.13	0.004	4.40
Fe %	67.04	67.48	67.08	67.20	—	—	—	—

GDS500A

RESULTS OF ANALYSIS FOR BRAMMER STANDARD BS317L
MATERIAL: STAINLESS STEEL GRADE 317 LOW CARBON

ELEMENT	RUN#1	RUN#2	RUN#3	AVERAGE	CERT	% REL	STDEV	RSD
Al %	0.005	0.005	0.005	0.005	0.005	0.067	0.0002	3.35
C %	0.025	0.027	0.026	0.026	0.027	3.09	0.001	3.83
Co %	0.14	0.14	0.14	0.14	0.14	1.55	0.001	0.42
Cr %	18.24	18.03	18.27	18.18	18.16	0.11	0.13	0.72
Cu %	0.23	0.23	0.23	0.23	0.23	0.78	0.001	0.34
Mn %	1.17	1.17	1.18	1.17	1.17	0.057	0.004	0.32
Mo %	3.10	3.11	3.14	3.12	3.07	1.54	0.020	0.63
Nb %	0.030	0.036	0.033	0.033	0.031	5.38	0.003	9.80
Ni %	13.62	13.54	13.61	13.59	13.53	0.44	0.044	0.32
P %	0.027	0.029	0.029	0.028	0.029	3.10	0.001	3.77
S %	<0.002	<0.002	<0.002	<0.002	0.0014	—	—	—
Si %	0.67	0.68	0.67	0.67	0.67	0.61	0.005	0.80
V %	0.089	0.089	0.090	0.089	0.090	0.81	0.0004	0.45
W %	0.018	0.020	0.018	0.019	0.018	3.15	0.002	8.56
Fe %	62.63	62.89	62.56	62.69	—	—	—	—

RESULTS OF ANALYSIS FOR BRAMMER STANDARD BS17-4PHB
MATERIAL: STAINLESS STEEL GRADE 17-4 PH

ELEMENT	RUN#1	RUN#2	RUN#3	AVERAGE	CERT	% REL	STDEV	RSD
Al %	0.035	0.035	0.035	0.035	0.035	0.48	0.0004	1.16
C %	0.039	0.042	0.040	0.040	0.042	4.37	0.002	4.71
Co %	0.038	0.040	0.036	0.038	0.040	4.83	0.0019	5.00
Cr %	15.62	15.59	15.53	15.58	15.60	0.13	0.046	0.29
Cu %	3.34	3.31	3.36	3.34	3.35	0.42	0.026	0.78
Mn %	0.56	0.57	0.56	0.56	0.56	0.76	0.003	0.49
Mo %	0.11	0.11	0.11	0.11	0.11	0.48	0.001	0.86
Nb %	0.31	0.30	0.30	0.30	0.31	2.20	0.003	0.88
Ni %	4.56	4.55	4.52	4.54	4.53	0.24	0.021	0.46
P %	0.023	0.020	0.022	0.021	0.021	1.90	0.002	7.34
S %	0.025	0.023	0.024	0.024	0.024	0.83	0.001	2.56
Si %	0.42	0.42	0.41	0.42	0.42	0.37	0.005	1.22
Ti %	0.005	0.003	0.005	0.004	0.005	16.0	0.001	31.0
V %	0.058	0.060	0.059	0.059	0.059	0.40	0.001	1.77
W %	0.011	0.008	0.013	0.011	0.010	5.67	0.002	21.8
Fe %	74.85	74.92	74.97	74.91	—	—	—	—

RESULTS OF ANALYSIS FOR BRAMMER STANDARD BS80F
MATERIAL: STAINLESS STEEL GRADE 303

ELEMENT	RUN#1	RUN#2	RUN#3	AVERAGE	CERT	% REL	STDEV	RSD
Al %	<0.002	<0.002	<0.002	<0.002	0.001	—	—	—
C %	0.061	0.059	0.059	0.060	0.062	3.92	0.001	2.25
Co %	0.16	0.16	0.16	0.16	0.16	1.06	0.0005	0.28
Cr %	17.06	17.26	17.10	17.14	17.10	0.23	0.11	0.62
Cu %	0.41	0.42	0.42	0.42	0.41	1.46	0.002	0.36
Mn %	1.77	1.77	1.77	1.77	1.76	0.53	0.004	0.20
Mo %	0.49	0.49	0.49	0.49	0.48	2.44	0.002	0.45
Nb %	0.016	0.014	0.014	0.015	0.016	9.17	0.001	8.03
Ni %	8.63	8.55	8.56	8.58	8.58	0.012	0.043	0.50
P %	0.032	0.032	0.032	0.032	0.036	10.6	0.0001	0.18
S %	0.34	0.34	0.34	0.34	0.35	2.13	0.002	0.49
Si %	0.62	0.62	0.65	0.63	0.63	0.35	0.019	3.02
Ti %	0.004	0.004	0.003	0.003	0.004	15.8	0.001	17.1
V %	0.084	0.083	0.086	0.084	0.087	3.26	0.002	1.79
W %	0.046	0.049	0.049	0.048	0.047	2.34	0.002	3.30
Fe %	70.27	70.14	70.26	70.22	—	—	—	—

RESULTS OF ANALYSIS FOR ARMI STANDARD 10A
MATERIAL: STAINLESS STEEL GRADE 416

ELEMENT	RUN#1	RUN#2	RUN#3	AVERAGE	CERT	% REL	STDEV	RSD
Al %	<0.002	<0.002	<0.002	<0.002	0.002	—	—	—
C %	0.12	0.12	0.12	0.12	0.12	0.19	0.001	0.60
Co %	0.029	0.031	0.029	0.029	0.030	2.00	0.001	3.45
Cr %	12.24	12.23	12.24	12.24	12.18	0.47	0.006	0.05
Cu %	0.13	0.13	0.13	0.13	0.13	1.31	0.001	0.87
Mn %	0.81	0.80	0.79	0.80	0.80	0.30	0.009	1.13
Mo %	0.12	0.12	0.12	0.12	0.12	1.00	0.0007	0.58
Ni %	0.40	0.40	0.39	0.40	0.40	0.40	0.005	1.16
P %	0.024	0.024	0.024	0.024	0.024	1.11	0.0002	0.88
S %	0.37	0.38	0.37	0.37	0.37	0.89	0.003	0.75
Si %	0.53	0.53	0.52	0.53	0.53	0.62	0.002	0.41
V %	0.039	0.039	0.040	0.039	0.040	2.00	0.001	1.79
W %	0.012	0.013	0.013	0.013	0.013	3.08	0.001	7.27
Fe %	85.17	85.19	85.20	85.19	—	—	—	—

RESULTS OF ANALYSIS FOR ARMI STANDARD 26A
MATERIAL: STAINLESS STEEL GRADE A286

ELEMENT	RUN#1	RUN#2	RUN#3	AVERAGE	CERT	% REL	STDEV	RSD
Al %	0.13	0.13	0.13	0.13	0.13	0.77	0.0003	0.20
C %	0.022	0.023	0.023	0.023	0.022	2.42	0.0001	0.51
Co %	0.063	0.063	0.063	0.063	0.060	5.22	0.0002	0.37
Cr %	15.15	15.21	15.14	15.17	15.07	0.64	0.038	0.25
Cu %	0.15	0.15	0.15	0.15	0.15	2.82	0.001	0.42
Mn %	1.06	1.06	1.06	1.06	1.05	1.02	0.002	0.14
Mo %	1.28	1.28	1.28	1.28	1.27	0.47	0.002	0.14
Nb %	0.019	0.019	0.016	0.018	<0.02	-	0.002	8.75
Ni %	24.84	24.85	24.90	24.86	24.94	0.31	0.032	0.13
P %	0.024	0.025	0.024	0.024	0.023	5.36	0.001	2.35
S %	<0.002	<0.002	<0.002	<0.002	0.001	—	—	—
Si %	0.65	0.65	0.64	0.65	0.64	0.90	0.001	0.22
Ti %	2.20	2.20	2.20	2.20	2.17	1.37	0.005	0.20
V %	0.17	0.17	0.17	0.17	0.17	0.08	0.001	0.70
Fe %	54.25	54.18	54.22	54.21	—	—	—	—

RESULTS OF ANALYSIS FOR NIST STANDARD C1288
MATERIAL: STAINLESS STEEL GRADE A743 (CN-7M)

ELEMENT	RUN#1	RUN#2	RUN#3	AVERAGE	CERT	% REL	STDEV	RSD
Al %	0.0020	0.0021	0.0022	0.0021	0.0025	16.0	0.0001	4.76
C %	0.057	0.056	0.056	0.056	0.056	0.54	0.001	1.24
Co %	0.10	0.10	0.10	0.10	0.10	0.33	0.001	0.73
Cr %	19.78	19.79	19.79	19.79	19.55	1.21	0.006	0.03
Cu %	3.78	3.78	3.77	3.78	3.72	1.51	0.007	0.18
Mn %	0.84	0.84	0.84	0.84	0.83	1.36	0.001	0.13
Mo %	2.88	2.89	2.88	2.88	2.83	1.79	0.006	0.20
Nb %	0.23	0.23	0.22	0.23	0.22	2.41	0.005	2.03
Ni %	29.11	29.09	29.12	29.11	29.30	0.66	0.015	0.05
P %	0.024	0.025	0.023	0.024	0.023	3.91	0.001	4.83
S %	0.011	0.011	0.011	0.011	0.010	11.0	0.0004	3.93
Si %	0.41	0.41	0.40	0.41	0.41	0.88	0.003	0.67
Ti %	0.013	0.013	0.013	0.013	0.012	6.39	0.0003	2.26
V %	0.087	0.087	0.088	0.087	0.086	0.97	0.001	0.66
W %	0.20	0.20	0.20	0.20	0.20	0.67	0.001	0.63
Fe %	42.49	42.48	42.48	42.48	—	—	—	—

Sample Preparation

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

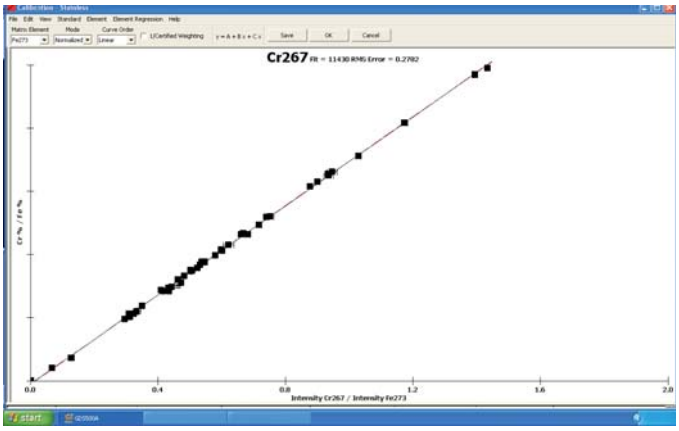
Accessories

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

Calibration Curves

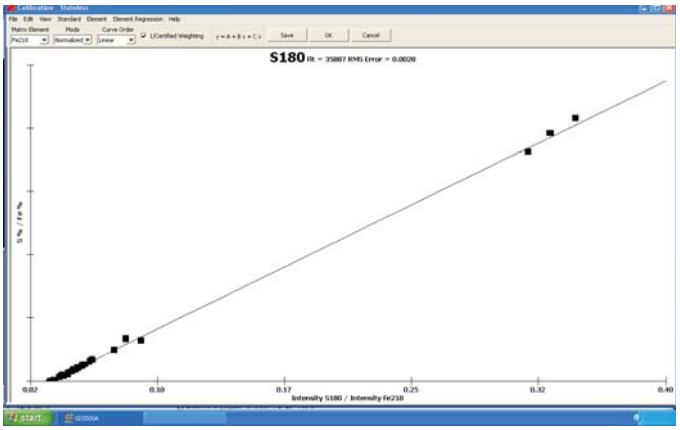
GDS calibration curves are inherently linear over a large concentration range. The chromium curve (top right) shows a very good fit through all the various grades of stainless.

The sulfur curve (bottom right) demonstrates the glow discharge lamp's advantage over other sources when analyzing volatile species. The GDS source does not melt the sample surface. Another great 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 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, and NIST & 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 GDS500A 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.

	A single burn	Three burns without dropping
Start-up and Preburn	60 sec.	60 sec.
Analyze	10 sec.	10 sec.
Analyze	—	10 sec.
Analyze	—	10 sec.
Total	70 sec.	90 sec.

Delivering the Right Results

LECO Corporation
3000 Lakeview Ave. • St. Joseph, MI 49085
Phone: 800-292-6141 • Fax: 269-982-8977
info@leco.com • www.leco.com • *ISO-9001:2000 No. FM 24045*

Form No. 209-076-029 *3/07-REV0*