Spectroscopy Performance Note

Bulk Analysis of Tool Steels
High Speed (T & M), Hot and Cold Work (H & D)

Preface

Tool steels are alloyed steels with varying combinations of resistance to softening upon heating, wear resistance, and toughness. These properties are desirable in tools which must withstand repeated blows or punching, maintain a sharp edge, and hold up to high temperatures. High speed tool steels include group "M" (Mo containing), and group "T" (W containing) materials that are used to make cutting tools. Other tool steels such as group "H" are designed to work in hot environments without deforming or softening. Group "D" tool steels demonstrate wear resistance at low temperatures.

Physical tests such as hardness, tensile yield, and elongation are not sufficient by themselves to classify tool steels. Chemical composition can be used as a definitive technique for classifying tool steels. The tool steel producer should control alloying composition of the heat to be sure it meets chemical specification and thereby have the desired properties for the targeted grade of tool steel. 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 and increasing the quality of the final product. Manufacturers that use tool steels should also verify the material before it is used. Tools are created for very specific use and if the chemical composition of the material is not correct then the tool will not withstand the stresses for which it was designed. The tool may fail prematurely adding additional replacement cost of the tool and any damages that may have been incurred.

The LECO GDS500A is an atomic emission spectrometer that electronically records the spectra of each analysis. All element wavelengths can be defined within the analytical range of the spectrometer. The glow discharge source uniformly removes (sputters) material from the sample surface. Analysis takes place away from the sample surface 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, both are extremely important when analyzing high alloy materials such as tool steels. Calibration curves are linear and cover a wide dynamic range. It is for these reasons that GDS is an excellent way to perform chemical analysis on tool steels.

GDS500A

RESULTS OF ANALYSIS FOR IARM STANDARD 48A
MATERIAL: T-1 TOOL STEEL

ELEMENT	RUN#1	RUN#2	RUN#3	AVERAGE	CERT	% REL	STDEV	RSD
C %	0.78	0.81	0.81	0.80	0.79	1.24	0.013	1.67
Mn %	0.33	0.34	0.34	0.34	0.33	1.82	0.003	0.75
P %	0.035	0.036	0.037	0.036	0.036	0.19	0.001	1.81
S %	0.020	0.023	0.021	0.021	0.021	1.75	0.002	7.29
Si %	0.29	0.29	0.28	0.29	0.29	1.20	0.002	0.71
Cu %	0.13	0.13	0.13	0.13	0.13	0.33	0.001	1.02
Ni %	0.23	0.23	0.23	0.23	0.23	0.58	0.001	0.64
Cr %	4.26	4.28	4.29	4.28	4.32	1.02	0.013	0.29
Mo %	0.39	0.40	0.40	0.40	0.40	0.20	0.004	1.06
V %	1.12	1.12	1.12	1.12	1.13	0.94	0.003	0.27
Co %	0.38	0.38	0.37	0.38	0.39	2.69	0.005	1.29
W %	18.03	18.43	18.48	18.31	17.99	1.80	0.25	1.35
Fe %	73.99	73.54	73.49	73.67	-	-	-	-

RESULTS OF ANALYSIS FOR BRAMMER STANDARD BSTM-1
MATERIAL: M-1 TOOL STEEL

ELEMENT	RUN#1	RUN#2	RUN#3	AVERAGE	CERT	% REL	STDEV	RSD
C %	0.86	0.86	0.87	0.86	0.86	0.30	0.008	0.88
Mn %	0.23	0.23	0.23	0.23	0.23	0.16	0.001	0.64
P %	0.007	0.007	0.009	0.008	0.007	9.05	0.001	9.92
S %	0.012	0.011	0.012	0.011	0.012	4.72	0.001	5.27
Si %	0.45	0.45	0.45	0.45	0.46	1.62	0.002	0.49
Cu %	0.053	0.053	0.055	0.054	0.054	0.31	0.001	2.25
Ni %	0.056	0.057	0.058	0.057	0.06	0.41	0.001	2.15
Cr %	3.68	3.65	3.68	3.67	3.72	1.40	0.016	0.42
Mo %	8.45	8.41	8.39	8.42	8.40	0.19	0.030	0.36
V %	1.05	1.06	1.05	1.05	1.05	0.22	0.002	0.22
Co %	0.45	0.45	0.45	0.45	0.45	0.19	0.003	0.60
W %	1.71	1.70	1.72	1.71	1.70	0.53	0.011	0.62
Fe %	82.99	83.07	83.02	83.03	-	-	-	-

RESULTS OF ANALYSIS FOR IARM STANDARD 42A
MATERIAL: H-13 TOOL STEEL

ELEMENT	RUN#1	RUN#2	RUN#3	AVERAGE	CERT	% REL	STDEV	RSD
C %	0.39	0.39	0.38	0.39	0.39	1.10	0.001	0.25
Mn %	0.34	0.34	0.34	0.34	0.35	3.60	0.001	0.32
P %	0.010	0.010	0.011	0.010	0.011	6.06	0.001	4.97
S %	0.007	0.008	0.006	0.007	0.007	1.43	0.001	8.57
Si %	1.04	1.04	1.04	1.04	1.04	0.19	0.001	0.10
Cu %	0.072	0.073	0.072	0.072	0.070	3.14	0.001	0.97
Ni %	0.32	0.32	0.32	0.32	0.32	0.76	0.002	0.57
Cr %	5.45	5.44	5.40	5.43	5.42	0.16	0.029	0.53
Mo %	1.23	1.23	1.22	1.22	1.29	5.22	0.007	0.54
V %	1.01	1.01	1.01	1.01	1.02	0.92	0.002	0.21
Co %	0.016	0.017	0.013	0.015	0.015	2.22	0.002	13.3
W %	0.022	0.023	0.021	0.022	(0.014)	-	-	-
Fe %	90.09	90.11	90.17	90.13	-	-	-	-

RESULTS OF ANALYSIS FOR BRAMMER STANDARD BS37C
MATERIAL: D-2 TOOL STEEL

ELEMENT	RUN#1	RUN#2	RUN#3	AVERAGE	CERT	% REL	STDEV	RSD
C %	1.53	1.52	1.53	1.53	1.52	0.46	0.005	0.30
Mn %	0.32	0.32	0.32	0.32	0.31	2.19	0.002	0.55
P %	0.018	0.017	0.019	0.018	0.018	0.37	0.001	3.69
S %	<0.003	<0.003	<0.003	<0.003	0.003	-	-	-
Si %	0.58	0.59	0.59	0.59	0.58	0.97	0.004	0.67
Cu %	0.057	0.056	0.058	0.057	0.060	5.33	0.001	2.31
Ni %	0.22	0.22	0.22	0.22	0.23	4.00	0.0004	0.20
Cr %	11.17	11.18	11.17	11.17	11.26	0.77	0.006	0.05
Mo %	0.79	0.78	0.78	0.78	0.78	0.14	0.004	0.52
V %	0.81	0.81	0.81	0.81	0.80	1.50	0.003	0.31
Co %	0.022	0.022	0.021	0.022	(0.025)	-	-	-
W %	0.073	0.074	0.076	0.074	0.070	5.76	0.002	2.25
Fe %	84.42	84.41	84.41	84.41	-	-	-	-

Sample Preparation

Tool 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 molybdenum curve (top right) shows a very good fit through all the various grades of tool steel.

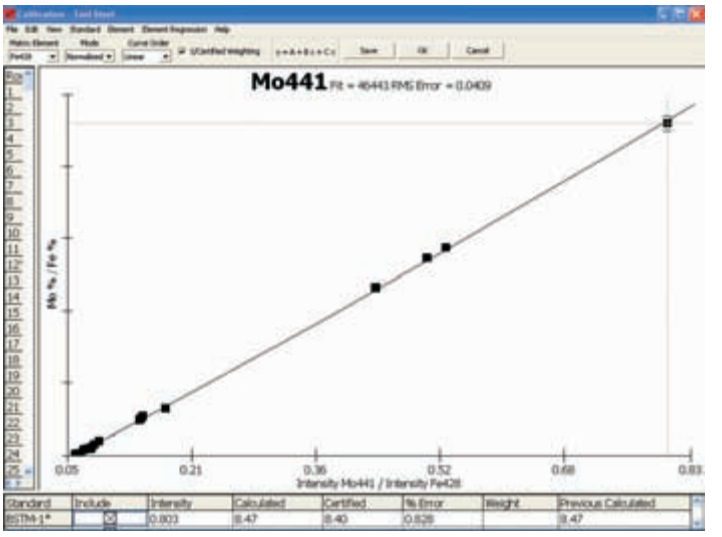
The tungsten curve (bottom right) exhibits a very good fit with high, mid, and low tungsten containing tool steels.

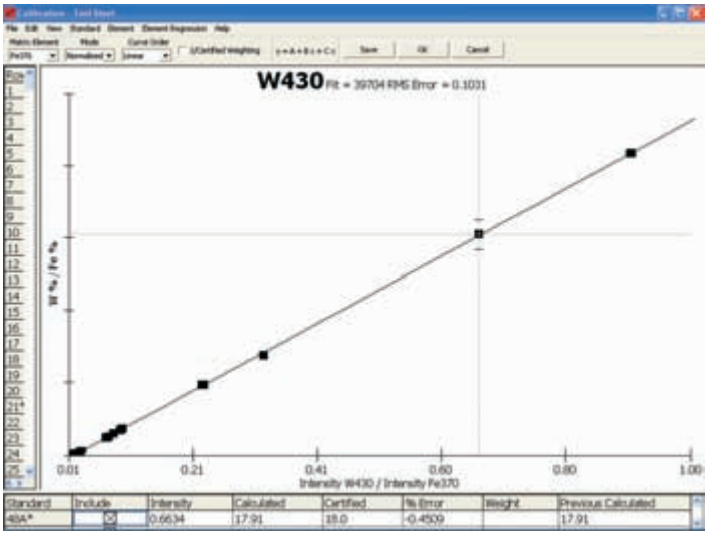
Calibration Standards

A factory-installed tool 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 BAS. 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. 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. This is possible since the actual analysis occurs away from the surface and the sputtering process continuously reveals fresh unsputtered sample material for each analysis.

	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.

Additional Information

Additional information regarding the analysis of tool steels (as well as coatings) is available at **www.leco.com** (resources/applications library/spectroscopy).

Delivering the Right Results

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