Brammer Standard Company, Inc.

Certificate of Analysis

B.S. LC-1R through LC-6

Reference Material for Carbon Steel with ultra-low Carbon

Analysis listed as percent by weight

Certified Analysis[1]

Element	**BS LC-1R**	**BS LC-2**	**BS LC-3**	**BS LC-4**	**BS LC-5**	**BS LC-6**	
C	**0.0014**	**0.0041**	**0.0056**	**0.0080**	**0.0110**	**0.0021**	**C**
ec[2]	*±0.0003*	*±0.0003*	*±0.0005*	*±0.0006*	*±0.0006*	*±0.0003*	
S	**0.0013**	**0.0024**	**0.0046**	**0.0070**	**0.0088**	**0.0008**	**S**
ec[2]	*±0.0003*	*±0.0003*	*±0.0004*	*±0.0004*	*±0.0005*	*±0.0003*	

Uncertified Analysis[3]

Mn	(0.43)	(0.45)	(0.45)	(0.46)	(0.46)	(0.47)	Mn
P	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.0007)	P
Si	(0.025)	(0.025)	(0.024)	(0.024)	(0.022)	(0.051)	Si
Cu	(0.002)	(0.002)	(0.001)	(<0.001)	(<0.002)	(0.001)	Cu
Ni	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.006)	Ni
Cr	(0.001)	(<0.002)	(0.002)	(0.002)	(0.002)	(0.002)	Cr
Al	(0.033)	(0.038)	(0.044)	(0.035)	(0.021)	(0.036)	Al

[1] The certified value listed is the present best estimate of the true value based on the results of an interlaboratory testing program.

[2] ec, the estimate of uncertainty, is based on value judgments of the material inhomogeneity and the 95% confidence interval. The half-width confidence interval C(95%) is shown on page 2.

[3] Data in parentheses are not certified and are provided for information only.

See reverse side for more information.

Certificate Number LC1R-LC6-042996

Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895
Telephone (281) 440-9396 Fax (281) 440-4432

BS LC-1R through LC-6 **Certificate Number LC1R-LC6-042996**

Carbon DATA IN PPM

Number	LAB-->	B	C	D	E	F	G	H	I	J	K	L	Avg	sd	C(95%)[1]	Certified	Diff.
NIST SRM 2168		11.3	9.4	9.3	---	8.5	9.4	7.2	7.5	7.5	9.9	9.7	9.0	1.3		7 ±3	+2.0
ECRM 088-1		23.7	28.8	30.8	---	26.7	22.5	22.9	21.1	19.9	35.8	26.6	25.9	4.9		25 ±6	+0.9
NIST SRM 2165		72.3	70.6	66.6	---	69.0	67.2	70.3	68.7	71.0	70.7	64.4	69.1	2.4		59 ±2	+10.1
JSS 1203-1		118.7	118.1	115.7	---	115.0	115.7	118.0	120.7	113.4	114.3	116.1	116.6	2.2		107 ±3	+9.6
NIST SRM 2166		156.0	157.1	144.4	---	150.5	151.8	151.1	157.5	162.0	151.0	146.4	152.8	5.4		150 ±10	+2.8
NIST SRM 2167		514.0	[627.9]	[480.5]	---	517.5	503.7	505.4	532.5	504.7	528.9	501.7	513.5	11.9		510 ±20	+3.5
BS LC-1R		15.7	16.6	14.7	---	12.5	15.1	13.2	12.1	11.1	14.5	13.8*	13.9	1.7	1.2	14	
BS LC-2		44.3	42.0	41.0	---	41.5	40.3	38.9	40.2	38.9	42.2	39.5*	40.9	1.7	1.2	41	
BS LC-3		59.3	56.1	52.6	---	53.0	53.2	54.7	54.9	53.8	65.3	52.4	55.5	4.0	2.9	56	
BS LC-4		85.5	78.1	82.4	---	84.7	84.4	80.5	74.8	79.9	75.8	71.6	79.7	4.7	3.3	80	
BS LC-5		111.0	110.8	107.9	---	109.5	110.7	112.4	113.0	110.3	108.4	104.6	109.8	2.4	1.7	110	
BS LC-6		24.5	21.0*	25.1	---	19.5	22.6	21.4	17.1	19.6	20.4	19.8*	21.1	2.4	1.7	21	

Sulfur

sd = standard deviation

Number	LAB-->	B	C	D	E	F	G	H	I	J	K	L	Average	sd	C(95%)[1]	Certified	Diff.
NIST SRM 2168		8.8	8.5	9.5	11.8	8.0	15.2	16.4	8.0	9.0	10.1	9.8	10.5	2.9		10 ±1	+0.5
ECRM 088-1		21.4	20.1	21.1	24.2	18.3	27.9	26.5	20.8	21.9	22.4	(23.4)**	22.5	2.9		19 ±3	+3.5
NIST SRM 2166		22.6	20.3	20.7	25.2	19.5	29.7	28.7	20.0	21.5	23.1	23.6	23.2	3.4		23 ±2	+0.2
NIST SRM 2165		39.1	35.9	35.4	42.6	33.5	45.1	43.9	36.8	37.4	37.9	38.3	38.7	3.7		38 ±2	+0.7
NIST SRM 2167		91.6	88.1	90.8	98.1	81.0	101.8	93.4	87.4	92.2	84.9	88.0	90.6	5.8		91 ±2	+0.4
JSS 1203-1		125.3	116.4	113.9	131.0	114.0	130.1	130.1	118.7	119.1	115.5	(142.3)**	121.4	7.0		--	
BS LC-1R		12.3	11.9	10.9	14.6	10.0	19.0	19.1	10.4	10.9	12.9	12.1	13.1	3.2	2.2	13	
BS LC-2		23.0	23.4	20.9	26.0	19.5	29.8	28.5	20.6	22.7	22.8	23.1	23.7	3.2	2.2	14	
BS LC-3		47.8	45.4	42.3	51.3	41.0	49.9	53.3	43.9	44.4	45.2	43.8	46.2	3.9	2.6	46	
BS LC-4		71.1	66.9	65.1	75.2	63.0	77.3	77.9	65.7	68.0	67.0	67.8	69.5	5.1	3.4	70	
BS LC-5		90.3	83.6	83.2	95.7	79.5	96.9	96.3	82.7	85.4	84.0	84.8	87.5	6.2	4.2	88	
BS LC-6		7.4	7.3	6.9	9.5	5.0	13.4	13.3	6.3	7.2	7.7	7.9	8.3	2.7	1.8	8	

Instruments used for carbon and sulfur analysis:

LECO CS MODEL Nr.	444	444	444	444	444	444	444	244	344	444	444	

[1] $C(95\%) = (t \times sd)/\sqrt{n}$ The half-width confidence interval, where t is the appropriate Student's t value, sd is the interlaboratory standard deviation, and n is the number of acceptable mean values. For further information regarding the confidence interval for the certified value, see ISO Guide 35:1989 section 4.

NOTE: Data in brackets were not used in the calculations.

* One of the two measurements was discarded as a high outlier.

** Lab L used different CRMs for sulfur calibration drift checking. Their data in parentheses was not used in the calculations. Lab L used ECRM 097-1 (0.0022% S) instead of ECRM 088-1.

Analysis: Chemical analyses were made on chips prepared by a power hacksaw from the certified portion of the bars. The analysts followed ASTM Standard Test Method E 1019. The laboratories participating in the testing normally followed the requirements of ISO Guide 25. The values listed above are the average of each analyst's results. The Certified Reference Materials (CRMs) numbered ECRM 088-1 and JSS 1203-1 were used for calibration drift-check by being analyzed at the beginning, middle, and end of the testing cycle. All other CRMs and test specimens were analyzed twice in random order.

Co-operating Laboratories: Some of the co-operating laboratories were:

Allegheny Ludlum Steel Corporation, Lockport, New York
Armco Inc., Research & Technology, Middletown, Ohio
Bethlehem Steel Corporation, Burns Harbor, Indiana
Brammer Standard Co., Inc., Houston, Texas
DOFASCO, Hamilton, Ontario, Canada
LECO Corporation, St. Joseph, Michigan
LTV Steel Company, Cleveland, Ohio
LTV Steel Company, E. Chicago, Illinois
Spectrochemical Laboratories, Inc., Pittsburgh, Pennsylvania
Thyssen Stahl AG, Duisburg, Federal Republic of Germany
U.S. Steel Corporation, Gary, Indiana

Testing Protocol: Some of the instructions given to the participating laboratories were -

1. Burn-off crucibles before use;
2. weight 1.000 g of all test materials to ±0.001 g or, for instruments with weight compensation, a weight of 0.950 g to 1.050 g was acceptable;
3. add a consistent amount of accelerator, between 1.5 g and 2.5 g ±0.1 g, to all of the crucibles;
4. calibrate their instruments by using the ASTM Standard Test Method E 1019;
5. test their instrument zero setting by analyzing SRM 2168;
6. analyze all materials in a single testing period.

Possible carbon bias: The CRMs tested as unknown samples validate the carbon calibration at the 0.0010%, 0.0025%, 0.0150%, and 0.0510% levels. The testing program shows that the carbon measurements for SRM 2165 and JSS 1203-1 are 0.0009% to 0.0010% higher than the certified values. Some possible explanations of the difference are: (1) All of the laboratories have a positive bias in the 0.005% to 0.012% range of their calibrations; (2) the CRMs have a larger uncertainty than stated on their certificates of analysis; (3) the bottles of CRMs used do not represent the original certified material. The BS LC series and additional CRMs will be used in a new interlaboratory testing program in a effort to resolve the difference between the certified carbon values and the recent testing program values for NIST SRM 1265 and JSS 1203-1. All purchasers of the BS LC set will be advised of any changes to the certified values for the BS LC series.

Other testing: Two laboratories measured the carbon content using previously established calibrations on their optical emission spectrometers with the following results.

	BS LC-1R	LC-2	LC-3	LC-4	LC-5	LC-6
Spark OES	0.00084%	0.0043%	0.0056%	0.00727%	0.0102%	0.00104%
Glow Discharge OES	0.0016	0.0043	0.0057	0.0080	0.0120	0.0022
Certified value	*0.0014*	*0.0041*	*0.0056*	*0.0080*	*0.0110*	*0.0021*

Homogeneity: This Reference Material was tested for homogeneity using ASTM Standard Practice E 826 and found acceptable.

Traceability: This Reference Material was also examined by optical emission spectrometry and found to be compatible with the following Certified Reference Materials: NIST SRM 1265, 1765, 1766, 1767, 1768. The following Certified Reference Materials were used to validate the analytical data are listed on page 2.

Source: BS LC-1R through LC-5 was produced by the LTV Steel Company Technical Center in Independence, Ohio. The five materials were prepared by casting a 100 pound melt into two ingots. The ingots were hot worked to the finished size.

The BS LC-6 material was produced by Carpenter Technology Corporation, Reading, Pennsylvania. The material was made in an electric arc furnace and cast into ingots. The bar stock was hot rolled and annealed.

Available Form: The Reference Materials marked BS LC-1R through BS LC-5 are available only in the form of blocks measuring approximately 44 mm x 44 mm x 13 mm thick and are sold by sets only. The Reference Material numbered BS LC-6 is available in disc form of approximately 38 mm diameter and 13 mm thick and is sold in a set or separately.

Use: This Reference Material is intended for use in optical emission spectrometric methods of analysis. The entire depth of the disc may be used.

Caution: As with any bar material, avoid optical emission spectrometric burns in the center of the blocks or disc (5 mm radius), as some segregation may be present.

Sample Preparation: For best analytical results, use the same method for preparing the analytical surface on all reference materials as you use for production specimens. Avoid overheating the disc during surface preparation.

Safety Notice: A Material Safety Data Sheet (MSDS) is not required for this material. This material will not release or otherwise result in exposure to a hazardous chemical, under normal conditions of use. Inquiries concerning this Reference Material should be directed to:

Brammer Standard Co., Inc. Phone: (281) 440-9396
14603 Benfer Road
Houston, Texas 77069-2895 USA Fax: (281) 440-4432

Certified by: _____ on April 26, 1996.
G. R. Brammer

References:

ASTM documents available from ASTM, 1916 Race Street, Philadelphia, PA, 19103.

E 826 - 85 (Reapproved 1990) Standard Practice for Testing Homogeneity of Materials for the Development of Reference Materials

E 1019-93 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel, and Cobalt Alloys

ISO Guides available from American National Standards Institute,
11 West 42nd St., 13th Floor, New York, NY 10036.

ISO Guide 25 (Third edition, 1990), General requirements for the competence of calibration and testing laboratories.

ISO Guide 30 (Second edition, 1991), Terms and definitions used in connection with reference materials.

ISO Guide 31 (First edition, 1981), Contents of certificates of reference materials.

ISO Guide 33 (First edition, 1989), Uses of certified reference materials.

ISO Guide 35 (Second edition, 1989), Certification of reference materials - General and statistical principles.

Other useful documents available from NIST, U.S. Department of Commerce, Gaithersburg, MD 20899.

NIST Special Publication 260-100, Handbook for SRM Users

NIST Special Publication 829, Use of NIST Standard Reference Materials for Decisions on Performance of Analytical Chemical Methods and Laboratories

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