

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 Analysis¹

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
<i>ec</i> 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
<i>ec</i> ²	±0.0003	±0.0003	±0.0004	±0.0004	±0.0005	±0.0003	

Uncertified Analysis³

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

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. 444 444 444 444 444 444 444 444 244 344 444 444

⁽¹⁾ C(95%) = (t x sd)/√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
<i>Certified value</i>	<i>0.0014</i>	<i>0.0041</i>	<i>0.0056</i>	<i>0.0080</i>	<i>0.0110</i>	<i>0.0021</i>

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.

