

# Brammer Standard Company, Inc.

## Certificate of Analysis

### BS 4150MOD-A

Certified Reference Material for AISI Steel Grade 4150 with Sulfur added

	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>	<b>Certified Values<sup>3</sup></b>	Certified Value <sup>1</sup>	Estimate of Uncertainty <sup>2</sup>
<b>Al</b>	<b>0.0023</b>	0.0003		<b>Ni</b>	0.002
<b>As</b>	<b>0.0038</b>	0.0006		<b>O</b>	0.0005
<b>C</b>	<b>0.503</b>	0.009		<b>P</b>	0.0006
<b>Co</b>	<b>0.0070</b>	0.0004		<b>S</b>	0.005
<b>Cr</b>	<b>0.799</b>	0.006		<b>Si</b>	0.006
<b>Cu</b>	<b>0.192</b>	0.005		<b>Sn</b>	0.0005
<b>Fe</b>	<b>96.7</b>	0.1		<b>Ti</b>	0.0005
<b>Mn</b>	<b>1.12</b>	0.01		<b>V</b>	0.001
<b>Mo</b>	<b>0.170</b>	0.004		<b>W</b>	0.0006
<b>N</b>	<b>0.0081</b>	0.0006			

#### Informational Values<sup>3,4</sup>

B (0.0004)	Ca (0.0007)	H (0.0001)	Mg (0.0004)	Nb (0.002)
Pb (0.0004)	Sb (0.002)	Zr (0.0005)		

<sup>1</sup> For each element, the certified value listed is the present best estimate of the true value based on the mean of the weighted results of an interlaboratory testing program. See page 3 for more information on its calculation.

<sup>2</sup> For each element, the uncertainty listed is based on a statistical evaluation of the contributions of homogeneity and the interlaboratory testing program. See page 3 for more information on its calculation.

<sup>3</sup> Values are given in weight percent. Values in brackets are reported by difference.

<sup>4</sup> Values in parentheses are not certified and are provided for information only.

Trace element information values for Ag, Bi, Ga, Ge, K, Na, Os, Pt, Re, and Zn are shown on page 3.

The requirements of ISO Guides 30, 31, and 35 were followed for the preparation of this Certified Reference Material and certificate of analysis.

Analysis	*	Al	*	As	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo	*	N
1	4	0.001367	5	0.002933	1	0.4772667	2	0.006	4	0.78	10	0.181	13	96.457	4	1.06367	4	0.16	2	0.0076
2	5	0.0018	4	0.0031	1	0.49	5	0.00603	4	0.782	5	0.1863333	16	[96.6]	4	1.1	3	0.162667	2	0.00773
3	14	0.001833	11	0.0032	1	0.49	10	0.0065	3	0.78566667	3	0.187	14	96.6333333	4	1.10	11	0.164	2	0.00783
4	3	0.002	12	0.003267	1	0.492	11	0.0065	10	0.79533333	4	0.1878333	16	[96.67334]	10	1.105	4	0.166667	2	0.0079
5	4	0.0021	4	0.003367	3	0.4935	5	0.00655	10	0.796	3	0.189	16	[96.68]	4	1.10667	10	0.167	2	0.008
6	11	0.0022	4	0.003533	1	0.4996667	5	0.00663	4	0.79603333	4	0.1893333	3	96.6966667	4	1.11	4	0.168	2	0.00804
7	12	0.002467	3	0.0036	3	0.5	14	0.00667	4	0.79633333	8	0.1893333	10	96.6966667	4	1.11167	4	0.168333	2	0.00808
8	5	0.002563	10	0.0038	11	0.50	4	0.0068	3	0.7982	14	0.1896667	16	[96.7033]	10	1.11267	3	0.1684	2	0.00812
9	12	0.002567	9	0.004067	1	0.5003333	4	0.00683	4	0.8	4	0.19	16	[96.71667]	4	1.1148	4	0.168533	2	0.00813
10	5	0.0026	12	0.004317	3	0.506	8	0.00692	3	0.80	4	0.190	4	96.7166667	3	1.11667	4	0.169	2	0.00827
11	4	0.003333	5	0.004387	1	0.507	4	0.00693	4	0.801	10	0.191	11	96.72	3	1.1187	10	0.169667	2	0.00827
12	4	0.003367	5	0.0046	1	0.5076667	12	0.00696	4	0.8026	4	0.1923	16	[96.7336334]	4	1.11933	3	0.17	2	0.00837
13	4	0.0034	4	0.0046	1	0.5086667	4	0.007	4	0.80266667	3	0.1926667	16	[96.80]	11	1.12	10	0.171	2	0.0084
14			4	0.004667	1	0.5113333	4	0.00713	4	0.80393333	10	0.1926667	10	96.873	4	1.12267	4	0.171667		
15					1	0.5119	4	0.00713	3	0.805	10	0.194			3	1.13	10	0.173		
16					1	0.5143333	3	0.0072	14	0.805	4	0.1943333			10	1.13	5	0.173		
17					1	0.52	4	0.0072	10	0.806	4	0.1945667			7	1.135	4	0.173133		
18					1	0.525	4	0.0076	10	0.80766667	11	0.195			10	1.142	4	0.174		
19							3	0.0078	11	0.808	4	0.1950667			4	1.14233	4	0.174667		
20							10	0.008	4	0.81566667	4	0.199333			4	1.14333	14	0.178333		
21							12	0.0088			4	0.199333			14	1.14667	3	0.179		
22											12	0.200333			3	1.15				
23											3	0.2026								
Average		0.002343		0.003817		0.5025		0.00698		0.7988		0.1920		96.681		1.1218		0.1702		0.00812
Std Dev		0.000084		0.000085		0.0037		0.00019		0.0039		0.0026		0.020		0.0042		0.0025		0.00027
H		0.00054		0.00065		0.0070		0.00083		0.0091		0.0041		0.23		0.011		0.0038		0.00089
U <sub>1</sub>		0.00054		0.00066		0.0079		0.00085		0.0099		0.0048		0.23		0.012		0.0046		0.00093
t-statistic		2.18		2.16		2.11		2.09		2.09		2.07		2.16		2.08		2.09		2.18
U <sub>2</sub>		0.0012		0.0014		0.017		0.0018		0.021		0.010		0.50		0.025		0.010		0.0020
U <sub>3</sub>		0.00033		0.00038		0.0039		0.00039		0.0046		0.0021		0.13		0.0053		0.0021		0.00056
Certified		<b>0.0023</b>		<b>0.0038</b>		<b>0.503</b>		<b>0.0070</b>		<b>0.799</b>		<b>0.192</b>		<b>96.7</b>		<b>1.12</b>		<b>0.170</b>		<b>0.0081</b>
Uncertainty		0.0003		0.0006		0.009		0.0004		0.006		0.005		0.1		0.01		0.004		0.0006
Tolerance		0.0012		0.0018		0.027		0.0018		0.018		0.015		0.5		0.02		0.012		0.0020

Analysis	*	Ni	*	O	*	P	*	S	*	Si	*	Sn	*	Ti	*	V	*	W		
1	3	0.0859	2	0.00117	10	0.0145	1	0.046	3	0.24533333	3	0.0077	11	0.0009	4	0.02673	4	0.001		
2	4	0.089267	2	0.0012	7	0.0158	10	0.0566	11	0.246	5	0.0079	17	0.001	3	0.027	10	0.001		
3	4	0.090667	2	0.001233	4	0.0163333	3	0.0573	6	0.24766667	10	0.008	5	0.0011	4	0.0273	3	0.0019		
4	3	0.0927	2	0.001263	4	0.0163333	1	0.05753	4	0.24766667	12	0.0081833	12	0.0012	4	0.0275	4	0.0021		
5	4	0.093	2	0.00134	5	0.0163667	1	0.058	10	0.24793333	4	0.0082	5	0.001233333	11	0.0276	5	0.0022		
6	10	0.093	2	0.0017	4	0.0164667	1	0.059	4	0.24846667	5	0.0082	12	0.001476667	4	0.02767	5	0.0022		
7	14	0.0932	2	0.0017	3	0.0169	1	0.05913	4	0.24933333	11	0.0087	5	0.001483333	10	0.0278	4	0.002333		
8	4	0.093567	2	0.001767	4	0.0169667	1	0.05927	3	0.25	4	0.0087667	4	0.0015	3	0.0279	12	0.002367		
9	4	0.094433	2	0.00182	3	0.017	1	0.0602	4	0.2503	4	0.0088667	4	0.001566667	3	0.0279	4	0.0024		
10	10	0.094667	2	0.001883	4	0.0171333	1	0.06057	3	0.2514	10	0.0089	10	0.0016	14	0.02797	4	0.002633		
11	3	0.094967	2	0.002227	11	0.0173	3	0.061	10	0.252	9	0.0089	14	0.001666667	10	0.028	5	0.002847		
12	8	0.095367	2	0.0025	12	0.0173333	1	0.06117	4	0.25266667	4	0.009	4	0.0017	3	0.0282	3	0.0029		
13	4	0.095533	2	0.0027	10	0.0173333	3	0.0615	4	0.25293333	3	0.009	3	0.0018	4	0.02823	4	0.003273		
14	4	0.095667			14	0.0174	1	0.062	4	0.25333333	5	0.0090067	4	0.001933333	5	0.02823	4	0.0040		
15	10	0.0961			4	0.0174767	11	0.0631	4	0.256	3	0.0091	10	0.002	4	0.0283				
16	5	0.096133			4	0.0175	1	0.0661	5	0.25633333	4	0.0093667	3	0.0021	4	0.02843				
17	11	0.0963			10	0.0175	1	0.0683	14	0.261	4	0.0094667	4	0.002133333	5	0.02877				
18	12	0.096533			4	0.0175667	12	0.06933	3	0.261	4	0.0099833	4	0.0023	10	0.02917				
19	3	0.097			3	0.0177	1	0.07437	17	0.26333333	10	0.0101667	10	0.002333333	4	0.0298				
20	4	0.097333			10	0.0180667	10	0.0874	4	0.2634			3	0.0024	12	0.03077				
21	4	0.099267			3	0.018367							4	0.0027	17	0.033				
22	4	0.0997			12	0.018433									10	0.035				
23															12	0.0360				
Average		0.0946		0.001731		0.01718		0.0615		0.2528		0.00897		0.001751		0.02898		0.002604		
Std Dev		0.0017		0.000088		0.00058		0.0017		0.0033		0.00025		0.000047		0.00083		0.000066		
H		0.0028		0.00048		0.0012		0.0023		0.0047		0.00093		0.00048		0.0016		0.00056		
U <sub>1</sub>		0.0033		0.00049		0.0014		0.0028		0.0058		0.00096		0.00048		0.0018		0.00056		
t-statistic		2.08		2.18		2.08		2.09		2.09		2.10		2.09		2.07		2.16		
U <sub>2</sub>		0.0068		0.0011		0.0028		0.0059		0.012		0.0020		0.0010		0.0037		0.0012		
U <sub>3</sub>		0.0015		0.00030		0.00061		0.0013		0.0027		0.00046		0.00022		0.00077		0.00033		
Certified		<b>0.095</b>		<b>0.0017</b>		<b>0.0172</b>		<b>0.062</b>		<b>0.253</b>		<b>0.0090</b>		<b>0.0018</b>		<b>0.029</b>		<b>0.0026</b>		
Uncertainty		0.002		0.0005		0.0006		0.005		0.006		0.0005		0.0005		0.001		0.0006		
Tolerance		0.006		0.0015		0.0028		0.015		0.018		0.0020		0.0015		0.004		0.0018		

Analysis	*	B	*	Ca	*	H	*	Mg	*	Nb	*	Pb	*	Sb	*	Zr
1	12	0.000177	12	0.000307	2	0.0000467	12	0.00016	12	0.00014667	12	0.0000803	4	0.001333333	5	0.0001
2	4	0.0002	4	0.000427	2	0.00005	12	0.0002	5	0.00014667	5	0.0001	12	0.001466667	12	0.00011
3	4	0.0002	3	0.00044	2	0.0000533	5	0.00023	5	0.0002	12	0.00013	11	0.0023	11	0.0006
4	4	0.000233	4	0.00044	2	0.0000567	4	0.00037	5	0.00021333	5	0.00015			10	0.0008
5	7	0.000537	12	0.00044	2	0.000117	3	0.00039	12	0.00022667	5	0.0002067			3	0.0008
6	4	0.00057	4	0.000537	2	0.00012	5	0.00039	11	0.0009	9	0.0004			4	0.00083
7	3	0.00059	5	0.001967	2	0.0001367	3	0.0007	10	0.0011	3	0.0005				
8	3	0.0009			2	0.0002			3	0.0015	4	0.0006333				
9									10	0.00166667	11	0.0009				
10									10	0.0017	10	0.001				
11									4	0.00183333						
12									3	0.0022						
13									4	0.0022						
14									14	0.0023						
15									4	0.0027						
16									4	0.00273333						
17									4	0.0043						
18									3	0.009						
Average		0.00043		0.0007		0.000098		0.00035		0.0019		0.00041		0.002		0.00054
Std Dev		0.00050		0.0012		0.000018		0.00036		0.0054		0.00042		0.011		0.00094
H		0.00030		0.0003		0.00019		0.00028		0.0005		0.00029		0.001		0.00032
U <sub>1</sub>		0.00058		0.0013		0.00019		0.00045		0.0054		0.00051		0.011		0.00099
t-statistic		2.36		2.45		2.36		2.45		2.11		2.26		4.30		2.57
U <sub>2</sub>		0.0014		0.0032		0.00045		0.0011		0.011		0.0012		0.046		0.0025
U <sub>3</sub>		0.00049		0.0012		0.00016		0.00042		0.0027		0.00036		0.026		0.0010
Informational		(0.0004)		(0.0007)		(0.0001)		(0.0004)		(0.002)		(0.0004)		(0.002)		(0.0005)

For each element, in accordance with the requirements of ISO 17034 and Guide 35, an effort must be made to account for the effects on the certified value of the uncertainty estimate from homogeneity testing (H) and the uncertainties of the contributing laboratories. The average (A) is calculated using a weighted mean where the reciprocal of the square of each laboratory's combined uncertainty (C<sub>L</sub>), calculated from its standard deviation (S<sub>L</sub>) and its uncertainty estimate (U<sub>L</sub>), is used as the weight (W<sub>L</sub>) for its mean (M<sub>L</sub>). The standard deviation (S) is calculated as the square root of the reciprocal of the sum of the weights. U<sub>1</sub> is the combined uncertainty from homogeneity and labs. U<sub>2</sub> is U<sub>1</sub> multiplied by the coverage factor (95 % t-statistic). U<sub>3</sub> is U<sub>2</sub> divided by the square root of the number of determinations (n). Thus:

$$C_L = \sqrt{S_L^2 + U_L^2} \quad W_L = \frac{1}{C_L^2} \quad A = \frac{\sum_{i=1}^n W_L M_L}{\sum_{i=1}^n W_L} \quad S = \frac{1}{\sqrt{\sum_{i=1}^n W_L}} \quad U_1 = \sqrt{H^2 + S^2} \quad U_2 = t \times U_1 \quad U_3 = \frac{U_2}{\sqrt{n}}$$

All but the final reported values are taken to two significant figures as determined by each quantity's uncertainty estimate. The final reported Uncertainty is U<sub>3</sub> rounded to one significant figure and represents the half width of the 95 % confidence interval for the **Certified** value. The final reported **Certified** value is A rounded to the same decimal place as the Uncertainty. The Uncertainty is a measure of the quality of the **Certified** value.

The Tolerance is a measure of the expected performance of an analysis. This involves further expanding the sample uncertainty to include instrument and operator uncertainty, for those without access to such calculations.

For further information regarding the confidence interval for the certified value see ISO Guide 35:2006 section 6.

Analysis	*	Ag	*	Bi	*	Ga	*	Ge	*	K	*	Na	*	Os	*	Pt	*	Re	*	Zn
1	12	0.64	12	0.02	12	6.2	12	58	12	0.01	12	0.12	12	0.01	12	0.13	12	0.09	12	10
2	12	0.65	12	0.02	12	6.2	12	59	12	0.03	12	0.14			12	0.14	12	0.1	12	10
3	12	0.65	12	0.03	12	6.3	12	59			12	0.15			12	0.15	12	0.1	12	11

**Analytical Method Codes:**

1 Combustion (ASTM E1019)	7 Photometric	13 Titrimetric
2 Fusion (ASTM E1019)	8 Flame Atomic Absorption	14 DCP Atomic Emission
3 Spark Atomic Emission	9 GF Atomic Absorption	15 HG Atomic Fluorescence
4 ICP Atomic Emission	10 X-Ray Fluorescence	16 Difference
5 ICP Mass Spectrometry	11 GD Atomic Emission	17 PIXE
6 Gravimetric	12 GD Mass Spectrometry	

ICP = Inductively Coupled Plasma      GF = Graphite Furnace      GD = Glow Discharge  
 DCP = Direct Current Plasma      HG = Hydride Generation

Lab Name	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034
LECO Corporation	St. Joseph, MI	A2LA	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Luvak Inc.	Boylston, MA	PRI	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Instituto Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Exova	Santa Fe Spring, CA	A2LA	17025
Exova	Glendale Heights, IL	A2LA	17025

A2LA = American Association for Laboratory Accreditation

ANAB = ANSI-ASQ National Accreditation Board

CNAS = China National Accreditation Service

NABL = National Accreditation Board for Testing and Calibration Laboratories

PCA = Polish Center For Accreditation

PRI = Performance Review Institute

**Analysis:** Chemical analyses were made on solid pieces and chips prepared by an end mill from representative samples for the certified portion of the lot in accordance with ASTM Standard Practice E1806. The laboratories participating in the testing followed the requirements of ISO Standard 17025.

**Traceability:** The following Certified Reference Materials were used to validate the analytical data: 11XC2, 12X353F, 12X356, 13X14211; AR 556, 558, 612B, 642, 645, 654, 657, 670, 875, 882, 911A, 950, 1648, 1650, 1652, 1653, 1656; BAS 239/3, 331, 434, 435, 455, 459, 459/1, 464/1, 486; BS D-6, HON U, SS3951, 42A, 55E, 56H, 59C, 61C, 68E, 70A, 80F, 85D, 230, 303, 304, 304A, 304B, 316D, 1018, 1144A, 4130, 4140B, 4142SE, 4150M, 4942A, 8620C; DSZU CA01A; IARM 30A, 30E, 30F, 30H, 30I, 30J, 32B, 182B; IMZ 103A, 116; JK 37; LECO 501-320, 501-501, 501-504, 501-505, 501-550, 501-644, 501-646, 501-675, 501-676, 501-677, 501-991, 501-993, 502-195, 502-197, 502-413, 502-702, 502-712, 502-855, 502-869, 502-894, 502-903, 501-646; SRM 32E, 73A, 101A, 101C, 132A, 156, 160B, 361, 362, 363, 364, 1154, 1262A, 1263A, 1265A, 1413, 1762, 1763, 1764, 2172, 3109A, 3163, 3169.

**Homogeneity:** This Certified Reference Material (CRM) was tested for homogeneity using ASTM Standard Method E826 and found acceptable. It was also examined by spark atomic emission spectrometry and found to be compatible with the following Reference Materials — BAS 455, 486; BS HON U, 42A, 56H, 70A, 230, 4140A, 4140B, 4140SE, 4150M; DSZU CA01A; LECO 501-676, 501-991, 502-416, 502-869, 502-870; SRM 1263A, 1764, 2172.

**Validity statement:** ISO Guide 31 states that the certification should contain an expiration date for all materials where instability has been demonstrated or is considered possible, after which the certified value is no longer guaranteed by the certifying body. The certification of BS 4150MOD-A is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

**Storage:** This CRM must be stored in a cool, dry, non-corrosive environment.

**Source:** The bar stock for this CRM was produced by Gerdau Special Steel North America; Jackson, MI.

**Form:** This CRM is machined in the form of a disc, approximately 38 mm in diameter, and 19 mm thick by Brammer Standard Company, Inc.

**Use:** This CRM is intended for use in spark atomic emission, glow discharge, and x-ray spectrometric methods of analysis. Refer to ISO Guide 33 for information about the use of Certified Reference Materials.

**Certified Area:** The entire depth of the CRM may be used.

Caution: As with any bar material, avoid spark atomic emission spectrometric burns in the center of the CRM (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 used for production specimens. Avoid overheating the sample during surface preparation.

Caution: CRM contains significant insoluble soft metal inclusions. Surface smearing may occur. Spark atomic emission spectrometers may require extended preburns to compensate.

**Certificate Number:** The unique identification number for this certificate of analysis is 4150MOD-A-110718. You may obtain information on revisions of certificates from the internet at [www.brammerstandard.com](http://www.brammerstandard.com).

**Safety Notice:** A Safety Data Sheet (SDS) 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.**  
14603 Benfer Road  
Houston, Texas 77069-2895 USA

**Phone: (281) 440-9396** Web: [www.brammerstandard.com](http://www.brammerstandard.com)

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**Brammer Standard Company, Inc., is accredited by the American Association For Laboratory Accreditation (A2LA) to ISO Standard 17034 as a Reference Material Producer for the production of Certified Reference Materials and Reference Materials (Certificate Number 656.02)**

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**The scopes of accreditation are listed on the website: [www.brammerstandard.com](http://www.brammerstandard.com)**

## **References:**

Versions used were those available at the time of testing and characterization

- |       |   |
|-------|---|
| E826  | Standard Practice for Testing Homogeneity of a Metal Lot or Batch in Solid Form by Spark Atomic Emission Spectrometry   |
| E1019 | Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques |
| E1806 | Standard Practice for Sampling Steel and Iron for Determination of Chemical Composition   |

ISO Standard 17025:2005 General requirements for the competence of testing and calibration laboratories

ISO Standard 9001:2015 Quality Management Systems - Requirements

ISO Guide 30:2015 Terms and definitions used in connection with reference materials + 2008 amendment

ISO Guide 31:2015 Reference materials - Contents of certificates and labels

ISO Guide 33:2015 Uses of certified reference materials

ISO Standard 17034:2016 General requirements for the competence of reference material producers

ISO Guide 35:2006 Reference Materials - General and statistical principles for certification

*ASTM documents available from ASTM, 100 Barr Harbor Dr., West Conshohocken, PA 19428.*

*ISO Guides and Standards available from Global Engineering - [www.global.ihs.com](http://www.global.ihs.com)*

*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

Certified by: \_\_\_\_\_ on November 07, 2018.

Beau R. Brammer  
President