

# BRAMMER STANDARD COMPANY, INC.

## Certificate of Analysis

### BS 187D

Certified Reference Material for Alloy 20 - UNS Number N08020

	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>0.0164</b>	0.0006	<b>S</b>	<b>0.0021</b>	0.0002
<b>B</b>	<b>0.0026</b>	0.0002	<b>Si</b>	<b>0.669</b>	0.006
<b>C</b>	<b>0.0337</b>	0.0007	<b>Sn</b>	<b>0.0085</b>	0.0004
<b>Ca</b>	<b>0.0063</b>	0.0004	<b>Ta</b>	<b>0.0008</b>	0.0003
<b>Co</b>	<b>0.089</b>	0.002	<b>Ti</b>	<b>0.0027</b>	0.0003
<b>Cr</b>	<b>19.91</b>	0.08	<b>V</b>	<b>0.073</b>	0.001
<b>Cu</b>	<b>3.52</b>	0.02	<b>W</b>	<b>0.086</b>	0.002
<b>Mn</b>	<b>0.938</b>	0.007			
<b>Mo</b>	<b>2.17</b>	0.01			
<b>N</b>	<b>0.046</b>	0.001			
<b>Nb</b>	<b>0.621</b>	0.006			
<b>Ni</b>	<b>32.3</b>	0.1			
<b>O</b>	<b>0.0026</b>	0.0004			
<b>P</b>	<b>0.0155</b>	0.0007			
<b>Pb</b>	<b>0.0019</b>	0.0002			

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

As (0.0035)

Fe [39.6]

Mg (0.0009)

Sb (0.0011)

Zr (0.0012)

<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 4 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 4 for more information on its calculation.

<sup>3</sup> Values are given in weight percent.

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

Trace element information values for Ag, Bi, Cl, Ga, Ge, K, Na, Re, and Zn are shown on page 4.

The requirements of ISO Guides 31, 34, and 35 were followed for the preparation of this Certified Reference Material and certificate of analysis. This is a Certified Reference Material as defined by ISO Guide 30.

## BS 187D

\* Code for method Certified values listed as weight percent

Analysis	*	Al	*	B	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Mn
1	5	0.015033	12	0.0019	3	0.032	4	0.005467	4	0.0831	4	19.698	3	3.45	4	0.915333
2	5	0.015267	5	0.002	1	0.032767	4	0.006067	5	0.0862	13	19.735	3	3.45	3	0.917
3	5	0.015333	4	0.002033	1	0.032933	4	0.00617	3	0.0862	4	19.73887	4	3.455	4	0.917333
4	4	0.015467	4	0.002227	1	0.032967	4	0.006437	4	0.086967	13	19.815	4	3.4550	4	0.9239
5	4	0.015967	5	0.0025	1	0.03310	5	0.0065	5	0.0870	10	19.8354	10	3.4899	10	0.92655
6	3	0.0162	4	0.002667	1	0.033475	3	0.00654	4	0.0879	10	19.86	10	3.49	4	0.933333
7	3	0.0171	4	0.0028	1	0.033533	4	0.006767	10	0.091	13	19.93567	4	3.533333	4	0.936667
8	4	0.0175	5	0.0029	1	0.033933	4	0.007	4	0.0910	3	19.95	4	3.54	10	0.94
9	12	0.0178	3	0.0029	1	0.034333	4	0.007033	8	0.091433	4	19.96	4	3.543333	7	0.944333
10	5	0.0180	3	0.00291	3	0.0344	12	0.0080	4	0.091533	4	20.00	4	3.55	4	0.946667
11	4	0.018633	7	0.002997	1	0.0353			4	0.094367	4	20.0	8	3.557	4	0.96
12			4	0.0030	1	0.0353			12	0.0950	4	20.04	4	3.560333	4	0.9622
13			3	0.00331	1	0.0355							4	3.5606	3	0.97
14					1	0.0360							4	3.576		
Average		0.01642		0.00255		0.03367		0.00634		0.0893		19.915		3.520		0.9383
Std dev		0.00065		0.00016		0.00064		0.00029		0.0018		0.051		0.015		0.0066
H		0.00071		0.00033		0.0010		0.00046		0.0018		0.12		0.025		0.009
U <sub>1</sub>		0.00096		0.00037		0.0012		0.00054		0.0025		0.13		0.029		0.011
t-statistic		2.23		2.18		2.16		2.26		2.20		2.20		2.16		2.18
U <sub>2</sub>		0.0021		0.00080		0.0026		0.0012		0.0055		0.29		0.063		0.024
U <sub>3</sub>		0.00064		0.00022		0.00069		0.00039		0.0016		0.085		0.017		0.0066
<b>Certified</b>		<b>0.0164</b>		<b>0.0026</b>		<b>0.0337</b>		<b>0.0063</b>		<b>0.089</b>		<b>19.91</b>		<b>3.52</b>		<b>0.938</b>
<b>Uncertainty</b>		<b>0.0006</b>		<b>0.0002</b>		<b>0.0007</b>		<b>0.0004</b>		<b>0.002</b>		<b>0.08</b>		<b>0.02</b>		<b>0.007</b>
Tolerance		0.0021		0.0008		0.0026		0.0012		0.005		0.29		0.06		0.024

Analysis	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P	*	Pb	*	S
1	4	2.128	2	0.0430	4	0.599	4	32.13333	2	0.002167	12	0.0140	3	0.0014	1	0.0013
2	4	2.133333	2	0.0449	4	0.608333	3	32.14	2	0.0026	4	0.014667	9	0.001533	3	0.0015
3	4	2.15	2	0.0453	3	0.61	6	32.15367	2	0.0027	10	0.015	5	0.001763	1	0.00170
4	3	2.15	2	0.04565	4	0.614333	6	32.20	2	0.002737	7	0.015267	5	0.0018	1	0.0018
5	10	2.151625	2	0.046233	4	0.61525	10	32.20818	2	0.00295	4	0.015467	5	0.0019	1	0.001967
6	10	2.16	2	0.0467	10	0.622025	4	32.21333	2	0.00295	3	0.0157	5	0.002033	1	0.002
7	3	2.16	2	0.04725	4	0.623967	4	32.25647			5	0.0160	12	0.0022	1	0.002067
8	4	2.163333	2	0.047667	3	0.632	4	32.26			5	0.0174	5	0.002277	12	0.0021
9	4	2.170333			4	0.632667	13	32.26367			5	0.017633	4	0.002323	1	0.00211
10	4	2.18			10	0.633333	10	32.27					5	0.002633	1	0.0022
11	4	2.194			4	0.64	4	32.3							1	0.0023
12	7	2.198667					3	32.31							1	0.00233
13	4	2.213333					4	32.38567							1	0.0024
14							4	32.48677								
15							4	32.52								
Average		2.171		0.0463		0.6210		32.297		0.00262		0.01547		0.00192		0.00207
Std dev		0.012		0.0011		0.0062		0.058		0.00025		0.00065		0.00016		0.00013
H		0.017		0.0012		0.0064		0.20		0.00033		0.00069		0.00030		0.00030
U <sub>1</sub>		0.021		0.0017		0.0089		0.21		0.00042		0.00095		0.00034		0.00033
t-statistic		2.18		2.36		2.23		2.14		2.57		2.31		2.26		2.18
U <sub>2</sub>		0.045		0.0039		0.020		0.45		0.0011		0.0022		0.00077		0.00072
U <sub>3</sub>		0.012		0.0014		0.0060		0.11		0.00044		0.00073		0.00024		0.00020
<b>Certified</b>		<b>2.17</b>		<b>0.046</b>		<b>0.621</b>		<b>32.3</b>		<b>0.0026</b>		<b>0.0155</b>		<b>0.0019</b>		<b>0.0021</b>
<b>Uncertainty</b>		<b>0.01</b>		<b>0.001</b>		<b>0.006</b>		<b>0.1</b>		<b>0.0004</b>		<b>0.0007</b>		<b>0.0002</b>		<b>0.0002</b>
Tolerance		0.04		0.004		0.020		0.4		0.0011		0.0022		0.0008		0.0007

**BS 187D** \* Code for method Certified values listed as weight percent

Analysis	*	Si	*	Sn	*	Ta	*	Ti	*	V	*	W
1	4	0.648733	3	0.0073	4	0.000567	12	0.0020	3	0.068	4	0.080067
2	3	0.65	9	0.008033	12	0.00065	5	0.002067	4	0.069367	5	0.082433
3	10	0.65	10	0.008375	5	0.000733	5	0.0025	5	0.0700	4	0.0840
4	6	0.653333	5	0.0087	5	0.0008	5	0.0025	5	0.070233	4	0.085667
5	3	0.654	5	0.0088	5	0.000937	4	0.0026	12	0.0725	5	0.0860
6	10	0.670225	12	0.0089	5	0.0011	3	0.003	3	0.0727	4	0.086033
7	4	0.673333	5	0.0089			10	0.0030	10	0.072925	5	0.086667
8	6	0.675333	4	0.009103			3	0.0031	10	0.073	4	0.086833
9	4	0.685333	4	0.009167			4	0.00317	5	0.073667	3	0.0885
10	4	0.688	5	0.0092			4	0.0034	4	0.074367	4	0.090433
11	4	0.69	4	0.0094			4	0.003433	4	0.074633		
12	4	0.690667	5	0.009567					4	0.0777		
13									4	0.077933		
14									13	0.0783		
Average		0.6693		0.00845		0.00077		0.00274		0.0732		0.0860
Std dev		0.0063		0.00034		0.00010		0.00019		0.0013		0.0019
H		0.0067		0.00052		0.00023		0.00034		0.0016		0.0017
U <sub>1</sub>		0.0092		0.00062		0.00025		0.00039		0.0020		0.0026
t-statistic		2.20		2.20		2.57		2.23		2.16		2.26
U <sub>2</sub>		0.020		0.0014		0.00064		0.00086		0.0044		0.0058
U <sub>3</sub>		0.0059		0.00040		0.00026		0.00026		0.0012		0.0018
<b>Certified</b>		<b>0.669</b>		<b>0.0085</b>		<b>0.0008</b>		<b>0.0027</b>		<b>0.073</b>		<b>0.086</b>
<b>Uncertainty</b>		<b>0.006</b>		<b>0.0004</b>		<b>0.0003</b>		<b>0.0003</b>		<b>0.001</b>		<b>0.002</b>
<b>Tolerance</b>		<b>0.020</b>		<b>0.0014</b>		<b>0.0006</b>		<b>0.0009</b>		<b>0.004</b>		<b>0.006</b>

**BS 187D** \* Code for method Informational values listed as weight percent

Analysis	*	As	*	Fe	*	Mg	*	Sb	*	Zr
1	5	0.0026	4	39.35333	12	0.00074	5	0.000947	4	0.000533
2	12	0.0037	3	39.6	5	0.0010	5	0.0011	10	0.000875
3	4	0.004467	4	39.65467	4	0.0010	12	0.0013	4	0.004733
4	5	0.004833	10	40.0						
Average		0.00349		39.64		0.00087		0.00108		0.00124
Std dev		0.00043		0.17		0.00017		0.00018		0.00022
H		0.00037		0.25		0.00023		0.00025		0.00026
U <sub>1</sub>		0.00057		0.30		0.00029		0.00031		0.00034
t-statistic		3.18		3.18		4.30		4.30		4.30
U <sub>2</sub>		0.0018		0.96		0.0013		0.0013		0.0015
U <sub>3</sub>		0.00090		0.48		0.00072		0.00076		0.00084
<b>(Informational)</b>		<b>(0.0035)</b>		<b>[39.6]</b>		<b>(0.0009)</b>		<b>(0.0011)</b>		<b>(0.0012)</b>

For each element, in accordance with the requirements of ISO Guides 34 and 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> times 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 Tolerance is the half width of the 95 % confidence interval for measurements 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.

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

BS 187D		* Code for analytical method											Trace analysis listed as mg/kg (ppm)		
Analysis	* Ag	* Bi	* Cl	* Ga	* Ge	* K	* Na	* Re	* Zn						
1	5 2.27	5 0.143	12 0.079	12 20	12 10	12 0.20	12 0.091	5 1.5	12 13						
2	12 3.5	12 0.25						12 1.5	5 19.67						

**Analytical Method Codes:**

- |                           |                           |                           |
|---------------------------|---------------------------|---------------------------|
| 1 Combustion (ASTM E1019) | 7 Photometric             | 13 Titrimetric            |
| 2 Fusion (ASTM E 1019)    | 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     |                           |
| 5 ICP Mass Spectrometry   | 11 GD Atomic Emission     |                           |
| 6 Gravimetric             | 12 GD Mass Spectrometry   |                           |

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

<u>Laboratory</u>	<u>Location</u>	<u>Registrar</u>	<u>Accreditation</u>
ATI Allvac	Lockport, NY	PRI/Nadcap	AC7101/2
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34
Dirats Laboratories	Westfield, MA	ACLASS	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
LECO Corporation	St. Joseph, MI	A2LA	17025
NSL Analytical	Cleveland, OH	ACLASS	17025
Shandong Metallurgical and Science Research	Jinan, China	CNAS	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Exova	Glendale Heights, IL	A2LA	17025
Northern Analytical Laboratory, Inc.	Londonderry, NH	PRI/Nadcap	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554

A2LA = American Association for Laboratory Accreditation  
 ACLASS = ANSI-ASQ National Accreditation Board  
 CNAS = China National Accreditation Service  
 Nadcap = National Aerospace and Defense Contractors Accreditation Program  
 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 E 1806. The laboratories participating in the testing followed the requirements of ISO Standard 17025. Methods of analysis used were a those listed on pages 2-4.

**Traceability:** The following Certified Reference Materials were used to validate the analytical data listed on pages 2-4 — 11XSG2, 12X41300, 12X44220, 13X32100, 13X41001, 28X7138; 501-024, 501-123, 501-320, 501-501, 501-502, 501-503, 501-504, 501-643, 501-644, 501-646, 501-676, 501-952, 501-993, 502-072, 502-102, 502-257, 502-348, 502-455; BAS 180/2, 260/3, 261, 261/1, 331, 334, 345, 363, 434, 464, 464/1, 474; BS HH5157A, HH5196A, 83B, 187, 187A, 187C, 690, 800, 825A; CT 082; CZ 2015A; ECRM 281, 296; IARM 5E, 25A, 25B, 52, 98B, 190A; IMZ 1.7/4, 1.12/3, 130, 132, 139, 169, 176A, 177, 178; SRM C1151A, C1152A, C1288, 1170B, 3107, 3109A, 3131A, 3155, 3162A, 3169.

**Homogeneity:** This Certified Reference Material (CRM) was tested for homogeneity using ASTM Standard Method E 826 and found acceptable. It was also examined by spark atomic emission spectrometry and found to be compatible with the following Reference Materials — BS CSN2-1, CSN 4, HH5157A, HH5196A, 83B, 187, 187A, 800, 825A; ECRM 287-1; SRM C1288, 126C, 348A.

**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 187D is valid indefinitely. The certification is nullified if this CRM is damaged, contaminated, or otherwise modified.

**Source:** The bar stock for this CRM was produced by Crucible Industries, Solvay, NY

**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 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 you use for production specimens. Avoid overheating the sample during surface preparation.

**Certificate Number:** The unique identification number for this certificate of analysis is 187D-101813. You may obtain information on revisions of certificates from the internet at [www.brammerstandard.com](http://www.brammerstandard.com).

**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 Web: [www.brammerstandard.com](http://www.brammerstandard.com)  
14603 Benfer Road  
Houston, Texas 77069-2895 USA Fax: (281) 440-4432 Email: [contact@brammerstandard.com](mailto:contact@brammerstandard.com)

**Brammer Standard Company, Inc., is accredited by the American Association For Laboratory Accreditation (A2LA) to ISO Guide 34 as a Reference Material Producer for the production of Certified Reference Materials and Reference Materials (Certificate Number 656.02)**

**Brammer Standard Company's Chemical Laboratory is accredited by A2LA to ISO Standard 17025. (Certificate Number 656.01)**

**By Certificate Number 10539, the Quality System of Brammer Standard Company, Inc., is registered to ISO 9001:2008 by National Quality Assurance (NQA), U.S.A.**

**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

- E 826 Standard Practice for Testing Homogeneity of a Metal Lot or Batch in Solid Form by Spark Atomic Emission Spectrometry
- E 1019 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques
- E 1806 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 9001:2008 Quality Management Systems - Requirements
- ISO Guide 30:1992 Terms and definitions used in connection with reference materials + 2008 amendment
- ISO Guide 31:2000 Reference materials - Contents of certificates and labels
- ISO Guide 33:2000 Uses of certified reference materials
- ISO Guide 34:2009 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, 1916 Race Street, Philadelphia, PA, 19103.*

*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 October 18, 2013.

Beau R. Brammer