

# Certificate of Analysis

**BS 9811**

**Certified Reference Material<sup>1</sup> for Custom 450 Stainless Steel Alloy  
(UNS Number S45000)**

	<b>Certified Value<sup>2</sup></b>	<b>Estimate of Uncertainty<sup>3</sup></b>	<b>Certified Value<sup>2</sup></b>	<b>Estimate of Ucertainty<sup>3</sup></b>
<b>Analysis listed as percent by weight</b>				
<b>C</b>	<b>0.027</b>	0.002	<b>Sn</b>	<b>0.004</b> 0.001
<b>Mn</b>	<b>0.380</b>	0.008	<b>V</b>	<b>0.086</b> 0.002
<b>P</b>	<b>0.016</b>	0.001	<b>W</b>	<b>0.013</b> 0.004
<b>S</b>	<b>0.0010</b>	0.0004		
<b>Si</b>	<b>0.36</b>	0.012		
<b>Cu</b>	<b>1.63</b>	0.02		
<b>Ni</b>	<b>6.55</b>	0.05	<b>Information Values<sup>4</sup></b>	
<b>Cr</b>	<b>14.87</b>	0.03	<b>Al</b>	0.003
<b>Mo</b>	<b>0.744</b>	0.012	<b>As</b>	0.003
<b>Ca</b>	<b>0.0014</b>	0.0001	<b>B</b>	0.0003
<b>Co</b>	<b>0.055</b>	0.003	<b>O</b>	0.0060
<b>N</b>	<b>0.0196</b>	0.0008	<b>Ti</b>	0.003
<b>Nb</b>	<b>0.62</b>	0.01		

<sup>1</sup> Brammer Standard Company, Inc., is accredited to ISO Guide 34 as a Reference Material Producer to produce Certified Reference Materials by A2LA (Certificate Number 656.02)

<sup>2</sup> The certified value listed is the present best estimate of the true value based on the results of an interlaboratory testing program.

<sup>3</sup> The uncertainties listed are 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.

<sup>4</sup> Information values are not certified and are provided for information only.

See the following pages for more information.

**Certificate Number 9811-032701p1**

Analysis	*	C	* Mn	* P	* S	* Si	* Cu	* Ni	* Cr
1	C	0.0253	XRF 0.365	AIC 0.015	C 0.0005	AIC 0.340	XRF 1.59	AIC 6.463	TCr 14.82
2	C	0.0266	XRF 0.37	MPH 0.015	C 0.0005	XRF 0.349	AIC 1.605	XRF 6.489	TCr 14.82
3	C	0.0268	AES 0.374	XRF 0.0152	C 0.00070	AES 0.354	AIC 1.61	XRF 6.50	TCr 14.84
4	C	0.027	AIC 0.376	XRF 0.0155	C 0.0010	AES 0.354	XRF 1.625	XRF 6.50	AES 14.842
5	C	0.027	AA 0.378	XRF 0.0158	C 0.0010	XRF 0.354	AES 1.628	TNi 6.52	XRF 14.861
6	C	0.028	MnP 0.378	AIC 0.0159	IC 0.0013	AGA 0.358	AIC 1.63	GNi 6.534	AGX 14.87
7	C	0.030	AIC 0.380	XRF 0.016	C 0.0017	GSi 0.359	XRF 1.632	GNi 6.54	XRF 14.88
8			AES 0.381	AGA 0.0161		GSi 0.365	XRF 1.635	AGX 6.55	AES 14.88
9			XRF 0.383	AIC 0.0162		AIC 0.366	AA 1.637	XRF 6.553	XRF 14.89
10			AGX 0.383	MPN 0.0164		GSi 0.370	AGX 1.64	AIC 6.58	AIC 14.90
11			XRF 0.387	AIC 0.0170		AIC 0.370	AES 1.65	AIC 6.58	XRF 14.912
12			MnP 0.3876	AIC 0.0174		GSi 0.3996	MCB 1.65	AES 6.599	
13			MnP 0.390				MCT 1.658	AES 6.60	
14			AIC 0.392					TNi 6.62	
Average		0.0272	0.3803	0.0160	0.00096	0.3616	1.630	6.545	14.865
Std Dev		0.0015	0.0076	0.0007	0.00044	0.0149	0.019	0.047	0.031
Certified		0.027	0.380	0.016	0.0010	0.36	1.63	6.55	14.87
t		2.4469	2.1604	2.201	2.4469	2.2010	2.1788	2.1604	2.2281
C(95%)		0.0013	0.0044	0.0005	0.00041	0.0095	0.012	0.027	0.021

Analysis	*	Mo	* Ca	* Co	* N	* Nb	* Sn	* V	* W
1	GMo	0.725	AAA 0.0012	AIC 0.049	FU 0.0186	XRF 0.597	AIC 0.003	XRF 0.082	AIC 0.007
2	XRF	0.731	AIC 0.0013	AIC 0.050	FU 0.0186	AIC 0.604	AES 0.00305	AIC 0.0845	XRF 0.008
3	AES	0.735	AIC 0.0013	XRF 0.053	TN 0.0188	AIC 0.609	AIM 0.0032	AGA 0.085	AIC 0.0088
4	AIC	0.737	AIC 0.0014	AIC 0.054	FU 0.0195	MNA 0.614	AIH 0.0033	MVE 0.0850	AIC 0.0093
5	AGX	0.739	AGA 0.0014	AGX 0.054	FU 0.01979	AIC 0.615	AIC 0.0033	XRF 0.085	MWC 0.0100
6	AIC	0.741	AES 0.00144	XRF 0.055	FU 0.020	AGX 0.619	MSn 0.0036	AES 0.085	XRF 0.015
7	AIC	0.741	AIC 0.0015	AAA 0.055	FU 0.0202	XRF 0.619	AIC 0.0039	AIC 0.0858	AGA 0.015
8	XRF	0.746	AIC 0.0015	AES 0.056	FU 0.0212	MNR 0.623	AES 0.004	XRF 0.086	XRF 0.015
9	AES	0.747	AIC 0.0016	XRF 0.056		AIC 0.624	AAG 0.0040	AIC 0.0866	AIM 0.0164
10	XRF	0.747		AES 0.056		AIC 0.624	AGA 0.004	AES 0.087	AIC 0.017
11	MMT	0.768		M5 0.0562		AES 0.626	AIM 0.0061	XRF 0.088	AIC 0.017
12	AIC	0.770		AIC 0.0562		AES 0.629		AAA 0.0911	
13				XRF 0.061		XRF 0.63			
14						AIC 0.634			
Average		0.7439	0.00140	0.0547	0.01959	0.6191	0.0038	0.0859	0.0126
Std Dev		0.0134	0.00012	0.0030	0.00091	0.0104	0.0009	0.0022	0.0039
Certified		0.744	0.0014	0.055	0.0196	0.62	0.004	0.086	0.013
t		2.201	2.306	2.1788	2.3646	2.1604	2.2281	2.201	2.2281
C(95%)		0.0085	0.00009	0.0018	0.0008	0.0060	0.0006	0.0014	0.0026

Analysis	*	Al	* As	* B	* O	* Ti
1	XRF	0.001	AAG 0.0025	AES 0.0002	FU 0.0056	AES 0.0017
2	AES	0.0025	AES 0.003	AES 0.00031	FU 0.0060	XRF 0.003
3	AES	0.005			FU 0.0060	XRF 0.004
4					FU 0.00626	XRF 0.005
Average		0.0028	0.0028	0.00026	0.0060	0.0034
Std Dev		0.0020	0.0004	0.00008	0.0003	0.0014
Certified		(0.003)	(0.003)	(0.0003)	(0.0060)	(0.003)

\* Methods of analysis listed on page 3

Data in parentheses are not certified but are provided for information only.

$C(95\%) = (t \text{ } sd) / n$  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.

## Methods of Analysis

Code	Element	Method
AA		Flame Atomic Absorption Spectrometry
AAA		Flame Atomic Absorption - standard addition method
AAG		Electro-thermal atomization (graphite furnace) Atomic Absorption Spectrometry
AES		AES - Spark Source Optical Emission Spectrometry
AGA		AES - Spark Source and Glow Discharge Spectrometry average
AGX		Glow Discharge and X-Ray Fluorescence Spectrometry average
AIC		AES - ICP -Inductively Coupled Plasma Spectrometry
AIH		AES - ICP -Inductively Coupled Plasma Spectrometry after hydride generation
AIM		AES - ICP Mass Spectrometry addition method
C	C, S	Combustion-Infrared Absorption (ASTM E 1019) traceable to CRMs
FU	N, O	Inert gas Fusion Method (ASTM E 1019) traceable to CRMs
GMO	Mo	Gravimetry, Benzoinoxime
GNi	Ni	Dimethylglyoxime gravimetric
GSI	Si	Gravimetry with perchloric acid
IC	S	Ion chromatography
M5	Co	MAS - 5-Cl-PADAB spectrophotometric
MCB	Cu	MAS - Bicyclohexane oxalyldihydrazone photometric
MCT	Cu	MAS - Tetraethylthiuram disulphide
MMT	Mo	MAS - Thiocyanate photometric
MNA	Nb	MAS - Absorptionmetric determination method with 4-(2-pyridylazo)-Resorcinol
MnP	Mn	MAS - Periodate oxidation
MNR	Nb	MAS - PAR photometric
MPH	P	MAS - Heteropoly molybdenum blue photometric
MPN	P	MAS - Butyl alcohol-trichloromethane extraction photometric
MSn	Sn	MAS - Phenylfluorone photometric
MVE	V	MAS - n-benzoyl phenylhydroxylamine extraction photometric
MWC	W	MAS - Chlorpromazine hydrochloride sodium thiocyanate - tri-chloromethane extraction
TCr	Cr	Persulfate oxidation, ferrous sulfate titrimetric
TNi	Ni	EDTA titration
XRF		X-Ray Fluorescence spectrometry

AES = Atomic Emission Spectrometry

MAS = Molecular Absorption Spectrometry (photometric, spectrophotometric methods)

**Co-operating Laboratories:** The co-operating laboratories were:

### Laboratory

Allvac, Lockport, New York  
 Allvac, Monroe, North Carolina  
 ANAREM, Prague, Czech Republic  
 Brammer Standard Co., Inc., Houston, Texas  
 China National Analysis Center for Iron and Steel, Beijing, China  
 Crucible Specialty Steel, Syracuse, New York  
 J. Dirats and Co., Inc., Westfield, Massachusetts  
 IncoTest, Huntington, West Virginia  
 LECO Corporation, St. Joseph, Michigan  
 Shiva Analyticals (India) Ltd., Hoskote, Bangalore, India  
 VHG Laboratories, Inc., Manchester, New Hampshire

### Laboratory contact

Thomas Herdlein  
 Patrick M. Cole  
 Karel Bi ovsk  
 Richard P. Beaumont  
 Prof. Wang Haizhou  
 William Mastroe  
 Eric E. Dirats  
 Melissa G. Staley  
 Dennis Lawrenz  
 Dr. T. V. Ramakrishna  
 Julie M. McIntosh

**Additional analytical data:** This material was used as an unknown test specimen number 9811 in a nationally recognized Proficiency Testing Program (PTP) for low-alloy steel. Most of the participating laboratories used one or more of the ASTM Standard Test Methods E 327, E 572, E 1019, and E 1086. The PTP data was not used in calculating the certified values listed on pages 1 and 2. The data shown below are the results from the PTP.

Combustion Instrument Analysis using ASTM Standard Test Method E 1019

	C	S	N	O
Number of Labs	26	23	19	18
Grand Average	0.0281	0.0008	0.0194	0.0069
Standard Deviation	0.0026	0.0004	0.0007	0.0010

Optical Emission Spectrometric Analysis using ASTM Standard Test Method E 1086

	C	Mn	P	S	Si	Cu	Ni
Number of Labs	18	16	17	14	18	17	16
Grand Average	0.0287	0.3815	0.0158	0.0012	0.3689	1.6457	6.4945
Standard Deviation	0.0029	0.0077	0.0017	0.0006	0.0167	0.0250	0.0763

  

	Cr	Mo	Co	V	Nb
Number of Labs	16	18	8	6	5
Grand Average	14.8646	0.7474	0.0572	0.0876	0.6306
Standard Deviation	0.0951	0.0176	0.0034	0.0034	0.0243

Optical Emission Spectrometric Analysis using ASTM Standard Test Method E 327

	Mn	Cu	Ni	Cr	Si
Number of Labs	4	4	4	4	4
Grand Average	0.3820	1.6635	6.5768	14.9113	0.3583
Standard Deviation	0.0053	0.0386	0.1213	0.1451	0.0129

X-ray Emission Spectrometric Analysis using ASTM Standard Test Method E 572

	Mn	P	Si	Cu	Ni	Cr	Mo	V	Co	Nb
Number of Labs	13	7	6	13	14	14	14	7	13	14
Grand Average	0.3709	0.0158	0.3586	1.6272	6.5141	14.8857	0.7361	0.0874	0.0555	0.6128
Standard Deviation	0.0136	0.0012	0.0176	0.0231	0.0292	0.0694	0.0158	0.0059	0.0064	0.0131

**Certification Process:** The requirements of ISO Guide 31, ISO Guide 34, ISO Guide 35, and ASTM Standard Guides E 1724 and E 1831 were followed for the preparation of this reference material and certificate of analysis. This is a Certified Reference Material as defined by ISO Guide 30.

**Analysis:** Chemical analyses were made on chips prepared by a lathe from the certified portion of the discs in accordance with ASTM Standard Practice E 1806. The laboratories participating in the testing normally followed the requirements of ISO Guide 25 and/or ISO Standard 17025. Individual values listed on page 2 are the average of each analyst's results. Methods of analysis are listed on page 3.

**Outliers:** Some outlying data was excluded from the data listed on page 2 due to technical assessment of the cooperating laboratories and statistical evaluation.

**Traceability:** The following Certified Reference Materials were used to validate the analytical data listed on page 2: SRM 15h, 32b, 126c, 131f, 166b, 343a, 345, 3103a, 3107, 3109a, 3161a; ECRM 284-1, 289-1, 295-1; BS CSN-1.

**Homogeneity:** This Certified Reference Material was tested for homogeneity using ASTM Standard Method E 826 and found acceptable. It was also examined by optical emission spectrometry using ASTM Standard Test Method E 1086 and found to be compatible with the following Reference Materials: SRM C1151, 1219, C1289, C2400; BS 17-4PH, 95, 95A, 96.

**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. Whereas this material is in a solid form and stable, no expiration date is specified.

**Source:** This material was produced by Carpenter Technology Corporation, Reading, Pennsylvania. It was melted by an electric arc furnace, bottom poured into ingots, hot rolled, and finished with a normalized heat treatment.

**Form:** This Certified Reference Material is in the form of a disc, approximately 38 mm in diameter and 12 mm thick.

**Use:** This Certified Reference Material is intended for use in optical emission and x-ray spectrometric methods of analysis. Refer to ISO Guide 33 for information about the use of Reference Materials.

**Certified area:** 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 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.

**Certificate Number:** The unique identification number for this certificate of analysis is 9811-032701-px, where x indicates the page number. Refer to future Brammer Standard Company catalogs for information on any revisions to this or other Brammer Standard reference materials. You may also obtain information on revisions of certificates from the internet at [brammerstandard.com](http://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. 14603 Benfer Road Houston, Texas 77069-2895 USA	Phone: (281) 440-9396 Fax: (281) 440-4432	web <a href="http://brammerstandard.com">brammerstandard.com</a> e-mail <a href="mailto:bramstan@netropolis.net">bramstan@netropolis.net</a>
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Certified by: \_\_\_\_\_ on March 27, 2001.  
G. R. Brammer

**Brammer Standard Company, Inc., is accredited to ISO Guide 34 as a Reference Material Producer for the production of Certified Reference Materials and Reference Materials by A2LA (Certificate Number 656.02) The scope of accreditation is listed on the website: [www.brammerstandard.com](http://www.brammerstandard.com)**

**By Certificate Number 10539, the Quality System of Brammer Standard Company, Inc., is registered to ISO 9002:1994 by National Quality Assurance, U.S.A.**

**Brammer Standard Company's Chemical Laboratory is accredited to ISO Guide 25 by A2LA. (Certificate Number 656.01)**

## **References:**

*ASTM documents available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, Telephone: 610-832-9500 Fax: 610-832-9555 e-mail: [service@astm.org](mailto:service@astm.org) Website: [www.astm.org](http://www.astm.org)*

E 327 - 94 Standard Test Method for Optical Emission Spectrometric Analysis of Stainless Type 18-8 Steels by the Point-to-Plane Technique

E 572 - 94 Standard Test Method for X-Ray Emission Spectrometric Analysis of Stainless Steel

E 826 - 85 (Reapproved 1996) Standard Practice for Testing Homogeneity of Materials for the Development of Reference Materials

E 1019 - 2000 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel, and Cobalt Alloys

E 1086 - 94 Standard Test Method for Optical Emission Vacuum Spectrometric Analysis of Stainless Steel by the Point-to-Plane Excitation Technique

E 1724 - 95 Standard Guide for Testing and Certification of Metal and Metal-Related Reference Materials

E 1806 - 96 Standard Practice for Sampling Steel and Iron for Determination of Chemical Composition

E 1831 - 96 Standard Guide for Preparing Certificates for Reference Materials Relating to Chemical Composition of Metals, Ores, and Related Materials.

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

ISO Standard 17025 (First edition, 1999), General requirements for the competence of calibration and testing laboratories.

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 (Second edition, 2000), Reference materials -Contents of certificates and labels.

ISO Guide 33 (Second edition, 2000), Uses of certified reference materials.

ISO Guide 34 (Second edition, 2000), General requirements for the competence of reference material producers.

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

**Certificate Number 9811-032701p6**