

# Brammer Standard Company, Inc.

## Certificate of Analysis

### BS 17-4PHC

Certified Reference Material for Stainless Steel Grade 17-4 - UNS Number S17400

	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>	0.0004		<b>N</b>	0.001
<b>As</b>	<b>0.0043</b>	0.0006		<b>Nb</b>	0.003
<b>B</b>	<b>0.0026</b>	0.0006		<b>Ni</b>	0.07
<b>C</b>	<b>0.033</b>	0.002		<b>O</b>	0.001
<b>Ca</b>	<b>0.0007</b>	0.0003		<b>P</b>	0.002
<b>Co</b>	<b>0.077</b>	0.003		<b>S</b>	0.002
<b>Cr</b>	<b>15.40</b>	0.07		<b>Si</b>	0.007
<b>Cu</b>	<b>3.23</b>	0.04		<b>Sn</b>	0.0009
<b>Fe</b>	<b>74.8</b>	0.1		<b>V</b>	0.003
<b>Mn</b>	<b>0.81</b>	0.02		<b>W</b>	0.004
<b>Mo</b>	<b>0.45</b>	0.01			

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

Pb (0.0001)

Ti (0.001)

Zr (0.002)

<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. 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 Ce, Ga, Ge, Ir, Mg, Na, Os, Pt, Re, Sb, Se, Y, and Zn are shown on page 4.

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

**Brammer Standard Company, Inc., 14603 Benfer Road, Houston, TX 77069-2895 USA**  
Telephone: (281) 440-9396 Fax (281) 440-4432 Website: [www.brammerstandard.com](http://www.brammerstandard.com)

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## BS 17-4PHC

\* Code for method

Certified values listed as weight percent

Analysis	*	Al	*	As	*	B	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mn
1	4	0.00196667	5	0.0037	4	0.00193333	1	0.0278333	3	0.0005225	10	0.0740333	3	15.29	4	3.1725	16	[74.680933]	14	0.786667
2	11	0.001975	11	0.0039	12	0.002	1	0.0315	12	0.00055667	5	0.0743	4	15.327333	4	3.174	4	74.684	4	0.792333
3	3	0.002	9	0.0039	3	0.00219	1	0.0316267	11	0.0006	11	0.0748	10	15.33	4	3.1987333	14	74.7	3	0.79775
4	14	0.00206667	5	0.0039	5	0.00233333	1	0.0317	4	0.0006	7	0.0753	3	15.38	3	3.20	13	74.701	4	0.798
5	4	0.00226667	4	0.00393333	4	0.0024	1	0.0328667	4	0.00069933	4	0.0756	17	15.38	3	3.2033333	16	[74.73]	4	0.799533
6	3	0.00245	4	0.004	5	0.00267667	1	0.033	4	0.00088	4	0.0758667	13	15.392333	4	3.2076667	16	[74.735]	4	0.799667
7	10	0.0025	3	0.0041	11	0.002725	3	0.033	14	0.001	4	0.0767	17	15.3943	4	3.2110667	16	[74.7388067]	10	0.8
8	4	0.0025	12	0.0044	4	0.0028	1	0.033			8	0.077	3	15.40	4	3.2233333	16	[74.7475]	4	0.802
9	4	0.0027	15	0.00478	7	0.00293	1	0.0339333			3	0.0777667	11	15.4	3	3.235	10	74.77	3	0.808333
10			5	0.00493333	3	0.002995	11	0.0342			4	0.0777667	14	15.4	10	3.24	4	74.82333333	10	0.808667
11			4	0.00493333	4	0.00303333	1	0.0343333			14	0.0778	4	15.403333	3	3.24	10	74.89333333	3	0.81
12			5	0.00505	3	0.0031	1	0.0347333			10	0.078	4	15.416667	4	3.2426667	16	[75.0133]	11	0.81325
13					4	0.0032	1	0.0351			4	0.0782	10	15.42	4	3.2496667	3	75.19333333	4	0.814333
14							1	0.0355			4	0.0782333	4	15.420367	10	3.25			4	0.815667
15							3	0.03615			8	0.0783667	4	15.438233	11	3.25			7	0.823
16											4	0.0792333	4	15.473333	4	3.2630667			8	0.83
17											3	0.0793	3	15.4775	14	3.2633333			3	0.83
18											4	0.0800667			8	3.28			4	0.8305
19											3	0.081625							4	0.840533
Average		0.00227		0.004294		0.002640		0.0335		0.000698		0.077366		15.396671		3.228020		74.834		0.8093
Std Dev		0.00011		0.000091		0.000088		0.0011		0.000016		0.000073		0.000077		0.000075		0.043		0.0043
H		0.00054		0.00069		0.00057		0.0017		0.00035		0.0026		0.059		0.021		0.18		0.009227
U <sub>1</sub>		0.00055		0.00070		0.00058		0.0020		0.00035		0.0026		0.059		0.021		0.19		0.010
t-statistic		2.31		2.20		2.18		2.14		2.45		2.10		2.12		2.11		2.18		2.10
U <sub>2</sub>		0.0013		0.0015		0.0013		0.0044		0.00086		0.0054		0.13		0.045		0.41		0.021
U <sub>3</sub>		0.00042		0.00044		0.00035		0.0011		0.00032		0.0012		0.031		0.011		0.11		0.0049
Certified		<b>0.0023</b>		<b>0.0043</b>		<b>0.0026</b>		<b>0.033</b>		<b>0.0007</b>		<b>0.077</b>		<b>15.40</b>		<b>3.23</b>		<b>74.8</b>		<b>0.81</b>
Uncertainty		0.0004		0.0006		0.0006		0.002		0.0003		0.003		0.07		0.04		0.1		0.02
Tolerance		0.0013		0.0018		0.0018		0.006		0.0007		0.009		0.21		0.16		0.4		0.06

Analysis	*	Mo	*	N	*	Nb	*	Ni	*	O	*	P	*	S	*	Si	*	Sn	*	V
1	3	0.43325	2	0.02356667	4	0.25266667	3	4.1033333	2	0.00873667	10	0.0187667	1	0.0232667	17	0.39	9	0.008833333	5	0.085033
2	4	0.43675	2	0.0255	4	0.25375	4	4.15575	2	0.0093	7	0.0203333	1	0.0250667	3	0.3923333	4	0.0091	4	0.088075
3	10	0.43766667	13	0.02576667	4	0.25523333	4	4.1736667	2	0.00943333	4	0.0206	1	0.0250667	4	0.3926667	3	0.0091	3	0.088333
4	3	0.44166667	2	0.0258	4	0.25533333	4	4.177	2	0.00952	4	0.0208333	1	0.0257967	4	0.3936667	5	0.0094	3	0.0884
5	14	0.445	2	0.02598	4	0.256	10	4.21	2	0.01043333	3	0.021	1	0.026	14	0.3963333	3	0.010	4	0.0889
6	4	0.44666667	2	0.0265	11	0.25625	10	4.21	2	0.01086667	17	0.021	3	0.026	17	0.3969333	4	0.01	3	0.089
7	4	0.44766667	2	0.02653333	3	0.2565	4	4.21	2	0.01126667	7	0.0210333	1	0.0260	4	0.3992333	4	0.010133333	4	0.0893
8	4	0.44866667	2	0.02666667	4	0.25966667	4	4.2247	2	0.01140	12	0.0213333	1	0.0263667	10	0.40	3	0.010225	4	0.089333
9	3	0.449	2	0.027	14	0.26066667	4	4.2263333	2	0.01236667	3	0.0214	1	0.0265667	11	0.4	5	0.010366667	10	0.089433
10	4	0.449	2	0.02783333	4	0.261	3	4.245	3	0.0214	1	0.0265667	3	0.40	5	0.0106	4	0.0902		
11	10	0.45	2	0.0291	4	0.26116667	3	4.25	3	0.021475	10	0.028	4	0.4013333	11	0.010675	11	0.010675	11	0.090825
12	3	0.45	2	0.03233333	5	0.26133333	3	4.26	4	0.0219	1	0.028	6	0.4036667	4	0.0107	4	0.0107	4	0.091
13	4	0.4516			10	0.26266667	11	4.2625	10	0.022	1	0.0280667	4	0.404	5	0.0107	4	0.0107	4	0.091733
14	4	0.453			3	0.266	17	4.27	4	0.0220333	11	0.028625	4	0.4044667					14	0.091967
15	7	0.46066667					4	4.2996	4	0.0221667	1	0.0292	3	0.405					8	0.092
16	4	0.46383333					4	4.3116667	4	0.0226667	3	0.0296	3	0.40975					3	0.09315
17	4	0.464					14	4.3233333	11	0.02285									10	0.095
18	11	0.4645					4	4.3341333	4	0.0229									4	0.095933
19	8	0.47							5	0.0239667										
Average		0.4526		0.02735		0.258445		4.235945		0.01031		0.02176		0.02718		0.399336		0.01000		0.090423
Std Dev		0.0042		0.00096		0.000085		0.000075		0.00048		0.00073		0.00089		0.000079		0.00035		0.00075
H		0.0066		0.0016		0.0048		0.025		0.0010		0.0014		0.0015		0.0061651		0.0010		0.0028
U <sub>1</sub>		0.0078		0.0018		0.0049		0.025		0.0011		0.0016		0.0018		0.0062		0.0010		0.0028
t-statistic		2.10		2.20		2.16		2.11		2.31		2.10		2.13		2.13		2.18		2.11
U <sub>2</sub>		0.016		0.0040		0.010		0.053		0.0026		0.0033		0.0038		0.013		0.0023		0.0059
U <sub>3</sub>		0.0038		0.0012		0.0028		0.013		0.00085		0.00076		0.0010		0.0033		0.00063		0.0014
Certified		<b>0.45</b>		<b>0.027</b>		<b>0.258</b>		<b>4.24</b>		<b>0.010</b>		<b>0.022</b>		<b>0.027</b>		<b>0.399</b>		<b>0.0100</b>		<b>0.090</b>
Uncertainty		0.01		0.001		0.003		0.07		0.001		0.002		0.002		0.007		0.0009		0.003
Tolerance		0.03		0.004		0.010		0.21		0.003		0.006		0.006		0.021		0.0027		0.009

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**BS 17-4PHC**

\* Code for method

Certified values listed as weight percent

Analysis	*	W																					
1	4	0.11633333																					
2	5	0.117																					
3	4	0.11866667																					
4	4	0.11875																					
5	4	0.11933333																					
6	4	0.12003333																					
7	4	0.12153333																					
8	14	0.12166667																					
9	4	0.12223333																					
10	10	0.12266667																					
11	3	0.12425																					
12	4	0.12466667																					
13	11	0.125																					
Average		0.120933																					
Std Dev		0.000088																					
H		0.0032																					
U <sub>1</sub>		0.0032																					
t-statistic		2.18																					
U <sub>2</sub>		0.0071																					
U <sub>3</sub>		0.0020																					
Certified		0.121																					
Uncertainty		0.004																					
Tolerance		0.012																					

**BS 17-4PHC**

\* Code for method

Informational values listed as weight percent

Analysis	*	Pb	*	Ti	*	Zr																	
1	12	0.0000297	12	0.00015667	12	0.00026333																	
2	5	0.0000333	5	0.00026667	4	0.00083333																	
3	4	0.00014233	11	0.0007	3	0.001925																	
4	3	0.0002	4	0.00119133	4	0.004																	
5	9	0.0003	3	0.0012																			
6			14	0.00136667																			
7			10	0.0016																			
8			4	0.0018																			
Average		0.000141		0.001		0.0018																	
Std Dev		0.000056		0.0055		0.0097																	
H		0.00021		0.00039638		0.0005																	
U <sub>1</sub>		0.00022		0.0055		0.0097																	
t-statistic		2.78		2.36		3.18																	
U <sub>2</sub>		0.00060		0.013		0.031																	
U <sub>3</sub>		0.00027		0.0046		0.015																	
Informational		(0.0001)		(0.001)		(0.002)																	

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 ( $C_L$ ), calculated from its standard deviation ( $S_L$ ) and its uncertainty estimate ( $U_L$ ), is used as the weight ( $W_L$ ) for its mean ( $M_L$ ). The standard deviation (S) is calculated as the square root of the reciprocal of the sum of the weights.  $U_1$  is the combined uncertainty from homogeneity and labs.  $U_2$  is  $U_1$  multiplied by the coverage factor (95 % t-statistic).  $U_3$  is  $U_2$  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  $U_3$  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.

### BS 17-4PHC

\* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Ce	*	Ga	*	Ge	*	Ir	*	Mg	*	Na	*	Os	*	Pt	*	Re	*	Sb
1	12	0.01	12	21	12	11	12	0.05	12	0.82	12	0.04	12	0.05	12	0.06	12	0.48	12	9.4
2	12	0.01	12	22	12	11	12	0.05	12	0.99	12	0.04	12	0.06	12	0.07	12	0.5	12	9.5
3	12	0.01	12	23	12	12	12	0.05	12	1.1	12	0.05	12	0.06	12	0.07	12	0.51	12	9.5
Analysis	*	Se	*	Y	*	Zn														
1	12	0.21	12	0.01	12	1.9														
2	12	0.22	12	0.01	12	2.1														
3	12	0.25	12	0.01	12	2.1														

### 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 WET                    |
| 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
NSL Analytical	Cleveland, OH	ANAB	17025
Exova	Glendale Heights, IL	A2LA	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Luvak Inc.	Boylston, MA	PRI	17025
Vitkovice Testing Center	Ostrava, Czech Republic	ILAC	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Shiva Analyticals	Hoskote, Bangalore	NABL	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025

A2LA = American Association for Laboratory Accreditation  
ANAB = ANSI-ASQ National Accreditation Board  
CNAS = China National Accreditation Service  
ILAC = International Laboratory Accreditation Cooperation  
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: 12Z15259Q, 12X3490, 12X4330A, 13X12853K, 13X14212, 13X14212L, 13X14418A, 13X14775S, 13X31603D, 13X32100, 13X32900A, 13X41800A, 13X42200, 14X93603A, 23X80010; AR 165, 513, 641, 654, 659, 662, 675, 882, 891, 892, 961, 1648, 1650, 1652, 1653; BAS 69, 72, 342, 435, 464/1, 469; BS H-13, H1C, HON U, 14-4PHA, 17-4PHB, 88C, 88F, 180B, 185A, 186A, 187C, 187D, 192, 200-1, 200-2, 200-4, 200A, 304B, 316D, 316E, 431, 800A, 2205, 4340A, 9811, 9905A; CKD 186A, CZ2003A; DSZU CA012; ECRM 085-1, 184-1; IARM 22B, 23C, 23D, 90B, 91B; IMN BB1; IMZ 123, 162; IPT 12A, 17A; JSS 169-5, 174-5, 175-7; LECO 501-503, 501-506, 501-644, 501-646, 501-673, 501-676, 502-415, 502-868, 502-869, 502-916, 502-921; SPL 16A; SRM C2400, 343A, 345, 345A, 361, 363, 1261, 1761, 1762.

**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: BS HON U, 17-4PHA, 17-4PHB, 88C, 88F, 192, 9811; CKD CZ2003A; DSZU CA012; LECO 501-676, 502-415, 502-869; SRM C2400.

**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 17-4PHC 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 supplied by Next Generation Metals; Boca Raton, FL.

**Form:** This CRM is machined in the form of a disc, approximately 44mm in diameter and 19mm 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 17-4PHC-121620. 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)

**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 Standard 17034 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 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

- 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 17025:2017 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 35:2017 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 December 16, 2020.

Beau R. Brammer  
President