

Brammer Standard Company, Inc.

Certificate of Analysis

BS H2E

Certified Reference Material for C-276 - UNS Number N10276

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.35	0.02		Mo	0.09
C	0.0030	0.0007		N	0.0009
Co	0.032	0.005		Ni	0.2
Cr	15.85	0.08		O	0.0002
Fe	5.41	0.05		V	0.01
Mg	0.0019	0.0004		W	0.05
Mn	0.55	0.02			

	Reference Value	Estimate of Uncertainty	Reference Values^{3,4}	Reference Value	Estimate of Uncertainty
B	0.0028	0.0007		S	0.00025
Cu	0.0070	0.0005		Si	0.005
P	0.005	0.002		Ti	0.002

Informational Values^{3,5}

As (0.0006)	Ca (0.0004)	Nb (0.009)	Pb (0.002)	Sb (0.00004)
Sn (0.001)	Ta (0.02)	Zr (0.002)		

¹ 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.

² 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.

³ Values are given in weight percent. Values in brackets are reported by difference.

⁴ Reference values are not certified and are provided for information only.

⁵ Values in parentheses are not certified and are provided for information only.

Trace element information values for Ga, Ge, Ir, Os, Re, Te, U, 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.

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* Code for method

Certified values listed as weight percent

Analysis	*	Al	*	C	*	Co	*	Cr	*	Fe	*	Mg	*	Mn	*	Mo	*	N	*	Ni
1	5	0.291333	1	0.002	4	0.025833	4	15.65	4	5.295	3	0.00072	8	0.525667	3	15.77	2	0.010	13	57.766
2	3	0.312	1	0.0023667	8	0.027233	10	15.715	4	5.295	14	0.001533	10	0.535	4	15.873333	2	0.01061	6	57.8323
3	4	0.328	1	0.0025	14	0.0279	4	15.752	3	5.36	5	0.0018	4	0.5359	17	15.965667	2	0.01113	4	58.0656
4	10	0.329333	1	0.0025	3	0.028	13	15.7736667	4	5.3961	4	0.0020	3	0.538	11	15.99	2	0.01167	17	58.1417
5	14	0.333	1	0.0026333	4	0.029	3	15.79	4	5.3983667	12	0.002233	4	0.54	4	15.990233	2	0.0121	14	58.3
6	4	0.3374	1	0.0029	11	0.0292	4	15.8633333	4	5.402	4	0.002267	4	0.541	14	16.0	2	0.01217	16	[58.3]
7	4	0.34	1	0.002966	5	0.029333	11	15.87	14	5.4033333	4	0.002297	11	0.542	4	16.004333	2	0.01233	11	58.35
8	10	0.35	1	0.0030667	5	0.0298	18	15.8766333	10	5.4050333	4	0.002567	4	0.542333	10	16.013367	2	0.01243	10	58.36
9	5	0.351333	3	0.0033	12	0.034333	10	15.89	10	5.413			10	0.542733	4	16.036	2	0.01272	4	58.48
10	4	0.352933	1	0.0033333	10	0.035	10	15.891	3	5.437			4	0.545333	4	16.04	2	0.01273	16	[58.5423]
11	11	0.354	11	0.0034	4	0.046	14	15.9	4	5.45			4	0.5473	10	16.045	2	0.013	16	[58.55]
12	4	0.36	1	0.0036667	3	0.0461	4	15.91	11	5.45			4	0.548333	4	16.05	2	0.0131		
13	4	0.369333	1	0.0045			4	15.91	4	5.4598			10	0.55	10	16.06				
14	3	0.396					4	15.9536667	10	5.460			14	0.555667	4	16.21				
15	4	0.3993					3	16.055	4	5.5103333			4	0.5599	4	16.266667				
16													17	0.574667	3	16.333				
17													3	0.588						
18													4	0.59						
Average		0.3495		0.003010		0.032311		15.853353		5.408998		0.00192		0.5499		15.981		0.01187		58.306
Std Dev		0.0037		0.000088		0.000091		0.000082		0.000082		0.00020		0.0037		0.022		0.00044		0.078
H		0.0054		0.00055		0.0015		0.072		0.032		0.00047		0.0071		0.072		0.0010		0.20
U ₁		0.0066		0.00056		0.0015		0.072		0.032		0.00051		0.0080		0.075		0.0011		0.22
t-statistic		2.14		2.18		2.20		2.14		2.14		2.36		2.11		2.13		2.20		2.23
U ₂		0.014		0.0012		0.0033		0.15		0.069		0.0012		0.017		0.16		0.0023		0.48
U ₃		0.0036		0.00034		0.0010		0.040		0.018		0.00043		0.0040		0.040		0.00067		0.14
Certified		0.35		0.0030		0.032		15.85		5.41		0.0019		0.55		15.98		0.0119		58.3
Uncertainty		0.02		0.0007		0.005		0.08		0.05		0.0004		0.02		0.09		0.0009		0.2
Tolerance		0.06		0.0021		0.015		0.24		0.15		0.0012		0.06		0.27		0.0027		0.6

Analysis	*	O	*	V	*	W
1	2	0.000307	17	0.1426667	4	3.180
2	2	0.0004	4	0.149	11	3.18
3	2	0.000433	4	0.1496333	3	3.182
4	2	0.00053	4	0.1497667	4	3.23
5	2	0.000667	4	0.15	10	3.233
6	2	0.0007	14	0.1506667	3	3.27
7	2	0.000703	10	0.1507667	10	3.2731
8	2	0.001	4	0.1511667	14	3.28
9	2	0.001	3	0.153	4	3.287
10			10	0.155	10	3.29
11			3	0.156	4	3.295367
12			4	0.1576667	4	3.316667
13			11	0.16	4	3.3301
14			5	0.1603333	4	3.335333
15			4	0.165	4	3.388333
16					4	3.4093
Average		0.000458		0.1533		3.2777
Std Dev		0.000050		0.0027		0.0071
H		0.00030		0.0034		0.023
U ₁		0.00030		0.0043		0.024
t-statistic		2.31		2.14		2.13
U ₂		0.00070		0.0093		0.051
U ₃		0.00023		0.0024		0.013
Certified		0.0005		0.15		3.28
Uncertainty		0.0002		0.01		0.05
Tolerance		0.0005		0.03		0.15

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* Code for method Reference values listed as weight percent

Analysis	*	B	*	Cu	*	P	*	S	*	Si	*	Ti
1	11	0.0018	10	0.004	5	0.000237	1	0.0001	4	0.0143333	14	0.003067
2	4	0.002	14	0.0041	7	0.00055	1	0.0002	12	0.0256667	4	0.003793
3	14	0.002233	3	0.0043	12	0.002067	1	0.0002	5	0.0270	11	0.0043
4	3	0.0023	12	0.0048	3	0.0032	12	0.00022	3	0.028	5	0.0044
5	3	0.00243	8	0.0054667	5	0.0033	1	0.00023333	4	0.029	12	0.0052
6	12	0.002533	5	0.0054667	4	0.004	1	0.000306	10	0.03	4	0.0056
7	5	0.002567	5	0.0055267	4	0.004	1	0.00048333	4	0.0313	4	0.006
8	7	0.003763	4	0.0056667	14	0.004833	11	0.0007	4	0.0323	4	0.008
9	4	0.004067	11	0.0084	11	0.0053	1	0.0008	3	0.034	10	0.0084
10	4	0.004567	4	0.0117333	10	0.006	1	0.00083333	11	0.0348	10	0.0084
11			3	0.012	4	0.006333	3	0.0009	4	0.0350667	4	0.008633
12			10	0.0125667	10	0.007967			14	0.0413	3	0.009
13					4	0.008			10	0.0431667	4	0.0091
14					4	0.0084			4	0.0435333	3	0.0108
Average		0.00283		0.007002		0.004585		0.000485		0.0298		0.006764
Std Dev		0.00010		0.000091		0.000085		0.000050		0.0012		0.000085
H		0.00054		0.00077		0.00065		0.00030		0.0015		0.00076
U ₁		0.00055		0.00078		0.00066		0.00031		0.0019		0.00076
t-statistic		2.26		2.20		2.16		2.23		2.16		2.16
U ₂		0.0012		0.0017		0.0014		0.00069		0.0041		0.0016
U ₃		0.00039		0.00049		0.00038		0.00021		0.0011		0.00044
Reference		0.0028		0.0070		0.005		0.00045		0.030		0.007
Uncertainty		0.0007		0.0005		0.002		0.00025		0.005		0.002
Tolerance		0.0021		0.0017		0.004		0.00040		0.015		0.006

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* Code for method Informational values listed as weight percent

Analysis	*	As	*	Ca	*	Nb	*	Pb	*	Sb	*	Sn	*	Ta	*	Zr
1	12	0.00026	12	0.000043	5	0.0008	12	0.0000257	12	0.0000447	5	0.0001	3	0.015	5	0.000037
2	15	0.000313	5	0.0002	5	0.00081	3	0.003			5	0.0001			5	0.00006
3	5	0.0004	4	0.00027	4	0.001167					12	0.000108			3	0.0001
4	5	0.0004	3	0.00039	14	0.003333					5	0.000137			12	0.0001467
5	9	0.000667	4	0.0004	10	0.004					9	0.000767			4	0.0008
6	3	0.0009	11	0.0004	4	0.007333					4	0.001033			4	0.001
7	4	0.000967	4	0.0007333	4	0.007533					3	0.0011			4	0.0012333
8					4	0.008					3	0.002			4	0.0025333
9					4	0.015									3	0.003
10					10	0.015433									10	0.0081
11					11	0.016										
12					3	0.017										
13					3	0.0176										
Average		0.00056		0.00035		0.009		0.002		0.0000447		0.0007		0.02		0.0017
Std Dev		0.00092		0.00035		0.054		0.011		0.0000071		0.0012		0.35		0.0058
H		0.00032		0.00028		0.001		0.0005		0.00017		0.0003		0.001		0.0005
U ₁		0.00098		0.00045		0.054		0.011		0.00017		0.0013		0.35		0.0058
t-statistic		2.45		2.45		2.18		12.71		12.71		2.36		12.71		2.26
U ₂		0.0024		0.0011		0.12		0.14		0.0022		0.0030		4.50		0.013
U ₃		0.00090		0.00042		0.032		0.096		0.0022		0.0011		4.50		0.0042
Informational		(0.0006)		(0.0004)		(0.009)		(0.002)		(0.00004)		(0.001)		(0.02)		(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. U₁ is the combined uncertainty from homogeneity and labs. U₂ is U₁ multiplied by the coverage factor (95 % t-statistic). U₃ is U₂ 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 U₃ 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.

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* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Ga	*	Ge	*	Ir	*	Os	*	Re	*	Te	*	U	*	Zn				
1	12	10	12	0.27	12	0.15	12	0.17	12	1.2	12	0.02	12	0.01	12	1.2				
2	12	11	12	0.28	12	0.17	12	0.21	12	1.5	12	0.02	12	0.02	12	1.3				
3	12	11	12	0.3	12	0.17	12	2.3	12	1.5			12	0.02	12	1.4				
4															4	74				
5															4	76				
6															4	76				

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 | 18 WET |

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, Guide 34
LECO Corporation	St. Joseph, MI	A2LA	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Luvak Inc.	Boylston, MA	PRI	17025
Exova	Santa Fe Springs, CA	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Evans Analytical Group	Liverpool, NY	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, Guide 34

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: 12X11572A, 13X17005, 215X10276A; AR 654, 670, 673, 875, 892, 950, 1648, 1652, 1653, & 1656; BAS 4/94, 149/2, 346A, 387; BS H2B2, H2, H230, H2A, H2B, H2C, H2D, H3C, H5E, H6B, HC3D, HC5, HC6A, SS3951, 92F, 93F, 316A, 316E, 410C, 416, 715D, 750C, 9905A; DSZU CA01a; ECRM 85-1, 86-1, 87-1; IARM 54B, 56C, 56G, 57C, 66A, 66B, 66C, 66D, 68D, 190A; IMZ 111, 112, 124, 152, 171; JSS 650-13; LECO 501-320, 501-501, 501-502, 501-504, 501-644, 501-674, 501-676, 501-993, 502-348, 502-411, 502-704, 502-712, 502-856, 502-870, 502-873, 502-874, 502-903, 502-913; SRM C2402, 8F, 349, 349A, 864, 865, 866, 867, 882, 1099, 1245A, 1413, 2159, 2168; VASKUT S-3; Y 41340b.

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 4/94, 351; BS H2, H2B, H2C, H2D, H6B, HC5V, HC6A; DSZU CA01a; LECO 501-676, 502-873; SRM C2402, 867, 882, 2168; Y 41340b.

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 H2E 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 Next Generation Metals; Boca Raton, FL.

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 H2E-053018. You may obtain information on revisions of certificates from the internet at 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

Fax: (281) 440-4432

Email: 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

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

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 May 30, 2018.

Beau R. Brammer

President