Brammer Standard Company, Inc.

Certificate of Analysis

BS 4330MOD

Certified Reference Material for 4330M Alloy Steel - UNS Number K23080

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.031**	0.002	**Nb**	**0.007**	0.001
As	**0.0038**	0.0006	**Ni**	**1.83**	0.01
C	**0.316**	0.006	**P**	**0.0052**	0.0005
Co	**0.034**	0.002	**S**	**0.0010**	0.0003
Cr	**0.848**	0.008	**Si**	**0.269**	0.009
Cu	**0.105**	0.004	**Sn**	**0.0062**	0.0009
Fe	**95.1**	0.1	**Ti**	**0.0027**	0.0004
Mn	**0.92**	0.01	**V**	**0.083**	0.004
Mo	**0.478**	0.009	**Zr**	**0.0016**	0.0005
N	**0.0031**	0.0005			

Informational Values[3,4]

B (0.0009)	Ca (0.001)	Mg (0.0002)	O (0.001)	Pb (0.001)
Sb (0.0007)	W (0.001)			

[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 3 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 3 for more information on its calculation.

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

[4] Values in parentheses are not certified and are provided for information only.

Trace element information values for Cl, Ga, Ge, and Re 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.

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

BS 4330MOD * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	C	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo	*	N
1	5	0.0276	4	0.0030	1	0.30736667	5	0.030867	4	0.82675	3	0.10	13	94.8746667	4	0.89633	4	0.46666667	2	0.001967
2	5	0.0284	12	0.0032333	3	0.31	4	0.031533	3	0.838	4	0.1006	16	[95]	4	0.902	4	0.467	2	0.002233
3	10	0.029	4	0.0032333	1	0.31	4	0.03225	4	0.84066667	4	0.10075	3	95.0233333	4	0.90475	4	0.46963325	2	0.00274
4	3	0.0299	9	0.0036333	1	0.31	4	0.0331	3	0.842	3	0.102	16	[95.039434]	7	0.91167	11	0.471	2	0.002867
5	4	0.03003	3	0.0038	1	0.3112	14	0.0331	4	0.8458	4	0.103333	16	[95.04]	4	0.91887	4	0.47293333	2	0.003067
6	11	0.0315	5	0.0038667	1	0.31166667	11	0.0341	4	0.84976667	4	0.103333	4	95.05	10	0.92	3	0.47333333	2	0.003233
7	4	0.0317	4	0.0039667	1	0.31233333	4	0.034967	10	0.850	10	0.104333	16	[95.05]	4	0.92033	10	0.47533333	2	0.0033
8	4	0.03197	5	0.0040267	3	0.313	8	0.035	3	0.850	4	0.104433	16	[95.069167]	14	0.921	4	0.47733333	2	0.0034
9	4	0.032	3	0.0044	1	0.31433333	3	0.0353	3	0.85033333	4	0.1055	10	95.08	4	0.92227	14	0.47933333	2	0.003833
10	4	0.0322	15	0.00448	11	0.316	4	0.035333	4	0.85056667	10	0.107	4	95.1166667	3	0.923	4	0.47973333	2	0.00403
11	3	0.0322			1	0.317	3	0.0355	14	0.85233333	11	0.107	16	[95.1233]	4	0.9257	10	0.48		
12	14	0.0323			1	0.31866667	4	0.0355	10	0.853	4	0.1073	14	95.3666667	4	0.92577	3	0.48		
13	4	0.0325			1	0.320	7	0.035633	11	0.856	14	0.107667	4	95.525	3	0.93	3	0.481		
14	3	0.0325			1	0.33733333	4	0.0359	4	0.86033333	8	0.108			8	0.93	3	0.481		
15	4	0.03287			1	0.33833333	4	0.035933	4	0.8609	4	0.108			11	0.93	7	0.48566667		
16	3	0.033					10	0.035933			8	0.108667			10	0.932	4	0.486		
17							8	0.0362			3	0.109			3	0.932	8	0.49		
18															4	0.93733	4	0.491		
19															3	0.93767				
Average		0.0312		0.00376		0.316482		0.034479		0.848430		0.105113		95.104		0.9249		0.478165		0.00307
Std Dev		0.0010		0.00010		0.000082		0.000077		0.000082		0.000077		0.031		0.0044		0.000075		0.00010
H		0.0018		0.00072		0.0058		0.0019		0.0099		0.0033		0.19		0.010		0.0072		0.00066
U_1		0.0021		0.00072		0.0058		0.0019		0.0099		0.0033		0.19		0.011		0.0072		0.00067
t-statistic		2.13		2.26		2.14		2.12		2.14		2.12		2.18		2.10		2.11		2.26
U_2		0.0044		0.0016		0.012		0.0040		0.021		0.0069		0.41		0.024		0.015		0.0015
U_3		0.0011		0.00052		0.0032		0.0010		0.0055		0.0017		0.11		0.0054		0.0036		0.00048
Certified		**0.031**		**0.0038**		**0.316**		**0.034**		**0.848**		**0.105**		**95.1**		**0.92**		**0.478**		**0.0031**
Uncertainty		0.002		0.0006		0.006		0.002		0.008		0.004		0.1		0.01		0.009		0.0005
Tolerance		0.006		0.0018		0.018		0.006		0.024		0.012		0.4		0.02		0.027		0.0015

Analysis	*	Nb	*	Ni	*	P	*	S	*	Si	*	Sn	*	Ti	*	V	*	Zr
1	12	0.0040	14	1.7933333	3	0.0050	1	0.0003	5	0.253	12	0.0047	3	0.0022	5	0.07803	12	0.0000253
2	5	0.00583	4	1.7999333	3	0.005	1	0.000333	10	0.25333333	5	0.0053	5	0.00229333	3	0.07867	3	0.001
3	11	0.0061	4	1.8055667	5	0.005	1	0.0008	17	0.25403333	5	0.0055	4	0.0024	4	0.07967	3	0.0014
4	4	0.00616	4	1.81	4	0.00503333	1	0.000867	4	0.25833333	5	0.005647	5	0.0024	4	0.0797	10	0.0018
5	4	0.00617	10	1.82	11	0.0051	1	0.0009	3	0.260	4	0.0057	4	0.00246667	4	0.08073	4	0.00186667
6	5	0.00619	4	1.8266667	4	0.0051	3	0.001	4	0.26333333	3	0.006	11	0.0025	4	0.08125	4	0.002
7	5	0.00653	3	1.83	4	0.00512667	11	0.001	3	0.26833333	5	0.006167	5	0.00266667	3	0.082	4	0.0022
8	14	0.00793	3	1.83	7	0.00513667	1	0.001	4	0.26973333	3	0.0071	4	0.0028	4	0.08263	11	0.0028
9	3	0.0080	3	1.830	3	0.0052	1	0.00103	4	0.2699	3	0.008	14	0.00293333	14	0.0828		
10	4	0.008	4	1.8327	4	0.00533333	1	0.0011	3	0.27	10	0.0082	3	0.003	4	0.0836		
11	3	0.008	4	1.833	10	0.0054	12	0.0012	10	0.27			4	0.00316667	10	0.084		
12	4	0.008	11	1.84	7	0.00553333	3	0.0012	3	0.27			3	0.0034	10	0.08403		
13	4	0.0083	10	1.84	4	0.00553333	1	0.0021	17	0.27					11	0.0849		
14	4	0.00843	4	1.8473	3	0.0057			14	0.27133333					3	0.085		
15	10	0.0085	17	1.85	4	0.0058			6	0.2758					3	0.0854		
16	3	0.0097	3	1.85					4	0.27766667					4	0.0864		
17									11	0.286					4	0.08703		
18									4	0.299								
Average		0.00734		1.8294		0.00520		0.000987		0.268878		0.00623		0.002702		0.0828		0.00164
Std Dev		0.00025		0.0054		0.00019		0.000088		0.000075		0.00010		0.000082		0.0020		0.00011
H		0.00095		0.015		0.00082		0.00042		0.0053		0.00088		0.00062577		0.0029		0.00051
U_1		0.00098		0.016		0.00084		0.00043		0.0053		0.00089		0.00063		0.0035		0.00053
t-statistic		2.13		2.13		2.14		2.18		2.11		2.26		2.20		2.12		2.36
U_2		0.0021		0.035		0.0018		0.00094		0.011		0.0020		0.0014		0.0075		0.0012
U_3		0.00052		0.0086		0.00046		0.00026		0.0026		0.00064		0.00040		0.0018		0.00044
Certified		**0.007**		**1.83**		**0.0052**		**0.0010**		**0.269**		**0.0062**		**0.0027**		**0.083**		**0.0016**
Uncertainty		0.001		0.01		0.0005		0.0003		0.009		0.0009		0.0004		0.004		0.0005
Tolerance		0.003		0.03		0.0018		0.0009		0.027		0.0027		0.0014		0.012		0.0015

BS 4330MOD * Code for method Informational values listed as weight percent

Analysis	*	B	*	Ca	*	Mg	*	O	*	Pb	*	Sb	*	W
1	4	0.0001	12	0.000036	12	0.0000203	2	0.000267	11	0.0000076	12	0.00062	3	0.0007
2	12	0.0001	4	0.0003	11	0.000095	2	0.00035	10	0.0005	5	0.000713	11	0.0009
3	3	0.0002	3	0.0004	4	0.0002	2	0.000363	3	0.0005			4	0.00113333
4	7	0.0002	11	0.0004	4	0.0002	2	0.000433	9	0.00066667			4	0.00116667
5	3	0.00035	4	0.0008733	4	0.0004	2	0.000567	4	0.00496667			4	0.00116667
6	11	0.0006	4	0.0050333			2	0.0006					12	0.0013
7	14	0.0010					2	0.0009					5	0.00167
8	4	0.0046					2	0.0012					5	0.0018
9							2	0.002333					4	0.0019
10							2	0.003733					3	0.002
11													5	0.0022
Average		0.0009		0.0012		0.00018		0.0011		0.0013		0.0007		0.0014
Std Dev		0.0021		0.0040		0.00010		0.0026		0.0054		0.0024		0.0042
H		0.0004		0.0005		0.00023		0.0004		0.0005		0.0004		0.0005
U_1		0.0022		0.0040		0.00026		0.0027		0.0054		0.0025		0.0043
t-statistic		2.36		2.57		2.78		2.26		2.78		12.71		2.23
U_2		0.0051		0.010		0.00071		0.0061		0.015		0.031		0.010
U_3		0.0018		0.0042		0.00032		0.0019		0.0068		0.022		0.0029
Informational		(0.0009)		(0.001)		(0.0002)		(0.001)		(0.001)		(0.0007)		(0.001)

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 it's 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:

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

*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 4330MOD * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Cl	*	Ga	*	Ge	*	Re
1	12	0.02	12	9.3	12	18	12	0.35
2	12	0.02	12	9.7	12	18	12	0.35
3	12	0.03	12	9.9	12	18	12	0.36

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
Dirats Laboratories	Westfield,MA	ANAB	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Eurofins EAG Materials Science, LLC	Liverpool, NY	A2LA	17025
Element Materials Technology	Glendale Heights, IL	A2LA	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
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Shiva Analyticals	Hoskote, Bangalore	NABL	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: 12X15259Q, 12X3490, 12X4330A, 13X12853K, 13X14212L, 13X14215L, 13X14418A, 13X14775S, 13X31603D, 13X32100, 13X32900, 13X32900A, 13X4100A, 13X41800A, 13X42200, 14X93603A, 23X80010; AR 165, 318/B, 612B, 614A, 654, 662, 673, 882, 886, 889, 892,. 961, 1648, 1650, 1652, 1653; BAS 69, 72, 342, 435, 464/1, 469; BS H-13, H1C, 17-4PHA, 50G, 60C, 60E, 185A, 186A, 187C, 187D, 200-1, 200-2, 200-4, 200A, 234, 316D, 431, 509, 800A, 1018, 1026, 2205, 4330V, 4340A, 9905A; CKD 186A; DSZU CA01A; ECRM 085-1, 184-1, 299-1; IARM 22B, 30J, 31F, 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, 502-328, 502-698, 502-712, 502-891, 502-916, 502-921; SPL 16A; SRM 160B, 343A, 361, 363, 364, 1162, 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 60A, 60C, 60E, 234, 4330V, 4340A; DSZU CA01A; ECRM 184-1, 299-1; SRM 343A, 1162.

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 4330MOD 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 Carpenter Latrobe Specialty Metals; Latrobe, PA.

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 4330MOD-120720. 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. **Phone: (281) 440-9396Web: www.brammerstandard.com**
14603 Benfer Road
Houston, Texas 77069-2895 USA **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 17025:2017 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 35:2006 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 December 07, 2020.

Beau R. Brammer

President