

Brammer Standard Company, Inc.

Certificate of Analysis

BS E52100

Certified Reference Material for AISI Steel Grade E52100 - UNS Number G52986

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values ³	Certified Value ¹	Estimate of Uncertainty ²
Al	0.019	0.002	N	0.0057	0.0008
As	0.0033	0.0007	Ni	0.066	0.003
C	0.99	0.03	O	0.0009	0.0003
Ca	0.0006	0.0002	P	0.011	0.001
Co	0.0067	0.0009	S	0.004	0.001
Cr	1.54	0.05	Sb	0.0011	0.0004
Cu	0.090	0.004	Si	0.270	0.009
Fe	96.6	0.1	Sn	0.0049	0.0009
Mn	0.371	0.008	V	0.0046	0.0007
Mo	0.0209	0.0009			
	Reference Value ¹	Estimate of Uncertainty ²	Reference Values ^{3,4}	Reference Value ¹	Estimate of Uncertainty ²
Mg	<0.0005		Ti	0.0010	0.0007
Nb	0.0010	0.0007	W	0.0015	0.0007
Pb	<0.0005		Zr	<0.005	

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

Trace element information values for B, Ba, Ce, Cl, Ga, Ge, La, Na, Re, 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.

Analysis	*	Al	*	As	*	C	*	Ca	*	Co	*	Cr	*	Cu	*	Fe	*	Mn	*	Mo
1	3	0.017	10	0.0024	1	0.96	12	0.00040	14	0.005867	3	1.46	4	0.081	16	[96.52933]	4	0.360333	5	0.0172
2	5	0.017333	12	0.0026	1	0.966333	3	0.0006	3	0.006	4	1.4945	10	0.081	4	96.54	4	0.363333	10	0.0195
3	5	0.017967	4	0.002767	1	0.970333	11	0.0006	4	0.006	4	1.517667	3	0.0863	16	[96.55]	3	0.366667	3	0.02
4	10	0.018	4	0.002967	1	0.974	4	0.00062	5	0.006033	4	1.52	3	0.087	16	[96.57]	3	0.368	3	0.02003
5	3	0.018267	9	0.0030	1	0.980333	4	0.00065	4	0.006417	3	1.523333	3	0.0876	16	[96.5791]	10	0.369	11	0.0202
6	3	0.0183	3	0.0031	1	0.985	4	0.0009	4	0.006467	10	1.53	3	0.087667	16	[96.58]	3	0.369	4	0.02067
7	3	0.018333	4	0.003133	1	0.987425			3	0.006567	14	1.53	8	0.087833	10	96.586667	4	0.369	4	0.0207
8	4	0.0186	3	0.0032	1	0.989167			3	0.006767	3	1.53	4	0.088667	4	96.587033	4	0.369133	4	0.02087
9	4	0.018667	11	0.0033	1	0.989733			4	0.006933	4	1.534333	4	0.089	13	96.593667	4	0.3698	7	0.02097
10	4	0.0188	2	0.003337	3	0.998			4	0.006967	3	1.535	4	0.089767	14	96.6	3	0.37	10	0.021
11	4	0.018967	5	0.003467	3	0.998667			3	0.0070	3	1.537	10	0.090	3	96.613333	8	0.37	3	0.021
12	11	0.0191	4	0.003633	11	1			11	0.0071	4	1.539267	3	0.090	16	[96.65334]	4	0.370133	4	0.02103
13	14	0.019167	5	0.003723	1	1.0			3	0.0071	4	1.539667	10	0.0903	16	[96.684367]	14	0.370667	4	0.02113
14	4	0.019167	5	0.003767	1	1.0000			4	0.0072	8	1.54	4	0.090433			3	0.371	4	0.02127
15	3	0.0192	5	0.003767	1	1.001567			4	0.007333	13	1.54	8	0.091			3	0.371	14	0.02127
16	4	0.0193	10	0.004	1	1.003333			10	0.008	4	1.540667	11	0.0913			10	0.371333	3	0.0217
17	4	0.020867			3	1.01			10	0.008	4	1.546667	4	0.091767			4	0.371667	3	0.022
18	3	0.021			1	1.019333			3	1.55	4	0.091833					5	0.373	4	0.02203
19	10	0.021033			3	1.02			4	1.557333	14	0.092967					10	0.379	3	0.023
20	4	0.022			1	1.026			11	1.56	5	0.0931					4	0.38		
21									10	1.566667	4	0.0932					11	0.38		
22									10	1.57	4	0.093967								
23									4	1.586667	3	0.095								
24											4	0.097233								
Average		0.01905		0.003260		0.993961		0.000602		0.00672		1.5404		0.089914		96.586		0.3710		0.02087
Std Dev		0.00060		0.000079		0.000071		0.000013		0.00021		0.0044		0.000065		0.032		0.0032		0.00070
H		0.0014		0.00067		0.010774		0.00035		0.00091		0.014		0.0030		0.19		0.0063		0.0015
U ₁		0.0016		0.00068		0.011		0.00035		0.00094		0.014		0.0030		0.19		0.0070		0.0017
t-statistic		2.09		2.13		2.09		2.57		2.12		2.07		2.07		2.18		2.09		2.10
U ₂		0.0033		0.0014		0.023		0.00091		0.0020		0.030		0.0062		0.42		0.015		0.0035
U ₃		0.00073		0.00036		0.0050		0.00037		0.00048		0.0063		0.0013		0.12		0.0032		0.00080
Certified		0.019		0.0033		0.99		0.0006		0.0067		1.54		0.090		96.6		0.371		0.0209
Uncertainty		0.002		0.0007		0.03		0.0002		0.0009		0.05		0.004		0.1		0.008		0.0009
Tolerance		0.006		0.0021		0.09		0.0005		0.0027		0.15		0.012		0.4		0.024		0.0027

Analysis	*	N	*	Ni	*	O	*	P	*	S	*	Sb	*	Si	*	Sn	*	V
1	2	0.004867	10	0.063	2	0.000525	5	0.007933	1	0.002866	3	0.0004	10	0.251333	5	0.0036667	10	0.004
2	2	0.005	3	0.0631	2	0.000567	12	0.0082	1	0.0031	12	0.000683	10	0.256	10	0.004	3	0.004
3	2	0.0050	11	0.0634	2	0.0007	4	0.009333	1	0.0032	5	0.000733	4	0.258667	5	0.0040	3	0.004
4	2	0.005144	4	0.064	2	0.000767	7	0.00959	12	0.0032	5	0.00087	10	0.263	4	0.004667	5	0.004067
5	2	0.005167	4	0.064367	2	0.00081	4	0.010	1	0.0033	10	0.001	3	0.264667	4	0.0047667	4	0.004233
6	2	0.005307	3	0.064667	2	0.00088	10	0.010	1	0.003333	4	0.0011	4	0.267333	3	0.0047667	11	0.0044
7	2	0.005333	4	0.0647	2	0.0009	4	0.010533	1	0.0034	9	0.0011	3	0.268	4	0.0048	10	0.0044
8	2	0.005557	4	0.0648	2	0.0009	4	0.0108	1	0.0040	5	0.001183	11	0.269	4	0.0048667	3	0.0045
9	2	0.005567	4	0.064967	2	0.000923	10	0.0108	1	0.0043	4	0.0012	4	0.269467	10	0.0049	4	0.004567
10	2	0.00564	3	0.065	2	0.00104	4	0.010867	1	0.0045	5	0.0013	14	0.269667	3	0.0049	4	0.004633
11	2	0.005775	8	0.065	2	0.0011	3	0.0112	10	0.0046	11	0.0022	3	0.27	5	0.0049333	5	0.004733
12	2	0.006	14	0.065233	2	0.001303	11	0.0116	1	0.004607			13	0.27	11	0.0051	4	0.0048
13	2	0.006233	4	0.066	2	0.001723	3	0.011867	1	0.004667	4	0.270167	3	0.0052	4	0.004933		
14	2	0.0066	3	0.066			4	0.011933	1	0.004667	6	0.270767	5	0.005267	3	0.005		
15	2	0.006667	5	0.066267			17	0.012	1	0.004683	3	0.271	3	0.006	14	0.005267		
16	2	0.007	4	0.066467			13	0.012	3	0.004767	3	0.273	3	0.006	3	0.005333		
17			3	0.067			3	0.012	3	0.0048	4	0.273067						
18			4	0.067133			3	0.012	1	0.005	4	0.273333						
19			4	0.067333			3	0.012	3	0.005	3	0.274333						
20			10	0.0686			3	0.012	11	0.0051	4	0.278667						
21			4	0.069			4	0.012133	3	0.0056	4	0.28						
22			3	0.0692			4	0.012167			4	0.2815						
23			10	0.073			4	0.013867			4	0.287						
24							10	0.0145										
Average		0.005678		0.0659		0.000891		0.011222		0.004223		0.001096		0.269999		0.00486		0.00461
Std Dev		0.000079		0.0014		0.000068		0.000065		0.000069		0.000053		0.000066		0.00017		0.00014
H		0.00085		0.0026		0.00041		0.0011		0.00075		0.00044		0.00053		0.00080		0.00078
U ₁		0.00085		0.0029		0.00041		0.0011		0.00075		0.00044		0.00053		0.00081		0.00079
t-statistic		2.13		2.07		2.18		2.07		2.09		2.23		2.07		2.13		2.13
U ₂		0.0018		0.0061		0.00090		0.0024		0.0016		0.0010		0.011		0.0017		0.0017
U ₃		0.00045		0.0013		0.00025		0.00048		0.00034		0.00030		0.0023		0.00043		0.00042
Certified		0.0057		0.066		0.0009		0.011		0.004		0.0011		0.270		0.0049		0.0046
Uncertainty		0.0008		0.003		0.0003		0.001		0.001		0.0004		0.009		0.0009		0.0007
Tolerance		0.0024		0.009		0.0008		0.003		0.003		0.0010		0.027		0.0027		0.0021

Analysis	*	Mg	*	Nb	*	Pb	*	Ti	*	W	*	Zr
1	3	0.000033	12	0.000183	12	0.000031	11	0.000057	12	0.00043	12	0.000040
2	12	0.000067	5	0.0003	5	0.00005	12	0.000353	5	0.0008	5	0.000053
3	4	0.0001	5	0.000353	5	0.00007	14	0.0007	5	0.000843	5	0.000063
4	5	0.0001	5	0.00056	3	0.0001	4	0.000867	5	0.0009	10	0.001
5	11	0.0002	4	0.0008	5	0.0001	5	0.000913	3	0.0012	11	0.001
6	4	0.000307	11	0.0009	9	0.0002	5	0.000967	4	0.001367	4	0.001033
7			4	0.0009	3	0.0002	3	0.001	3	0.0017	3	0.0019
8			10	0.001			10	0.001	4	0.001833	4	0.002
9			4	0.0010			4	0.001	4	0.002	4	0.002233
10			4	0.001133			4	0.001067	4	0.0022		
11			3	0.0016			3	0.0011	10	0.003		
12			3	0.001667			4	0.0012				
13			3	0.002			5	0.001567				
14							3	0.0016				
15							3	0.001933				
Average		0.000102		0.000954		0.000066		0.001022		0.001479		0.00104
Std Dev		0.000019		0.000088		0.000017		0.000082		0.000095		0.00011
H		0.00020		0.00042		0.00017		0.00043		0.00049		0.00043
U ₁		0.00020		0.00043		0.00017		0.00044		0.00050		0.00045
t-statistic		2.57		2.18		2.45		2.14		2.23		2.31
U ₂		0.00050		0.00093		0.00042		0.00094		0.0011		0.0010
U ₃		0.00021		0.00026		0.00016		0.00024		0.00034		0.00034
Reference		<0.0005		0.0010		<0.0005		0.0010		0.0015		<0.005
Uncertainty				0.0007				0.0007		0.0007		
Tolerance				0.0009				0.0009		0.0014		

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 E52100

* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	B	*	Ba	*	Ce	*	Cl	*	Ga	*	Ge	*	La	*	Na	*	Re	*	Se
1	12	0.37	12	0.06	12	0.008	12	0.02	12	5.8	12	12.0	12	0.008	12	0.02	12	0.02	12	0.06
2	12	0.49							12	6.0	12	13.0			12	0.02	12	0.04	12	0.07
3	12	0.67							12	6.6	12	14.0			12	0.03	12	0.04		
Analysis	*	Y	*	Zn																
1	12	0.005	12	0.87																
2			12	0.89																
3			12	0.93																

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 | AAS |
| 6 | Gravimetric | 12 | GD Mass Spectrometry | | |

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

Lab Name	Location	Registrar	Accreditation
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034
LECO Corporation	St. Joseph, MI	A2LA	17025
Vitkovice Testing Center	Hulvaky, Ostrava	Czech Accreditation Institute	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Eurofins EAG Materials Science, LLC	Liverpool, NY	A2LA	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
APL, Inc	Milwaukee, WI	A2LA	17025
TUV Rheinland Pvt Ltd	Bangalore, India	NABL	17025
Andrew S. McCreath & Son, Inc.	Harrisburg, PA	A2LA	17025
Luvak Inc.	Boylston, MA	PRI	17025
Shiva Analyticals Private Limited	Hoskote, Bangalore	NABL	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	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: 12Z19965A, 12X3490, 12X52986A, 12X61500A, 12XLA50; AR 115, 546, 614, 644, 645, 657, 659, 660, 668, 673, 675, 881, 886, 889, 892, 8931650, 1651, 1653; BAS 290/2, 401/1, 460, 464/1; BS CE 26, 05E, 45B, 53MOD, 53B, 53C, 53D, 53E, 53G, 54B, 54C, 55G, 56H, 61G, 70B, 181, 406, 1016, 1018, 1020, 1026, 1045, 1144A, 1290, 1765, 2931, 2931A, 2952, 4130, 4140C, 4142SE, 4820A, 4931; CKD 165A, 166A, 184A, 186A, 244C, 249C; DSZU CA01A, CA02, CA08, CA013; ECRM 195-1; IARM 30V, 39B, 39C, 42A, 49D, 2999; IMZ 113, 119; IPT 12A, 31, 39, 43, 97; LECO 501-506, 501-643, 501-644, 501-676, 501-677, 501-991, 502-060, 502-364, 502-698, 502-712, 502-856, 502-893, 502-903, 502-916, 502-990, 502-991, 503-501, 503-520; SRM 14G, 160B, 361, 363, 364, 1269, 3109A, 3131A.

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 05E, 53MOD, 53B, 53C, 53D, 53E, 53G, 54B, 54C, 2952.

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 E52100 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 Republic Steel; Massillon, OH.

Form: This CRM is machined in the form of a disc, approximately 38mm 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 E52100-020922. 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
Fax: (281) 440-4432

Web: www.brammerstandard.com
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 35:2017 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

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 February 9, 2022.

Beau R. Brammer
President