

Brammer Standard Company, Inc.

Certificate of Analysis

BS 55G

Certified Reference Material for Mold Steel Grade P20 - UNS Number T51620

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²	
Al	0.0123	0.0007		N	0.0079	0.0005
As	0.0062	0.0007		Ni	0.131	0.006
C	0.386	0.007		O	0.0015	0.0005
Ca	0.0016	0.0003		P	0.010	0.001
Co	0.0093	0.0006		S	0.0026	0.0005
Cr	1.79	0.01		Sb	0.0026	0.0005
Cu	0.106	0.005		Si	0.58	0.01
Fe	95.6	0.3		Sn	0.0074	0.0008
Mn	0.853	0.008		Ti	0.0044	0.0006
Mo	0.421	0.006		V	0.0056	0.0008
	Reference Value ¹	Estimate of Uncertainty ²	Reference Values^{3,4}	Reference Value ¹	Estimate of Uncertainty ²	
B	0.0003	0.0001		Pb	<0.01	
Mg	0.0002	0.0001		W	0.029	0.005
Nb	<0.01			Zr	<0.01	

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 Ce, Ga, Ge, Ir, La, Na, Nd, Os, Re, Ta, U, 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	5	0.010633	3 0.00535	3 0.3785	4 0.0011	12 0.0080	3 1.76466667	5 0.0940	16 [95.432733]	4 0.8393333	4 0.40275
2	10	0.0112	12 0.0055	1 0.3787233	12 0.00126667	10 0.0081	4 1.7735	10 0.098233	13 95.551	8 0.84	3 0.411667
3	4	0.0117	10 0.0056667	1 0.3796667	3 0.001325	3 0.00815	3 1.77866667	4 0.09825	14 95.6	3 0.845	3 0.415333
4	5	0.011733	5 0.0057	1 0.3823333	14 0.00136667	5 0.008767	3 1.78	3 0.103	4 95.6	7 0.845	4 0.416
5	4	0.011833	3 0.0058	3 0.3826667	4 0.0014	4 0.008933	4 1.781	4 0.103	4 95.6066667	3 0.8485	4 0.416667
6	4	0.0120	3 0.0059	1 0.384	3 0.00146	14 0.008967	3 1.785	4 0.1041	16 [95.615]	14 0.8503333	3 0.4175
7	3	0.0120	9 0.006	1 0.3843333	3 0.00155	4 0.0090	4 1.78533333	7 0.105333	16 [95.62]	4 0.8506667	4 0.419433
8	3	0.01205	4 0.0060333	1 0.386	4 0.00163333	3 0.009067	4 1.78626667	8 0.106	16 [95.633]	4 0.8509333	3 0.42
9	14	0.012167	4 0.0061	3 0.386	4 0.00173667	4 0.00921	3 1.79	3 0.106	16 [95.637]	4 0.8513333	3 0.4206
10	3	0.012333	5 0.0061667	1 0.3872	4 0.0022	4 0.009233	17 1.79	3 0.1065	16 [95.64]	4 0.8522333	3 0.421
11	4	0.0128	10 0.0063	1 0.3876667		5 0.009317	10 1.797	8 0.107	10 95.6733333	10 0.8533333	3 0.4215
12	3	0.0128	17 0.0065733	1 0.3878333		10 0.0094	4 1.79866667	3 0.1075	3 95.80	10 0.855	4 0.422533
13	3	0.013	4 0.0066467	3 0.39		3 0.0097	4 1.7988	4 0.107667	16 [95.81]	4 0.8553333	4 0.423667
14	3	0.0136	4 0.0068667	1 0.3906667		3 0.0097	3 1.799	10 0.108		4 0.85542	14 0.424
15	4	0.01419	5 0.0068667	1 0.392		8 0.009863	3 1.8	3 0.108		3 0.8563333	10 0.425
16			5 0.0071333	3 0.3925		5 0.0099	8 1.80	4 0.108		3 0.857	10 0.425333
17			3 0.0073	1 0.3926667		3 0.0101	4 1.8028	3 0.109		4 0.8576667	4 0.426127
18						4 0.010467	14 1.82666667	4 0.109267		3 0.858	8 0.43
19						3 0.01095	10 1.83	14 0.110333		3 0.8653333	4 0.432333
20								4 0.111667		3 0.868	
21								4 0.113933			
Average		0.012269	0.00623	0.386045	0.001568	0.00927	1.7928	0.105942	95.642	0.852738	0.4213
Std Dev		0.000082	0.00020	0.000077	0.000042	0.00037	0.0043	0.000069	0.031	0.000071	0.0037
H		0.00077	0.00058	0.0052	0.00036	0.00068	0.015	0.0023	0.53	0.0089	0.0055
U ₁		0.00077	0.00061	0.0052	0.00036	0.00077	0.016	0.0023	0.53	0.0089	0.0066
t-statistic		2.14	2.12	2.12	2.26	2.10	2.10	2.09	2.18	2.09	2.10
U ₂		0.0017	0.0013	0.011	0.00081	0.0016	0.034	0.0048	1.15	0.019	0.014
U ₃		0.00043	0.00031	0.0027	0.00026	0.00037	0.0077	0.0011	0.32	0.0042	0.0032
Certified		0.0123	0.0062	0.386	0.0016	0.0093	1.79	0.106	95.6	0.853	0.421
Uncertainty		0.0007	0.0007	0.007	0.0003	0.0006	0.01	0.005	0.3	0.008	0.006
Tolerance		0.0021	0.0021	0.021	0.0008	0.0018	0.03	0.015	1.2	0.024	0.018

Analysis	*	N	* Ni	* O	* P	* S	* Sb	* Si	* Sn	* Ti	* V
1	2	0.006467	5 0.119	2 0.0009	10 0.00836667	1 0.001733	3 0.0021	17 0.56	12 0.00623333	10 0.0037	5 0.0046
2	2	0.00745	17 0.123	2 0.00093333	12 0.00873333	3 0.00185	12 0.00216667	3 0.560333	10 0.0064	3 0.0038	4 0.004843
3	2	0.007567	4 0.12575	2 0.0009733	5 0.00876667	1 0.0019	5 0.0023	4 0.562333	4 0.00663333	5 0.0040	5 0.004903
4	2	0.00777	4 0.12653	2 0.00104	4 0.00913333	1 0.0021	5 0.00246667	14 0.564667	5 0.00693333	3 0.004	4 0.0051
5	2	0.007967	4 0.1276667	2 0.00144	4 0.00966667	12 0.0021	5 0.0025	4 0.570033	5 0.00700333	3 0.004	4 0.0053
6	2	0.008	4 0.1276667	2 0.0017967	7 0.00985	1 0.0023	5 0.00257667	4 0.572333	5 0.00703333	4 0.0040633	3 0.005433
7	2	0.00803	8 0.128	2 0.0018	3 0.00995	1 0.002633	9 0.00276667	4 0.572367	4 0.00703333	4 0.0041333	3 0.0056
8	2	0.008033	4 0.1290667	2 0.0018667	17 0.010	1 0.00269	10 0.0033	4 0.5738	3 0.00725	5 0.0042967	5 0.005633
9	2	0.008087	3 0.1293333	2 0.00188	3 0.01023333	1 0.0027	9 0.00353333	3 0.5755	3 0.0074	3 0.00435	10 0.0059
10	2	0.008267	3 0.1305	2 0.002	10 0.0104	3 0.002767		4 0.575667	5 0.00746667	5 0.0046333	4 0.005933
11	2	0.008347	14 0.1313333	2 0.0023	4 0.01056667	1 0.002767		10 0.576	3 0.0077	4 0.0046667	3 0.006
12	2	0.0084	10 0.1313333		3 0.0106	1 0.002843		3 0.58	9 0.0077	3 0.00475	4 0.0061
13	2	0.008478	4 0.1316		4 0.0108	10 0.0029		4 0.582377	3 0.00775	3 0.00485	3 0.0061
14	2	0.0089	3 0.132		3 0.0108	1 0.003		3 0.5865	3 0.008	4 0.0050	14 0.006367
15			3 0.1335		3 0.011	3 0.003		3 0.588	4 0.00813333	14 0.005	3 0.00675
16			3 0.1335		3 0.011	1 0.003		6 0.59	3 0.00816667	4 0.0050167	
17			4 0.1336667		4 0.01103333	3 0.00335		3 0.597	10 0.0084	4 0.0050667	
18			10 0.135		4 0.0111	1 0.003407					
19			3 0.137		3 0.0111						
20			3 0.14		4 0.01286667						
21			4 0.14433								
Average		0.00788	0.1311	0.00151	0.01024	0.00256	0.00263	0.575701	0.00743	0.004431	0.005638
Std Dev		0.00026	0.0024	0.00011	0.00036	0.00012	0.00011	0.000077	0.00024	0.000077	0.000082
H		0.00064	0.0026	0.00035	0.00071	0.00042	0.00042	0.0068	0.00062	0.0005072	0.00056
U ₁		0.00069	0.0036	0.00037	0.00080	0.00044	0.00043	0.0068	0.00067	0.00051	0.00056
t-statistic		2.16	2.09	2.23	2.09	2.11	2.31	2.12	2.12	2.12	2.14
U ₂		0.0015	0.0074	0.00082	0.0017	0.00092	0.0010	0.014	0.0014	0.0011	0.0012
U ₃		0.00040	0.0016	0.00025	0.00037	0.00022	0.00033	0.0035	0.00034	0.00026	0.00031
Certified		0.0079	0.131	0.0015	0.010	0.0026	0.0026	0.58	0.0074	0.0044	0.0056
Uncertainty		0.0005	0.006	0.0005	0.001	0.0005	0.0005	0.01	0.0008	0.0006	0.0008
Tolerance		0.0015	0.018	0.0014	0.003	0.0015	0.0015	0.03	0.0024	0.0018	0.0024

Analysis	*	B	*	Mg	*	Nb	*	Pb	*	W	*	Zr
1	3	0.000125	12	0.0001367	12	0.0001033	5	0.00002	3	0.024667	5	0.00003
2	3	0.000233	3	0.00014	5	0.0001167	5	0.00003	4	0.0254	5	0.00004
3	4	0.000233	3	0.000215	4	0.0001667	12	0.0000377	5	0.025967	12	0.0000533
4	5	0.000233	5	0.0002333	5	0.0003333	5	0.000043	10	0.026	4	0.00073333
5	3	0.00028	4	0.0002667	3	0.0025	3	0.0001	3	0.0265	3	0.0016
6	12	0.00029	4	0.00030	3	0.00265	9	0.0004	4	0.026833	3	0.0017
7	3	0.00029	3	0.00035	4	0.0026667	3	0.0006	4	0.0278	10	0.0017
8	5	0.0003			10	0.0028	10	0.0010	7	0.028233	4	0.00192333
9	3	0.00035			4	0.0030	3	0.00153333	3	0.02885	4	0.00206667
10	7	0.0004			3	0.0032	3	0.00295	14	0.0299	3	0.00215
11					3	0.0032			3	0.030	10	0.00233333
12					14	0.0034667			4	0.0302	3	0.0034
13					3	0.004			4	0.030333		
14					3	0.004			3	0.033		
15									4	0.033767		
16									3	0.0341		
17									4	0.03487		
Average		0.000235		0.000258						0.029201		
Std Dev		0.000030		0.000023						0.000077		
H		0.00022		0.00023						0.0012		
U₁		0.00022		0.00023						0.0012		
t-statistic		2.26		2.45						2.12		
U₂		0.00051		0.00056						0.0025		
U₃		0.00016		0.00021						0.00060		
Reference		0.0003		0.0002		<0.01		<0.01		0.029		<0.01
Uncertainty		0.0001		0.0001						0.005		
Tolerance		0.0002		0.0002						0.015		

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.

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* Code for analytical method

Trace analysis listed as mg/kg (ppm)

Analysis	*	Ce	*	Ga	*	Ge	*	Ir	*	La	*	Na	*	Nd	*	Os	*	Re	*	Ta
1	12	0.07	12	9.3	12	5.1	12	0.01	12	0.04	12	0.04	12	0.02	12	0.01	12	0.26	5	18
2	12	0.08	12	9.8	12	5.2	12	0.01	12	0.04	12	0.04	12	0.03	12	0.01	12	0.26	5	21
3	12	0.08	12	9.8	12	5.2	12	0.01	12	0.05	12	0.04	12	0.03	12	0.01	12	0.27	5	21
Analysis	*	U	*	Y	*	Zn														
1	12	0.006	12	0.006	12	1.7														
2	12	0.006	12	0.009	12	1.7														
3	12	0.007	12	0.01	12	1.8														
4					5	6.1														
5					5	6.2														
6					5	6.5														

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
Evans Analytical Group	Liverpool, NY	A2LA	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Element Materials Technology	Glendale Heights, IL	A2LA	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
LECO Corporation	St. Joseph, MI	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Analytical Process Laboratories	Milwaukee, WI	A2LA	17025
Vitkovice Testing Center	Ostrava, Czech	ILAC	17025
TUV Rheinland Pvt. Ltd.	Bangalore, India	NABL	17025
Element Materials Technology	Huntington Beach, CA	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554

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: 13X125370, 23X80030; AR 414B, 612B, 614A, 619D, 644, 645, 654, 657, 659, 662, 668, 673, 675, 676, 881, 882, 884, 885, 889, 1650, 1652, 1653; BAS 4-94, 72, 112, 261, 342, 346A, 404/1, 406/2, 410/2, 461, 464/1; BS CSN 2-1, CSN 4, HON T, 33C, 41, 46B, 50A, 55A, 55B, 545D, 70B, 80F, 81G, 85D, 181, 406, 1026, 1290, 1765, 1962, 1982, 1932, 4130, 4142SE; CKD 170H, 244C, 249C; ECRM 085-1, 096-1, 184-1, 194-1, 195-1, 196-1, 401/2, 463/1; IARM 30G, 31B, 38A, 156A, 182A, 182B, 189A, 190A, 305A; IMZ 123; IPT 12A, 17A; JK 37; JSS 652-5, 654-5; LECO 501-024, 501-504, 501-505, 501-644, 501-646, 501-676, 501-679, 502-328, 502-328, 502-414, 502-698, 502-702, 502-712, 502-855, 502-856, 502-903, 502-916; SRM 15E, 72G, 153, 160B, 344, 346A, 361, 362, 363, 364, 1155, 1225, 1263A, 1765, 1766, 1767, 2159.

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, 112, 404/1, 410/2; BS CSN 2-1, CSN 4, HON T, 33C, 41, 50A, 55A, 55B, 55D, 70B, 1962, 1982; CKD 170H; ECRM 096-1, 184-1; LECO 501-676; SRM 72G, 346A, 1225, 1263A, 1765, 1766, 1767, 2159.

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 55G 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 Crucible Service Centers; Solvay, NY.

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 55G-020821. 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 17025:2017 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 08, 2021.

Beau R. Brammer
President