

Brammer Standard Company, Inc.

Certificate of Analysis

BS 291EF

Certified Reference Material for Chill Cast Iron

	Certified Value ¹	Estimate of Uncertainty ²	Certified Values³	Certified Value ¹	Estimate of Uncertainty ²	
Al	0.048	0.001		Nb	0.0033	0.0006
B	0.0055	0.0002		Ni	0.100	0.003
C	3.22	0.01		P	0.0190	0.0004
Ca	0.0010	0.0001		Pb	0.0005	0.0002
Cr	0.015	0.001		S	0.0118	0.0009
Cu	0.235	0.004		Si	2.07	0.02
Fe	93.6	0.1		Sn	0.0480	0.0006
Mg	0.044	0.001		Ti	0.0156	0.0003
Mn	0.479	0.004		V	0.0082	0.0002
Mo	0.0075	0.0005		Zr	0.0023	0.0002

Informational Values^{3,4}

As (0.0005)

Co (0.0032)

Sb (0.01)

W (0.0031)

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 5 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 5 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.

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	*	B	*	C	*	Ca	*	Cr	*	Cu	*	Fe	*	Mg	*	Mn	*	Mo
1	3	0.04568667	3	0.00519	3	3.13	3	0.00074	3	0.0122	4	0.225	10	93.25	3	0.0436	4	0.46733333	3	0.0067
2	10	0.046	3	0.00523	3	3.14	3	0.00077	3	0.0126	3	0.22833	4	93.4	3	0.04364	3	0.473	3	0.0068
3	3	0.0465	3	0.00526	3	3.15	3	0.00078	3	0.0127	4	0.2296	14	93.433333	3	0.04364	3	0.47333333	3	0.0069
4	3	0.0466	3	0.00529	3	3.16	3	0.00079	3	0.0129	10	0.23	4	93.443233	3	0.04366	3	0.474	3	0.0069
5	14	0.0467	3	0.00532	3	3.16	3	0.00082	10	0.013	3	0.231	4	93.58	3	0.04366	4	0.47423333	3	0.007
6	3	0.0468	14	0.0053333	3	3.17	3	0.00082	3	0.0134	3	0.231	3	93.59	3	0.04369	3	0.475	3	0.007
7	3	0.0469	3	0.00535	3	3.17	4	0.00083333	3	0.0137	3	0.231	3	93.6	3	0.04377	3	0.475	3	0.0071
8	3	0.047	3	0.00535	3	3.18	3	0.00084	3	0.0138	3	0.231	3	93.6	3	0.04379	3	0.475	4	0.00713333
9	3	0.0473	3	0.00535	3	3.18	3	0.00085	3	0.0138	3	0.232	16	[93.62]	3	0.04381	3	0.476	3	0.0072
10	3	0.0474	3	0.00536	3	3.18	3	0.00086	3	0.0138	3	0.232	16	[93.64]	3	0.04385	3	0.476	3	0.0072
11	3	0.0474	3	0.00536	3	3.19	3	0.00086	3	0.0139	3	0.233	16	[93.66]	3	0.04386	3	0.477	3	0.0072
12	3	0.0475	4	0.0053667	3	3.19	3	0.00088	3	0.0139	3	0.233	16	[93.69]	3	0.04389	3	0.477	3	0.0073
13	3	0.0475	3	0.00537	3	3.2	3	0.00089	3	0.014	3	0.233	3	93.71	3	0.04391	3	0.477	3	0.0073
14	3	0.0477	3	0.00537	3	3.2	14	0.0009	3	0.014	3	0.233	16	[93.72]	3	0.04398	3	0.477	3	0.0073
15	3	0.0477	3	0.00538	3	3.2	3	0.00091	3	0.0141	3	0.233	16	[93.73]	3	0.04401	3	0.477	3	0.0073
16	3	0.0477	3	0.00539	3	3.2	3	0.00091	3	0.0141	3	0.234	10	93.883333	3	0.04404	3	0.477	3	0.0074
17	3	0.0477	3	0.00539	3	3.2	3	0.00092	3	0.0142	3	0.234			3	0.04405	3	0.477	3	0.0074
18	3	0.0477	3	0.0054	3	3.21	3	0.00093	3	0.0143	3	0.234			3	0.04406	3	0.478	3	0.0074
19	3	0.0478	3	0.00542	3	3.21	3	0.00093	3	0.0143	3	0.234			3	0.04407	3	0.479	3	0.0074
20	3	0.0478	3	0.00542	3	3.21	3	0.00094	4	0.01436667	3	0.234			3	0.04411	3	0.479	3	0.0074
21	3	0.0479	3	0.00542	3	3.21	3	0.00094	3	0.0144	3	0.234			3	0.04412	3	0.479	3	0.0074
22	3	0.0479	3	0.00544	3	3.21	3	0.00094	3	0.0144	3	0.235			3	0.04412	10	0.48	3	0.0074
23	4	0.0479	3	0.00544	3	3.22	3	0.00094	3	0.0146	3	0.235			3	0.04414	3	0.48	3	0.0074
24	3	0.048	3	0.00546	3	3.22	3	0.00096	3	0.0146	3	0.235			3	0.04415	3	0.48	3	0.0074
25	3	0.0481	3	0.00546	3	3.22	3	0.00096	3	0.0146	3	0.235			3	0.04417	3	0.48	3	0.0075
26	3	0.0481	3	0.00546	3	3.22	3	0.00096	3	0.0146	3	0.235			3	0.04419	3	0.48	3	0.0075
27	3	0.0481	3	0.005467	3	3.23	3	0.00097	3	0.0146	3	0.235			3	0.04419	3	0.48	3	0.0075
28	3	482	3	0.00547	3	3.23	3	0.00098	3	0.0147	3	0.235			3	0.04424	3	0.48	3	0.0075
29	3	0.0482	3	0.00547	3	3.23	3	0.00098	3	0.0149	3	0.235			3	0.04424	3	0.48	3	0.0075
30	3	0.0483	3	0.00548	3	3.23	3	0.00098	3	0.015	3	0.236			3	0.04426	3	0.48	3	0.0075
31	3	0.0483	3	0.00548	3	3.24	3	0.00098	3	0.015	3	0.236			3	0.04429	3	0.481	3	0.0075
32	3	0.0483	3	0.00548	3	3.24	3	0.001	3	0.015	3	0.236			3	0.04432	3	0.481	3	0.0075
33	3	0.0484	3	0.0055	3	3.24	3	0.001	4	0.015067	3	0.236			3	0.04434	3	0.481	3	0.0075
34	3	0.0484	3	0.0055	3	3.24	3	0.001	14	0.0151	3	0.236			3	0.04436	3	0.481	3	0.0076
35	5	0.048433	3	0.00551	3	3.25	3	0.00101	3	0.0152	3	0.236			3	0.04439	14	0.481667	3	0.0076
36	3	0.0485	3	0.00551	3	3.25	3	0.00102	3	0.0152	3	0.237			3	0.04442	3	0.482	3	0.0076
37	3	0.0485	3	0.00552	3	3.25	3	0.00102	4	0.015233	3	0.237			3	0.04444	3	0.482	3	0.0076
38	3	0.0486	3	0.00553	3	3.25	3	0.00102	3	0.0153	3	0.237			3	0.04449	3	0.482	3	0.0076
39	3	0.0486	3	0.00554	3	3.25	3	0.00104	3	0.015333	3	0.238			3	0.04449	3	0.482	3	0.0076
40	3	0.0487	3	0.00554	3	3.26	3	0.00104	3	0.0155	3	0.238			3	0.0445	3	0.482	3	0.0077
41	3	0.0488	3	0.00555	3	3.26	3	0.00104	3	0.0157	3	0.238			3	0.04453	3	0.482	3	0.0077
42	3	0.0488	3	0.00556	3	3.28	3	0.00104	3	0.0158	3	0.238			3	0.04454	3	0.482	3	0.0077
43	3	0.0488	3	0.00556	3	3.28	3	0.00105	3	0.0158	3	0.238			3	0.04454	3	0.482	5	0.007733
44	3	0.0489	3	0.00557	3	3.28	3	0.00109	3	0.0159	3	0.238			3	0.04454	3	0.483	3	0.0078
45	3	0.049	3	0.00557	3	3.29	4	0.0011	3	0.016	3	0.238					3	0.483	3	0.0078
46	3	0.049	3	0.00558	3	3.3	3	0.00114	5	0.0162	3	0.238					3	0.483	3	0.0078
47	3	0.0491	3	0.0056	3	3.3	3	0.00116	3	0.0164	3	0.239					3	0.484	3	0.0079
48	3	0.0491	3	0.00563	3	3.31	3	0.00118	3	0.0165	3	0.239					3	0.484	3	0.0079
49	3	0.0492	3	0.00565	1	3.26667	4	0.0012	3	0.0165	4	0.23917					3	0.486	3	0.008
50	3	0.0492	3	0.00566			3	0.00132	3	0.0171	3	0.24					3	0.486	3	0.0082
51	3	0.0496	3	0.00569			3	0.00138	3	0.0181	3	0.24					3	0.488	3	0.008333
52	3	0.0498	4	0.0058			3	0.00143	3	0.0182	3	0.24					3	0.489	14	0.008367
53	3	0.0501	4	0.005967					3	0.0192							10	0.491667	4	0.0088
54																	3	0.492	10	0.009
55																	3	0.492		
Average		0.04811		0.00548		3.220		0.000978		0.01527		0.0235		93.613		0.04411		0.4792		0.00746
Std Dev		0.00068		0.00011		0.046		0.000055		0.00094		0.0032		0.026		0.00067		0.0052		0.00015
H		0.0020		0.00074		0.022		0.00039		0.001		0.0045		0.24		0.0019		0.007		0.00085
U ₁		0.0021		0.00075		0.051		0.00039		0.0015		0.0055		0.24		0.0020		0.0085		0.00086
t-statistic		2.01		2.01		2.01		2.01		2.01		2.01		2.13		2.02		2.00		2.01
U ₂		0.0042		0.0015		0.10		0.00079		0.0030		0.011		0.51		0.0041		0.017		0.0017
U ₃		0.00058		0.00021		0.015		0.00011		0.0004		0.0015		0.13		0.00061		0.0023		0.00023
Certified		0.048		0.0055		3.22		0.0010		0.015		0.235		93.6		0.044		0.479		0.0075
Uncertainty		0.001		0.0002		0.01		0.0001		0.001		0.004		0.1		0.001		0.004		0.0005
Tolerance		0.003		0.0008		0.03		0.0003		0.003		0.012		0.5		0.003		0.012		0.0015

Analysis	*	Nb	*	Ni	*	P	*	Pb	*	S	*	Si	*	Sn	*	Ti	*	V	*	Zr
1	5	0.00038333	10	0.0917333	4	0.0176333	5	0.0001	1	0.00818	3	2.04333	5	0.0398667	3	0.0146	4	0.00773333	10	0.001
2	10	0.001	3	0.0951	3	0.0176667	3	0.0001	3	0.0101	4	2.04967	3	0.044	3	0.0148	14	0.00773333	5	0.00104667
3	3	0.0025	4	0.0959667	3	0.0179	5	0.00012333	3	0.0102	3	2.05	4	0.0462333	3	0.0149	3	0.0078	3	0.0018
4	3	0.0026	3	0.0962	3	0.0182	4	0.00013333	3	0.0104	3	2.06	3	0.0464333	3	0.0149	3	0.0079	4	0.0018
5	4	0.00266667	3	0.0967	3	0.0184	3	0.0002	3	0.0104	3	2.06	3	0.0469	3	0.0149	3	0.008	3	0.002
6	3	0.0028	3	0.0968	4	0.0184667	5	0.0002	3	0.0106	3	2.06	3	0.047	3	0.0152	3	0.008	3	0.002
7	3	0.0029	3	0.0969	10	0.0185	3	0.0002	3	0.0107	3	2.06	3	0.0472	3	0.0152	3	0.0081	3	0.002
8	3	0.0029	3	0.097	3	0.0185	9	0.0002	3	0.0109	3	2.06	3	0.0475	3	0.0153	3	0.0081	3	0.002
9	3	0.0029	10	0.097	3	0.0185	3	0.0003	3	0.011	3	2.06	3	0.0476	3	0.0154	3	0.0081	3	0.002
10	3	0.003	3	0.0972	3	0.0186	3	0.0003	3	0.0111	3	2.06	3	0.0476	3	0.0154	3	0.0081	3	0.0021
11	3	0.003	3	0.0975	3	0.0186	3	0.0003	3	0.0111	3	2.06	3	0.0476	3	0.0155	3	0.0081	3	0.0021
12	3	0.003	3	0.0976	3	0.0186	3	0.0003	3	0.0112	3	2.06	3	0.0477	3	0.0155	3	0.0081	3	0.0021
13	3	0.003	3	0.0977	3	0.0186	3	0.0003	3	0.0112	3	2.06	3	0.0477	3	0.0155	3	0.0081	3	0.0021
14	3	0.003	3	0.0978	5	0.0186667	3	0.0003	3	0.0112	3	2.06	3	0.0477	3	0.0155	3	0.0081	3	0.0021
15	3	0.0031	3	0.0978	3	0.0187	3	0.0003	3	0.0114	3	2.06	3	0.0478	3	0.0155	3	0.0081	3	0.0022
16	3	0.0032	3	0.0978	3	0.0187	3	0.0003	3	0.0114	3	2.06	3	0.0478	3	0.0155	3	0.0081	3	0.0022
17	3	0.0032	4	0.0978333	3	0.0187	3	0.0004	3	0.0115	3	2.06333	3	0.0478	3	0.0155	3	0.0081	3	0.0022
18	3	0.0032	3	0.0979	3	0.0187	3	0.0004	3	0.0115	3	2.07	9	0.0479	3	0.0155	3	0.0081	3	0.0022
19	3	0.0032	3	0.0979	3	0.0188	3	0.0004	3	0.0115	14	2.07	3	0.0479	3	0.0156	3	0.0081	3	0.0022
20	3	0.0032	3	0.0979	3	0.0188	3	0.0004	3	0.0115	3	2.07	3	0.0479	3	0.0156	3	0.0082	3	0.0022
21	3	0.0033	3	0.098	3	0.0188	3	0.0004	1	0.011667	3	2.07	3	0.0479	3	0.0156	3	0.0082	3	0.0022
22	3	0.0033	3	0.0981	3	0.0188	3	0.0004	3	0.0117	3	2.07	3	0.0479	3	0.0156	3	0.0082	3	0.0022
23	3	0.0033	3	0.0981	14	0.018833	3	0.0004	3	0.0118	3	2.07	3	0.048	3	0.0157	3	0.0082	3	0.0023
24	3	0.0033	3	0.0982	3	0.0189	3	0.0004	3	0.0118	3	2.07	3	0.048	3	0.0157	3	0.0082	3	0.0023
25	3	0.0033	3	0.0983	3	0.0189	3	0.0005	3	0.0118	3	2.07	3	0.048	3	0.0157	3	0.0082	3	0.0023
26	3	0.0034	4	0.098333	3	0.0189	3	0.0005	3	0.0119	3	2.07	3	0.0481	3	0.0157	3	0.0082	3	0.0023
27	3	0.0034	3	0.0984	3	0.0189	3	0.0005	3	0.0119	3	2.07	3	0.0481	3	0.0157	3	0.0082	3	0.0023
28	3	0.0034	3	0.0984	3	0.019	3	0.0005	3	0.0119	3	2.07	3	0.0481	3	0.0157	3	0.0082	3	0.0023
29	3	0.0034	3	0.0985	3	0.019	3	0.0005	3	0.012	3	2.07	3	0.0481	3	0.0158	3	0.0082	3	0.0023
30	3	0.0034	3	0.0985	3	0.019	3	0.0005	3	0.012	3	2.07	3	0.0481	3	0.0158	3	0.0082	3	0.0023
31	3	0.0034	3	0.0986	3	0.0191	3	0.0005	3	0.012	17	2.07027	3	0.0482	3	0.0158	3	0.0082	3	0.0023
32	3	0.0035	3	0.0986	3	0.0191	3	0.0005	3	0.0121	3	2.08	3	0.0483	3	0.0158	3	0.0082	3	0.0023
33	3	0.0036	3	0.0986	3	0.0191	3	0.0005	3	0.0121	3	2.08	3	0.0483	3	0.0158	3	0.0082	3	0.0024
34	3	0.0036	3	0.0987	3	0.0191	3	0.0005	3	0.0122	3	2.08	3	0.0483	3	0.0158	3	0.0082	3	0.0024
35	3	0.0036	3	0.0987	3	0.0191	3	0.0005	3	0.0122	3	2.08	3	0.0483	3	0.0158	3	0.0082	3	0.0024
36	3	0.0036	3	0.0988	3	0.0192	3	0.0005	3	0.0122	3	2.08	3	0.0484	3	0.0158	3	0.0082	3	0.0024
37	3	0.0037	3	0.0989	3	0.0192	3	0.0005	3	0.0123	3	2.08	3	0.0484	4	0.0158	3	0.0083	3	0.0024
38	3	0.0037	14	0.098967	3	0.0192	3	0.0005	3	0.012333	3	2.08	3	0.0484	14	0.015833	3	0.0083	3	0.0024
39	3	0.0037	3	0.099	3	0.0192	3	0.0005	3	0.0124	3	2.08	3	0.0485	3	0.0159	3	0.0083	3	0.0024
40	3	0.0037	3	0.0991	3	0.0192	3	0.0005	3	0.0124	3	2.09	3	0.0485	3	0.0159	3	0.0083	3	0.0024
41	3	0.0038	3	0.0993	3	0.0192	3	0.0005	3	0.0124	3	2.09	3	0.0485	3	0.0159	3	0.0084	3	0.0025
42	3	0.0038	3	0.0996	3	0.0193	10	0.0006	3	0.0124	3	2.09	3	0.0485	3	0.0159	3	0.0084	3	0.0025
43	3	0.0039	3	0.0996	3	0.0194	3	0.0006	3	0.0126	3	2.09	3	0.0485	3	0.0159	3	0.0084	3	0.0025
44	3	0.0039	3	0.0997	3	0.0194	3	0.0006	1	0.012767	3	2.09	3	0.0486	3	0.0159	3	0.0084	3	0.0025
45	3	0.0039	3	0.0998	3	0.0194	3	0.0006	3	0.0129	3	2.09	3	0.0486	3	0.0159	3	0.0084	3	0.0026
46	3	0.0039	3	0.0999	3	0.0194	3	0.0006	3	0.013	3	2.09	3	0.0486	3	0.0159	3	0.0084	3	0.0026
47	3	0.0041	3	0.0999	3	0.0195	3	0.0006	10	0.013	3	2.1	3	0.0487	3	0.0159	3	0.0085	3	0.0026
48	3	0.0041	3	0.1	3	0.0195	3	0.0007	3	0.0131	3	2.1	3	0.0488	3	0.0159	3	0.0085	3	0.0026
49	3	0.0042	3	0.1	3	0.0195	3	0.0007	3	0.0133	4	2.10	3	0.0488	3	0.016	3	0.0085	3	0.0027
50	3	0.0043	3	0.1	3	0.0195	3	0.0007	3	0.0134	3	2.1	3	0.049	3	0.016	4	0.0085	3	0.0028
51	3	0.0047	3	0.1	3	0.0197	3	0.0007	3	0.0135	3	2.11	3	0.049	3	0.016	5	0.008533	3	0.003
52			3	0.1	4	0.0198	3	0.0007	3	0.0136	3	2.11	10	0.049	10	0.016	5	0.008567		
53			3	0.1003	3	0.0199	3	0.0008	3	0.0138	3	2.11	3	0.0491	4	0.0161	10	0.0087		
54			3	0.1011	10	0.020	3	0.0009	1	0.014733			3	0.0492	3	0.0161	3	0.0087		
55			3	0.103333	3	0.02							4	0.0503	4	0.016233	10	0.0090		
56			3	0.107									4	0.050467			3	0.009		
57													10	0.052433						
Average		0.00334		0.0988		0.01901		0.000156		0.01177		2.069		0.04801		0.01563		0.00821		0.00230
Std Dev		0.00012		0.0013		0.00028		0.000013		0.00017		0.015		0.00067		0.00023		0.00017		0.00010
H		0.00061		0.0028		0.001274		0.00022		0.0010		0.016		0.0020		0.001166		0.00088		0.00053
U ₁		0.00062		0.0031		0.0013		0.00022		0.0010		0.022		0.0021		0.0012		0.00090		0.00054
t-statistic		2.01		2.00		2.00		2.01		2.01		2.01		2.00		2.00		2.00		2.01
U ₂		0.0012		0.0063		0.0026		0.00044		0.0021		0.044		0.0042		0.0024		0.0018		0.0011
U ₃		0.00017		0.00084		0.00035		0.000060		0.00028		0.0061		0.00055		0.00032		0.00024		0.00015
Certified		0.0033		0.100		0.0190		0.0005		0.0118		2.07		0.0480		0.0156		0.0082		0.0023
Uncertainty		0.0006		0.003		0.0004		0.0002		0.0009		0.02		0.0006		0.0003		0.0002		0.0002
Tolerance		0.0018		0.009		0.0016		0.0004		0.0027		0.06		0.0018		0.0012		0.0008		0.0006

Analysis	*	As	*	Co	*	Sb	*	W
1	3	0.0001	3	0.001	10	0.012	3	0.0017
2	3	0.0001	3	0.0012			3	0.0019
3	3	0.0001	3	0.0013			3	0.0019
4	3	0.0001	3	0.0014			4	0.00193333
5	3	0.0002	3	0.0014			3	0.002
6	3	0.0002	3	0.0015			3	0.002
7	3	0.0002	3	0.0018			3	0.0022
8	3	0.0002	3	0.0022			3	0.0022
9	3	0.0002	3	0.0022			3	0.0022
10	3	0.0002	3	0.0024			3	0.0023
11	3	0.0002	3	0.0025			3	0.0023
12	3	0.0002	3	0.0025			3	0.0024
13	3	0.0002	3	0.0027			3	0.0024
14	3	0.0003	3	0.0027			3	0.0024
15	3	0.0003	3	0.0028			4	0.00243333
16	3	0.0003	3	0.0028			10	0.0025
17	3	0.0003	3	0.0028			3	0.0025
18	3	0.0003	3	0.0029			3	0.0027
19	3	0.0003	3	0.0029667			3	0.0027
20	3	0.0003	14	0.0029667			3	0.0027
21	3	0.0003	4	0.003			3	0.0029
22	3	0.0003	3	0.0032			3	0.003
23	3	0.0003	3	0.0032			3	0.0031
24	3	0.0003	3	0.0032			3	0.0031
25	3	0.0003	3	0.0032			3	0.0031
26	3	0.0003	10	0.0033			3	0.0031
27	3	0.0003	3	0.0034			3	0.0031
28	3	0.0003	3	0.0034			3	0.0032
29	3	0.0003	3	0.0035			3	0.0032
30	3	0.0003	3	0.0036			3	0.0033
31	3	0.0003	5	0.003667			3	0.0033
32	3	0.0003	3	0.0038			3	0.0034
33	3	0.0003	3	0.0039			3	0.0034
34	3	0.0003	3	0.004			3	0.0034
35	3	0.0004	3	0.004			3	0.0035
36	3	0.0004	3	0.0041			3	0.0036
37	3	0.0004	4	0.004133			3	0.0036
38	3	0.0004	3	0.0042			3	0.0038
39	3	0.0004	5	0.004233			3	0.0038
40	3	0.0004	3	0.0043			3	0.0039
41	3	0.0004	3	0.0044			3	0.0039
42	3	0.0004	3	0.0044			3	0.004
43	3	0.0004	3	0.0045			3	0.004
44	3	0.0004	3	0.0046			3	0.0041
45	3	0.0004	3	0.0047			3	0.0041
46	3	0.0005	3	0.0057			3	0.0041
47	3	0.0005	3	0.0058			3	0.0043
48	5	0.000747					3	0.0044
49	5	0.001833					3	0.0046
50	5	0.0021						
51	9	0.0024						
52	10	0.0028						
53								
54								
55								
56								
Average		0.000460		0.0032		0.01		0.0031
Std Dev		0.000230		0.0073		0.28		0.0066
H		0.00030		0.0006		0.00		0.0006
U ₁		0.00038		0.0073		0.28		0.0066
t-statistic		2.01		2.01		12.71		2.01
U ₂		0.00076		0.015		3.53		0.013
U ₃		0.00011		0.0022		3.53		0.0019
Informational		(0.0005)		(0.0032)		(0.01)		(0.0031)

For each element, in accordance with the requirements of ISO Guides 34 and 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.

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
NSL Analytical	Cleveland, OH	ANAB	17025
Exova	Santa Fe Spring, CA	A2LA	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI	17025
Dirats Laboratories	Westfield, MA	ANAB	17025
Luvak Inc.	Boylston, MA	PRI	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	17025
Brammer Standard Company, Inc.	Houston, TX	A2LA	17025, 17034

A2LA = American Association for Laboratory Accreditation
 ANAB = ANSI-ASQ National Accreditation Board
 PCA = Polish Center For Accreditation
 PRI = Performance Review Institute

Analysis: Chemical analyses were made on solid pieces and chips 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: 11XC1N, 11XC4Q, 11XC6U, 11XSG1A; AR 306, 323, 673; BAS 464/1; BS CI4, LF2B, 8, 29, 291, 291BB, 291DJ, 1026; CKD 234, 238, 239; CZ 20034 14A; LECO 501-024; SPL 2a, 3a, 8a, 15a; SRM 7G, 9F, 16F, 33D, 160B, 342A, 361, 362, 363, 365, 1140, 3109A, 3113, 8620C.

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 CI4, 8, 29, 291, 291BB, 291DJ; CZ 20034 14A; SRM 1140.

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 291EF 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 cast stock for this CRM was produced by Shijiazhuang Trump Scientific Co, LTD.; Shijiazhuang, China.

Form: This CRM is machined in the form of a disc, approximately 35 mm in diameter and ~ 30 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 certified area of each disc is the portion extending upward 25 mm from the analytical surface.

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.

Certificate Number: The unique identification number for this certificate of analysis is 291EF-030118. You may obtain information on revisions of certificates from the internet at.

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 March 1, 2018.

Beau R. Brammer

President