Brammer Standard Company, Inc.

Certificate of Analysis

BS 750D

Certified Reference Material for Inconel X750 - UNS Number N07750

Certified Values[3]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Al	**0.70**	0.02	**N**	**0.0041**	0.0004
As	**0.0006**	0.0003	**Nb**	**0.89**	0.01
B	**0.0024**	0.0005	**Ni**	**71.3**	0.2
C	**0.039**	0.002	**O**	**0.0019**	0.0003
Cr	**15.50**	0.06	**S**	**0.0005**	0.0002
Fe	**8.42**	0.08	**Si**	**0.188**	0.008
Mg	**0.0051**	0.0004	**Sn**	**0.0008**	0.0003
Mn	**0.188**	0.008	**Ti**	**2.53**	0.05
Mo	**0.026**	0.002	**Zr**	**0.014**	0.001

Reference Values[3,4]

	Certified Value[1]	Estimate of Uncertainty[2]		Certified Value[1]	Estimate of Uncertainty[2]
Co	**0.023**	0.004	**V**	**0.028**	0.003
Cu	**0.026**	0.003	**W**	**0.005**	0.002
P	**0.005**	0.001			

Informational Values[3,5]

Ta (0.007)

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 Ca, Ga, Ge, Hf, Ir, Na, Os, Pb, Re, Sb, 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.

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

BS 750D * Code for method Certified values listed as weight percent

Analysis	*	Al	*	As	*	B	*	C	*	Cr	*	Fe	*	Mg	*	Mn	*	Mo	*	N
1	12	0.6133333	5	0.0003133	4	0.0017	1	0.0354667	4	14.96167	4	8.24	5	0.0042	3	0.168	10	0.0193	2	0.0035
2	4	0.655	12	0.0004233	12	0.0017	1	0.0364333	4	15.24	4	8.2881333	12	0.0046	4	0.178	4	0.0208333	2	0.003575
3	4	0.67	5	0.0004767	12	0.0019	1	0.037	18	15.31333	10	8.29	14	0.0047333	3	0.178	12	0.0220	2	0.0036
4	4	0.6783333	12	0.00055	3	0.002	1	0.0373333	3	15.33	10	8.3308	3	0.005	10	0.179	10	0.0228	2	0.003633
5	10	0.6846267	9	0.0007333	4	0.0022	1	0.038	10	15.412	18	8.3366667	4	0.0053	8	0.179667	3	0.0233333	2	0.003763
6	4	0.685	4	0.0008333	4	0.0024667	3	0.038	3	15.45	4	8.34	4	0.0053933	4	0.18	5	0.0236	2	0.00399
7	10	0.694	5	0.0009333	3	0.0025	1	0.0382333	13	15.461	4	8.343	8	0.0054	10	0.181	4	0.0236667	2	0.004
8	18	0.6966667	3	0.001	5	0.0025	1	0.0386	3	15.467	10	8.345	4	0.0055	10	0.185533	4	0.0238333	2	0.004027
9	4	0.6967667			4	0.0025667	1	0.0389	4	15.47667	3	8.36	4	0.0055333	4	0.185667	4	0.0242333	2	0.00409
10	4	0.6991333			4	0.0027	1	0.0394	3	15.48667	4	8.3927333	5	0.0055667	10	0.186	10	0.0247	2	0.0043
11	14	0.7			4	0.0028	1	0.0395	17	15.49127	4	8.3988333	3	0.0056	4	0.1867	4	0.0256667	2	0.0043
12	10	0.706			7	0.00285	1	0.0396667	14	15.5	4	8.3996667	12	0.0059	4	0.186767	12	0.0259667	2	0.0045
13	4	0.7077			5	0.0029	1	0.04	10	15.50333	4	8.4			10	0.187863	10	0.02612	2	0.004623
14	4	0.7087			14	0.0029333	3	0.041	4	15.52667	4	8.419			4	0.1883	5	0.0266	2	0.0049
15	3	0.71			10	0.0030	1	0.0410667	4	15.54	10	8.42			14	0.188667	10	0.027		
16	4	0.7166667			3	0.00351	1	0.0425333	10	15.543	14	8.4233333			4	0.189133	4	0.0275		
17	10	0.72					1	0.0435	4	15.55	3	8.43			3	0.19	4	0.028		
18	3	0.724							10	15.554	10	8.4411733			4	0.1914	14	0.0280		
19	4	0.7266667							10	15.5589	10	8.456			10	0.195	4	0.0311667		
20	10	0.7343333							4	15.5767	3	8.551			3	0.196	3	0.032		
21	4	0.735167							10	15.58	4	8.5667			4	0.199	10	0.033		
22	10	0.735833							4	15.6795	3	8.616667			5	0.204667	3	0.0374		
23	3	0.744							4	15.84333	4	8.63			4	0.21				
24	3	0.771667													12	0.22				
25															12	0.236667				
Average		0.7042		0.000618		0.002427		0.0390		15.495		8.4152		0.00507		0.1879		0.02609		0.00405
Std Dev		0.0039		0.000069		0.000096		0.0012		0.027		0.0053		0.00021		0.0025		0.00096		0.00015
H		0.0081		0.000306		0.000462		0.001489		0.085223		0.051261		0.000603		0.003523		0.0012222		0.000554
U_1		0.0090		0.00031		0.00047		0.0019		0.089		0.052		0.00064		0.0043		0.0016		0.00057
t-statistic		2.07		2.36		2.13		2.12		2.07		2.07		2.20		2.06		2.08		2.16
U_2		0.019		0.00074		0.0010		0.0040		0.19		0.11		0.0014		0.0090		0.0032		0.0012
U_3		0.0038		0.00026		0.00025		0.00098		0.039		0.022		0.00040		0.0018		0.00069		0.00033
Certified		**0.70**		**0.0006**		**0.0024**		**0.039**		**15.50**		**8.42**		**0.0051**		**0.188**		**0.026**		**0.0041**
Uncertainty		0.02		0.0003		0.0005		0.002		0.06		0.08		0.0004		0.008		0.002		0.0004
Tolerance		0.06		0.0005		0.0015		0.006		0.19		0.24		0.0014		0.024		0.006		0.0012

Analysis	*	Nb	*	Ni	*	O	*	S	*	Si	*	Sn	*	Ti	*	Zr
1	10	0.82	10	71.01	2	0.0014333	1	0.00014	12	0.1500	4	0.0004333	10	2.44	4	0.0104
2	3	0.8486667	16	[71.02334]	2	0.0015067	1	0.0002667	4	0.153333	5	0.0006	3	2.4433333	12	0.0120
3	10	0.8623333	4	71.1500	2	0.0015633	12	0.0002767	18	0.153333	5	0.0006367	10	2.463	14	0.012067
4	4	0.87	16	[71.23]	2	0.00157	12	0.00031	12	0.16	5	0.00066	4	2.48	4	0.012503
5	3	0.873	16	[71.24]	2	0.0016667	1	0.0003333	4	0.171333	12	0.00073	4	2.4866667	4	0.012767
6	10	0.874	4	71.2567	2	0.0018	1	0.00048	4	0.182667	12	0.00079	18	2.49	3	0.0129
7	10	0.88	3	71.283333	2	0.0018533	1	0.0005	6	0.183333	9	0.001	3	2.49	5	0.013233
8	4	0.88	10	71.29	2	0.0019	1	0.0005	10	0.184	4	0.0010667	3	2.500	4	0.013267
9	4	0.8817	13	71.291	2	0.002	1	0.0005	10	0.184	3	0.0011	4	2.5026667	3	0.014
10	4	0.8891	16	[71.3]	2	0.0021	1	0.0006	3	0.188			10	2.51	3	0.014067
11	14	0.8893333	10	71.300	2	0.0022	1	0.0007	4	0.188667			10	2.5151333	5	0.014133
12	4	0.89	3	71.314	2	0.0022	1	0.0011667	4	0.19			4	2.5167	4	0.014133
13	4	0.8901667	14	71.366667	2	0.0023			3	0.19			4	2.5196	4	0.0142
14	10	0.8909333	10	71.367	2	0.0023333			4	0.190133			10	2.52275	4	0.014233
15	4	0.8933333	6	71.406333					4	0.192			10	2.528	4	0.014233
16	4	0.8953	4	71.576667					10	0.192233			4	2.5287333	10	0.0143
17	10	0.8960233	18	71.613333					14	0.193667			4	2.57	10	0.015
18	3	0.90	10	71.643333					10	0.194693			14	2.57	12	0.0150
19	4	0.9103333							10	0.195			4	2.5886667	10	0.015843
20	3	0.916							4	0.195133			3	2.59	10	0.0163
21	4	0.9211							3	0.197333			4	2.599567	4	0.017
22	4	0.954							4	0.198433			4	2.607333		
23									4	0.2033			4	2.608433		
24									3	0.205						
25									4	0.20566						
26									10	0.212						
Average		0.8888		71.301		0.001888		0.000482		0.1883		0.000845		2.5330		0.01387
Std Dev		0.0041		0.025		0.000085		0.000038		0.0027		0.000067		0.0050		0.00045
H		0.009508		0.334022		0.000425		0.000288		0.003527		0.000333		0.020095		0.000914
U_1		0.010		0.33		0.00043		0.00029		0.0045		0.00034		0.021		0.0010
t-statistic		2.08		2.11		2.16		2.20		2.06		2.31		2.07		2.09
U_2		0.022		0.71		0.00094		0.00064		0.0092		0.00078		0.043		0.0021
U_3		0.0046		0.17		0.00025		0.00018		0.0018		0.00026		0.0089		0.00046
Certified		**0.89**		**71.3**		**0.0019**		**0.0005**		**0.188**		**0.0008**		**2.53**		**0.014**
Uncertainty		0.01		0.2		0.0003		0.0002		0.008		0.0003		0.05		0.001
Tolerance		0.03		0.7		0.0009		0.0005		0.024		0.0008		0.15		0.003

BS 750D * Code for method Reference values listed as weight percent

Analysis	*	Co	*	Cu	*	P	*	V	*	W
1	10	0.0168567	12	0.0190	5	0.0013	10	0.021	12	0.002533
2	8	0.0177333	12	0.0196667	4	0.0019667	4	0.0230333	12	0.0026
3	5	0.0184	10	0.020	12	0.0026333	4	0.0237667	5	0.00285
4	4	0.0185667	5	0.0216667	12	0.0029	10	0.024	10	0.003
5	10	0.0186	3	0.0217333	3	0.003	3	0.025	5	0.004833
6	12	0.0190	10	0.0224333	10	0.0031	14	0.0260667	4	0.0051
7	12	0.0190	4	0.0225333	3	0.0032667	5	0.0263333	4	0.006333
8	3	0.0194	4	0.0227667	4	0.004	10	0.0269	4	0.0068
9	10	0.0200333	5	0.0228333	3	0.0043	4	0.0269667	4	0.0070
10	3	0.0209333	4	0.0233	4	0.0043	10	0.0272	4	0.008667
11	4	0.022	8	0.0236	10	0.0043	4	0.0273667		
12	5	0.0228333	4	0.0250333	10	0.0043067	4	0.0284		
13	4	0.0229333	3	0.026	4	0.0043333	4	0.0289667		
14	14	0.0258667	3	0.0262	4	0.0055467	12	0.0290		
15	4	0.0259333	4	0.0267667	5	0.0056	4	0.0294		
16	4	0.0273	4	0.0273333	10	0.006	10	0.03136		
17	10	0.028	10	0.0288	7	0.0063833	10	0.0313667		
18	4	0.0298333	4	0.0298333	10	0.007	3	0.0322		
19	4	0.0308	3	0.03	3	0.007	4	0.0333333		
20	4	0.033	3	0.0301	14	0.0072667	3	0.034		
21			10	0.031	4	0.007333	12	0.0350		
22			14	0.0317	3	0.0074	3	0.0368		
23			4	0.032733	4	0.0079				
24			10	0.035417						
Average		0.022851		0.025852		0.004832		0.02828		0.00497
Std Dev		0.000071		0.000065		0.000066		0.00090		0.00010
H		0.001148		0.001217		0.000592		0.001271		0.000599
U_1		0.0011		0.0012		0.00060		0.0016		0.00061
t-statistic		2.09		2.07		2.07		2.08		2.26
U_2		0.0024		0.0025		0.0012		0.0032		0.0014
U_3		0.00054		0.00051		0.00026		0.00069		0.00043
Reference		**0.023**		**0.026**		**0.005**		**0.028**		**0.005**
Uncertainty		0.004		0.003		0.001		0.003		0.002
Tolerance		0.012		0.009		0.003		0.009		0.004

BS 750D * Code for method Informational values listed as weight percent

Analysis	*	Ta
1	12	0.00078
2	5	0.0009533
3	5	0.0010367
4	5	0.0015667
5	3	0.0035
6	4	0.0038
7	10	0.00496
8	3	0.010
9	4	0.0104
10	4	0.0339
Average		0.007
Std Dev		0.047
H		0.000685
U_1		0.047
t-statistic		2.26
U_2		0.11
U_3		0.034
Informational		**(0.007)**

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 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 750D * Code for analytical method Trace analysis listed as mg/kg (ppm)

Analysis	*	Ca	*	Ga	*	Ge	*	Hf	*	Ir	*	Na	*	Os	*	Pb	*	Re	*	Sb
1	12	0.4	12	12	12	0.6	12	0.07	12	0.05	12	0.01	12	0.08	12	0.31	12	0.06	12	0.47
2	12	0.43	12	12	12	0.61	12	0.08	12	0.05			12	0.09	12	0.35	12	0.06	12	0.49
3	12	0.48	12	12	12	0.62	12	0.08	12	0.06			12	0.09	12	0.37	12	0.07	12	0.49
4	4	3																		
5	4	4																		
6	4	7																		

Analysis	*	U	*	Zn
1	12	0.02	12	3.3
2	12	0.02	12	3.3
3	12	0.02	12	3.4

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	18	PIXE

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
Anderson Laboratories, Inc.	Greendale, WI	A2LA	17025
NSL Analytical	Cleveland, OH	ANAB	17025
Laboratory Testing, Inc.	Hatfield, PA	PRI/Nadcap	17025
Dirats Laboratories	Westfield,MA	ANAB	17025
Carpenter Technology Corporation	Reading, PA	A2LA	17025
Instytut Metalurgii Zelaza	Gliwice, Poland	PCA	AB 554
Evans Analytical Group	Liverpool, NY	A2LA	17025
Elemental Analysis, Inc.	Lexington, KY	A2LA	17025
Luvak Inc.	Boylston, MA	PRI/Nadcap	17025
National Analysis Center For Iron And Steel	Beijing, China	CNAS	17025
Exova	Santa Fe Springs, CA	A2LA	17025
Exova	Glendale Heights, Il	A2LA	17025
TUVRheinland	Bangalore, India	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: 13X12534, 13X12853, 28X6255; AR 615B, 614A, 654, 657, 670, 673, 875, 892, 911A, 950, 957, 1648, 1650, 1652, 1653; BAS 4/94, 55, 206/3, 245, 334, 335, 351, 387, 409, 433, 451, 459; BS H-13, SS3951, 30D, 48B, 61G, 93F, 199B, 200-4, 304, 304A, 316E, 410C, 690A, 718C, 718D, 750A, 750B, 750C, 1026, 1030, 8620E; DSZU Ca01a; ECRM 85-1, 86-1, 87-1; IARM 54B, 56C, 56D, 56G, 57A, 57B, 57C, 57D, 62B, 62E, 68C, 100B, 241A; IMZ 1.7/4, 73, 74, 111, 112, 184; LECO 501-320, 501-501, 501-502, 501-503, 501-504, 501-644, 501-674, 501-676, 501-993, 502-416, 502-494, 502-868, 502-873; SRM 55D, 72F, 90, 101C, 349, 361, 362, 365, 864, 865, 866, 867, 1095, 1155A, 1188, 1244, 1264A, 1269, 2159, 3103A.

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 690A; DSZU CA01a; LECO 501-676, 502-873; SRM 864, 865.

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 750D 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 VDM Metals USA, LLC; Reno, NV.

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 750D-120117. 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 9001:2008 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 9001:2008 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 01, 2017.

Beau R. Brammer

President