

Certificate of Analysis

BS 9905

**Certified Reference Material¹ for Steel Alloy Number F-91 (ASTM 182)
(UNS Number K90901)**

	Certified Value²	Estimate of Uncertainty³	Certified Value²	Estimate of Ucertainty³
Analysis listed as percent by weight				
C	0.107	0.003	Nb	0.076 0.004
Mn	0.333	0.005	O	0.0021 0.0003
P	0.008	0.001	Sn	0.009 0.002
S	0.008	0.0006	V	0.236 0.006
Si	0.327	0.005	W	0.003 0.001
Cu	0.115	0.005	Information Values⁴	
Ni	0.123	0.004	B	0.0004
Cr	8.22	0.05	Ca	0.0001
Mo	0.90	0.01	Pb	0.0002
Al	0.017	0.002	Sb	0.002
As	0.007	0.002	Ti	0.002
Co	0.016	0.002	Zr	0.001
N	0.055	0.002		

¹ Brammer Standard Company, Inc., is accredited to ISO Guide 34 as a Reference Material Producer to produce Certified Reference Materials by A2LA (Certificate Number 656.02)

² The certified value listed is the present best estimate of the true value based on the results of an interlaboratory testing program.

³ The uncertainties listed are based on value judgments of the material inhomogeneity and the 95% confidence interval. The half-width confidence interval C(95%) is shown on page 2.

⁴ Information values are not certified and are provided for information only.

See the following pages for more information.

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Analysis	C	Mn	P	S	Si	Cu	Ni	Cr
1	AGA 0.104	AGA 0.324	AIC 0.0056	C 0.007	AIC 0.320	MCB 0.108	MND 0.118	TCr 8.17
2	C 0.1048	AA 0.327	AIC 0.0061	C 0.00710	AGA 0.324	ECS 0.1118	AIC 0.119	AIC 8.17
3	C 0.1048	MP 0.330	MPN 0.0062	AGA 0.0074	GSI 0.325	AIC 0.112	AA 0.121	AGD 8.18
4	C 0.106	AIC 0.332	AIC 0.007	C 0.0076	AIC 0.326	XRF 0.113	XRF 0.123	XRF 8.19
5	C 0.106	AIC 0.333	AIC 0.0079	C 0.0077	GSI 0.327	AGA 0.114	AGA 0.123	TCr 8.19
6	C 0.1061	MnP 0.333	AIC 0.0079	C 0.0078	AA 0.327	IN 0.114	AIC 0.123	AIC 8.20
7	CP 0.1063	AIC 0.333	AIC 0.008	C 0.0078	GSI 0.327	XRF 0.114	AIC 0.123	TCr 8.21
8	C 0.107	XRF 0.334	AGA 0.0084	C 0.0079	AA 0.329	AIC 0.116	AIC 0.123	AIC 8.228
9	C 0.107	XRF 0.335	MPH 0.0087	C 0.0079	GSI 0.332	AIC 0.117	AIC 0.126	XRF 8.26
10	C 0.108	AIC 0.335	AIC 0.009	CP 0.0080	AIC 0.333	MCT 0.117	GNI 0.1231	XRF 8.267
11	C 0.108	MnP 0.339		C 0.008		AIC 0.117	AIC 0.127	TCr 8.29
12	C 0.110	AIC 0.340		C 0.0080		AIC 0.119	XRF 0.129	TCr 8.306
13						XRF 0.122		
Average	0.1065	0.3329	0.0075	0.0077	0.3270	0.1150	0.1232	8.222
Std Dev	0.0017	0.0045	0.0012	0.0003	0.0038	0.0036	0.0031	0.048
Certified	0.107	0.333	0.008	0.008	0.327	0.115	0.123	8.22
t	2.201	2.201	2.2622	2.201	2.2622	2.1788	2.201	2.201
C(95%)	0.0010	0.0028	0.0008	0.0002	0.0027	0.0022	0.0020	0.030

Analysis	Mo	Al	As	Co	N	Nb	O	Sn
1	GMO 0.8737	AIC 0.0136	AAH 0.0049	AIC 0.013	FU 0.052	XRF 0.068	FU 0.0018	MSn 0.0078
2	AIC 0.896	XRF 0.014	MAD 0.0052	AIC 0.014	FU 0.0539	AIC 0.073	FU 0.0018	AIC 0.0082
3	MMT 0.900	XRF 0.015	AAH 0.0052	AIC 0.015	FU 0.0539	AES 0.073	FU 0.0020	AIC 0.0084
4	AIC 0.901	AIC 0.016	AIH 0.0066	AES 0.0153	FU 0.0540	AIC 0.0747	FU 0.0022	AIC 0.0087
5	AA 0.901	AIC 0.0168	AAG 0.0067	AIC 0.0153	FU 0.0548	AES 0.075	FU 0.0022	AIC 0.009
6	AGA 0.906	AA 0.0179	AIC 0.0068	AAG 0.0154	FU 0.055	AES 0.0753	FU 0.0023	AIC 0.009
7	AIC 0.906	AIC 0.018	AAG 0.007	IN 0.0159	FUP 0.0556	AIC 0.076	FU 0.0023	AIC 0.009
8	XRF 0.906	AIC 0.018	AES 0.007	XRF 0.016	FU 0.0559	AIC 0.0766		AIC 0.0091
9	XRF 0.908	MCC 0.0181	AAG 0.007	AIC 0.0162	FU 0.0560	AIC 0.077		AAG 0.0096
10	AIC 0.91	AES 0.0185	IN 0.0072	AES 0.0163	FU 0.0561	AIC 0.078		AGA 0.0099
11	AIC 0.91	AES 0.0186	AAH 0.0074	AIC 0.0166	FU 0.060	ADC 0.078		AES 0.0108
12	AIC 0.926	AIC 0.0187	AES 0.0077	AES 0.0172		AIC 0.078		AES 0.0111
13		AGA 0.0189	AES 0.0081	AAA 0.018		MNA 0.0783		AIM 0.0114
14		AES 0.019				XRF 0.082		
15		AIC 0.019						
Average	0.904	0.0173	0.0067	0.0157	0.0552	0.0759	0.00209	0.0094
Std Dev	0.012	0.0018	0.0010	0.0013	0.0020	0.0033	0.00022	0.0011
Certified	0.90	0.017	0.007	0.016	0.055	0.076	0.0021	0.009
t	2.201	2.1448	2.1788	2.1788	2.2281	2.1604	2.4469	2.1788
C(95%)	0.008	0.0010	0.0006	0.0008	0.0014	0.0019	0.00020	0.0007

Analysis	V	W	B	Ca	Pb	Sb	Ti	Zr
1	AES 0.229	IN 0.0029	AIC 0.0001	AES 0.0001	AAG 0.0001	AAG 0.0012	AIC 0.0011	OES 0.0006
2	AES 0.233	XRF 0.003	ASE 0.0001	ADC 0.0001	AIC 0.0001	AIC 0.0015	AIC 0.0011	OES 0.0012
3	AIC 0.233	AIC 0.003	ASE 0.0001	AIC 0.00014	AAG 0.00016	AAE 0.0015	AIC 0.0016	XRF 0.002
4	AES 0.233	AIC 0.003	MBD 0.00012	AIC 0.00014	AAG 0.0002	AAE 0.0016	AIC 0.002	
5	XRF 0.234	XRF 0.003	AIC 0.0004		AAE 0.0002	AIH 0.0017	XRF 0.002	
6	MVE 0.234	AIC 0.003	AES 0.0004		AAE 0.0002	MSM 0.0018	AIC 0.0020	
7	AIC 0.234	AES 0.0035	AIC 0.0005		AIC 0.0003	AIC 0.0019	OES 0.0022	
8	AIC 0.234	AES 0.0035	AES 0.0005		AIC 0.0005	IN 0.0019	OES 0.0026	
9	AIC 0.234	AIC 0.0039	ADC 0.0005			AGA 0.003	XRF 0.006	
10	AA 0.2364		AES 0.0005					
11	IN 0.238		AES 0.00081					
12	XRF 0.242		AES 0.00086					
13	AIC 0.242							
14	AIC 0.245							
Average	0.2358	0.0032	0.00041	0.00012	0.00022	0.00179	0.0023	0.0013
Std Dev	0.0044	0.0003	0.00026	0.00002	0.00013	0.00051	0.0015	0.0007
Certified	0.236	0.003	(0.0004)	(0.0001)	(0.0002)	(0.002)	(0.002)	(0.001)
t	2.1604	2.306						
C(95%)	0.0025	0.0003						

* Methods of analysis listed on page 3

Data in parentheses are not certified but are provided for information only.

Data listed as mass fraction expressed as percent.

$C(95\%) = (t \times sd) / n$ The half-width confidence interval, where t is the appropriate Student's t value, sd is the interlaboratory standard deviation, and n is the number of acceptable mean values. For further information regarding the confidence interval for the certified value see ISO Guide 35:1989 section 4.

Methods of Analysis

Code	Element	Method
AA		Flame Atomic Absorption Spectrometry
AAA		Flame Atomic Absorption - standard addition method
AAE		Graphite Furnace (Flameless) Atomic Absorption Spectrometry after three-phase extraction
AAG		Electro-thermal atomization (graphite furnace) Atomic Absorption Spectrometry
AAH		Flame Atomic Absorption Spectrometry with hydride generation
ADC		AES - DCP - Direct Current Plasma Spectrometry
AES		AES - Spark Source Optical Emission Spectrometry
AGA		AES - Spark Source and Glow Discharge Spectrometry average
AGD		AES - GD - Glow Discharge Spectrometry
AIC		AES - ICP -Inductively Coupled Plasma Spectrometry
AIH		AES - ICP -Inductively Coupled Plasma Spectrometry after hydride generation
AIM		AES - ICP Mass Spectrometry addition method
ASE		AES - Inductively Coupled Plasma after solvent extraction
C	C, S	Combustion-Infrared Absorption (ASTM E 1019) traceable to CRMs
CP	C, S	Combustion-Infrared Absorption traceable to pure substances
ECS	Cu	Sulphide precipitation, electro- deposition, gravimetric
FU	N, O	Inert gas Fusion Method (ASTM E 1019) traceable to CRMs
FUP	N, O	Inert gas Fusion Method traceable to pure substances
GMo	Mo	Gravimetry, Benzolnoxime
GNi	Ni	Dimethylglyoxime gravimetric
GSi	Si	Gravimetry with perchloric acid
IN		INAA - Neutron Activation Analysis
MAD	As	MAS - Molybdenum blue photometric after separation by distillation
MBD	B	MAS - Distillation separation-curcumin photometric
MCB	Cu	MAS - Bicyclohexane oxalyldihydrazone photometric
MCC	Al	MAS - Chromazuol S photometric after separation with cupferron
MCT	Cu	MAS - Tetraethylthiuram disulphide
MMT	Mo	MAS - Thiocyanate photometric
MNA	Nb	MAS - Absorptionmetric determination method with (4-(2-pyridylazo))-Resorcinol
MND	Ni	MAS - Dimethylglyoxime photometric
MnP	Mn	MAS - Potassium periodate oxidation photometric
MPH	P	MAS - Heteropoly molybdenum blue spectrophotometry
MPN	P	MAS - Butyl alcohol-trichloromethane extraction photometric
MSM	Sb	MAS - malachite green photometric
MSn	Sn	MAS - Phenylfluorone photometric
MVE	V	MAS - n-benzoyl phenylhydroxylamine extraction photometric
TCr	Cr	Persulfate oxidation, ferrous sulfate titrimetric
XRF		X-Ray Fluorescence spectrometry

AES = Atomic Emission Spectrometry
MAS = Molecular Absorption Spectrometry (photometric, spectrophotometric methods)

Co-operating Laboratories: The co-operating laboratories were:

Laboratory

AK Steel Research, Middletown, Ohio
 Allegheny Ludlum Technical Center, Brackenridge, Pennsylvania
 Allvac, Monroe, North Carolina
 ANAREM, Prague, Czech Republic
 An-Tech Laboratories, Houston, Texas
 Brammer Standard Co., Inc., Houston, Texas
 China National Analysis Center for Iron and Steel, Beijing, China
 Crucible Specialty Steel, Syracuse, New York
 J. Dirats and Co., Inc., Westfield, Massachusetts
 Ellwood Quality Steels Company, New Castle, Pennsylvania
 IncoTest, Huntington, West Virginia
 LECO Corporation, St. Joseph, Michigan
 Shiva Analyticals (India) Ltd., Hoskote, Bangalore, India
 VHG Laboratories, Inc., Manchester, New Hampshire

Laboratory contact

Howard P. Vail
 Sally Bissell-Seymour
 Patrick M. Cole
 Karel Bi ovsk
 Ray Smoko
 Richard P. Beaumont
 Prof. Wang Haizhou
 William Mastroe
 Eric E. Dirats
 Steve Lubinski
 Melissa G. Staley
 Dennis Lawrenz
 Dr. T. V. Ramakrishna
 Julie M. McIntosh

Certification Process: The requirements of ISO Guide 31, ISO Guide 34, ISO Guide 35, and ASTM Standard Guides E 1724 and E 1831 were followed for the preparation of this reference material and certificate of analysis. This is a Certified Reference Material as defined by ISO Guide 30.

Analysis: Chemical analyses were made on chips prepared by a lathe from the certified portion of the discs in accordance with ASTM Standard Practice E 1806. The laboratories participating in the testing normally followed the requirements of ISO Guide 25 and/or ISO Standard 17025. Individual values listed on page 2 are the average of each analyst's results. Methods of analysis used were a combination of ASTM Standard Test Method E 1019 and E 415 plus additional ICP and AA spectrometric methods.

Outliers: Some outlying data was excluded from the data listed on page 2 due to technical assessment of the cooperating laboratories and statistical evaluation.

Traceability: The following Certified Reference Materials were used to validate the analytical data listed on page 2: NIST SRM 15h, 32b, 36, 36a, 125b, 160a, 343a, 361, 362, 166b, 1754, 1762, 2166, 3103a, 3107a, 3109a, 3161a.

Homogeneity: This Reference Material was tested for homogeneity using ASTM Standard Method E 826 and found acceptable. It was also examined by optical emission spectrometry using ASTM Standard Test Method E 415 and found to be compatible with the following Reference Materials: CRMs: SS 473; CKD 180A through 189A; RMs: BS 47A, 47B, 48A, 410A.

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. Whereas this material is in a solid form and stable, no expiration date is specified.

Source: This material was produced by Operadora de Industrias CH, S.A. de C.V., Tlalnepantla, Edo. de Mexico, Mexico. It was melted by an electric arc furnace, vacuum degassed, aluminum killed, bottom poured into ingots, hot rolled, and finished with a normalized heat treatment.

Form: This Reference Material is in the form of a disc, approximately 38 mm in diameter and 19 mm thick.

Use: This Reference Material is intended for use in optical emission and x-ray spectrometric methods of analysis. Refer to ISO Guide 33 for information about the use of Reference Materials.

Certified area: The entire depth of the disc may be used.

Caution: As with any bar material, avoid optical emission spectrometric burns in the center of the disc (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 you use for production specimens. Avoid overheating the disc during surface preparation.

Certificate Number: The unique identification number for this certificate of analysis is 9905-020801-px, where x indicates the page number. Refer to future Brammer Standard Company catalogs for information on any revisions to this or other Brammer Standard reference materials. You may also obtain information on revisions of certificates from the internet at brammerstandard.com.

Safety Notice: A Material Safety Data Sheet (MSDS) 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 brammerstandard.com e-mail bramstan@netropolis.net
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Certified by: _____ on February 8, 2001.
G. R. Brammer

Certificate Number 9905-020801p4

Brammer Standard Company, Inc., is accredited to ISO Guide 34 as a Reference Material Producer for the production of Certified Reference Materials and Reference Materials by A2LA (Certificate Number 656.02) The scope of accreditation is listed on the website: www.brammerstandard.com

By Certificate Number 10539, the Quality System of Brammer Standard Company, Inc., is registered to ISO 9002:1994 by National Quality Assurance, U.S.A.

Brammer Standard Company's Chemical Laboratory is accredited to ISO Guide 25 by A2LA. (Certificate Number 656.01)

References:

ASTM documents available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, Telephone: 610-832-9500 Fax: 610-832-9555 e-mail: service@astm.org Website: www.astm.org

E 415 - 85 (Reapproved 1999) Standard Test Method for Optical Emission Vacuum Spectrometric Analysis of Carbon and Low-Alloy Steel

E 826 - 85 (Reapproved 1996) Standard Practice for Testing Homogeneity of Materials for the Development of Reference Materials

E 1019 - 2000 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel, and Cobalt Alloys

E 1724 - 95 Standard Guide for Testing and Certification of Metal and Metal-Related Reference Materials

E 1806 - 96 Standard Practice for Sampling Steel and Iron for Determination of Chemical Composition

E 1831 - 96 Standard Guide for Preparing Certificates for Reference Materials Relating to Chemical Composition of Metals, Ores, and Related Materials.

ISO Guides available from Global Engineering - www.global.ihs.com

ISO Standard 17025 (First edition, 1999), General requirements for the competence of calibration and testing laboratories.

ISO Guide 25 (Third edition, 1990), General requirements for the competence of calibration and testing laboratories.

ISO Guide 30 (Second edition, 1991), Terms and definitions used in connection with reference materials.

ISO Guide 31 (Second edition, 2000), Reference materials -Contents of certificates and labels.

ISO Guide 33 (Second edition, 2000), Uses of certified reference materials.

ISO Guide 34 (Second edition, 2000), General requirements for the competence of reference material producers.

ISO Guide 35 (Second edition, 1989), Certification of reference materials - General and statistical principles.

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

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