



Certificate of Analysis

IARM 328A

Alloy 945 / UNS N09945

Certified Reference Material

Certified Values listed in wt.% with associated uncertainties

Al	0.189 ± 0.006	As	0.0009 ± 0.0007	B	0.0011 ± 0.0002	C	0.006 ± 0.001
Co	0.003 ± 0.001	Cr	20.57 ± 0.02	Cu	1.94 ± 0.01	Fe	22.41 ± 0.04
Mg	0.0008 ± 0.0006	Mn	0.017 ± 0.003	Mo	3.16 ± 0.02	N	0.0056 ± 0.0003
Nb	3.14 ± 0.09	Ni	47.03 ± 0.07	O	0.0006 ± 0.0002	P	0.004 ± 0.001
Pb	0.00002 ± 0.00002	S	0.0006 ± 0.0001	Sb	0.00023 ± 0.00003	Si	0.021 ± 0.003
Sn	0.0002 ± 0.0002	Ta	0.004 ± 0.002	Ti	1.53 ± 0.01	V	0.008 ± 0.002
W	0.015 ± 0.007	Zr	0.004 ± 0.002				

Indicative Values listed in ppm

Ag (<0.1)	Bi (<10)	Ca (<40)	La (<5)
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Description and Intended Use

This CRM may come in the form of a solid disc or chips. The intended use of this CRM may include, but is not limited to, the calibration of instruments and the validation of analytical methods.

Interpretation of Data

1. Certified values listed reflect analysis results submitted by qualified analytical laboratories using a combination of methods and instrumentation that emulate actual methods and instrumental techniques currently utilized in the analytical community, and are reported as wt% unless otherwise noted.
2. This material was tested using both the solid disks and chips prepared from individual sections of bar. The certified values are considered representative of the overall average composition of the material.
3. Any data reported and enclosed by a parentheses () is a "best estimate" and is not certified. This data could not be quantified sufficiently for certification. It was, however, reported by enough laboratories to be considered as potentially present in the matrix of the material being examined.
4. "Provisional Certificate of Analysis" reports values that support a fully certified reference material; it also indicates that values may be in a continued process of statistical evaluation and are subject to change.
5. Chips are not certified for Oxygen analysis.



The following data and accompanying statements represent all pertinent information reported in the ILAP as it applies to the chemical characterization of this material.

	Ag	Al	As	B	Bi	C	Ca	Co	Cr	Cu	Fe	La	Mg	Mn	Mo	N
1	0.000006	0.1696	0.00015	0.00058	0.000002	0.004281	0.0005	0.00011	20.51	1.904	22.258	0.0004	0.00007	0.0058	3.11	0.0049
2	0.00001	0.18	0.0004	0.0009	0.00003	0.0044	0.0042	0.0013	20.522	1.919	22.35	<0.0005	0.0002	0.011143	3.1144	0.00496
3	<0.00001	0.182	0.00046	0.001	0.0029	0.0046	<0.0001	0.0013	20.53	1.925	22.357		0.0002	0.0124	3.13	0.00518
4	<0.00001	0.182	0.0008	0.0011	<0.000001	0.0048	<0.001	0.0017	20.53	1.9251	22.385		0.00072	0.0126	3.144	0.0054
5	<0.0001	0.1847	0.0008	0.0011	<0.00001	0.0049	<0.0010	0.0017	20.55	1.93	22.40		0.0011	0.015	3.1493	0.0055
6	<0.0002	0.185	0.0011	0.00129	<0.00001	0.0052		0.002	20.573	1.9345	22.4183		0.0014	0.0156	3.151	0.00556
7		0.18529	0.0023	0.0013	<0.0001	0.0055		0.0029	20.58	1.937	22.42		0.0016	0.0157	3.161	0.0056
8		0.1912		0.0014	<0.0002	0.0058		0.0034	20.5816	1.938	22.42			0.0179	3.174	0.00568
9		0.192		0.0016	<0.001	0.0059		0.0037	20.584	1.95	22.45			0.019	3.175	0.0057
10		0.193				0.0061		0.0042	20.585	1.951	22.4588			0.019	3.18	0.0058
11		0.197				0.0061		0.0054	20.5853	1.9513	22.47			0.02	3.1829	0.006
12		0.20				0.0067			20.59	1.952	22.50			0.021	3.184	0.0061
13		0.202				0.0075			20.64	1.954				0.0212	3.1887	0.0064
14		0.208				0.01				1.9788				0.024	3.19	
15						0.011								0.0254		
Mean	0.00001	0.189	0.0009	0.0011	0.001	0.006		0.003	20.57	1.94	22.41		0.0008	0.017	3.16	0.0056
STDV.	0.000003	0.01	0.0007	0.0003	0.002	0.002		0.002	0.04	0.02	0.06		0.0006	0.005	0.03	0.0004
Certified	(0.00001)	0.189	0.0009	0.0011	(0.001)	0.006	(<0.004)	0.003	20.57	1.94	22.41	(<0.0005)	0.0008	0.017	3.16	0.0056
95% C.I.		0.006	0.0007	0.0002		0.001		0.001	0.02	0.01	0.04		0.0006	0.003	0.02	0.0003
Methods	IM,H,A	X,O,I	IM,H,A	O,I	IM,I,H,A	C	O,I	X,O,I	X,W,O,I	X,O,I	X,O,I	IM,I	O,I,IM,H,A	X,O,I	X,O,I	F

	Nb	Ni	O	P	Pb	S	Sb	Si	Sn	Ta	Ti	V	W	Zr
1	2.794	46.83	0.0003	0.0023	0.000004	0.00027	0.0002	0.015714	0.00007	0.0005	1.48	0.0036	0.005	0.0002
2	3.013	46.88	0.00032	0.0028	0.00001	0.0003	0.0002	0.0165	0.0001	0.001	1.49	0.0052	0.0068	0.001
3	3.07	46.962	0.00038	0.003	0.0000139	0.0004	0.0002	0.017	0.0001	0.001	1.5136	0.0063	0.0078	0.001
4	3.095	46.985	0.0004	0.0033	0.00002	0.00047	0.00021	0.018	0.0001	0.001	1.516	0.0065	0.009	0.0011
5	3.098	47.004	0.0005	0.0033	0.00002	0.000485	0.00024	0.018	0.0001	0.0015	1.525	0.0069	0.01	0.0033
6	3.1147	47.04	0.0005	0.0038	0.00005	0.0005	0.00025	0.0196	0.00015	0.0024	1.5276	0.0074	0.0108	0.0035
7	3.1149	47.0583	0.0005	0.0048	0.00005	0.0005	0.00025	0.02	0.00018	0.003	1.528	0.008	0.016	0.004
8	3.1198	47.075	0.00067	0.005		0.00058	0.0003	0.023	0.0008	0.0047	1.539	0.0082	0.018	0.0049
9	3.132	47.08	0.0007	0.0058		0.00062		0.0249		0.006	1.54	0.0088	0.0183	0.0088
10	3.14	47.1181	0.0007	0.006		0.0007		0.025		0.0081	1.542	0.009	0.02	0.009
11	3.145	47.13	0.00103	0.006		0.0008		0.029		0.0093	1.544	0.0105	0.044	
12	3.172	47.256	0.0012	0.0073		0.0008		0.0308			1.5476	0.0109		
13	3.2113					0.0008					1.549143	0.013		
14	3.40					0.001					1.554			
15	3.51543					0.001					1.57			
Mean	3.14	47.03	0.0006	0.004	0.00002	0.0006	0.00023	0.021	0.0002	0.004	1.53	0.008	0.015	0.004
STDV.	0.2	0.1	0.0003	0.002	0.00002	0.0002	0.00004	0.005	0.0002	0.003	0.02	0.003	0.01	0.003
Certified	3.14	47.03	0.0006	0.004	0.00002	0.0006	0.00023	0.021	0.0002	0.004	1.53	0.008	0.015	0.004
95% C.I.	0.09	0.07	0.0002	0.001	0.00002	0.0001	0.00003	0.003	0.0002	0.002	0.01	0.002	0.007	0.002
Methods	X,O,I	X,W,O,I	F	X,O,I	IM,H,A	C	IM,H,A	X,W,O,I	O,IM,H,A	X,O,I	X,O,I	X,O,I,IM	X,O,I	X,O,I,IM

Legend: W = Classical, C = Combustion, F = Fusion, A = AA or GFAA, I = ICP or DCP, IM=ICP-MS, D = DC Arc, O = AES, X = XRF, G = GDAES or GDMS, H = Hollow Cathode AES

Participating Laboratories

Exova - Glendale Heights
Oerlikon Metco
Laboratory Testing, Inc.
Exova - Middlesbrough
Jorgensen Forge Corp.
ATI Specialty Materials, Monroe
Exova - Gary

Glendale Heights, IL
Fort Saskatchewan, AB
Hatfield, PA
Middlesbrough, UK
Seattle, WA
Monroe, NC
Gary, IN

Exova - Portland
ATI Specialty Materials, Lockport
VDM-Metals USA, LLC
Huntington Alloys Corporation
AB Sandvik Materials Technology
Special Metals IncoTest
Latrobe Specialty Metals, A Carpenter Co.

Portland, OR
Lockport, NY
Florham Park, NJ
Huntington, WV
Sweden
Hereford, UK
Latrobe, PA

Traceability

Members of the "Inter-Laboratory Analysis Program" (ILAP) validate test methods and instrument performance utilizing SRMs, CRMs, and RMs produced by recognized Certifying Bodies. The specific SRMs, CRMs, and RMs applicable to the material covered by this certificate are:

ALPHA AR644	ALPHA AR646	ALPHA AR654	ALPHA AR668	ALPHA AR673	ALPHA AR881	ALPHA AR946	ALV 111	ALV PF37
BCS 346	BCS 350	BCS 351	BCS 351/1	BCS 432/2	BCS 454/1	BCS 461/1	BCS 462/1	BCS CRM-346
BS 275A	BS 59A	BS 59E	BS 718A	BS 718B	BS 825	BS 925	BS CSN-4	ECRM 099-1
ECRM 182-1	ECRM 298-1	FLS 3	HAS 905A	HAS 925A	HF4114	IARM 190A	IARM 25B	IARM 25C
IARM 275A	IARM 54B	IARM 56D	IARM 59B	IARM 59C	IARM 59D	IARM 60A	IARM 69E	ICV-GFAA
IH PT71	IH RR02-1	IH SDN1030	IN R5657	INCO B5967	JK 1C	JK 27	JK 2D	JK 37
LECO 501-503	LECO 501-550	LECO 501-551	LECO 501-643	LECO 501-644	LECO 501-673	LECO 501-991	LECO 501-992	LECO 502-102
LECO 502-256	LECO 502-257	LECO 502-412	LECO 502-414	LECO 502-456	MBH 219X1867C	MBH 22X808C	MBH 28X07718A	MBH 28X6252L
N26000	NIST 1245	NIST 1247	NIST 1763	NIST 1765	NIST 2159	NIST 2159	NIST 3102A	NIST 3107
NIST 3113	NIST 3114	NIST 3127A	NIST 3128	NIST 3131A	NIST 3150	NIST 3151	NIST 3151	NIST 3161A
NIST 3163	NIST 3169	NIST 361	NIST 364	NIST 865	NIST 867	NIST 899C	PET1	RH12/3
RH18/10	RH31/8	RN13/10	RN14/18	RN2/19	RN5/28	SUS RE12/2	SYN Q6FB	

Homogeneity and Uncertainty

"Uncertainty" values, as reported adjacent to certified concentration values, are based on a 95% Confidence Interval. These estimated uncertainties include the combined effects of method imprecision, material inhomogeneity, and any bias between methods. Homogeneity data from experimental XRF results are reflected in both the overall statistics and certified data. Homogeneity samples are selected by a systematic sampling procedure. The number of samples may be determined by equation 1, where N_{prod} is the number of units produced and N_{min} is the number of samples used for homogeneity testing. These samples are arranged in a simple randomized design such that each sample is analyzed multiple times by XRF. Homogeneity is also determined within sample using an applied version of ASTM E826. A single factor ANOVA is used to calculate uncertainty due to inhomogeneity (U_{hom}). Uncertainty of the material is calculated by equation 2, where $H=U_{hom}$, S = Standard deviation, t = t-value at 95% CI, and n = number of observations.

$$1. N_{min} = \max(10, \sqrt[3]{N_{prod}})$$

$$2. U_{CRM} = \frac{\sqrt{H^2 + S^2}}{\sqrt{n}} * t$$

The International Standards Organization (ISO) definitions, expressed in ISO Guide 30–1992 list the following:

Certifying Body: Any technically competent body (organization or firm, public or private) that issues a reference material certificate with the information detailed in ISO Guide 31. The only generally accepted certifying body in the United States for primary standards or Standard Reference Materials (SRM) is the U. S. Department of Commerce, National Institute of Standards & Technology (NIST), Gaithersburg, MD. All other certifying bodies in the United States produce Reference Materials (RM) or Certified Reference Materials (CRM).

Reference Material (RM): Material or substance, with one or more property values that are sufficiently homogeneous and well established, to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials.

Certified Reference Material (CRM): Reference material, accompanied by a certificate, with one or more property values certified by a procedure, which establishes its traceability to an accurate realization of the unit in which the property values are expressed, and for which each certified value is accompanied by an uncertainty at a stated level of confidence.

Inter-Laboratory Analysis Program (ILAP): ASTM Standard E691-87 applies to inter-laboratory studies to "Determine the Precision of a Single Test Method", but also outlines a well thought out and logical plan for conducting an inter laboratory program involving multiple analytical techniques. Therefore, the guidelines established in ASTM E691-87 were applied to all aspects of this inter laboratory program, including the protocols for planning, handling, analysis and treatment of resulting data.

Methods of Analysis: The "Inter Laboratory Analysis Program" analyzes a wide variety of materials, and as a result, no single analytical method would provide optimum analytical results. Therefore, a combination of ASTM Standard Methods for classical wet chemistry, ICP, AA, Optical Emission, X-Ray spectrometric, and other accepted methods were used to produce analytical data. Carbon, Sulfur, Nitrogen, and Oxygen results were supplied from combustion and OE instrument procedures.

Expiration of Certification: The certification of this IARM is valid indefinitely, within the uncertainty specified, provided the IARM is handled and stored in accordance with the instructions stated on this certificate. The certification is nullified if the IARM is damaged, contaminated, otherwise modified, or used in a manner for which it was not intended.

Instructions for Use: The test surface is on the side opposite to the labeled surface, which includes the IARM number. The entire thickness of the unit is certified. However, the user is cautioned not to measure disks less than 2 mm thick when using X-ray fluorescence spectrometry. Each packaged disk has been prepared by finishing the test surface using a lathe. The user must determine the correct surface preparation procedure for each analytical technique. The user is cautioned to use care when either resurfacing the disk or performing additional polishing, as these processes may contaminate the surface. The minimum sample size for chips should be individually evaluated based on the analytical technique used; this would typically be greater than 0.1 grams. The material should be stored in a cool, dry location when not in use. **Chips are not to be used for Oxygen analysis.**

Selection of Materials: A "batch" or "series" is defined as a continuous length of bar produced from a single heat. The majority of IARM materials are in wrought condition; other methods of manufacture are utilized if necessary. ILAP samples are removed from equal sections from the total length of the bar. A portion of each section is converted to chips and a thin (pin) disk for analysis by classical wet chemistry, ICP, AA, and combustion procedures, and the balance remains as a thick disk for OES and X-Ray analysis.



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