

ANALYTICAL REFERENCE MATERIALS INTERNATIONAL

CERTIFICATE OF A CERTIFIED REFERENCE MATERIAL

Grade : Hastaloy X
Part Number (Q.A. NO.) : IARM-69B

Certification Date : 05/30/98

Certificate No. : 69B-053098-ARM-F

INTERPRETATION OF DATA

1. Certified values listed below 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.
2. 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.
3. The "Inter-laboratory Analysis Program" (ILAP) utilized in the establishment of the data is an ongoing program with permanent membership. Certain elements may be selected by a consensus of the members for more extensive testing. Therefore the data in **brackets []** indicates further testing is in process.
4. The "**± Confidence Interval at 95%**" is enclosed by a **parentheses ()** below the individual element's concentration.

IMPORTANT : A "USER REGISTRATION CARD" ACCOMPANIES ALL SHIPMENTS. THIS CARD SHOULD BE COMPLETED IMMEDIATELY UPON RECEIPT OF MATERIALS WITH THE APPROPRIATE USER INFORMATION. THIS IS THE ONLY WAY IN WHICH ARMI CAN GUARANTEE CUSTOMER UPDATES OR POSSIBLE DATA MODIFICATIONS!

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|--------------------------------------|---------------------------------------|---------------------------------------|-------------------------------------|---------------------------------------|-------------------------------------|----------------------------------------|---------------------------------------|
| <u>ALUMINUM</u> 0.20 (0.0120) | <u>BORON</u> (0.0007) | <u>CARBON</u> 0.074 (0.0013) | <u>COBALT</u> 1.58 (0.0130) | <u>CHROMIUM</u> 21.90 (0.0515) | <u>COPPER</u> 0.11 (0.0051) | <u>IRON</u> 17.84 (0.0753) | <u>MAGNESIUM</u> 0.006 (0.0013) |
| <u>MANGANESE</u> 0.68 (0.0157) | <u>MOLYBDENUM</u> 8.78 (0.0634) | <u>NITROGEN</u> 0.0155 (0.0003) | <u>NIOBIUM</u> 0.11 (0.0074) | <u>NICKEL</u> 47.37 (0.0719) | <u>OXYGEN</u> 0.0011 (0.0002) | <u>PHOSPHORUS</u> 0.013 (0.0012) | <u>SULFUR</u> 0.0004 (0.0002) |
| <u>SILICON</u> 0.38 (0.0238) | <u>TITANIUM</u> 0.011 (0.0030) | <u>VANADIUM</u> 0.10 (0.0115) | <u>TUNGSTEN</u> 0.78 (0.0100) | <u>ZIRCONIUM</u> 0.005 (0.0014) | | | |

The laboratories participating in the "Inter-Laboratory Analysis Program" (ILAP) and certification of this material are as follows :

Allegheny Ludlum Corp., Brackenridge, PA
 Anderson Laboratories, Inc., Greendale, WI
 Cannon Muskegon Corp., Muskegon, MI
 Chicago Spectro Service Laboratory, Inc., Chicago, IL

Haynes International, Inc., Kokomo, IN
 Howmet Alloy Division, Dover, NJ
 Howmet Corp Mat'ls Controls Lab, Whitehall, MI
 Inco Alloys International, Inc., Huntington, WV

Laboratory Testing, Inc., Dublin, PA
 Lockheed Martin Astronautics, Denver, CO
 Metals Analysis Inc., Huntington Park, CA
 Teledyne Allvac, Monroe, NC

TRACEABILITY : All members of the "Inter-Laboratory Analysis Program" (ILAP) listed above validate test methods and instrument performance utilizing SRMs produced by the National Institute of Standards and Technology, (NIST) as well as other CRMs and RMs produced by recognized Certifying Bodies from around the world. The specific SRMs, CRMs and RMs applicable to the material covered by this certificate are :

BCS 351, NIST 362, 3107, 101G, 362, 348, 166C, 126C, LECO 501-643 - 501-647, 501-501, 501-502, 501-504, 501-676, BS H3B, NIST 1765, 361, 349a, 661, 367, 2165, 16f, 1254, 364, 1187, 363, 2423, 2425a, 2424a, 168, 348a, 367, 2165, 364, 123b, 348a, 132b, c2402, 3167, ICP-NIST 160b, 1208-1, 361, 134a, 173b, 168, 135, 349, 155, 343a, WET-NIST 168, 349a, 1187, c2402, 349a, LECO 501-553, 502-016, HAYNES 718, H-5, LECO 501-503, 501-553, Alpha Resources AR512, NIST 121D, 349, 865, MBH 28X 3G, IARM 69A, SRM 310A, 3107, 3113, 3126A, 3131A, 3132, 3137, 3139A, 344, 3150, 3162A, 3165, 3169, IARM 69A, SPEX LOT #5-17AL, 5-38FE, 5-27V, NIST 131E

A specific line of traceability is established to NIST and other Certifying Bodies for those elements that are noted as "Certified Values" on the Certificates of Analyses referenced above.

SEE REVERSE SIDE FOR STATISTICAL DATA AND ADDITIONAL INFORMATION REGARDING THIS MATERIAL

THE FOLLOWING DATA AND ACCOMPANYING STATEMENTS REPRESENT ALL PERTINENT INFORMATION REPORTED IN THE INTER-LABORATORY PROGRAM AS IT APPLIES TO THE CHEMICAL CHARACTERIZATION OF THIS MATERIAL AS OF 05/30/98.

| 69B | Al | B | C | Co | Cr | Cu | Fe | Mg | Mn | Mo | N | Nb | Ni | O | P | S | Si | Ti | V | W | Zr | |
|-----------|--------|----------|--------|--------|---------|--------|---------|--------|--------|--------|--------|--------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--|
| 1 | 0.24 | 0.0011 | 0.0773 | 1.60 | 21.99 | 0.12 | 17.987 | 0.0081 | 0.72 | 8.95 | 0.016 | 0.13 | 47.469 | 0.0014 | 0.015 | 0.0008 | 0.4305 | 0.02 | 0.13 | 0.7953 | 0.0074 | |
| 2 | 0.23 | 0.001 | 0.076 | 1.598 | 21.96 | 0.1126 | 17.966 | 0.008 | 0.719 | 8.877 | 0.016 | 0.12 | 47.42 | 0.0013 | 0.014 | 0.0005 | 0.4231 | 0.018 | 0.118 | 0.795 | 0.0063 | |
| 3 | 0.219 | 0.0006 | 0.076 | 1.5975 | 21.95 | 0.112 | 17.931 | 0.0076 | 0.702 | 8.845 | 0.0158 | 0.119 | 47.37 | 0.0012 | 0.0138 | 0.0005 | 0.401 | 0.013 | 0.114 | 0.786 | 0.006 | |
| 4 | 0.2156 | 0.0005 | 0.076 | 1.59 | 21.95 | 0.11 | 17.92 | 0.0074 | 0.694 | 8.83 | 0.0155 | 0.112 | 47.37 | 0.0011 | 0.0134 | 0.0004 | 0.40 | 0.012 | 0.109 | 0.78 | 0.0040 | |
| 5 | 0.206 | 0.0002 | 0.075 | 1.588 | 21.944 | 0.11 | 17.92 | 0.006 | 0.694 | 8.82 | 0.0155 | 0.112 | 47.33 | 0.0010 | 0.013 | 0.0002 | 0.398 | 0.01 | 0.1032 | 0.775 | 0.004 | |
| 6 | 0.20 | | 0.0744 | 1.582 | 21.92 | 0.110 | 17.90 | 0.0058 | 0.69 | 8.82 | 0.0154 | 0.1073 | 47.272 | 0.0010 | 0.012 | 0.0002 | 0.374 | 0.010 | 0.0998 | 0.77 | 0.004 | |
| 7 | 0.199 | | 0.0742 | 1.58 | 21.91 | 0.110 | 17.82 | 0.005 | 0.68 | 8.78 | 0.0154 | 0.1069 | | 0.0008 | 0.0118 | 0.0001 | 0.373 | 0.01 | 0.097 | 0.766 | 0.003 | |
| 8 | 0.1963 | | 0.074 | 1.58 | 21.91 | 0.103 | 17.79 | 0.004 | 0.666 | 8.773 | 0.0153 | 0.1015 | | | 0.011 | | 0.37 | 0.0080 | 0.091 | 0.765 | 0.003 | |
| 9 | 0.192 | | 0.0726 | 1.55 | 21.867 | 0.1030 | 17.79 | | 0.665 | 8.7685 | 0.0150 | 0.10 | | | 0.010 | | 0.352 | 0.007 | 0.09 | 0.76 | | |
| 10 | 0.19 | | 0.0719 | 1.55 | 21.86 | 0.10 | 17.76 | | 0.66 | 8.67 | | 0.100 | | | | | 0.32 | 0.0068 | 0.082 | | | |
| 11 | 0.187 | | 0.071 | | 21.760 | 0.099 | 17.690 | | 0.66 | 8.627 | | 0.091 | | | | | | 0.006 | 0.07 | | | |
| 12 | 0.175 | | | | 21.724 | 0.09 | 17.599 | | 0.6414 | 8.62 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| MEAN | 0.2042 | 0.0007 | 0.0744 | 1.5816 | 21.8954 | 0.1067 | 17.8394 | 0.0065 | 0.6826 | 8.7817 | 0.0155 | 0.1091 | 47.3718 | 0.0011 | 0.0127 | 0.0004 | 0.3842 | 0.0110 | 0.1004 | 0.7769 | 0.0047 | |
| STDV. | 0.0188 | 0.0004 | 0.0019 | 0.0182 | 0.0810 | 0.0080 | 0.1185 | 0.0015 | 0.0247 | 0.0998 | 0.0003 | 0.0111 | 0.0685 | 0.0002 | 0.0016 | 0.0002 | 0.0333 | 0.0045 | 0.0171 | 0.0130 | 0.0016 | |
| CERTIFIED | 0.20 | (0.0007) | 0.074 | 1.58 | 21.90 | 0.11 | 17.84 | 0.006 | 0.68 | 8.78 | 0.0155 | 0.11 | 47.37 | 0.0011 | 0.013 | 0.0004 | 0.38 | 0.011 | 0.10 | 0.78 | 0.005 | |
| 95% C.I. | 0.0120 | | 0.0013 | 0.0130 | 0.0515 | 0.0051 | 0.0753 | 0.0013 | 0.0157 | 0.0634 | 0.0003 | 0.0074 | 0.0719 | 0.0002 | 0.0012 | 0.0002 | 0.0238 | 0.0030 | 0.0115 | 0.0100 | 0.0014 | |

The International Standards Organization (ISO) definitions, expressed in ISO Guide 30-1981-(E) list the following:

CERTIFYING BODY : A technically competent body (organization or firm, public or private) that issues a Reference Material Certificate. The only generally accepted certifying body in the United States is the U. S. Department of Commerce, National Institute of Standards & Technology, (NIST), Gaithersburg, MD.

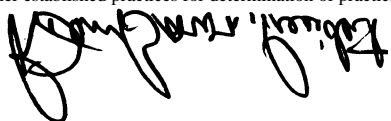
REFERENCE MATERIAL (RM) : A material or substance with one or more properties which are sufficiently well established to be used for calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials.

CERTIFIED REFERENCE MATERIAL (CRM) : A reference material with one or more properties whose values are certified by a technically valid procedure accompanied by or traceable to a certificate or other documentation which is issued by a Certifying Body.

INTER-LABORATORY ANALYSIS PROGRAM : Although ASTM Standard E691-87 applies to inter-laboratory studies to "Determine the Precision of a Single Test Method", it is also a well thought out and logical plan for conducting an inter-laboratory program involving multiple techniques. Therefore, the planning, conducting, analyzing, protocol and treatment of data resulting from this inter-laboratory program was performed utilizing the guidelines established in ASTM E691-87.

METHODS OF ANALYSIS : In view of the fact that the "Inter-Laboratory Analysis Program" entails a wide variety of materials, no single method would provide optimum data results. Therefore the methods utilized were a combination of ASTM Standard Methods for classical wet chemistry, ICP, AA, Optical Emission and X-Ray spectrometric methods. The determinations for Carbon, Sulfur, Nitrogen and Oxygen are the result of combustion instrument procedures.

SELECTION OF MATERIALS : A "batch" or "series" is defined as a single bar of one continuous length. The majority of materials are in wrought condition. Other methods of manufacture are utilized as a last resort, only in the case of those materials being unavailable in wrought condition. "Batch" samples are taken by removing a one inch cross section for every thirteen inches of total length from the entire bar. Twenty-five percent of the one inch cross section is converted to chips for analysis by classical wet chemistry, ICP, AA, and combustion procedures and seventy-five percent remains in a solid disk form for OES and X-Ray analysis where applicable. Each member of the ILAP is furnished both a solid sample and the corresponding supply of chips from a specific location on the batch bar. This massive sampling procedure results in the homogeneity being reflected as a product of the overall statistics and certified data. To insure that there are no gross abnormalities in the batch homogeneity, effective with materials certified after 10/20/91, specific homogeneity testing is being performed utilizing applicable sections, determined by the ILAP program management, for homogeneity test procedures as outlined in ASTM E-826-87, NBS Handbook 91, "Experimental Statistics", as well as other established practices for determination of practical homogeneity.



Certified by: _____
 R. Dan Brown, President
 ANALYTICAL REFERENCE MATERIALS INTERNATIONAL

Certificate No. : 69B-05/30/98-ARM-F
 Certification Date : 05/30/98
 Revision Date/No. : N/A