

Brammer Standard Company, Inc.

Certificate of Analysis

B.S. 186A

Reference Material for INVAR 36 Alloy

| | Certified Value ¹ | Estimate of of Uncertainty ² | Information vlaues ³ | |
|-------------------|------------------------------|-----------------------------------------|---------------------------------|----------|
| Carbon | 0.040 | 0.002 | Aluminum | (0.001) |
| Manganese | 0.72 | 0.02 | Niobium | (<0.002) |
| Phosphorus | 0.008 | 0.001 | Tin | (0.002) |
| Sulfur | 0.0053 | 0.0006 | Titanium | (<0.003) |
| Silicon | 0.19 | 0.01 | Tungsten | (0.01) |
| Copper | 0.016 | 0.001 | | |
| Nickel | 35.86 | 0.12 | | |
| Chromium | 0.16 | 0.01 | | |
| Molybdenum | 0.0032 | 0.0010 | | |
| Vanadium | 0.0012 | 0.0005 | | |
| Selenium | 0.229 | 0.005 | | |
| Cobalt | 0.028 | 0.003 | | |
| Nitrogen | 0.0026 | 0.0003 | | |

(analysis listed as percent by weight)

¹ The certified value listed is the present best estimate of the true value based on the results of an interlaboratory testing program.

² The uncertainties listed are based on value judgments of the material inhomogeneity and possible bias in the determined analytical values. No attempt is made to derive exact statistical measurements of imprecision because several methods were used in the determination of most constituents.

³ Values in parentheses are not certified and are provided for information only.

CAUTION: Because this Reference Material contains a high percent of nickel and selenium, care must be taken in its application. Make certain that corrections are made for possible element interference and dilution effects.

See reverse side for more information.

Certificate Number REV186A-073010

New Certificate Number REV-186A-073010 was Revised on July 30, 2010 to show estimates of uncertainty

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Some of the co-operating laboratories were:

Allegheny Ludlum Steel Corp., Brackenridge, Pennsylvania
 Allegheny Ludlum Steel Corp., Lockport, New York
 Analytical Associates, Inc., Detroit, Michigan
 Anderson Laboratories, Inc., Greendale, Wisconsin
 ARMCO Research & Technolohg, Middletown, Ohio
 Brammer Standard Co., Inc., Houston, Texas
 Crucible Specialty Steel, Syracuse, New York
 J. Dirats and Co., Inc., Westfield, Massachusetts
 Hoesch Stahl AG, Dortmund, Germany
 Charles C. Kawin Company, Broadview, Illinois
 VHG Laboratories, Inc., Manchester, New Hampshire

| BS 186A | Analysis listed as percent by weight | | | | | | | | | | Certificate Number |
|-----------|--------------------------------------|-------|--------|--------|-------|--------|--------|-------|--------|--------|--------------------|
| | | | | | | | | | | | REV186A-073010 |
| Analysis | C | Mn | P | S | Si | Cu | Ni | Cr | Mo | V | Se |
| 1 | 0.039 | 0.70 | 0.0073 | 0.0046 | 0.17 | 0.015 | 35.72 | 0.148 | 0.0022 | 0.001 | 0.226 |
| 2 | 0.0398 | 0.71 | 0.008 | 0.005 | 0.186 | 0.015 | 35.74 | 0.15 | 0.0025 | 0.001 | 0.228 |
| 3 | 0.0412 | 0.712 | 0.008 | 0.0050 | 0.187 | 0.0151 | 35.77 | 0.154 | 0.003 | 0.001 | 0.228 |
| 4 | 0.0412 | 0.714 | 0.008 | 0.0055 | 0.188 | 0.0158 | 35.82 | 0.156 | 0.0033 | 0.0010 | 0.233 |
| 5 | 0.0415 | 0.72 | 0.008 | 0.0056 | 0.19 | 0.016 | 35.92 | 0.16 | 0.004 | 0.0016 | |
| 6 | | 0.73 | | 0.006 | 0.20 | 0.017 | 35.94 | 0.16 | 0.004 | 0.0018 | |
| 7 | | 0.73 | | | 0.20 | | 35.95 | 0.17 | | | |
| 8 | | 0.735 | | | | | 36.01 | | | | |
| Average | 0.0405 | 0.718 | 0.0079 | 0.0053 | 0.189 | 0.0157 | 35.859 | 0.157 | 0.0032 | 0.0012 | 0.2288 |
| Std Dev | 0.0011 | 0.013 | 0.0003 | 0.0005 | 0.010 | 0.0008 | 0.110 | 0.007 | 0.0008 | 0.0004 | 0.0030 |
| Certified | 0.040 | 0.72 | 0.008 | 0.0053 | 0.19 | 0.016 | 35.86 | 0.16 | 0.0032 | 0.0012 | 0.229 |
| t | 2.78 | 2.36 | 2.78 | 2.57 | 2.45 | 2.57 | 2.36 | 2.45 | 2.57 | 2.57 | 3.18 |
| C(95%) | 0.0013 | 0.011 | 0.0004 | 0.0005 | 0.009 | 0.0008 | 0.092 | 0.007 | 0.0008 | 0.0004 | 0.0048 |

continued from above

| Analysis | Co | N | Al | Nb | Sn | Ti | W |
|-----------|--------|---------|---------|----------|---------|----------|--------|
| 1 | 0.025 | 0.0025 | 0.0006 | 0.0002 | 0.0008 | 0.0002 | 0.002 |
| 2 | 0.0257 | 0.0025 | 0.001 | 0.001 | 0.001 | 0.001 | 0.007 |
| 3 | 0.026 | 0.0028 | 0.002 | <0.001 | 0.001 | 0.002 | 0.013 |
| 4 | 0.028 | 0.0028 | | <0.002 | 0.0019 | 0.002 | 0.017 |
| 5 | 0.028 | | | | 0.002 | <0.001 | 0.024 |
| 6 | 0.0295 | | | | 0.0022 | | |
| 7 | 0.032 | | | | | | |
| 8 | 0.033 | | | | | | |
| Average | 0.0284 | 0.00265 | 0.0012 | | 0.0015 | | 0.0126 |
| Std Dev | 0.0029 | 0.00017 | 0.0007 | | 0.0006 | | 0.0086 |
| Certified | 0.028 | 0.0026 | (0.001) | (<0.002) | (0.002) | (<0.003) | (0.01) |
| t | 2.36 | 3.18 | 4.30 | | 2.57 | | 2.78 |
| C(95%) | 0.0025 | 0.00028 | 0.0018 | | 0.0006 | | 0.0106 |

$C(95\%) = (t \times sd) / \sqrt{n}$ 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 35:2006 section 6.

Values in parentheses are not certified and are provided for information only.

Analysis: Chemical analyses were made on millings from cross-sections of the bars. Each individual value listed above is the average of each analyst's results.

Analytical Methods: Methods of analysis used were a combination of ASTM Standard Methods E 350, E 353, E 1019, plus additional ICP, and AA spectrometric methods. The following Certified Reference Materials were used to validate the analytical data listed above: NIST SRM 73c, 101g, 121d, 126c, 160b, 339, 344, 345, 348a; BCS 466/1, 467/1, 475; ECRM 284-1, 286-1; IMZ 127/3; JK 37.

Homogeneity: This Reference Material was tested for homogeneity using ASTM Standard Method E 826 and found acceptable. It was also examined by spark atomic emission spectrometry and found to be compatible with the NIST Certified Reference Materials SRM 1158.

Form: This Reference Material was machined by Brammer Standard Company in the form of a disc, approximately 38 mm diameter and 12 mm thick. The bar stock used for this material was produced by hot-rolling billets.

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

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

Caution: As with any bar material, avoid spark atomic 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 REV-186A-073010. This BS 186A Certificate of Analysis was revised to show the estimate of uncertainty for the certified values. After reviewing the analytical data, the niobium, titanium, and tungsten values were changed to uncertified and a fourth digit was certified for sulfur and vanadium..

The first Certificate of Analysis for BS 186A was certified on October 1, 1991. Refer to the "Certificates" section of the Brammer Standard Company website for any revision to this or other Brammer Standard Company's Certificates of Analysis.

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:

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email: contact@brammerstandard.com

Certified by: _____ on July 30, 2010
Beau R. Brammer

Referenced Documents

ASTM documents available from ASTM, 1916 Race Street, Philadelphia, PA, 19103.

Versions used were those available at the time of interlaboratory testing

- E 350 Standard Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
- E 353 Standard Test Methods for Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
- E 826 Standard Practice for Testing Homogeneity of Materials for the Development of Reference Materials
- E 1019 Standard Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel, and Cobalt Alloys

ISO Guides available from American National Standards Institute, 11 West 42nd St., 13th Floor, New York, NY 10036.

ISO Guide 35:2006 Certification of reference materials - General and statistical principles.

ISO Guide 33:2000 Uses of certified reference materials

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