

CERTIFICATE OF ANALYSIS



CARPENTER
Specialty Alloys

Benchmark Reference Material IS0070A
Thermo-Span® Alloy



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This cast-structure certified reference material is in the form of a 1.25 in. (32 mm) square solid, approx. 1.0 in. (25 mm) thick. It is intended for use in spectrometric methods of analysis.

Element	% by Weight	Uncertainty ¹ , %
Carbon	0.014	
Manganese	0.015	
Silicon	0.32	±0.04
Phosphorus	0.003	
Sulfur	<0.001	
Chromium	5.54	±0.01
Nickel	24.47	±0.04
Molybdenum	0.006	
Copper	0.010	
Cobalt	29.00	±0.04
Vanadium	0.043	
Titanium	0.82	±0.02
Aluminum	0.47	±0.04
Tungsten	<0.01	
Niobium	4.63	±0.02
Tantalum	<0.01	
Boron	0.0038	
Iron	34.66	±0.06

Certified by: Thomas R. Dulski

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First Revision: November 10, 1995
Second Revision: September 5, 1997
Third Revision: December 3, 1997

¹Uncertainties are based on the confidence interval of the means, calculated from $\pm\{[ts/(n)^{1/2}]_{\text{homog.}}^2 + [ts/(n)^{1/2}]_{\text{cert.}}^2\}^{1/2}$. Elements with no listed uncertainty have not been homogeneity tested, or have not been homogeneity tested with sufficient significant digits for the calculation of an uncertainty.

**THIS SAMPLE IS SUBJECT TO THE STANDARD TERMS AND CONDITIONS
ATTACHED TO THIS CERTIFICATE OF ANALYSIS.**

CARPENTER TECHNOLOGY CORPORATION ("SELLER")
TERMS AND CONDITIONS OF SALE FOR REFERENCE MATERIALS FOR CHEMICAL ANALYSIS

1. **ACCEPTANCE / CONTRACT FORMATION** - These terms and conditions shall apply to any contract of sale for Seller's materials or performance of conversion services irrespective of whether Seller's accompanying documentation constitutes an offer to Buyer or an acceptance of Buyer's prior offer to Seller. Offers or acceptances by Buyer may be communicated orally, delivered in person or by telephone or in writing, delivered by regular mail, hand delivery, overnight courier, facsimile or electronic mail. Additional or conflicting terms from those in these terms and conditions in an offer or acceptance by Buyer are expressly objected to and shall not be deemed accepted by Seller unless Seller's acceptance thereof is in writing and specifically refers to each such additional or conflicting term.

2. **DELIVERY / FORCE MAJEURE** - All shipping and delivery dates are approximate and subject to availability of materials. Seller shall not be responsible for any prohibition, failure, interruption or delay in manufacture or delivery which may be caused by sabotage, fire, flood, explosion, labor dispute, strike, work stoppage, riot, insurrection, war, act of, or priorities granted by request of or for the benefit, directly or indirectly, of any governmental body, authority or agency, shortage of raw materials or supplies, act of God, insufficient capacity, or other cause beyond Seller's control. In the event of any such prohibition, failure, interruption or delay, Seller may, at its option, extend the delivery time or cancel the order, in whole or in part. **IN NO EVENT SHALL SELLER BE LIABLE FOR ANY SPECIAL, INCIDENTAL, INDIRECT OR CONSEQUENTIAL DAMAGES OR CLAIMS FOR LABOR RESULTING FROM ANY FAILURE OR DELAY IN DELIVERY.**

3. **COMPLIANCE WITH LAWS** - Seller intends to comply with all laws or regulations applicable to the performance by Seller of each order, provided; however, that any failure of Seller to so comply shall not be a defense to, or excuse Buyer from, performance by Buyer of any order.

4. **WARRANTY / CLAIMS / LIMITATIONS OF LIABILITY** - Seller will, as Buyer's sole and exclusive remedy and at Seller's option, replace or, without replacement, render credit for any material sold to Buyer which, if properly selected, stored, processed and used by the Buyer shall prove defective within thirty (30) days from the date of shipment. Seller's material shall be deemed defective only to the extent that it materially deviates from the chemical, physical, and mechanical portions of Buyer's applicable specifications, as agreed to and accepted by Seller, and Seller's standard manufacturing and commercial tolerances, variations and practices. Seller will, as Buyer's sole and exclusive remedy and at Seller's option, reprocess or render credit for any conversion services performed by Seller which do not conform to Buyer's applicable processing specifications as agreed to by Seller, within thirty (30) days from the date services were performed.

Samples supplied by Seller are solely for the purpose of evaluating the suitability of such material or services for potential use and, as such, the samples are not intended to serve as warranties of any type, either express or implied. Buyer shall have sole responsibility for selection and specification of the goods or services appropriate for the end use of such goods or services, even if Buyer has informed Seller of the end use for such goods or services. Buyer acknowledges that it alone has determined that the materials purchased or processed hereunder will suitably meet the requirements of their intended use.

SELLER SHALL NOT BE LIABLE TO BUYER OR ANY OTHER PERSON OR ENTITY FOR, AND BUYER RELEASES SELLER FROM ANY AND ALL LIABILITY FOR NEGLIGENCE BY SELLER WITH RESPECT TO ANY ACTIVITY ENGAGED IN BY SELLER WITH REGARD TO THE GOODS OR SERVICES SOLD HEREUNDER AND FROM ANY AND ALL LIABILITY IMPOSED UPON MANUFACTURERS OR SELLERS OF GOODS OR SERVICES UNDER ANY PRODUCT LIABILITY THEORY OR UNDER ANY SIMILAR LEGAL THEORY. SELLER SHALL NOT, UNDER ANY CIRCUMSTANCES INCLUDING, BUT NOT LIMITED TO, DELAY IN DELIVERY, BREACH OF CONTRACT, BREACH OF WARRANTY, NEGLIGENCE, TORT, STRICT LIABILITY, OR USE OF MATERIALS SOLD OR PROCESSED BY SELLER, BE LIABLE TO BUYER OR ANY OTHER PARTY FOR ANY SPECIAL, INCIDENTAL, INDIRECT OR CONSEQUENTIAL DAMAGES, OR FOR LOSSES OF ANY KIND WHATSOEVER. IN NO EVENT SHALL SELLER'S LIABILITY FOR DEFECTIVE MATERIAL SOLD TO BUYER EXCEED THE PURCHASE PRICE THEREOF, AND IN NO EVENT SHALL SELLER'S LIABILITY FOR NON-CONFORMING CONVERSION SERVICES EXCEED THE PRICE PAID FOR SAID SERVICES.

EXCEPT AS SPECIFICALLY SET FORTH IN THESE TERMS AND CONDITIONS, AND NOTWITHSTANDING ANY LANGUAGE IN THIS OR ANY OTHER PROVISION TO THE CONTRARY, SELLER NEITHER MAKES, NOR ASSUMES ANY LIABILITY UNDER, ANY WARRANTY, EXPRESS OR IMPLIED, WHETHER OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR OTHERWISE. NO REPRESENTATIONS OR WARRANTY, EXPRESS OR IMPLIED, MADE BY ANY SALES REPRESENTATIVE OR OTHER AGENT OR REPRESENTATIVE OF SELLER WHICH IS NOT SPECIFICALLY SET FORTH IN THESE TERMS AND CONDITIONS SHALL BE BINDING UPON SELLER.

Buyer agrees to notify Seller within ten (10) days of discovery of defective materials or non-conforming conversion services. No claim shall be allowed by any party other than the Buyer. Any claim for breach of the express warranty that is not made within the timeframes set forth herein shall be deemed to have been waived. Unless otherwise agreed to in writing by Seller, Buyer shall set aside, protect, and hold such materials without further processing until Seller has an opportunity to inspect and advise of the disposition, if any, to be made of such materials. In no event shall any materials be returned, reworked, or scrapped by Buyer without the written authorization of Seller.

5. **PRICES AND FREIGHT** - All quoted prices, extras (including applicable surcharges), and all freight or transportation rates, are subject to change, without notice, to reflect Seller's prices and extras, and applicable freight or transportation rates, in effect as of the date of shipment. Unless otherwise agreed, freight will be charged from the point of original manufacture or processing.

6. **TITLE / SECURITY INTEREST** - Failure by Buyer to make any payment due hereunder, or on request to give proper shipping instructions, or to accept delivery at times stated, or to comply with all terms of any contract between Buyer and Seller shall give Seller, in addition to all other available remedies, the right at its option to deduct any undelivered quantities of material from the total quantity of material to be furnished whether under this or any other contract between Buyer and Seller. Title to materials shall pass immediately upon delivery to a carrier at the point of shipment. Buyer hereby grants to Seller a security interest (which shall be deemed a purchase money security interest) in all goods and materials provided to Buyer by Seller or upon which Seller performs services for Buyer, to secure payment by Seller for all such goods, materials or services. In the event of nonpayment by Buyer of any debt, obligation or liability now or hereafter incurred or owing by Buyer to Seller, Seller shall have all rights of, and all of the remedies available to, an unpaid secured creditor under the applicable state Uniform Commercial Code (UCC), and all other rights

and remedies available at law or in equity. Buyer agrees, and, to the extent permitted by law, Seller is authorized to, execute and file whatever documents are necessary, including security agreements or financing statements, to evidence and perfect the security interest granted by this paragraph.

7. **TAXES** - Any excise, levies or taxes which Seller is required to pay or collect, under any existing or future law or regulation (domestic or foreign), upon or with respect to the sale, purchase, delivery, storage, processing, use, consumption or transportation of any of the material covered hereby, shall be for the account of the Buyer, and Buyer agrees to pay the amount thereof to Seller upon request.

8. **DELIVERY / RISK OF LOSS** - Unless otherwise specifically stated on a document of sale furnished by Seller or agreed to in writing and signed by Seller, delivery shall occur, and risk of loss shall pass to Buyer, upon delivery of the material to a carrier at the point of shipment. Transportation shall be at Buyer's sole risk and expense, and any claim for loss or damage in transit shall be against the carrier only.

9. **CANCELLATION / CHANGE ORDER REQUESTS** - An order cannot be modified or cancelled by Buyer without the written consent of Seller and in no event shall any order be modified or cancelled for any portion thereof already processed, manufactured, or in process of manufacture, processing or performance, at the time the request for modification or cancellation is received by Seller, except upon terms, satisfactory to Seller, which protect and indemnify Seller against all loss.

10. **QUANTITY** - Seller reserves the right to deliver commercially reasonable overages or underages of weight, length, size and/or quantity, and any reasonable variation shall constitute compliance with Buyer's order, and the unit price will continue to apply. If this order is for Buyer's requirements, Buyer shall, upon Seller's request, provide information sufficient to confirm Buyer's actual requirements.

11. **PAYMENT TERMS** - Unless otherwise specifically stated on a document of sale furnished by Seller or agreed to in writing and signed by Seller, the terms of payment for each order without setoff shall be net cash (U.S. Dollars) in thirty (30) days from date of invoice or ½% discount for cash in ten (10) days from date of invoice. Each discount shall be on the purchase price only, exclusive of freight or transportation, taxes and other charges. Restrictive endorsements on Buyer's checks will not reduce Buyer's obligations to Seller. The unpaid portion of any amounts due to Seller shall bear interest at the rate of 1.5% per month, or the maximum legal rate if less.

12. **ADEQUATE ASSURANCE / RIGHTS OF SELLER** - Seller may, at any time or times, suspend performance of any order or require payment in cash, security or other adequate assurance satisfactory to Seller when, in Seller's opinion, the financial condition of Buyer or other grounds for insecurity warrant such action.

13. **ASSIGNMENT / SUBCONTRACTING** - Buyer shall not assign any order or any interest therein without the written consent of Seller. Any such actual or attempted assignment without Seller's proper written consent shall entitle Seller to cancel such order upon notice to Buyer.

14. **PATENT INFRINGEMENT INDEMNIFICATION** - Buyer shall indemnify, hold harmless and defend Seller against any liability whatsoever for patent, trademark or trade name infringement in any way arising out of the preparation, manufacture or processing of any material, or performance of services, in accordance with Buyer's order, specifications or instructions.

15. **TOOLING** - Unless otherwise expressly agreed, all tools, dies, fixtures, jigs, gauges, and related drawings and designs shall be and remain Seller's property and shall be held by Seller at its disposal. Buyer shall be responsible for all costs of maintenance, repair and replacement of any such items, whether owned by Seller or Buyer, if used exclusively for the manufacture or processing of materials by Seller for Buyer. If any such items remain inactive for a period of three (3) years, Seller reserves the right to dispose of such items at its discretion.

16. **GOVERNMENT CONTRACT TERMS / MANDATORY FLOW DOWNS** - If Buyer's order is for a U.S. government contract, and goods or services ordered from Seller are to be used in the performance of said contract, only those mandatory flow down clauses of applicable U.S. government procurement regulations required by federal statute to be included in U.S. government subcontracts shall be incorporated herein by reference.

17. **MERGER CLAUSE / ENTIRE AGREEMENT / MODIFICATION OF TERMS** - These terms and conditions and sales documentation constitute the entire contract between Seller and Buyer. To the extent that any terms in the sales documents and these terms and conditions conflict, the terms on the front of Seller's sales documents shall control and prevail. No modification hereof shall be of any force and effect unless in writing and signed by the party claimed to be bound thereby. A waiver of any of the terms or conditions hereof shall not be deemed a continuing waiver, but shall apply solely to the instance to which the waiver is directed. If any portion of these terms and conditions is declared to be unenforceable by a court of competent jurisdiction, all other portions shall be considered to be valid and enforceable to the extent that they are reasonably severable. The headings contained in these terms and conditions are for convenience of reference only and are not intended to have any substantive significance in interpreting this document.

18. **GOVERNING LAW / JURISDICTION / ARBITRATION** - These terms and conditions and sales documentation of Seller accompanying them shall be governed by, and construed in accordance with the laws of the State of Delaware, without application of the conflict of law principles thereof. The parties agree that any claim, dispute or controversy arising from or relating to any contract for Seller's goods or services, directly or indirectly, shall be resolved by arbitration conducted in accordance with the then prevailing Commercial Arbitration Rules of the American Arbitration Association. The arbitration shall be conducted by a panel of three arbitrators. One arbitrator shall be selected by Seller, a second by Buyer, and the third of which shall be selected by the two arbitrators selected by the parties. Unless otherwise agreed, the arbitration shall be held in Reading, Pennsylvania. Each party shall bear its own counsel and expert witness costs, and the parties shall each pay one-half of the fees of the arbitrators; provided, however, the arbitrators may, in their discretion, award fees and costs to either party. Any determination or award in arbitration rendered by all or a majority of the arbitrators shall be conclusive and binding upon the parties and may be entered as a final judgment in any court having jurisdiction. Any action to enforce the arbitration provisions herein, to enforce any determination or award resulting from arbitration, or to seek remedies not available in arbitration, may be brought only in the state and federal courts located in the Commonwealth of Pennsylvania, and the parties hereto consent to be subject to the jurisdiction of such courts.

1. SOURCE: Carpenter Technology Corporation - Production Heat.
2. PREPARER: Carpenter Technology Corporation. Eight-inch (203 mm) cast billet.
3. DESCRIPTION: The reference material is an iron-cobalt-nickel alloy with major additions of chromium and niobium. It is in the form of a 1.25 in. (32 mm) square solid, approx. 1.0 in. (25 mm) thick.
4. INTENDED USE: Calibration of optical emission, X-ray fluorescence, and other comparative instrumental methodologies.
5. STABILITY, TRANSPORTATION, AND STORAGE: No special precautions.
6. INSTRUCTIONS FOR USE: Prepare and analyze at the same time and in the same manner as unknown test samples.
7. METHOD OF PREPARATION: The billet was cut into 1.0 in. (25 mm) thick slices. Two slices were selected, and each was cut into twenty-four 1.25 in. (38 mm) square solids.
8. HOMOGENEITY: Homogeneity testing involved XRF analysis of all 48 pieces for 16 elements. Data analysis indicated that all 48 pieces should be accepted. The following analytes were not homogeneity tested: carbon, sulfur, and boron.
9. CERTIFIED VALUES: Four solids were selected to represent the set of 48 solids, and 25 grams of chips were milled at full cross section from each. All chips were combined, degreased with methylene chloride, dried, and blended. The chips were analyzed with a three replicate minimum, using wet chemical techniques, maintaining traceability.
10. UNCERTAINTIES: The reported total uncertainties ($\mu_{\text{tot.}}$) have been calculated from:

$$\mu_{\text{tot.}} = \pm (\mu_{\text{cert.}}^2 + \mu_{\text{homog.}}^2)^{1/2}, \text{ where}$$

$$\mu_{\text{cert.}} = \pm ts_{\text{cert.}}/(n_{\text{cert.}})^{1/2}, \text{ and}$$

$$\mu_{\text{homog.}} = \pm ts_{\text{homog.}}/(n_{\text{homog.}})^{1/2}, \text{ and where the values of } t \text{ are selected for the 95\%}$$

confidence interval at the appropriate degrees of freedom. $s_{\text{cert.}}$ and $s_{\text{homog.}}$ are standard deviations and $n_{\text{cert.}}$ and $n_{\text{homog.}}$ are replicate numbers for the certification and homogeneity testing, respectively.

11. MEASUREMENT TECHNIQUES: Carbon and sulfur: combustion/IR absorption; silicon, nickel, and niobium: gravimetric; chromium, cobalt, and iron: volumetric; phosphorus, titanium, and tantalum: molecular absorption spectrophotometric; manganese, molybdenum, copper, vanadium, and aluminum: FAA; tungsten and boron: ICP-OES.

Wet Chemical Testing Report: IS0070A

Grade: Thermo-Span® Alloy

Element	Method	IS0070A	Control	Certified	Found
C	Leco CS344	.014	NBS126c	.025	.027
		.014	NBS345	.048	.049
		.014	NBS2166	.015	.016
Mn	Flame Atomic Absorption	.0145	NBS364	.255	.2547
		.0152			
		.0149			
Si	Gravimetric - single dehydration (HClO ₄)	.316	NBS363	.74	.728
		.309	NBS865	.41	.383
		.337			
P	Solvent Extraction - Colorimetric (Molybdate)	.0031	NBS349	.002	.0018
		.0029	NBS865	.012	.0121
		.0030			
S	Leco CS344	<.001	NBS126c	.005	.005
		<.001	NBS345	.012	.010
		<.001	NBS2166	.0023	.0023
Cr	Potentiometric Titration (Ferrous Ammonium Sulfate)	5.537	NBS135	5.15	5.209
		5.534	NBS101f	18.49	18.488
		5.536			
Ni	Ion Exchange - Gravimetric (Dimethylglyoxime)	24.465	NBS348	25.8	25.711
		24.503	"	"	25.742
		24.504			
Ni	Ion Exchange - Gravimetric (Dimethylglyoxime)	24.427	NBS868	37.78	37.727
		24.439	"	"	37.737
Mo	Flame Atomic Absorption	.0059	NBS8j	.038	.0411
		.0054			
		.0061			
Cu	Flame Atomic Absorption	.0093	NBS8j	.020	.0261
		.0097			
		.0095			
Co	Ion Exchange - Potentiometric Titration	28.988	NBS868	16.1	15.966
		29.019	"	"	15.961
		28.985	"	"	16.025
		29.043	"	"	16.095
		28.969	"	"	16.096
V	Flame Atomic Absorption	.0429	NBS8j	.015	.0153
		.0429			
		.0429			
Ti	Ion Exchange - Colorimetric (Peroxy-Complex)	.822	NBS868	1.48	1.459
		.811	BCS351	1.06	1.051
		.829			

Wet Chemical Testing Report: IS0070A

Grade: Thermo-Span® Alloy

Element	Method	IS0070A	Control	Certified	Found
Al	Flame Atomic Absorption	.490 .470 .456	NBS348	.23	.238
W	Ion Exchange - Solution ICP	.0053 .0008 .0003	NBS361	.017	.0182
Nb	Ion Exchange - Gravimetric (Cupferron)	4.619 4.661 4.584 4.654 4.634	NBS868 BCS351	2.99 5.20	2.894 5.167
Nb	Ion Exchange - Gravimetric (Cupferron)	4.643 4.639 4.609	NBS868 " "	2.99 " "	2.971 2.979 3.029
Ta	Ion Exchange - Colorimetric (Pyrogallol)	.0010 .0010 .0016 .0016	NBS361	.020	.0192
B	Solution - ICP (Mercury Cathode)	.00385 .00382 .00369	NBS348 " NBS348a " NBS444 "	.0031 " .0055 " .0033 "	.00300 .00296 .00548 .00536 .00320 .00307
Fe	Ammonia Separation - Redox Titration (Potassium Dichromate)	34.659 34.633 34.677	NBS348 NBS868 NBS1159 "	53.3 40.5 51.0 "	53.317 40.567 50.921 59.972



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