



OREMET-WAH CHANG

An Allegheny Teledyne Company

P.O. Box 460, 530 W. 34TH Avenue

Albany, OR 97321

Phone: 541-967-9000 Fax: 541-967-6994

OREMET WAH-CHANG MATERIAL SPECIFICATION

SPECIFICATION: OMC-105

REVISION: K

DATE: Sept. 1999

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TITLE: TITANIUM AND TITANIUM ALLOY CASTINGS

1. SCOPE

- 1.1 This specification outlines casting descriptions and manufacturing methods used to produce titanium and titanium alloy rammed graphite castings meeting ASTM B 367 for both commercial and military applications. See the attached Addenda listing references and practices specific to either Commercial or Government applications.

2. REFERENCES: The following publications form a part of this specification to the extent specified herein. Unless otherwise denoted in the Purchase Order, the latest approved revisions shall prevail.

ASTM B367	Standard Specification For Titanium and Titanium Alloy Castings
ASTM E446	Reference Radiographs For Steel Castings, Vol II
ASTM E186	Reference Radiographs For Steel Castings, Vol I, II
ASTM E280	Reference Radiographs For Steel Castings, Vol I
ASTM E1320	Reference Radiographs For Titanium Castings, Vol I, II
MSS SP-55	Visual Method For Surface Evaluation of Surface Irregularities
ASTM E 8	Test Methods of Tension Testing of Metallic Materials
ASTM E 10	Test Methods For Brinell Hardness of Metallic Materials

3. CLASSIFICATION OF TITANIUM CASTINGS

The following pattern classes are designed to recognize responsibility for dimensional control between the customer and OREMET-WAH CHANG (OWC). The definition of pattern classes does not negate good workmanship and foundry practice on the part of OWC.

- 3.1 Class I: Castings made to this designation are "products of the pattern" as supplied by the customer. Dimensioning of the pattern equipment and/or castings will not be a requirement. The customer assumes the responsibility that resultant castings will meet dimensional requirements.
- 3.2 Class II: Utilizing the customer supplied pattern, OWC will dimensionally inspect the pattern and recommend modifications as necessary to produce a dimensionally acceptable casting to the applicable casting drawing requirements, providing, the casting tolerances of the customer supplied casting drawing fall within the dimensional control criteria of Para. 4 herein. The cost for this service will vary depending upon the complexity of the pattern equipment. In the event of necessary pattern modifications, the customer shall be notified in writing. All modifications and related costs must be approved in writing by the customer prior to implementing the modifications. If requested by the customer at the time of placement of the Purchase Order, a first article dimensional casting layout will be performed and will be available for customer review.
- 3.3 Class III: OWC will provide the pattern equipment and insure that the resulting castings will meet the dimensional tolerances of the applicable casting drawing providing the casting tolerances of the customer



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supplied casting drawing fall within the dimensional control criteria of Para. 4 herein. A first article dimensional casting layout will be performed on castings produced from this equipment. Upon request, the dimensional report will be available for customer review.

4. DIMENSIONAL CONTROL:

Unless otherwise agreed upon and specified in the Purchase Order, the following dimensional criteria shall supersede drawing dimensions for Class II and Class III castings.

4.1 Minimum Section Thickness: 3/16", 1/8" if less than one square inch of surface.

4.2 Base Tolerance:	Up to one linear inch	$\pm 1/32''$
	1 inch up to 10 inches	$\pm 1/16''$
	10 inches up to 20 inches	$\pm 1/8''$
	20 inches up to 60 inches	$\pm 3/16''$

4.3 Additional Tolerances:

4.3.1 For dimensions across the parting line: $\pm 1/8''$

4.3.2 Added tolerance for dimensions affected by parting line and parallel to the parting line (mismatch)	Less than 10"	$\pm 1/16''$
	10" and above	$\pm 1/8''$

4.4 Radius Dimensions:	General radius to conform to base dimensions.
	Sharp to 1/8" radius $\pm 1/32''$ (convex)
	Up to 1/2" fillet radius $\pm 1/32''$ (concave)

4.5 Finish Stock: Nominal 1/8" on all machined surfaces on dimensions less than 12 inches.
Nominal 3/16" - 1/4" on all machined surfaces greater than 12".

4.6 Angles: ± 1 degree.

Note: These dimensions are not limiting to the process, but represent capabilities without trial and correction effort.

5. PART IDENTIFICATION

5.1 Identification nomenclature shall be cast or marked using low stress steel stamps or vibratory pencil in a location indicated on the part drawing. If the location is not provided, nomenclature shall be located if possible in a non-machined area. Identification shall include the ASTM specification number, material grade symbol (i.e.; C2), manufacturer's name or mark, pattern number and the unique part identification number which is traceable to the heat/pour number.



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6. CHEMICAL COMPOSITION (see TABLE I)

- 6.1 Samples for chemical analysis shall be obtained from the pour being represented and shall be in the "as-cast" condition.
- 6.2 Methods for chemical analysis shall be by standard OWC analytical procedures.
- 6.3 Variations to chemical composition requirements may be obtained with prior arrangement between OWC and the Purchaser. Variations must be defined in the Purchase Order.
- 6.4 "Other elements," if referenced in the chemical table are elements that may be present in a metal or alloy in small quantities inherent to the manufacturing process, but not added intentionally.
- 6.5 Alloys other than those listed in the following table may be produced with prior arrangement between OWC and the purchaser.

TABLE I

ELEMENT	ALLOY	CP2 GRADE C-2	CP3 GRADE C-3	6Al-4V GRADE C-5	Ti-Pd GRADE 7B	Ti-Pd GRADE 8A
Nitrogen (max)		0.05	0.05	0.05	0.05	0.05
Carbon (max)		0.10	0.10	0.10	0.10	0.10
Hydrogen (max)		0.015	0.015	0.015	0.015	0.015
Iron (max)		0.20	0.25	0.40	0.20	0.25
Oxygen (max)		0.40	0.40	0.25	0.40	0.40
Aluminum				5.5 - 6.75		
Vanadium				3.5 - 4.5		
Palladium (min)					0.12	0.12
Other Elements (each) max *		0.10	0.10	0.10	0.10	0.10
Other Elements (total) max *		0.40	0.40	0.40	0.40	0.40
All values are reported in weight percent						

* Need not be reported. By agreement between supplier and purchaser, analysis may be required and limits established for elements or compounds not specified in this table.

7. MECHANICAL PROPERTIES (see TABLE II)

- 7.1 Test specimens for certification testing shall be poured at the same time and in the same manner as the castings they represent. One test specimen in the "as-cast" condition shall be tested per heat unless "as-processed" properties are requested. "As-processed" mechanical properties must be requested at the time of the inquiry and placement of the Purchase Order.



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- 7.2 Tension test specimens shall be machined and tested in accordance with ASTM E-8, "Tension Testing of Metallic Materials." Tensile properties will be developed using a strain rate of 0.003 to 0.007 inches per inch per minute through the yield strength and then increased to produce failure within one additional minute.
- 7.3 Hardness tests shall be an average of three Brinell (10/3000/30) impressions per heat in accordance with ASTM E 10. The test may be conducted on the casting or representative test specimen.

TABLE II
MECHANICAL PROPERTY REQUIREMENTS

GRADE	Tensile Strength Min., (KSI)	Yield Strength 0.2% Offset min., (KSI)	Elongation in 1-in min., (%)	(Supplementary) Hardness HB, max.
CP2 (C-2)	50	40	15	210
CP3 (C-3)	65	55	12	235
6-4 (C-5)	130	120	6	365
Ti-Pd (7B)	50	40	15	210
Ti-Pd (8A)	65	55	12	235

8. MANUFACTURING PROCESS

8.1 Melting

- 8.1.1 Material melted for casting shall be accomplished by a melting process suitable for titanium metal.

8.2 Cleaning

- 8.2.1 Castings shall be cleaned by methods conventionally used for titanium metals. Pickling is a supplementary requirement and must be specified at the time of inquiry and placement of the Purchase Order. When pickling is specified, the party responsible for part dimensions (see Section 2) must be conscious of the impact of material removal as it relates to pattern equipment.
- 8.2.2 Although castings are produced in an inert chamber, inherent to castings produced in the rammed graphite mold process is a carbon enriched material (alpha case) that exists as a harder layer generally within .002" to .004" of the as-cast surface. This layer is primarily removed in routine sandblasting. The enriched layer diminishes with distance away from the casting surface with matrix material generally reached within .008" to .010". Isolated cases have been observed in titanium alloy 6Al-4V in thick sections where light traces of diffusion extend to .015". When removal of all "alpha case" is essential for design considerations such as low cycle fatigue, or other considerations, OWC will remove alpha case by a combination of sand blasting, and when specified, pickling.



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8.2.3 When required to verify that all "alpha case" has been removed, determination of carbon diffusion depth will be determined in the following manner:

8.2.3.1 For Titanium 6Al-4V and similar alpha/beta alloys, diffusion depth shall be determined by metallographic examination, i.e.; optical microscope.

8.2.3.2 For commercially pure titanium alloys, alpha case is not readily discernible using normal laboratory methods. Based on documented studies, OWC will, when specified, remove .015" per surface from the as-cast condition. Certifications will state that .015" has been removed in lieu of stating the material is alpha case free.

8.3 Conditioning

8.3.1 Surface

Surface defects may be removed by grinding and/or cosmetic weldment and/or other processes suitable for titanium metal.

8.3.2 Internal

Weld Repairs shall be made using the Gas Tungsten Arc Process (GTAW). Repairs shall be made in accordance with qualified procedures using qualified welders. See the applicable Commercial or Government Addendum for weld definitions.

Hot Isostatic Pressing (HIP) may be used at the discretion of OWC as a method to heal or reduce internal discontinuities in castings.

8.4 Post Weld Heat Treatment

8.4.1 Post weld heat treatment shall be performed in accordance with applicable qualified weld procedures.

8.4.2 Hot Isostatic Pressing (HIP) may be substituted for required heat treatment provided all requirements for that treatment are met and temperatures detrimental to the material properties are not reached.

9. CASTING GRADES

9.1 Standard

9.1.1 Internal Standards

Areas identified on the customer supplied drawing as being machined surfaces (on the finished part) shall be free of casting defects.



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9.1.2 Surface Standards

Standard grade castings shall be visually inspected and evaluated in accordance with MSS SP-55.

9.1.3 Castings are typically shipped in a sandblasted condition.

9.2 Premium

9.2.1 Internal Standards

All Castings will be 100% radiographed. Areas of the part that cannot be radiographed due to part configuration shall be noted on the Technique Sheet and reported to the customer. Radiographic acceptance criteria are as listed in TABLE III.

Areas identified on the customer supplied drawing as being machined surfaces (on the finished part) shall be free of casting defects.

Reference Radiographs ASTM E-446, 186, 280 (Steel) and ASTM E-1320 (Titanium) are provided in the table. The titanium plate standards (E-1320) were selected based on their similarity in size and distribution to the discontinuities displayed in E-446 (for thicknesses less than or equal to two inches). In this thickness range, either standard reference may be referenced on the Purchase Order. For section thicknesses greater than two inches, the applicable steel reference standard should be utilized.

TABLE III

ASTM STANDARD ⇒	E - 446	E - 186	E - 280		E - 1320
MATERIAL THICKNESS ⇒	< 2"	2" - 4.5"	> 4.5"		< 2"
DISCONTINUITY TYPE ⇓				DISCONTINUITY TYPE	
Category A	2	2	2	Scattered Gas	5
Gas Porosity				Clustered Holes	5
Category B	2	2	2	More Dense Inclu.	8
Sand & Slag Inclusions				Less Dense Inclu.	7
Category C	2	2	2	Centerline Shrink	6
Shrinkage (CA, CB, CC, CD)				Shrink Cavity	2
				Scattered Shrink Cavity	5
Categories D, E, F not accepted					



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9.2.2 Surface Standards

Premium grade castings shall be visually inspected and evaluated in accordance with MSS SP-55.

9.2.3 Castings are typically shipped in a sandblasted condition.

9.3 Special Requirements

9.3.1 Additional requirements may be applied to either Standard or Premium castings if specified at the time of inquiry and placement of the Purchase Order.

9.3.2 Source Inspection is permitted but must be requested at the time of the inquiry and placement of the Purchase Order. Any testing carried out for the inspecting company that is duplication will be subject to additional charges. Delays caused by Source Inspection will be added to the acknowledged leadtime.

10. CERTIFICATIONS

10.1.1 A Material Certification Report of chemical analysis and other tests specified by the Purchaser shall be provided.

10.1.2 When radiography is specified, certification shall include final film of the finished casting and the shooting technique.

Initiated By:

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REVISION HISTORY

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