

Metal Standards & Specifications for Investment Castings



Investment Casting Institute

Acknowledgements

The Investment Casting Institute would like to thank the following individuals who contributed to the contents of this publication.

Matt Cavins from O'Fallon Castings

Mark Lewis from Electralloy

Mark Olds from Pine Tree Castings

Al Torok from
Yamaha Marine Precision
Propellers, Inc.

Sam Scherff from Intercast



Investment Casting Institute

136 Summit
Avenue
Montvale, NJ 07645-
1720

Phone 201-573-9770 Fax: 201-573-
9771 www.investmentcasting.org

Copyright reserved: Neither the Investment Casting Institute nor its officers
accept legal responsibility for information, advice given or opinions express

Contents

Introduction.....	2-3
--------------------------	------------

Part I Tables: Chemical Range Percentages and Properties

Aluminum Alloys (Tables 1 and 2).....	4
Copper Base Alloys (Tables 3 and 4).....	5-6
Iron, Carbon and Low Alloy Steels (Tables 5 and 6).....	7-8
Hardenable Martensitic Stainless Steels (Tables 7 and 8).....	9
Austenitic Stainless Steels (Tables 9 and 10).....	10
Tool Steels (Tables 11 and 12).....	11-12
High Nickel Alloys (Tables 13 and 14).....	13
High Cobalt Alloys (Tables 15 and 16).....	14
Duplex Stainless Steels (Tables 17 and 18)	15
Titanium Base Alloys (Tables 19 and 20).....	16

Part II Tables: Cross Index of Various Alloys

Aluminum Alloys (Table 21).....	17
Copper Base Alloys (Table 22).....	18
Iron Base Alloys (Table 23)	19
Cobalt Base Alloys (Table 25).....	20
Austenitic Stainless Steels (Table 26).....	20
Precipitation Hardening Stainless Steels (Table 27).....	20
Martensitic Stainless Steels (Table 28).....	21
Duplex Stainless Steels (Table 29).....	21
Vacuum Ferrous Alloys (Table 30)	21
Nickel Base Alloys (Table 31).....	22
Tool Steels (Table 32)	23
Titanium Base Alloys (Table 33).....	24



Investment Casting Institute

136 Summit Avenue
Montvale, NJ 07645-1720
Phone 201-573-9770 Fax: 201-573-9771
www.investmentcasting.org

Copyright reserved: Neither the Investment Casting Institute nor its officers accept legal responsibility for information, advice given or opinions expressed.

Metal Standards & Specifications for Investment Castings

I. Scope

Metal standards and specifications is a vast subject that includes ASM, ASTM, military and an extensive list of end-user documents that specify casting material, performance and acceptance criteria. This is a summary of the most commonly used alloys in the investment casting industry as well as typical industry casting standards that would apply where purchasers of such castings do not provide detailed specifications covering all aspects of metal quality.

II. Purpose

The purpose of this publication is to define a typical level of metal quality to be furnished by investment casting foundries, as a service to purchasers of investment castings who do not cite detailed specifications.

III. General

- A. There are several independent (ASTM, AMS, EMS, AISI, MIL, SAE, ACI etc.) materials specifications writing groups in the United States. The trend is for those groups to conform to the American Society of Testing Materials specifications in the hope of reducing the number of specifications, thus simplifying the jobs of users and producers of investment castings.
- B. Whenever possible for each alloy in this standard, the chemical range of an existing selected specification is

used in order to avoid a variety of chemical ranges for the same alloy.

- C. This publication does not relate to dimensional tolerances, visual standards, soundness and internal defects of investment castings, which are covered in the Investment Casting Handbook published by the Institute. Standards provided in the Handbook are typical for the industry.

IV. Metallurgical Standards

A. General

1. This section shows the chemical ranges considered typical in the industry.
2. When chemical analysis is done, it will be done by spectrometric, x-ray fluorescence, or other approved methods using comparative standards traceable to the National Bureau of Standards.

B. Tables

1. Each set of tables shows the trade names normally cast and the standard chemical and mechanical properties ranges as established in Investment Casting Industry.
2. Heat treatment if needed, will be decided between the buyer and seller of castings.

V. Quality Control Standards

A. General

1. Purchasers of investment castings should work out detailed requirements for metal quality for each part. These requirements include but are not limited to: appearance, surface finish, surface cleanliness, soundness, non-fill and other special requirements.
2. This section of the standard describes the typical metal quality of investment casting.

It does not guarantee the adequacy of these standards for any part since design and intended function are controlled by the customer. If a part requires characteristics other than these described it is the responsibility of the purchaser to generate and specify those requirements prior to requesting a quote for the part.

B. Chemical Analysis

The foundry should control its melting stock and melting practices to provide castings that meet the analyses specified in tables.

C. Mechanical Properties

1. Mechanical properties of the heats or castings will not be determined unless specifically required by the purchase order. If not mentioned in the request for the quote and required by purchase order its cost will be extra and borne by the purchaser.
2. Tensile properties and/or hardness's are the most commonly specified mechanical properties and, for information only, Tables show those values that are typically obtained from the various alloys. Ranges are shown for most alloys because the properties are frequently controlled by heat treatment and casting process. If desired, a specific requirement can be established between the purchaser and foundry.
3. The tensile properties are measured on cast bars, either end gated or center gated depending on the alloy. These bars are cast with production heats and heat treated with castings. The finished

dimensions of these bars are approximately .6 cm (1/4") diameter and 2.5 cm (1") gage length.

4. Hardness measurements on castings can be used by the foundry to control heat treatment, check for decarburization and to assure consistency of casting practices. The frequency of testing should be as agreed between the purchaser and the foundry.
5. Other special property measurements such as Charpy impact, elevated temperature tensile strength, stress rupture, corrosion testing, etc., can be performed for critical applications if required. All such requirements must be negotiated by the purchaser and foundry.

D. Certifications

No certifications of chemical, mechanical, or other properties will be provided, unless specifically requested.

VI. Alloy Trademarks and Patents

Many alloys in the industry were proprietary developments and registered patents (U.S., U.K., etc.). Others have been marketed under registered trademarks. Several owners of such patents or trademarks extract royalties for the use of the name or melting the alloys. This publication is intended to be a useful reference and not an authority on the ownership of a particular alloy name or the rights associated with a particular chemistry.

Each investment caster, designer or alloy specifier retains responsibility for the proper selection of an alloy in regards to its patented or trademarked rights, or royalties. Special care should be taken accordingly and the company with such claims to an alloy is the best source of information regarding their rights.

VII. Cross Reference Tables

Every attempt has been made to include most common alloys, preferred chemistry and mechanical properties. Many cross references to various other standards have been added (see **Tables 21-33**).

TABLE 1 - ALUMINUM ALLOYS Typical Chemical Range Percentages											
Trade Name	Cu	Si	Mg	Ti	Fe	Mn	Zn	Cr	Other	Trace	
										Ea.	Tot.
Pure Aluminum	0.03	0.2	0.03	-	0.2	0.03	0.03	-	-	0.03	0.05
A206	4.2 5.0	0.10	0.15 0.35	0.15 0.30	0.15	0.20 0.50	0.03	-	Ni 0.15 Sn 0.05	0.03	0.05
RR350	4.50 5.50	0.2	-	.15- .25	0.3	.20 .30	-	-	Ni 1.3-1.8 Co .10-.40 Zr .10-.30	0.05	0.3
A354	1.6 2.0	8.6- 9.4	.40- .6	0.2	0.2	0.1	0.1	-	-	0.05	0.15
355	1.0 1.5	4.5- 5.5	.40- .6	0.25	0.6	0.5	0.35	0.25	-	0.05	0.15
C355	1.0 1.5	4.5- 5.5	.40- .60	0.2	0.2	0.1	0.1	-	-	0.05	0.15
356	0.25	6.5- 7.5	.20- .45	0.25	0.6	0.35	0.35	-	-	0.05	0.15
A356	0.2	6.5- 7.5	.25- .45	0.2	0.2	0.1	0.1	-	-	0.05	0.15
A357	0.2	6.5- 7.5	.40- .7	.04- .20	0.20	0.10	0.10	-	Be 0.04 0.07	0.05	0.09
A-201 (KO-1)	4.0 5.0	0.05	.15- .35	.15- .35	0.10	.20 .40	-	-	Ag .40-1.0	0.03	0.1
D712(40E)	0.25	0.3	.50-65	.15- .25	0.5	0.1	5.0 6.5	.40 .60	-	0.05	0.2
Precedent 771	0.1	0.15	.8-1.0	.10-.20	0.15	0.1	6.5 7.5	.06 .20	-	0.05	0.15

Where two numbers are not shown in a block, the value is a maximum. This applies to all tables of chemistry unless specifically noted.

TABLE 2 - TYPICAL PROPERTIES OF SEPARATELY CAST TEST BARS OF ALUMINUM BASE ALLOYS			
Alloy	Tensile Strength MPa (ksi) Range	0.2% Yield Strength MPa (ksi) Range	% Elongation Range (in 2.5cm)
356	207-276 (30-40)	138-207 (20-30)	3-7
A356	(32-45)	152-241 (22-34)	2-5
A357	(38-50)	186-276 (28-40)	2-5
355 C355	241-345 (35-50)	193-269 (28-39)	1-3
D712(40E)	234-276 (34-40)	172-221 (25-32)	4-8
A354	324-379 (47-50)	248-310 (36-42)	2-3
RR350	221-310 (32-45)	165-262 (24-38)	1.5-5
Precedent 71	241-379 (35-55)	172-310 (24-45)	2-5
A201 (KO-1)	386-414 (56-60)	331-345 (48-50)	3-5
A206	276-400 (40-58)	165-331 (24-48)	5-8

NOTE: The above mechanical property values are for information only. They do not necessarily apply to castings. Any requirements for mechanical properties beyond this standard must be negotiated with the foundry.

TABLE 3 - COPPER BASE ALLOYS Typical Chemical Range Percentages														
Alloy & (CDA No.)	Al	Zn	Sn	Pb	Ni	Fe	Si	Be	Co	Mn	P	Cr	Cu	Total Others
Aluminum Bronze A (C95200)	8.5 9.5	--	--	--	--	2.5 4.0	--	--	--	--	--	--	86.0 ¹	1.0
Aluminum Bronze B (C95300)	9.0 11.0	--	--	--	--	0.8 1.5	--	--	--	--	--	--	86.0 ¹	1.0
Aluminum Bronze C (C95400)	10.0 11.5	--	--	--	1.5	3.0 5.0	--	--	--	.50	--	--	83.0 ¹	50
Aluminum Bronze D (C95500)	10.0 11.5	--	--	--	3.0 5.5	3.0 5.0	--	--	--	3.5	--	--	78.0 ¹	.50
BeCu 10C (C82000)	.10	.10	.10	.02	.20	.10	.15	.45 .8	2.4 2.7 ²	--	--	.09	Bal.	--
BeCu 20C (C82500)	.15	.10	.10	.02	.20	.25	.20 .35	1.9 2.25	.35 .7 ²	--	--	.09	Bal.	--
BeCu 165C (C82400)	.15	.10	.10	.02	.20	.20	--	1.6 1.85	.20 .65	--	--	.09	Bal.	
BeCu 275C (C82800)	.15	.10	.10	.02	.20	.25	.20 .35	2.5 2.85	.35 .7 ²	--	--	.09	Bal.	
SeBiLoy (C89510)	.005	4.0 6.0	4.0 6.0	.09	1.0	.20	.005				.05		86.0 88.0	SB.25 Bi .5-1.5 Se .35-.75
CuBi (C89836)	.005	2.0 4.0	4.0 7.0	.25	.90	.35	0.005				.06		87.0 91.0	Sb .25 Bi 1.5-3.5 S .08
Pure Copper (C80100)													99.95 ¹	
Chrome Copper (C81500)	.10	.10	.10	.02	--	.10	.15	--	--	--	--	.4 1.5	Bal.	
Leaded Yellow Brass (C85400)	.35	24.0 32.0	5.0 1.5	1.5 3.8	1.0	.7	.05	--	--	--	--	--	65.0 70.0	
Red Brass (C83600)	.005	4.0 6.0	4.0 6.0	4.0 6.0	1.0	.30	.005	--	--	--	.05	--	84.0 86.0	
Manganese Bronze A (C86500)	.50 1.5	36.0 42.0	1.0	.40	1.0	.40 2.0	--	--	--	.10 1.5	--	--	55.0 60.0	
Manganese Bronze C (C86300)	5.0 7.5	22.0 28.0	.20	.20	1.0	2.0 4.0	--	--	--	2.5 5.0	--	--	60.0 66.0	
Tin Bronze (C90300)	.005	3.0 5.0	7.5 9.0	.30	1.0	.20	.005	--	--	--	.05	--	86.0 89.0	
Red Brass (C83300)		2.0 6.0	1.0 2.0	1.0 2.0									92.0 94.0	
Leaded Yellow Brass (C85200)	.005	20.0 27.0	.7 2.0	1.5 3.8	1.0	.6	.05				.02		70.0 74.0	S 0.05 Sb 0.25
Leaded Yellow Brass (C85700)	.80	32.0 40.	.50 1.5	.8 1.5	1.0	.7	.05						58.0 64.0	
Silicon Brass (C87500)	.50	12.0 16.0	--	.09	--	--	3.0 5.0	--	--	--	--	--	79.0 ¹	--
Silicon Bronze (C87200)	1.5	5.0	1.0	.50	--	2.5	1.0 5.0	--	--	1.5	0.50	--	89.0 ¹	
Silicon BR (C87300)	0.0	0.25	0.0	.0.09		0.20	3.5 4.5			0.8			94.0 ¹	
Silicon BR (C87600)		4.0 7.0		.0.09		0.20	3.5 4.5			0.25			88.0	

1 - Minimum, others where no range is shown is maximum.

2 - Ni+Co

**TABLE 4 - TYPICAL PROPERTIES OF SEPARATELY
CAST TEST BARS OF COPPER BASE ALLOYS**

<i>Alloy - (CDA No.)</i>		<i>Tensile Strength MPa(ksi)</i>	<i>Yield Strength MPa(ksi)</i>	<i>% Elongation Range (in 2.5cm)</i>	<i>Hardness (HRB) Range Minimum</i>
Al. Bronze A (C95200)	A.C. H.T	450 (65)	170 (25)	20	110BNH
Al. Bronze B (C95300)	A.C. H.T	450 (65) 550 (80)	170 (25) 275 (40)	20 12	110 BNH 160 BNH
Al. Bronze C (C95400)	A.C. H.T	515 (75) 650 (90)	205 (30) 310 (45)	12 6	150 BNH 190 BNH
Al. Bronze D (C95500)	A.C. H.T	620 (90) 760 (110)	275 (40) 415 (60)	6 5	190 BNH 200 BNH
Be Copper 10C (C82000)	A.C. Hard.	311 (45) 621 (90)	104 (15) 483 (70)	15 3	52 HRB 96 HRB
Be Copper 20C (C82500)	A.C. Hard.	518 (75) 1035 (150)	278 (40) 828 (120)	15 1	82 HRB 43 HRC
BeCopper 165C (C82400)	A.C. Hard.	483 (70) 1001 (145)	242 (35) 932 (135)	15 1	78HRB 38HRC
BeCopper 275C (C82800)	A.C. Hard.	552 (80) 1139 (165)	347 (50) 1069 (155)	10 0.5	85HRB 37HRC
Se Bi Loy (C89510)		210 (30)	135 (20)	12	37 BNH (500)
Cu Bi (C89836)		228 (33)	103 (15)	20	65 BHN (500)
Copper (C80100)		138-207 (25)	9	40	44 BNH
Cr Copper (C81500)		228 (33)	138 (20)	20	70-78 HRB
Leaded Yellow Brass (85400)		207 (30)	76 (11)	20	50 BNH
Red Brass (C83600)		207 (30)	97 (14)	20	60 BHN
Mn. Bronze A (C86500)		448 (65)	172 (25)	20	100 BHN
Mn. Bronze C (C86300)		758 (110)	414 (60)	12	223 BHN
Tin Bronze (C90300)		276 (40)	124 (18)	20	70 BHN
Silicon Brass (C87500)		414 (60)	165 (24)	16	115 BHN (500)
Silicon Bronze (C87200)		316 (45)	127 (18)	20	42HRB
Silicon Brass (C87300)		310 (45)	124 (18)	20	85 BHN (500)
Silicon Br (C87600)		413 (60)	206 (30)	16	76HRB
Red Brass (C83300)		220 (32)	68 (10)	35	35 HRB
Leaded Yellow Brass (C85200)		241 (35)	83 (12)	25	46 BHN (500)
Leaded Yellow Brass (C85700)		276 (40)	97 (14)	15	76 BHN (500)

Note: The above mechanical property values are for information only. They do not necessarily apply to castings. Any requirements for mechanical properties beyond this standard must be negotiated with the foundry.

* Yield strength is determined by 0.5% extension under load or 0.2% offset method. A.C. = as cast, H.T. = heat treated

TABLE 5 - IRONS and CARBON and LOW ALLOY STEELS Typical Chemical Range Percentages (%)*									
ALLOY	C	Mn	Si	Ni	Cr	Mo	P	S	Other
1.2% Silicon Iron	.04	---	.90 1.3	---	---	---	.01	.03	C+P+S+Mn .15 Max
2.5% Silicon Iron	.04	-	2.3 2.7	--	---	---	.01	.03	C+P+S+Mn .15 Max
IC 1010	.05 .15	.30 .60	.40 .80	---	--	---	.04	.04	
IC 1020	.15 .25	.20 .60	.20 .60	---	--	---	.04	.045	
IC 1030	.25 .35	.70 1.0	.20 .60	---	---	---	.04	.045	
IC 1040	.35 .45	.70 1.0	.20 1.0	---	---	---	.04	.045	
IC 1050	.45 .55	.70 1.0	.20 1.0	---	---	---	.04	.045	
IC 1060	.55 .65	.60 .90	.20 1.0	---	--	---	.04	.045	
IC 1090	.85 .98	.60 .90	.20 1.0	---	---	---	.04	.045	
IC 2345	.40 .50	.70 .90	.20 .80	3.25 3.75	---	---	.04	.04	
IC 3120	.15 .25	.60 .80	.20 .80	1.1 1.4	.55 .75	---	.04	.04	
IC 4130	.25 .35	.40 .70	.20 .80	---	.80 1.10	.15 .25	.04	.04	
IC 4140	.35 .45	.70 1.0	.20 .80	---	.80 1.10	.15 .25	.04	.04	
IC 4150	.45 .55	.75 1.0	.20 .80	--	.80 1.10	.15 .25	.04	.04	
IC 4330	.28 .35	.60 .70	.20 .80	1.65 2.0	.70 .90	.20 .30	.04	.04	
IC 4340	.36 .44	.70 .90	.20 .80	1.65 2.0	.70 .90	.20 .30	.04	.04	
IC 4620	.15 .25	.40 .70	.20 .80	1.65 2.0	---	.20 .30	.04	.045	
IC 6120	0.30	.70 .1.00	.20 .80	---	.70 1.0	---	.04	.045	V.05-.15
IC 6150	.45 .55	.65 .95	.20 .80	---	.80 1.10	---	.04	.045	V.15 Min.
IC 8620	.15 .25	.65 .95	.20 .80	.40 .70	.40 .70	.15 .25	.04	.045	
IC 8630	.25 .35	.65 .95	.20 .80	.40 .70	.40 .70	.15 .25	.04	.045	
IC 8640	.35 .45	.70 1.05	.20 .80	.40 .70	.40 .60	.15 .25	.04	.04	
IC 8665	.6 .70	.7 1.05	.20 .80	.40 .70	.40 .60	.15 .25	.04	.04	
IC 8730	.25 .35	.70 .90	.20 .80	.40 .70	.40 .60	.15 .30	.04	.04	
IC 8740	.35 .45	.75 1.0	.20 .80	.40 .70	.40 .60	.20 .30	.04 .04	.04 .04	
IC 52100	.95 1.10	.25 .55	.20 .80	---	1.30 1.60	---	.04	.045	
IC 1722AS	.27 .34	.45 .65	.55 .75	---	1.0 - 1.5	.40 .60	.04	.04	
Ductile Iron Ferritic	3.2 4.0	.25 .65	2.0 2.6	---	---	---	.03	.03	Mg .03-.08
Ductile Iron Pearlitic	3.3 4.0	.50 .70	2.1 2.5	1.5 2.0	---	.30 .50	.03	.03	Mg .03-.08

* Where not specified above Ni, Cr, Mo and Cu shall not exceed .25% each.
This is not typically analyzed unless by previous agreement between purchaser and foundry.

TABLE 6 – TYPICAL PROPERTIES OF SEPARATED CAST TEST BARS OF IRONS AND CARBON AND LOW ALLOY STEELS					
<i>Alloy</i>	<i>Condition</i>	<i>Tensile Strength MPa (ksi)</i>	<i>0.2% Yield Strength MPa (ksi)</i>	<i>% Elongation Range (in 4D)</i>	<i>Hardness Range or Max</i>
1.2% Si		345-414 (50-60)	255-296 (37-43)	30-35	55 HRB
2.5% Si				0	85 HRB
IC 1010	Annealed	345-414 (50-60)	207-241 (30-35)	30-35	50-55 HRB
IC 1020	Annealed	414-483 (60-70)	276-310 (40-45)	25-40	80 HRB
IC 1025	Annealed	434-503 (63-73)	290-324 (42-47)	25-35	80 HRB
IC 1030	Annealed Hardened	448-517 (65-75) 586-1034 (85-150)	310-345 (45-50) 414-1034 (60-150)	20-30 0-15	75 HRB 20-50 HRC
IC 1035	Annealed Hardened	483-552 (70-80) 621-1034 (90-150)	310-379 (45-55) 586-1034 (85-150)	20-30 0-15	80 HRB 25-52 HRC
IC 1045	Annealed Hardened	552-621 (80-90) 690-1241 (100-180)	345-414 (50-60) 621-1241 (90-180)	20-25 0-10	100 HRB 25-57 HRC
IC 1050	Annealed Hardened	621-758 (90-110) 862-1241 (125-180)	345-448 (50-65) 690-1241 (100-180)	20-25 0-10	100 HRB 30-60 HRC
IC 1060	Annealed Hardened	690-827 (100-120) 827-1379 (120-200)	379-483 (55-70) 690-1241 (100-180)	12-20 0-5	25 HRC 30-60 HRC
IC 1090	Annealed Hardened	758-1034 (110-150) 896-1241 (130-180)	483-552 (70-80) 876-1241 (130-180)	5-10 0-3	30 HRC 37-50 HRC
IC 2345	Annealed Hardened	--- (---) 896-1394 (130-200)	--- (---) 758-1241 (110-180)	--- 5-10	100 HRB 30-58 HRC
IC 3120	Annealed	--- (---)	--- (---)	---	100 HRB
IC 4130	Annealed Hardened	--- --- 896-1172 (130-170)	--- (---) 690-896 (100-130)	--- 5-20	100 HRB 23-49 HRC
IC 4140	Annealed Hardened	--- (---) 876-1394 (130-200)	--- (---) 690-1069 (100-155)	--- 5-20	100 HRB 29-57 HRC
IC 4150	Annealed Hardened	--- (---) 965-1394 (140-200)	--- (---) 827-1241 (120-180)	--- 5-10	100 HRB 25-58 HRC
IC 4330	Annealed Hardened	--- (---) 876-1310 (130-190)	--- (---) 690-1207 (100-175)	--- 5-20	20 HRC 25-48 HRC
IC 4340	Annealed Hardened	--- (---) 876-1394 (130-200)	--- (---) 690-1241 (100-180)	--- 5-20	20 HRC 20-55 HRC
IC 4620	Annealed Hardened	--- (---) 758-1034 (110-150)	--- (---) 621-896 (90-130)	--- 10-20	100 HRB 20-32 HRC
IC 6120	Annealed	--- (---)	--- (---)	--	100 HRB
IC 6150	Annealed Hardened	--- (---) 965-1394 (140-200)	--- (---) 827-1241 (120-180)	--- 5-10	100 HRB 30-60 HRC
IC 8620	Annealed Hardened	--- (---) 690-896 (100-130)	--- (---) 552-758 (80-110)	--- 10-20	100 HRB 20-45 HRC
IC 8630	Annealed Hardened	--- (---) 827-1172 (120-170)	--- (---) 690-896 (100-130)	--- 7-20	100 HRB 25-50 HRC
IC 8640	Annealed Hardened	--- (---) 876-1394 (130-200)	--- (---) 690-1241 (100-180)	--- 5-20	20 HRC 30-60 HRC
IC 8665	Annealed Hardened	--- (---) 1172-1517 (170-220)	--- (---) 965-1394 (140-200)	--- 0-10	25 HRC --
IC 8730	Annealed Hardened	--- (---) 827-1172 (120-170)	--- (---) 758-1034 (110-150)	--- 7-20	100 HRB --
IC 8740	Annealed Hardened	--- (---) 965-1394 (140-200)	--- (---) 827-1241 (120-180)	--- 5-10	100 HRB 30-60 HRC
IC 52100	Annealed Hardened	--- (---) 1241-1585 (180-230)	--- (---) 965-1241 (140-180)	--- 1-7	25 HRC 30-65 HRC
IC 1722AS	Annealed Hardened	--- (---) 876-1172 (130-170)	--- (---) 690-1241 (100-140)	-- 6-12	25 HRC 25-48 HRC
Ductile Iron Ferritic	Annealed	414-552 (60-80)	276-345 (40-50)	18-24	143-200 HBW
Ductile Pearlitic	Normalized	690-830 (100-120)	483-552 (70-80)	3-10	243-303 HBW

TABLE 7 - HARDENABLE STAINLESS STEELS Typical Chemical Range Percentages										
Trade Name (AISI Equivalent)	C	Mn	Si	P	S	Ni	Cr	Mo	Cu	Other
CA-15 (410) J91150	0.05 0.15	1.00	1.50	.04	.04	1.00	11.5 14.0	.50	---	
IC 416 (416) J91161	0.15	1.25	1.50	.05	.15 .35	.50	11.50 14.0	.50	.50	0.10-.30Se alternate for S, 0.50Zr
CA-40 (420) J91153	0.20 0.40	1.00	1.50	.04	.04	1.0	11.5 14.0	.5	---	
IC 431 (431) J91651	0.08 0.15	1.00	1.00	.04	.04	1.50 2.20	15.0 17.0	---	---	
IC 440A (440A)	-0.60 0.75	1.00	1.00	.04	.03	---	16.0 18.0	.75	---	
IC 440C (440C) J91639	0.95 1.20	1.00	1.00	.04	.03	.75	16.0 18.0	.35 .75	---	
IC 440F (440F)	0.95 1.2	1.0	1.0	.04	.15 .35	.50	16.0 18.0	.75	.50	0.10-0.30Se alternate for S
IC 436 Greek Ascoloy J91631	0.15 0.20	1.00	1.00	.04	.03	1.80 2.20	12.00 14.00	.50	.50	2.50-3.50W
IC 17-4 J92180	0.06	.70	.50 1.00	.04	.03	3.60 4.60	15.50 16.70	---	2.80 3.50	0.15-.40 Cb + Ta, .05N Ta 0.05% Max
AM-355	0.08 0.15	.40 1.10	.75	.04	.03	3.50 4.50	14.50 15.50	2.00 2.60		.05-.13N; .15-.25C + N
CA-6NM J91540	0.06	1.00	1.00	.04	.03	3.5 4.5	11.5 14.0	.40 1.00	---	
IC 15-5 J92110	0.05	0.60	0.50 1.00	0.25	0.25	4.20 5.00	14.00 15.50	---	2.50 3.20	.15-.30 Cb + Ta, .05N

* Nitrogen analysis is not routinely measured for commercial castings. To assure harden-ability, nitrogen must be in range and its analysis should be requested by the purchaser.

TABLE 8 – TYPICAL PROPERTIES OF SEPARATELY CAST TEST BARS OF HARDENABLE, STAINLESS STEELS					
Alloy	Condition	Tensile Strength MPa (ksi) Range	0.2% Yield Strength MPa (ksi) Range	% Elongation Range (in 4D)	Hardness Range or Max
CA-15 (410) J91150	Sol. Anneal Hardened	--- 655-1394 (95-200)	--- 517-1103 (75-160)	--- 5-12	100 Rb 94Rb-45 Rc
IC 416 J91161	Sol. Anneal Hardened	--- 655-1394 (95-200)	--- 517-1103 (75-160)	--- 3-8	100 Rb 94Rb-45 Rc
CA-40 (420)	Sol. Anneal Hardened	--- 1394-1551 (220-225)	--- 896-1448 (130-210)	--- 0-5	25 Rc 30-52 Rc
IC 431 J91651	Sol. Anneal Hardened	--- 759-1103 (110-160)	--- 517-724 (75-105)	--- 5-20	30 Rc 20-40 Rc
IC 440A	Sol. Anneal Hardened	--- ---	--- ---	--- ---	30 Rc 35-56 Rc
IC 440C J91639	Sol. Anneal Hardened	--- ---	--- ---	--- ---	35 Rc 40-60 Rc
IC 440F	Sol. Anneal Hardened	--- ---	--- ---	--- ---	35 Rc 40-60 Rc
IC436 Greek Ascoloy	Sol. Anneal	---	---	---	36 Rc
IC 17-4 J92180	Sol. Anneal Hardened	--- 1034-1310 (150-190)	--- 965-1103 (140-160)	--- 6-20	36Rc 34-44Rc
AM-355	Hardened	1394-1517 (200-220)	1034-1138 (150-165)	6-12	---
IC 15-5	Hardened	931-1172 (135-170)	759-1000 (110-145)	5-15	26-38 Rc

NOTE: The above mechanical property values are for information only. They do not necessarily apply to casting. Any requirements for mechanical properties beyond this standard must be negotiated with the foundry.

* Not generally sold in hardened condition.

TABLE 9 - AUSTENITIC STAINLESS STEELS
Typical Chemical Range Percentages

<i>Trade Name UNS #</i>	<i>C</i>	<i>Mn</i>	<i>Si</i>	<i>P</i>	<i>S</i>	<i>Ni</i>	<i>Cr</i>	<i>Mo</i>	<i>Cu</i>	<i>Other</i>
CF-20 (302) J 92602	0.20	1.50	2.00	0.04	0.04	8.0 11.0	18.0 21.0	0.75	0.75	
CF-16F (a) (303) J92701	0.16	1.50	2.00	0.04	---	9.0 12.0	18.0 21.0	---	---	Either: 0.20-.35Se, 1.50 Mo or 0.40-.80Mo, 0.20-.40S
CF-8 (304) J 92500	0.08	1.50	2.00	0.04	0.04	8.0 11.0	18.0 21.0	---	---	
CF-3 (304L) J92500	0.03	1.50	2.00	0.04	0.04	8.0 12.0	17.0 21.0	---	---	
CH-20 (309) J93402	0.20	1.50	2.00	0.04	0.04	12.0 15.0	22.0 26.0	---	---	
CK-20 (310) J 94202	0.20	2.00	2.00	0.04	0.04	19.0 22.0	23.0 27.0	---	---	
CF-8M (316) J 92900	0.08	1.50	2.00	0.04	0.04	9.0 12.0	18.0 21.0	2.0 3.0		
CF-3M (316L) J92800	0.03	1.50	1.50	0.04	0.04	9.0 13.0	17.0 21.0	2.0 3.0	---	
IC 321 (321)* J92630	0.08	2.00	1.00	0.04	0.03	9.0 12.0	17.0 19.0	---		Ti = (5xC) (min)
CF-8C (347) J92710	0.08	1.50	2.00	0.04	0.04	9.0 12.0	18.0 21.0	---	---	Cb = (8xC) (min) – 1.0Cb (max)
CN-7M N08007	0.07	1.50	1.50	0.04	0.04	27.5 30.5	19.0 22.0	2.0 3.0	3.0 4.0	
HK J94224	0.20 0.60	2.00	2.00	0.04	0.04	18.0 22.0	24.0 28.0	.50	---	

* CF-8C is recommended in lieu of IC-321 for castability

**TABLE 10 – TYPICAL PROPERTIES OF SEPARATELY CAST TEST
BARS OF AUSTENITIC STAINLESS STEELS**

<i>Alloy</i>	<i>Condition</i>	<i>Tensile Strength MPa(ksi) Range</i>	<i>0.2% Yield Strength MPa(ksi) Range</i>	<i>% Elongation Range (in 4D)</i>	<i>Hardness Rb Max.</i>
CF-20	Solution Anneal	448-517 (65-75)	207-241 (30-35)	35-60	90
CF-3, CF-8	Solution Anneal	483-586 (70-85)	276-345 (40-50)	35-50	90
CH-20	Solution Anneal	483-552 (70-80)	207-276 (30-40)	30-45	90
CK-20	Solution Anneal	414-517 (60-75)	207-276 (30-40)	35-45	90
CF-3M, -8M, IC 316F	Solution Anneal	483-586 (70-85)	276-345 (40-50)	35-50	90
CF-8C	Solution Anneal	483-586 (70-85)	221-248 (32-36)	30-40	90
CN-7M	Solution Anneal	418-517 (65-75)	172-241(25-35)	35-45	90
IC 321	Solution Anneal	418-517 (65-75)	207-276 (30-40)	35-45	90
HK	Solution Anneal	418-517 (65-75)	241-310 (35-45)	10-20	100

NOTE: The above mechanical property values are for information only. They do not necessarily apply to casting. Any requirements for mechanical properties beyond this standard must be negotiated with the foundry.

TABLE 11 - TOOL STEELS
Typical Chemical Range Percentages

<i>Alloy</i>	<i>C</i>	<i>Mn</i>	<i>Si</i>	<i>Cr</i>	<i>Mo</i>	<i>W</i>	<i>V</i>	<i>P</i>	<i>S</i>	<i>Other</i>
CA-2 IC CA-2	.95 1.05	.75	1.50	4.75 5.75	90 1.30	---	.20-.50 Optional	.03	.03	
IC CA-6	65 .75	1.80 2.20	1.00	.80 1.20	.80 1.30	---	---	.025	.025	
IC CD-2	1.40 1.60	1.00	1.50	11.00 13.00	.70 1.20	---	.40-1.00 Optional	.03	.03	.70-1.00 Co Optional
IC CD-3	2.10 2.30	.75	1.00	11.50 13.00	.40	---		.025	.025	
D-5 IC CD-5	1.35 1.60	.75	1.50	11.00 13.00	.70 1.20	---	.35 .55	.03	.03	2.50 – 3.50 Co Ni Optional .40-.60
IC CD-6	2.10 2.35	.75	.80 1.20	11.5 13.0	.40	.80 1.20	---	.025	.025	
IC CD-7	2.15 2.45	.75	1.00	11.5 13.0	.80 1.20	---	3.50 4.50	.025	.025	
IC CH-11	.30 .40	.75	.95 1.15	4.6 5.4	1.20 1.60	---	.30 .50	.025	.025	
CH-12 IC CH-12	.30 .40	.75	1.50	4.75 5.75	1.25 1.75	1.00 1.70	.20 .50	.03	.03	
CH-13 IC CH-13	.30 .42	.75	1.50	4.75 5.75	1.25 1.75	---	.75 1.20	.03	.03	
IC CL-6	.65 .75	.75	1.00	.80 1.0	---	---	---	.025	.025	Ni 1.50-1.90
CM-2 IC CM-2	.78 .88	.75	1.00	3.75 4.50	4.50 5.50	5.50 6.75	1.25 2.20	.03	.03	.25Ni .25 Co
IC C1-M-2 High C	.95 1.05	.75	1.00	3.75 4.50	4.50 5.50	5.50 6.75	1.75 2.20	.025	.025	.25Ni
IC CM-4	1.25 1.35	.75	1.00	3.75 4.50	4.50 5.50	5.20 6.20	3.60 4.40	.025	.025	
IC CM-42	1.00 1.20	.75	1.00	3.50 4.25	9.00 10.00	1.25 1.75	.95 1.35	.025	.025	Co 7.50-8.50
IC CM-43	1.15 1.35	.75	1.00	3.50 4.25	8.25 9.25	1.50 2.00	1.50 2.00	.025	.025	Co 7.75-8.75
CO-1 IC CO-1	.85 1.00	1.00 1.30	1.50	.40 1.00	---	.40 .60	.30	.03	.03	
IC CO-2	.85 .95	1.50 1.80	1.00	.40	.30	---	.30	.025	.025	
IC CO-7	1.10 1.20	.75	1.00	.50 .70	---	1.65 1.85	.15 .25	.025	.025	
IC CS-1	.45 .55	.75	1.00	1.35 1.65	---	2.35 2.65	---	.025	.025	
IC CS-2	.45 .55	.75	.90 1.20	---	.40 .60	---	.30	.025	.025	
IC CS-4	.50 .60	.70 .90	1.80 2.20	.30	---	---	.30	.025	.025	
CS-5 IC CS-5	.50 .65	.60 1.00	1.75 2.25	.35	.20 .80	---	.35	.03	.03	
CS-7 IC CS-7	.45 .55	.40 .80	.60 1.00	3.00 3.50	1.20 1.60	---	---	.03	.03	
IC CT-1	.65 .75	.75	1.00	3.75 4.50	---	17.25 18.75	.90 1.30	.025	.025	
IC CT-2	.80 .90	.75	1.00	3.75 4.50	1.00	17.50 10.00	1.80 2.40	.025	.025	
IC CT-6	.75 .85	.75	1.00	4.00 4.75	.70 1.00	18.50 21.25	1.50 2.10	.025	.025	Co 10.00-13.70

**TABLE 12 - HARDNESS VALUES OF CASTINGS
AND SEPARATELY CAST TEST BARS OF TOOL**

	HARDNESS		
Alloy	Annealed with Slow Cool Max.	Cycle Anneal Max.	Hardened Range (Rc)
IC CA-2	20 Rc	27 Rc	47-60
IC CA-6	100 Rb		48-59
IC CD-2		35 Rc	50-59
IC CD-3		35 Rc	47-61
IC CD-5	100 Rb		44-61
IC CD-6	100 Rb		50-63
IC CD-7	24 Rc		50-63
IC CH-11	100 Rb		46-55
IC CH-12	100 Rb		50-53
IC CH-13	100 Rb		45-53
IC CL-6	95 Rb		39-60
IC CI-M-2		30 Rc	61-63
IC CM-2		30 Rc	61-63
IC CM-4	30 Rc		62-64
IC CM-42		35 Rc	60-64
IC CM-43	27 Rc		61-64
IC CO-1		100 Rb	45-61
IC CO-2		100 Rb	38-60
IC CO-7	95 Rb		35-64
IC CS-1		100 Rb	44-57
IC CS-2		100 Rb	44-55
IC CS-4	100 Rb		42-53
IC CS-5	100 Rb		37-59
IC CS-7		100 Rb	35-57
IC CT-1	100 Rb		60-66
IC CT-2	100 Rb		60-66
IC CT-6	30 Rc		60-64

TABLE 13 - NICKEL BASE ALLOYS Typical Chemical Range Percentages															
<i>Trade Name</i>	<i>UNS</i>	<i>C</i>	<i>Mn</i>	<i>P</i>	<i>S</i>	<i>Si</i>	<i>Ni</i>	<i>Cr</i>	<i>Mo</i>	<i>Cu</i>	<i>Fe</i>	<i>Co</i>	<i>V</i>	<i>W</i>	<i>Other</i>
Alloy B	N30012	.12	1.0	.030	.030	1.00	Bal.	1.00	26.00 30.00		4.00 6.00	2.50	.20 .60		
Alloy C (CW-6M)	N30107	.07	1.0	.04	.03	1.00	Bal.	17.0 20.0	17.0 20.0		3.00				
Alloy C (CW-12MW)	N30002	.12	1.0	.03	.03	1.0	+ Co Bal.	15.5 17.5	16.0 18.0		4.5 7.0	2.5	.20 .40	3.75 5.25	
Alloy X	N06002	.20	1.0	.04	.03	1.00	Bal.	20.50 23.00	8.00 10.00		17.00 20.00	.50 2.50		.20 1.00	
Invar	K93600	.12	.20 .50	.04	.03	.40	35.0 37.0				Bal.				
CY 40	N06040	0.40	1.50	0.03	0.03	3.00	Bal.	14.0 17.0			Bal.				
In 625 (2)	N26625	.10	50	.015	.015	.50	Bal.	20.0 23.0	8.0 10.0	.30	5.0	1.0			0.4Ti, 0.41Al, 3.15-4.15 Cb+Ta
NiCu M35-1	N24135	0.35	1.50	0.03	0.03	1.25	Bal.			26.0 33.0	3.50				0.50 Cb
NiCu M25S	N24025	0.25	1.50	0.03	0.03	3.5 4.5	Bal.			27.0 33.0	3.50				
NiCu M30C	N24130	0.30	1.50	0.03	0.03	1.0 2.0	Bal.			26.0 33.0	3.5				1.0-3.0 Cb
47-50		.05	.60	.02	.02	.60	47.0 50.0				Bal.				

TABLE 14 – TYPICAL PROPERTIES OF SEPARATELY CAST TEST BARS OF NICKEL BASE ALLOYS					
<i>Alloy</i>	<i>Condition</i>	<i>Tensile Strength MPa (ksi)</i>	<i>0.2% Yield Strength MPa (ksi)</i>	<i>% Elongation Range (in 2.5 cm)</i>	<i>Hardness Range</i>
Alloy B	Annealed	517-586 (75-85)	345-414 (50-60)	8-12	90-100 Rb
Alloy C	As Cast Annealed	552-655 (80-95) 517-655 (75-95)	310-379 (45-55) 310-379 (45-55)	8-12 8-12	90-100 Rb 90 Rb - 25 Rc
Alloy X	A.C.24°C A.C.816°C	434-483 (63-70) 241-310 (35-45)	283-310 (41-45)	10-15 12-20	85-96 Rb
Invar	As Cast	345-414 (50-60)	172-207 (25-30)	30-40	50-60 Rb
CY40	As Cast	448-517 (65-75)	241-276 (35-40)	10-20	80-90 Rb
In 625 (2)	Annealed	552-758 (80-100)	276-379 (40-55)	15-30	10-20 Rc
NiCu M35-1	As Cast	448-517 (65-75)	221-262 (32-38)	25-35	65-75 Rb
NiCu M25S	Annealed Hardened	690-758 (100-110) 827-965 (120-140)	379-448 (55-65) 586-690 (85-100)	5-10 0	20-28 Rc 32-38 Rc
NiCu M30C	As Cast	448-552 (65-80)	227-276 (33-40)	25-35	67-78 Rb
47-50	Annealed	414-483 (60-70)	138-207 (20-30)	25-35	55-60 Rb

TABLE 15 - COBALT BASE ALLOYS
Typical Chemical Range Percentages

<i>Trade Name</i>	<i>UNS</i>	<i>C</i>	<i>Mn</i>	<i>P</i>	<i>S</i>	<i>Si</i>	<i>Ni</i>	<i>Cr</i>	<i>Mo</i>	<i>Fe</i>	<i>Co</i>	<i>W</i>	<i>Other</i>
Cobalt J	R31001	2.2 2.8	2.00	.03	.03	2.0	2.5	31.0 34.0		3.0	Bal.	16.0 19.0	.25B, 2.0 Total
Cobalt 3	R30103	2.0 2.7	1.0	.03	.03	1.0	3.0	29.0 33.0		3.0	Bal.	11.0 14.0	2.0 Total
Cobalt 6	R30006	.9 1.4	1.0			1.5	3.0	27.0 31.0	1.5	3.0	Bal.	3.5 5.5	
Cobalt 12	R30012	1.10 1.70	1.00	.03	.03	1.00	3.00	28.0 32.0		3.00	Bal.	7.00 9.50	
Cobalt 19	--	1.5 2.0	1.0	.03	.03	1.0		29.0 33.0		3.0	Bal.	9.0 12.0	
Cobalt 21	R30021	.20 .30	1.0	.04	.04	1.0	1.75 3.75	25.0 29.0	5.0 6.0	3.0	Bal.		.007B
Cobalt 25	R30605	.05 .15	1.0 2.0	.04	.04	1.0	9.0 11.0	19.0 21.0		3.0	Bal.	14.0 16.0	
Cobalt 31	R30031	.45 .55	1.0	.04	.04	1.0	9.5 11.5	24.5 26.5		2.0	Bal.	7.0 8.0	
Cobalt 36	R30036	.35 .45	1.5	.03	.03	.35	9.0 11.0	17.5 19.5		2.0	Bal.	14.0 16.0	.01-.05B
Cobalt 93		2.75 3.25	1.5	.03	.03	1.5		15.0 19.0	14.0 18.0	Bal.	4.0 7.0		1.5-2.5V
N-155	R30155	.08 .16	1.00 2.00	.04	.03	1.00	19.0 21.0	20.0 22.5	2.50 3.50	Bal.	18.50 21.00	2.00 3.00	.10-0.20N, 0.75-1.25 Cb + Ta
Tantung G		1.8 2.2						26.0 29.0		2.0	Bal.	15.0 17.0	.15-.25B; 4.5-5.5 Ta
WI-52		.40 .50	.50	.04	.04	.50	1.0	20.0 22.0		1.0 2.5	Bal.	10.0 12.0	1.5-2.5 Cb + Ta
F75	R30075	.35	1.00	0.02	0.01	1.00	0.5	27.0 30.0	5.0 7.0	.75	Bal.	0.2	B 0.01, Al 0.01, N 0.25, Ti 0.1

**TABLE 16 – TYPICAL PROPERTIES OF SEPARATELY CAST TEST
BARS OF COBALT BASE ALLOYS**

<i>Alloy</i>	<i>Condition</i>	<i>Tensile Strength</i> <i>MPa (ksi)</i>	<i>0.2% Yield Strength</i> <i>MPa (ksi)</i>	<i>% Elongation</i> <i>Range</i> <i>(in 2.5 cm)</i>	<i>Hardness</i> <i>Rc Range</i>
J	As Cast				55-60
3	As Cast				48-53
6	As Cast				37-45
12	As Cast				44-50
19	As Cast				47-52
21	As Cast	655-896 (95-130)	448-655 (65-95)	8-20	24-32
25	As Cast	621-827 (90-120)	414-517 (60-75)	15-25	20-25
31	As Cast	724-896 (105-130)	517-621 (75-90)	6-10	20-30
36	As Cast	621-724 (90-105)	414-483 (60-70)	15-20	30-36
93	As Cast				61-65
N-155	Solution Anneal	621-690 (90-100)	345-414 (50-60)	15-30	90-100 (Rb)
Tantung G					48-53
WI-52	As Cast	621-724 (90-105)	448-517 (65-75)	5-9	32-38
F75	As Cast	655-758 (95-110)	483-552 (70-80)	8-15	25-34

NOTE: The above mechanical property values are for information only. They do not necessarily apply to casting. Any requirements for mechanical properties beyond this standard must be negotiated with the foundry.

TABLE 17 - DUPLEX STAINLESS STEELS Typical Chemical Range										
<i>Alloy UNS#</i>	<i>C</i>	<i>Mn</i>	<i>Si</i>	<i>Cr</i>	<i>Ni</i>	<i>Mo</i>	<i>N</i>	<i>P</i>	<i>S</i>	<i>Other</i>
CF3MN J92804	.03	1.50	1.50	17.0-22.0	9.0-13.0	2.0-3.0	.10-.30	.040	.040	-
CK3MCuN J93254	.025	1.20	1.00	19.5-20.5	17.5-19.5	6.0-7.0	.18-.24	.045	.010	Cu .50-1.00
CD4MCu J93370	.04	1.00	1.00	24.5-26.5	4.75-6.00	1.75-2.25	-	.04	.04	Cu 2.75-3.25
CD4MCuN J93372	.04	1.00	1.00	24.5-26.5	4.7-6.0	1.7-2.3	0.10-0.25	.04	.04	Cu 2.7-3.3
CD3MCuN J93373	.03	1.20	1.10	24.0-26.7	5.6-6.7	2.9 - 3.8	0.22-0.33	.03	.03	Cu 1.40-1.90
CD6MN J93371	.06	1.00	1.00	24.0-27.0	4.0-6.0	1.75-2.5	0.15-0.25	.04	.04	-
CD3MN J92205	.03	1.50	1.00	21.0-23.5	4.5-6.5	2.5- 3.5	0.10- 0.30	.04	.02	Cu 1.00 Max
CE3MN J93404	.03	1.50	1.00	24.0-26.0	6.0-8.0	4.0-5.0	0.10-0.30	.04	.04	-
CD3MWCuN J93380	.03	1.00	1.00	24.0-26.0	6.5-8.5	3.0-4.0	0.20-0.30	.03	.025	Cu 0.50-1.0 W 0.5-1.0

TABLE 18 – TYPICAL PROPERTIES OF SEPARATELY CAST TEST BARS FOR DUPLEX STAINLESS STEEL				
<i>ALLOY</i>	<i>CONDITION</i>	<i>TENSILE STRENGTH MIN, MPa (ksi)</i>	<i>YIELD STRENGTH MIN, MPa (ksi)</i>	<i>% ELONGATION (4D)</i>
CF3MN	Sol. Anneal	655 (95)	450 (65)	25
CK3MCuN	Sol. Anneal	550 (80)	260 (38)	35
CD4MCu	Sol. Anneal	690 (100)	485 (70)	16
CD4MCuN	Sol. Anneal	690 (100)	485 (70)	16
CD3MCuN	Sol. Anneal	690 (100)	450 (65)	25
CD6MN	Sol. Anneal	655 (95)	450 (65)	25
CD3MN	Sol. Anneal	620 (90)	415 (60)	25
CE3MN	Sol. Anneal	690 (100)	515 (75)	18
CD3MWCuN	Sol. Anneal	690 (100)	450 (65)	25

TABLE 19 - TITANIUM BASE ALLOYS

Typical Chemical Range Percentages

<i>Alloy</i>	<i>N</i>	<i>C</i>	<i>H</i>	<i>Fe</i>	<i>O</i>	<i>Al</i>	<i>V</i>	<i>Sn</i>	<i>Pd</i>	<i>Mo</i>	<i>Ni</i>	<i>Zr</i>	<i>Nb</i>	<i>Other Min. Each</i>	<i>Elements Min. Total</i>
Commercially Pure Grades															
C2	0.05	0.10	0.015	0.20	0.40	—	—	—	—	—	—	—	—	0.10	0.40
C3	0.05	0.10	0.015	0.25	0.40	—	—	—	—	—	—	—	—	0.10	0.40
Ti-Pb7B	0.05	0.10	0.015	0.20	0.40	—	—	—	0.12 min	—	—	—	—	0.10	0.40
Ti-Pd8A	0.05	0.10	0.015	0.25	0.40	—	—	—	0.12 min	—	—	—	—	0.10	0.40
Ti-Pd16	0.03	0.10	0.0150	0.30	0.18	—	—	—	0.04	—	—	—	—	0.10	0.40
									0.08						
Ti-Pd17	0.03	0.10	0.0150	0.20	0.25	—	—	—	0.04	—	—	—	—	0.10	0.40
									0.08						
6Al -4V	0.05	0.10	0.015	0.40	0.25	5.5 6.75	3.5 4.5	--	--	--	--	--	--	0.10	0.40
F 1108 6Al -4V	0.05	0.10	0.015	0.03	0.02	5.5 6.75	3.5 4.5	--	--	--	--	--	--	--	--
5Al -2.5Sn	0.05	0.10	0.015	0.50	0.20	4.00 6.00	--	2.0 3.0	--	--	--	--	--	0.10	0.40
8Al -1Mo -1V															
6Al -2Mo -4Zr -2Sn															
Grade C12	0.05	0.10	0.015	0.30	0.25	--	--	--	--	0.2 0.4	0.6 0.9	--	--	0.1	0.4
3Al -2.5Sn - Pd	0.03	0.10	0.0150	0.25	0.15	2.5 3.5	--	2.0 3.0	0.04 0.08	--	--	--	--	0.1	0.4
4Al -2.5V -Fe	0.03	0.08	0.015	1.2 1.8	0.20 0.30	3.5 4.5	2.0 3.0	--	--	--	--	--	--	0.1	0.4

TABLE 20 - TITANIUM BASE ALLOYS
Typical Properties of Separately Cast Test

<i>Alloy</i>	<i>Condition</i>	<i>Tensile Strength Range MPa (ksi)</i>	<i>0.2% Yield Strength Range MPa (ksi)</i>	<i>% Elongation Range (in 2" or 50 mm)</i>	<i>Hardness Range</i>
Grade C2	As Cast	345 (50)	275 (40)	15	Rb 96
Grade C3	As Cast	450 (65)	380 (55)	12	Rc 24
Ti-Pd7B	As Cast	345 (50)	275 (40)	15	Rb 96
Ti-Pd8A	As Cast	450 (65)	275 (55)	12	Rc 24
Ti-Pd16	As Cast	345 (50)	275 (40)	15	Rb 96
Ti-Pd17	As Cast	240 (35)	170 (25)	20	Rc 24
6Al -4V	As Cast	895 (130)	825 (120)	6	Rc 39
6Al -4V ELI					
F 1108	Hipped & Annealed	860 (125)	758 (110)	8	Rc 36
5Al -2.5Sn	As Cast	795 (115)	725 (105)	8	Rc 36
8Al -1Mo -1V					
6Al -2Mo -4Zr -2Sn					
Grade C12	As Cast	483 (70)	345 (50)	8	Rc 24
3Al -2.5Sn - Pd	As Cast	620 (90)	483 (70)	15	Rc 39
4Al -2.5V -Fe	As Cast	895 (130)	794 (115)	10	Rc 39

Part II Tables: Cross-Index of Various Alloys

TABLE 21 – ALUMINUM ALLOYS			
<i>Alloy</i>	<i>Other Designations</i>	<i>AMS</i>	<i>OTHERS</i>
355	QQ-A-596, QQ-A-601 (6)	4210, 4212, 4281	SAE-322
356	QQ-A-596, QQ-A601 (8)	4217, 4260, 4284, 4285, 4286	SAE 323
357			
40E	QQ-A-601		SAE 310
43	QQ-A-601		SAE 33
AlMag35	QQ-A-601	4238, 4239	
A140		4227	
354	Mil-A-21180		
C612	ASTM B108-ZC60A		
C355	Mil-A-21180	4215	
A356	Mil-A-21180	4218	

TABLE 22 – MISCELLANEOUS COPPER ALLOYS

Alloy & (CDA No.)	Trade Name UNS	Nominal Comp.	ASTM	FEDERAL	MILITARY	SAE
Aluminum Bronze A (C95200)	C95200	88-3-9	B14B GR.A	QQ-B-675 QQ-C.390 B	MIL-C-22087	J461 J462
Aluminum Bronze B (C95300)	C95300	89-1-10	B146 GR.B	QQ-B-675 QQ-C-390 B	MIL-C-16033	J461 J462
Aluminum Bronze C (C95400)	C95400	86-4-10	B148 GR.C	QQ-B-675 QQ-C-390B	MIL-C-11866 MIL-C-15345	J461 J462
Aluminum Bronze D (C95500)	C95500	81-4-4-11	B148 GR. D	QQ-B-675 QQ-C-390B	MIL-C-11866 MIL-C-15345	J461
BeCu 10C (C82000)	C82000	97-0.5-2.5	B770	QQ-C-390	MIL-C-19464	-
BeCu 20C (C82500)	C82500	97-2	B770	QQ-C-390	MIL-C-22087 MIL-C-19464	-
BeCu 165C (C82400)	C82400	97-1.7-.25	B770			
BeCu 275C (C82800)	C82800	96.6-2.6-.5	B770	QQ-C-390	MIL-C-19464	
Se Bi Loy (C89510)	C89510	87-1-.55-5-5	-	-	-	-
Cu Bi (C89836)	C89836	89-2.2-5.3-3	-	-	-	-
Pure Copper (C80100)	C80100	99-95min	-	-	-	-
Chrome Copper (C81500)	C81500	99-1	-	-	MIL-C-19310	-
Leaded Yellow Brass (C85400)	C85400	67-1-3-29	B584	QQ-C390 QQ-C-390		J461 J462
Red Brass (C83600)	C83600	85-5-5-5	B584 B62	QQ-C-390B QQ-C-525	MIL-C-11866 MIL-C-15345 MIL-C-22087 MIL-C-22229	J461 J462
Manganese Bronze A (C86500)	C86500	65 ksi TENSILE	B584	QQ-C-390B QQ-C-523	MIL-C-15345 MIL-C-22087 MIL-C-22229	J461 J462
Manganese Bronze C (C86300)	C86300	110 ksi TENSILE	B584	QQ-C-390B QQ-C-523	MIL-C-22229 MIL-C-11866 MIL-C-15345	J461 J462
Tin Bronze (C90300)	C90300	88-8-0-4	B584	QQ-C-390B QQ-C-525	MIL-C-11866 MIL-C-15345 MIL-C-22229	J461 J462
Red Brass (C83300)	C83300	93-1.5-1.5-4	-	-	-	-
Leaded Yellow Brass (C85200)	C85200	72-3-1-24	B584	QQ-C-390	MIL-C-11866	J461 J462
Leaded Yellow Brass (C85700)	C85700	61-1-1-35	B584	QQ-C-390	MIL-C-11866	
Silicon Brass (C87500)	C87500	82-14Zn-4Si	B584	-	MIL-C-22087 MIL-C-20152	J461 J462
Silicon Bronze (C87200)	C87200	96-4		QQ-C-390	MIL-C-11866 MIL-C-22229	
Silicon Brass (C87300)	C87300	88-3-14	B584	QQ-C-390	MIL-C-11866 MIL-C--22229	J461 J462
Silicon Brass (C87600)	C87600	90-4.5-5.5	B584	QQ-C-390	MIL-C-11866 MIL-C-22229	J461 J462
Red Brass (C87300)	C87300	88-3-14	-	-	-	-

TABLE 23 – IRON BASE				
<i>Alloy</i>	<i>AMS</i>	<i>PWA</i>	<i>GE</i>	<i>Other Designations</i>
N155	5376	IM-IM4430	B50A336, C50E39	AISI-661
INVAR 36				
KOVAR				
DUCTILE IRON				

TABLE 24 – CARBON AND LOW ALLOY					
<i>Alloy</i>	<i>ASTM A 732</i>	<i>AMS</i>	<i>UNS</i>	<i>GE</i>	<i>Other Designations</i>
IC 1020	1A		J02002		SAE J403
IC 1030	2A, 2Q		J03011		
IC 1040	3A, 3Q		J04002		
IC 1045			J04502		
IC 1050	4A, 4Q		J05001		
IC 4020	6N		J13512		
IC 4130	7Q	5236	J13045, J13048	19A2063	
IC 4140	8Q	5338	J14049, J14046 J14047	B2M17	HC32
IC 4330	9Q	5328	J23055, J23260		
IC 4340	10Q	5330	J24054, J24060, J24055		
IC 4620	11Q		J12094, J12093		
IC 6120	5N		J13052		
IC 6150	12Q		J15048, J15047		
IC 8620	13Q	5334	J12048, J13042		
IC 8630	14Q	5335	J13051, J13050, J13049		
IC 52100	15A		J19966, J19965		
Silicon iron		5210			

TABLE 25 – COBALT BASE					
<i>Alloy</i>	<i>AMS</i>	<i>PWA</i>	<i>GE</i>	<i>UNS</i>	<i>Other Designations</i>
3				R30103	E1250 (Bendix)
6	5387		B50A557	R30006	
21	5385		B50R99 B50TA251	R30021	
F-75				R30075	ASTM F-75
FSX414			B50A489		
23	5375			R30023	
25		653, 654	B50T53	R30605	L605, HS25
31	5382	653,654 IM-4500	C50TF 1056 (air) C50TF21 (vac)	R30031	M-3503 (Lycoming) X-40, HS31
93					ES1291 (Bendix)
X-45					

TABLE 26 – AUSTENITIC STAINLESS STEELS					
<i>Alloy</i>	<i>AMS</i>	<i>UNS</i>	<i>GE</i>	<i>ASME</i>	<i>ASTM</i>
302	5358	S30200	B2M3	SA-479	A743, CF-20
303	5341	S30300	B2MB		A743, 744, CF-16F
304	5370	S30400	B50YP124, B50YP43	SA-479	A743, CF-8
304L	5371	S30403	B50YPL24LC	SA-479	A351, CF3LC
310	5366	S31000		SA-479	A743, CK20
316	5360, 5361	S31600		SA-479	A743, 744, 351, MIL-5-81591
347	5362, 5364	S34700	B2M18	SA-479	CF8C
330		N08605			A351, HT30, SAE70330, A297, HT

TABLE 27 – PRECIPITATION HARDENING STAINLESS STEELS					
<i>Alloy</i>	<i>AMS</i>	<i>UNS</i>	<i>GE</i>	<i>ASME</i>	<i>Other Designations</i>
17-4 pH	5355, 5342, 5343, 5344	S17400	B50TF36, C50T28	SA-564	ASTM A747, CB7Cu-1, AISI-630
15-5 pH	5400, 5346, 5347, 5356,	S15500		SA-705	XM-12, ASTM A564, 693
13-8 pH	5840	S13800			
AM-355	5368	J92001			EMS-55444 (-11-) AISI-634

TABLE 28 – MARTENSITIC STAINLESS STEELS					
<i>Alloy</i>	<i>AMS</i>	<i>UNS</i>	<i>GE</i>	<i>ASME</i>	<i>Other Designations</i>
410	5350	J91150	B50A468, B50TA200	SA-479	CA-15, ASTM A217, 743
416	5349	J91161		SA-194	MIL-S-81591
420		J91153			MIL-S-81591, ASTM A743, CA4
431	5353, 5372	J91651			MIL-S-22216, CB30
440A		J91606			MIL-S-81591
440C	5352	J91639			MIL-S-81591
440F					
Greek Ascoloy	5354	J91631	B50A430		AISI-615, STAINLESS 418 ASTM A565
M-151			B50TF85		

TABLE 29 – DUPLEX STAINLESS STEELS					
<i>Alloy</i>	<i>AISI</i>	<i>UNS</i>	<i>GE</i>	<i>ASTM</i>	<i>Other Designations</i>
CF3MN	316N	J92804		A351, A743	
CK3MCuN		J93254		A951, A743, A744	254 SMO
CD4MCu		J93370		A351, A890	
CD4MCuN		J93372		A890, A995	
CD6MN		J93371		A890, A995	
CD3MN		J92205		A781, A890	2205
CE3MN		J93404		A890	958
CD3MWCuN		J9		A351, A890	

TABLE 30 – VACUUM FERROUS					
<i>Alloy</i>	<i>AMS</i>	<i>PWA</i>	<i>GE</i>	<i>UNS</i>	<i>Other Designations</i>
14-4 pH	5340			J92240	
17-4 pH	5355,5342, 5343,5344			J92200	
15-5 pH	5347,5356,5357			J92110	
PH 13-8MO	5412		A10347	S13800	
AF 1410				K92571	M3712 (Lycoming)
C450				S45000	
A286				S66286	

TABLE 31 – NICKEL BASE					
<i>Alloy</i>	<i>AMS</i>	<i>PWA</i>	<i>GE</i>	<i>UNS</i>	<i>Other Designations</i>
Ni B	5396			N10001	
Ni C	5388			N10002	ASTM A494, CW-12MW
Ni X	5390			N06002	
M35-1				N24135	ASTM A-494
M25S				N24025	ASTM A-494
M30C				N24130	ASTM A-494
Inconel 600		661	B50WB054, B50T1240	N06600	
Inconel 625	5401	1468	B50TF107	N06625	
IN 100	5397	658, 1494	C50TF23	N13100	
Rene 41	5399		C50T53, C50TF2		
N07041					
IN 713 C	5391	655		N07713	
IN 713 LC	5377		B50T1239		
Inconel 718	5383	649, 1469, 1490	B50TF68, B50TF16		
MAR M 509		647	B50TF89		
Inconel 722			B50T1234, B50WB22	N07722	
IN 792 + Hf		1456			
IN 738		1451	B50A563		
IN 939		1495			
Inco X-750				N07750	
René 77			C50TF15, C50T67		
René 80			C50TF47, C50TF28		
René 100			C50T188		
René 120			C50TF42, C50TF48		
René 125			C50TF60		
MAR M 200		659		N13009	
MAR M 247		1447, 1489	B50A467		
U 500	5384		C50T39, C50T55	N07500	
Waspalloy		652, 1471			
Astroloy			B50T61	N13017	
N13017					
B1900	5405	663		N13010	
MAR M302		657	B50T90		
B100		789			
INCO 706		1453			
IN 657			R20501		ASTM A-560
NX 188			643		
Thetaloy			651		

TABLE 32 – TOOL STEELS				
<i>Alloy</i>	<i>ASTM</i>	<i>UNS</i>	<i>ISO</i>	<i>Other</i>
CA-2 /IC CA-2	ASTM A 597 CA-2		TC 17/SC 11 N 422 GX100CrMoV5 (CA1)	
/IC CA-6				
CD-2 /IC CD-2	ASTM A 597 CD-2		TC 17/SC 11 N 422 GX150CrMoCoV11 (CB1)	
/IC CD-3				
D-5 /IC CD-5	ASTM A 597 CD-5		TC 17/SC 11 N 422 GX140CrCoMoNiV11 (CCI)	
/IC CD-6				
/IC CD-7				
/IC CH-11				
CH-12 /IC CH-12	ASTM A 597 CH-12		TC 17/SC 11 N 422 GX35CrMoWV5 (CG1)	
CH-13 /IC CH-13	ASTM A 597 CH-13		TC 17/SC 11 N 422 GX37CrMoV5 (CH1)	
/IC CL-6				
CM-2 /IC CM-2	ASTM A 597 CM-2		TC 17/SC 11 N 422 GX83WMoCrV6 (CE1)	
/IC C1-M-2				
/IC CM-4				
/IC CM-42				
/IC CM-43				
CO-1 /IC CO-1	ASTM A 597 CO-1		TC 17/SC 11 N 422 G90CrW1 (CJ1)	
/IC CO-2				
/IC CO-7				
/IC CS-1				
/IC CS-2				
/IC CS-4				
CS-5 /IC CS-5	ASTM A 597 CS-5		TC 17/SC 11 N 422 G55SiMnMo2 (CD1)	
CS-7 /IC CS-7	ASTM A 597 CS-7		TC 17/SC 11 N 422 GX50CrNi3 (CF1) – C .45/.55	
/IC CT-1				
/IC CT-2				
/IC CT-6				

TABLE 33 – TITANIUM BASE ALLOYS – CROSS REFERENCES				
<i>Alloy</i>	<i>UNS</i>	<i>ASTM</i>	<i>AMS</i>	<i>OTHERS</i>
Grade C2		ASTM B 367 Grade C2		
Grade C3		ASTM B 367 Grade C3		
Ti-Pd7B		ASTM B 367 Grade Pd7B		
Ti-Pd8A		ASTM B 367 Grade Pd8A		
Ti-Pd16		ASTM B 367 Grade Pd16		
Ti-Pd17		ASTM B 367 Grade Pd17		
6Al -4V	UNS R56400	ASTM B 367 Grade C5		
F 1108	UNS R56406	ASTM F 1108		
5Al -2.5Sn		ASTM B 367 Grade C6		
8Al-1Mo-1V	UNS R54810			
6Al-2Mo-4Zr-2Sn	UNS R54620			
Grade C12	UNS R533400	ASTM B 367 Grade 12		
3Al -2.5Sn - Pd		ASTM B 367 Grade Pd18		
4Al -2.5V -Fe	R54250	ASTM B 367 Grade C38		