

# *All Metals & Forge*

**Ferrous & Non-Ferrous Materials**

**A SERVICE CENTER  
& FORGE FACILITY**

**SUPPLYING  
GLOBAL MARKETS**



**STOCKLIST & REFERENCE MANUAL NO. 751**





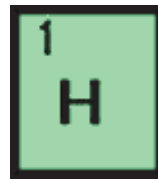
# Steelforge.com - A Site to Behold

as seen on CNBC & CBS NEWS



## Ferrous/Non-Ferrous Materials Overview

If you buy, specify or recommend metals, this is a must read! We use this overview for all of our in house training programs.



## Periodic Table of Elements

Use this interactive table to find information on all the elements. Info includes history characteristics, market pricing.



## SteelLog

Search AM&F's glossary of 5000 metal and metal working terms.



## SteelWeights

FREE DOWNLOADABLE SOFTWARE!

Automatically calculate the weight of any metal, shape or part configuration.



## AlloyInfo Reports

View materials properties on 3500 metals including chemistry and mechanical properties plus machining and application data.



## MetalsWatch

AM&F's bi-monthly newsletter, including archives since 1994



## Specifications

1000's of product specifications!



## Metric Conversion

An automated metric conversion utility; a real time saver!

**Coming Soon! Fall '03**

## Specification Cross Index

160,000 International materials specifications

## Business & Financial News

Domestic & International business, financial news, weather (750 global cities), stock prices (U.S. & European markets . . . ongoing updates!

## E-Mail News Alert

Daily news alerts - you choose the subjects - FREE!!



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### IMPORTANT ORDERING & INQUIRY INFORMATION

The Industrial Purchasing Agent is keenly aware of the necessity of precise, prompt, and competitive quotation information from their raw material suppliers, therefore to serve your requirements to the fullest and most competitively, we request that when calling our Sales Executives that you have as much of the following information as possible:

1. Delivery (Immediate or Future), 2. Alloy or Grade (Required or Alternate), 3. Specification (Material, Heat Treatment, Testing, Etc.), 4. Size (Regarding Forgings - FINISHED SIZE, PLEASE), 5. Quantity (Immediate or Scheduled), 6. Delivery (Now or Scheduled)

The information in this reference manual is correct to the best of our knowledge. We assume no responsibility for errors or omissions. All Metals & Steel publishes this Reference Manual for our customers and reserves the right to add or delete information without notification.

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## Products & Services

*the facilities and capabilities to SOLVE YOUR STEEL PROBLEMS*

A service center & forge facility ALL METALS & FORGE is your ISO 9001:2000 & AS 9100:2001 source for open-die forgings, rolled rings and specialty steels in stock. Our highly trained representatives review your situation and initiate a selection process to meet your needs. Metallurgists, engineers and quality control personnel investigate and formulate answers to your special problems.

**SPECIALTY STEELS** Specialty Steels, High Temperature Alloys, Corrosion Resistant Alloys, Nickel Alloys, Cobalt Alloys, Stainless Steel, Titanium, Aluminum, Alloy Steel, Carbon Steel, Tool Steel, Tungsten, Molybdenum, Trade Named Metals and Foreign Speced Materials.

**ALL MILL FORMS** Sheet, Strip, Plate, Bar, Rounds, Wire, Tubing, Pipe, Fittings, Flanges, Forging Billet and Custom Open-Die Forged Products and Rolled Rings (rectangular and contoured up to 160"/4050 mm)

**OPEN-DIE FORGINGS & ROLLED RINGS** Rolled Rings (rectangular and contoured up to 160"/4050 mm), Discs, Hubs, Blocks, Shafts, Sleeves & Cylinders, Bars & Rounds, Flanged Shafts, Custom Shapes . . . All custom fabricated to your specifications.

**COLD & HOT FORMING** Martenstic, Ferritic, Austenitic, Springback, Rod, Bar & Wire.

**DESIGNER ALLOYS - YOU DESIGN IT! WE MELT IT! FORM IT! AND SHIP IT!** See page 6.

**HEAT TREATING** Quenching, Annealing, Normalizing, Tempering, Surface (Case) Hardening and other heating and cooling processes.

**CUTTING** Cold Shearing, Melting, Thermal, Plasma & Powder Cutting, Arc-Air Gouging, Water Jet Cutting

**MACHINING** Drilling, Milling, Reaming, Sawing, Tapping, Threading, Turning, Boring

**JOINING** Mechanical Fastening, Brazing, Soldering, Resistance Welding, Fusion Welding, SMAW, SAW, GTAW, GMAW, PAW & EBW

**FINISHING** Hot & Cold Rolling, Annealing, Descaling, Polishing, Brushing, Buffing, Grinding, Anodizing

## Quality Assurance

*the quality program to SOLVE YOUR STEEL PROBLEMS*

In September 1997, SAE (The Society of Automotive Engineering) in conjunction with Boeing, General Electric and United Technologies, unveiled its aerospace version of ISO 9000, called "AS9000". It's main purpose is to specifically address the aerospace industry's quality issues and alleviate quality program redundancy from one aerospace company to another. This would help lower costs so that manufacturing and supply companies would not need to have multiple quality programs in place. The bottom line is to increase quality, while lowering the per unit cost to the end-user.

Effective January 20, 1998, All Metals & Forge became the first metal & forging supply company in the United States to attain certification under the new AS9000 program. All Metals & Forge has maintained the ISO 9002 certification since March 1994. This demonstrates that All Metals & Forge's quality improvement program is in place, continuing to grow and taking a leadership role in the metals supply industry. The new updated registration is ISO 9000:2000 and AS9100.

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## Business Development

*working as partners to SOLVE YOUR STEEL PROBLEMS*

**BUSINESS DEVELOPMENT** Partnering. This industry trend is shaping the way All Metals & Forge does business today. We are developing closer customer relations and taking on a larger role in the total supply and manufacturing chain. A closer connection with our customers' is key. Our ability to anticipate customers' needs, willingness to become involved with their business, and our capacity of responding quickly and cost effectively have established All Metals & Forge as a premiere vendor. Today we forge more than metal, we forge relationships that lead to solutions.

**PROJECT PLANNING** The project management team at All Metals & Forge recognizes the benefits of helping you formulate solutions from the inception stage of your project. We can be instrumental in every phase from selection of raw materials to recommendation of proper finishing techniques and even shipping and warehousing.

**ENGINEERING COLLABORATION** Allow our experts to review your drawings and make recommendations on how to keep costs to a minimum. Over our many years of experience, we have developed many cost-saving methods of production which we are glad to share with you.

**INVENTORY PROGRAMS** At the times when the economies of scale dictate the manufacture of excess units or when you need product on an on-demand basis but lack warehousing facilities, call All Metals & Forge.

**CONSULTING ASSIGNMENTS** Certain steel requirements command a single source responsibility for all operations. You can trust All Metals & Forge. We guarantee accuracy and timely documentation including certification of tests and all procedures. Our documented quality program meets and exceeds ISO 9001:2000 and AS9100 requirements.

## Information Resources

*supplying the tools to SOLVE YOUR STEEL PROBLEMS*

**ALLOY INFO REPORTS** Instant Reports on the Internet. Complete chemistry, physicals, specifications, heat treatment, machinability, design characteristics, availability, costing - **Over 3000 Alloys** • Stainless Steels • Nickel • Titanium • Aluminum • Alloy Steel • Tool Steel • Tungsten • Carbon • Molybdenum • Trade Named Metals - Downloadable from our website.

**STEELWEIGHTS ON-LINE** Instant Calculations for All Alloys. Finally, you can estimate weight of product you need. **Free Downloadable Software**, or operates from our website [steelforge.com](http://steelforge.com).

**METALSWATCH** Bi-monthly Newsletter, since 1994, published by All Metals & Forge and Purchasing Magazine Executive Editor, Thomas Stundza. Each issue packed with cutting-edge info, trends, market analysis . . . everything you need to keep you in the know! Features: Cover Story, Metal Chips, Purchasing Focus & MetalsWatch Extra - Downloadable from our website.

**STEELLOG** A Metallurgical Dictionary. SteeLog provides over 5000 common and uncommon metallurgical and metalworking terms and their definitions. Handy and useful formulas to help with your daily calculations.

**SPECIFICATION CROSS INDEX** 160,000 International materials specifications.

**ELECTRONIC INQUIRIES** Buyers who need price quotes NOW visit our website. Our VIP Priority Service assures a quick response to your requirements via your fax machine or e-mail.

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## What is a Designer Alloy?

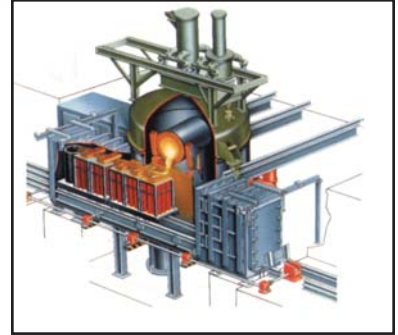


### CUSTOM ALLOYS

*Customer specific designer alloys*

### EXISTING ALLOYS

*Requiring controlled chemistry  
Requiring quicker delivery  
Needed in small heat lots*



### VACUUM MELT ALLOYS

*Usually available airmelt only*

### FOREIGN ALLOYS

*Not available in USA*



### OBSOLETE

*or out of date alloys*

## Air or Vacuum Melted Designer Alloys

IN HEAT LOTS AS SMALL AS 250 LBS

- *Stainless Steel (300-400-500) • Nickel Alloys • Cobalt Alloys • Super Alloys • Ph Grades*
- *Alloy Steels • Carbon Steels • Tool Steels*

**FROM ROUND OR SQUARE CAST INGOT:**

- *Bar-Forged or Rolled or Drawn • Forged Products - Bars - Shafts - Step Shafts*
- *Blocks - Hubs - Rings (Seamless or Welded - Contoured or Conventional)*
- *Extrusions - Bar - Shapes - Tube - Pipe • Wire*

**FROM FLAT CAST SLAB:**

- *Plate • Sheet • Strip • Flat Bar*

## When You Need It, And Can't Find It!

**YOU DESIGN IT - WE MELT IT, FORM IT & SHIP IT!**



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**NAM** National Association of Manufacturers

MEMBER FORGING INDUSTRY ASSOC.



# Stocklist



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ALLOY	SHAPES									PARTIAL LIST OF SPECIFICATIONS						
	Round	Hexagon	Square	Flat	Strip	Sheet	Plate	Tubing	Pipe	*ASME Same as ASTM With Prefix "S" Used				Others Available		
										AISI	AMS	*ASTM	MILITARY	FED	CORPORATE	
Alloy #25 (L-605)	✓	•	✓	✓	✓	✓	✓	•	•	670	5537 5759 5796 5097	F-90	R-5031		B50R278 B50T26 B50T1270 PWA1032	B50R301 B50T59 B50TF1 PWA1064
N-155 (Multimet)	✓	•	✓	✓	✓	✓	✓	•	•	661	5531 5532 5585 5768 5769	AA61 A567 A639	R-5031 E-6844			
PH-13-8-MO	✓	•	✓	✓			✓	•	•		5629 5840	A564			DMS-2100 BMS-7-189 STMO-5-602	
15-5 PH	✓	✓	✓	✓	✓	✓	✓	✓	•		5658 5659					
15-7 MO	✓				✓	✓	•			632	5520 5657	A461 A564	S-8955			
16-25-6 MO	✓	•	✓	✓			✓	•	•	650	5725 5727 5728	A457 A458 A477	S-16538		B50R106 B50R289	
17-4-PH	✓	✓	✓	✓	✓	✓	✓	✓	•	630	5604 5622 6543	A461 A564	C-24111 S-862 S-81506	S-763	B50TF4 B50T102 MBO-160-003 LBO-160-133	B50T62
17-7 PH	✓		✓	✓	✓	✓				631	5528 5529 5568 5644 5673 5824	A313 A461 A564	S-25043 W-46078	S-763 S-788	B50R280 B50T62	
17-22 (A) 17-22 (AS) 17-22	✓								✓	601	6304 6302	A193	S-11595		B50T10 PWA733 PWA749 PWA768 B50T19	B50T1135 PWA749 PWA722
Haynes Alloy 188	✓	•	•	•	✓	✓					5608 5772				B50TF73 PWA641 PWA1042	B50TF74 PWA1015
Haynes Alloy 230	✓	•	•	•	✓	✓	✓				5878 5891	B435 B564 B572 B619 B626	N06230			
19-9 DL	✓				✓	✓	✓	✓		651	5526 5527 5579 5720 5721 5722	A453 A457 A458 A477	S-46042			
21-6-9 (Nitronic 40)	✓	•	•	•	✓	✓	✓	•			5596 5656	A276 A580	T-9821			
22-4-9 (Nitronic 60)	✓	•	•	•			✓					A479				
22-13-5 (Nitronic 50)	✓	•	•	•							5764	A479				
M252	✓	•	•	•						689	5551 5756 5757	A637			B50R327 C50T30	
A-286	✓	✓	✓	✓	✓	✓	✓	✓	✓	660	5525 5731 5732 5734 5735 5736 5737 5804	A453 A461 A638			B50A369 B50T12 B50T1180 B21B74 C50T1028 M-3702 MBO-160-029	B50R313 B50T81 B50T1181 C50T41 PWA1075
300-M(4349 MOD)	✓	•	✓	✓				✓			6416 6417 6419		S-8844 S-83135		EMS-96244 BMS-726 DMS-1935	

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ALLOY	SHAPES										PARTIAL LIST OF SPECIFICATIONS				
	Round	Hexagon	Square	Flat	Strip	Sheet	Plate	Tubing	Pipe	*ASME Same as ASTM With Prefix "S" Used				Others Available	
										ASIS	AMS	*ASTM	MILITARY	FED	CORPORATE
AM-350	✓	•	•	✓	✓	✓	✓			633	5546 5548 5554 5745 5774 5775		S-8840	S-763	
AM-355	✓	•	•	•	✓	✓	✓			634	5547 5549 5594 5743 5744 5780 5781	A461 A565	S8840	S-763	B50T1138 B50T1147 C50T1073 LBO-160-107 M-3703
Aquamet 17 (17-4PH)	✓	•	•	•											
Aquamet 18 (304)	✓														
Aquamet 19(Sealoy)	✓														
Aquamet 22(Nitronic 50)	✓	•	•	•											
Almar	✓	✓	✓	✓							5739 5740	A564	S46123		
Custom 450	✓	✓	✓	✓							5763	A564			
Custom 455	✓	✓	✓	✓							5578 5617 5672 5860	A313 A564			
U-500	✓	✓	✓	✓							5751 5753	A567 A637			C50T39 PWAA688
W-545	✓				✓	✓	✓				5543 5741	A453			
S-590	✓				✓	✓	✓				5533 5570				
U-700	✓	•	•	•											PWAA689 PWA1020
S-816	✓	•	•	•							5534 5765	A461 A639			B50A131 B50R312
D-979	✓				✓	✓	✓				5509				
Carpenter #20CB3											5746				
Astroloy	✓														PWA1013 PWA1076
Astroloy V	✓						✓						S81378		MILS3178
Carpenter #10	✓											A493			
Carpenter #20 CB3	✓				✓	✓	✓	✓	✓			B462 B463 B464 B468 B471 B472 B474 B475			
Carpenter #49	✓				✓	✓							N-14411 N-22840		PWA774 PWA775
AL-4750	✓	•	•	•	✓	✓							N-14411 N-22840		PWA774 PWA775
Columbium (Niobium)	✓		✓	✓	✓	✓		✓			7850				
Columbium 10W-2.5ZR	✓			✓	✓	✓					7851 7855				
Discaloy A-286	✓	✓	✓	✓	✓	✓	✓			662	5733	A453 A461 A638			
Elgiloy	✓			✓	✓								C-45662		
Greek Ascology	✓	✓	✓	✓	•					615	5508 5616 5817	A565			B50T30
Hastelloy B-2	✓	•	✓	✓	✓	✓	✓	✓	✓			B295 A296 B304 B333 B335 A494			B50R91 B50T38 RBO-170-003
Hastelloy C-276	✓	•	✓	✓	✓	✓	✓	✓	✓			B574 B575			PWA1078
Hastelloy G, G2, G3	✓						•					B626			

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										AIISI	AMS	*ASTM	MILITARY	FED	CORPORATE
Hastelloy N	✓				✓	✓					5511	B366 B434 B573			PWA1012 PWA1036
Hastelloy W	✓				•	•					5755 5786 5787				B21B71 (B50R239)
Hastelloy X	✓	•	✓	✓	✓	✓	•	•	680	5536 5587 5754 5798 5799	A567 B336 B572			B50T79 B50TF83 B50TF25 PWA1038 PWA1066	
Heavy Metal (Tungsten Base)	✓		✓	✓						7725			T-21014		
High Expansion	✓									5624 5625					
Hipernik	✓				✓	✓							N-14411 N-22840		PWA774 PWA775
Hipernom Incoloy 800-800H	✓			✓	✓	✓	✓	✓		5766	B163 B336 B407 B408 B409 B514 B515 B564		N144411		
Incoloy 801 (T)	✓				✓	✓	✓			5552 5742					B50T9
Incoloy 802	✓						✓								
Incoloy 825	✓				✓	✓	✓	✓			B163 B423 B424 B425				
Incoloy 901	✓	•	•	•					681 682	5660 5661					PWA1003 PWA1022 PWA1024 PWA1047
Incoloy 902 (Ni-Span-C)						•				5221					
Inconel 600	✓	✓	✓	✓	✓	✓	✓	✓		5540 5580 5665 5683 5687	B163 B166 B167 B168	N6710 N-6840 N-15721 N-22986 N-22978 N-23228 T-7840	W-390	E14H22 B50R51 B50R238 PWA1060 PWA1062 PWA1070	
Inconel 601	✓	✓			✓	✓	✓	✓		5717 5870					PWA1044 PWA1059
Inconel 617	✓	•	•	•	✓	✓	✓	✓							
Inconel 625	✓	•	✓	✓	✓	✓	✓	✓		5599 5666 5837	B443 B444 B446				B50T92 PWA1069 PWA1072
Inconel 702	✓	•	✓	✓	✓	✓	✓	✓		5550					B50T37
Inconel 706	✓	•	•	•	✓	✓	✓			5605 5606 5701 5702 5703					PWA1025 PWA1026 PWA1043
Inconel 718	✓	•	✓	✓	✓	✓	✓	✓		5589 5590 5596 5597 5662 5663 5664 5832	A637 A670	N-24469			B50T68 B50T69 B50TF2 B50TF14 B50TF15 C50T82 PWA1009 PWA1010 PWA1048 PWA1065 EMS-581 RBO-170-101 MBO-171-041

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										AIISI	AMS	*ASTM	MILITARY	FED	CORPORATE
Inconel 722 (W)	✓	•	•	✓	✓	✓	✓	✓	✓		5541 5714				B50R156 B50T33 BSQT73 B50T1233
Inconel 725	✓	✓	✓	✓	✓	✓	✓	✓	✓			B805			UNSO7725
Inconel X-750	✓	•	✓	✓	✓	✓	✓	✓	✓	633	5542 5582 5598 5667 5668 5669 5670 5671 5698	A461 A637	N-7786 N-8550 N-24114 R-5031 S-21977	W-562	B50R216 B50YP44 B50T1232 PWA1031 PWA1063
Inconel X-751	✓														
Invar 36 (Super Invar)	✓	•	✓	✓	✓	✓	✓	•	•				T-23011 S-16598		
Invar 42	•	•	•	•											
Invar 36FM	✓	•	✓	✓	✓		✓						I-23011 S-16598		PWA772
42% Ni-Fe	✓				✓	✓	✓						I23011		PWA733
46%Ni-Fe	✓				✓	✓	✓						I-23011		
49% Ni-Fe	✓				✓	✓	✓						N-14411 N-22840		
52% Ni-Fe	✓				✓	✓	✓						L-23011		
Kovar	✓	•	•	•	✓	✓	✓	✓	••		7726 7727 7728		I-23011		
Lapellov	✓											A565			B50B311
Maraging "250"	✓	•	•	•							6512		S-46850		PWA734
Maraging "300"	✓	•	•	•							6514		S46850		HMS6-1404 LBO-160-164 MBO-160-006
Maraging "350"	✓	•	•	•											
Molybdenum (Sintered/Arc Cast)	✓		✓	✓	✓	✓	✓	✓			7800 7801 7805 7806 7807				B24B3
Molybdeum + .5% Ti	✓		✓	✓	✓	✓	✓				7811 7823 7817				
Molybdenum TZM	✓				✓	✓	✓	✓							
Moly Permalloy	✓				✓	✓	✓	✓			7701 7702 7705		N-14411		
Mu Metal				✓	✓	✓	✓		•		7701 7702 7705		N-14411		
HyMu-80	✓	•	✓	✓	✓	✓	✓				7701 7702 7705		N-14411		
MP35N (Multiphase)	✓	•	•	•							5758 5844 5845				
MP 159	✓	•	•								7475				
Monel 400	✓	✓	✓	✓	✓	✓	✓	✓	✓		4544 4574 4575 4675 4730 4731	B127 B163 B164 B165 B366 B395	N-894 N-24106 T-842 T-1368 T-23520	N-281	B14H3 B14H23 B50R209
Monel 404	✓	•	•	•	✓	✓	✓							N-281	
Monel R-405	✓	•	•	•							4674	B164	N-894	N-286	B14H25
Monel K-500	✓		✓				✓				4676		F-23999 N-17406 W-4471		
Monel 502	✓		✓								4677		N-17506	N-286	
Nickel 200	✓	•	•	✓	✓	✓	✓	✓	•			B160 B161 B162 B336 F175	N-19153 N-46025 N46026	N-301	PWA6000 PWA6010 PWA6015

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ALLOY	SHAPES									PARTIAL LIST OF SPECIFICATIONS					
	Round	Hexagon	Square	Flat	Strip	Sheet	Plate	Tubing	Pipe	*ASME Same as ASTM With Prefix "S" Used			Others Available		
										AISI	AMS	*ASTM	MILITARY	FED	CORPORATE
Nickel 201	✓		✓	✓	✓	✓	✓	✓	✓			B160 B161 B162 B163 B336			PWA6000 PWA6010 PWA6015
Nickel 205	✓										5555	F9	N-46025		
Nickel 270	✓											F239			
TD Nickel	✓														PWA1014 PWA1035
Nichrome "V"	✓		✓								5676 5677 5682	B344 B446			
Nimonic 75	✓				✓	✓						A637			PWA673
Nimonic 80A & 90	✓	•	•	•	✓	✓									
Nitralloy 135 MOD	✓										6470 6471 6472	A355	S-869 S-6709		B50R263
Nitronic 40 (21-6-9)	✓	•	•	•	✓	✓	✓				5656	A276			
Nitronic 50 (22-13-5)	✓	•	•	•							5764	A479			
Nitronic 60 (22-4-9)	✓	•	•	•								A479			
Pyromet X-15	✓										5761				
Rene 41	✓		✓	✓	✓	✓	✓			683	5545 5712 5713 5800	A461			B14H177 B50T44 B50T59 B50TF9 B50TF75 B50TF76 C50T71 EM-565
Rhenium Alloys	✓		✓	✓	✓										
Molybdenum-Rhenium															
Tungsten-Rhenium															
Super Invar	✓	•	•	•	✓	✓	✓								
Tantalum	✓			✓	✓	✓	✓	✓			7849				
Tantalum 10W	✓			✓	✓	✓	✓				7847 7848				
Titanium (C.P.) A30 35A A40 50A A55 65A A70 75A 100A	✓	•	✓	✓	✓	✓	✓	✓	✓		4900 4901 4902 4921 4941	B265 B337 B338 B348 F-67	T-7993 T-9046 T-9047 T-12117		B50R291 B50T1 B50R292 B50R325 B50R326 B50R328
Titanium Ti-17	•	•	•												B50TF57
Titanium 3AL-2.5								✓	✓						
Titanium 4AL-3Mo-1V	✓										4912		T-9046		
Titanium 4AL-4Mn	✓										4925		T-9047		
Titanium 5AL-2.5Sn	✓		✓	✓	✓	✓	✓				4909 4910 4924 4953 4966 4926	B265 B348 B367	T-9046 T-9047 F-83142		
Titanium 6AL-2Sn-4Zr-2Mo	✓			✓	✓	✓	✓				4975 4976		T-9046 T-9047		PWA1209 PWA1210 PWA1212 PWA1214 PWA1218
Titanium 6AL-Sn-4Zr-Mo	✓										4981	B265	T-9046		PWA1212 PWA1216 PWA1219 PWA1220
Titanium 6AL-4V	✓	✓	✓	✓	✓	✓	✓				4906 4907 4911 4928 4930 4954 4965 4966	B265 B338 B367	T-9046 T-9047		PWA1215 PWA1217 DMS-1570 M-3400
Titanium 6AL-6V-2Sv	✓	•	•	✓	✓	✓	✓				4918 4970 4971 4978	B381	T-9046 T-9047 F-83142		PWA1207 [WA1208
Titanium 7AL-4Mo	✓			✓							4970		T-9047		
Titanium 8Mn	✓			✓	✓	✓					4908		T-9046		

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										AIISI	AMS	*ASTM	MILITARY	FED	CORPORATE
Titanium 8AL-1Mo-IV	✓	•	•	✓	✓	✓	✓				4915 4916 4972 4973		T-9046 T-9047		PWA1202 PWA1204 PWA217
Titanium 13-5V-11Cr-3AL	✓				✓	✓	✓				4917		T-9046 T-9047		
TPA	✓										5700				
Tungsten	✓		✓	✓	✓	✓	✓				7897 7898 7899				
Tungsten Base-Heavy Metal	✓		✓	✓							7725				
Tungsten-Moly 10% 15% 30% 40% 50%	✓				✓	✓	✓								
Tungsten-Thoria 1% 1.5% 2% 4%	✓				✓	✓									
Vascojet 1000 (H-11)	✓	✓	✓								6437 6485 6487 6488	A681	T-570		HBO-160-001 MMS-260 EMS-642
Waspalloy	✓	•	•	•	✓	✓	✓	✓		685	5544 5586 5704 5706 5707 5709 5828	A641 A637			PWA686 PWA1004 PWA1005 PWA1007 PWA1016 PWA1027
Zirconium	✓		✓	✓	✓	✓	✓					B350			
Zircalloy No. 2	✓		✓	✓								B350			
Zircalloy No. 4	✓		✓	✓								B350			
201	✓				✓	✓	✓			201	A412 A429 A666		S-17996	S-766	
202	✓				✓	✓	✓			202	A314 A429 A473	A412		S-763 S-766	
2205 Duplex	✓	•	•	•	✓	✓	•								
Ferralium 255							•					A479			
301-Sheet/Strip in All Tempers, Annealed 1/4H 1/2H 3/4H FH					✓	✓				301	5517 5518 5519	A167 A177 A264 A314 A368 A666	S-5059 T-5695	S-682 S-763 S-766	B50R167
302-Bars Available in Condition "B" Sheet/Strip in Various Tempers	✓	✓	✓	✓	✓	✓	✓	✓		302	5515 5516 5560 5565 5636 5637 5688	A167 A177 A217 A240 A264 A276 A296 A313 A314 A368 A473 A492 A479 A493 A511 A580 A666	S-8531 S-854 S-862 S-5059 S-7720 S-46044 T-5677 W-6712	S-763 S-766 S-854 W-423	B7A2 B7A23 B7A27B
303 Bars Available in Condition "B"	✓	✓	✓	✓		✓				303	5640	A194 A314 A320 A473 A581 A582	S-853 S-862 S-7720 W-52263	S-763 S-764	B7A13 B50R331
303-SE Bars Available in Condition "B"	✓	✓	✓	✓						302-SE	5640 5641 5738	A194 A314 A320 A473 A511 A581 A582	S-7720 W-52263	S-763 S-764	
304 Bars Available in Condition "B"	✓	✓	✓	✓	✓	✓	✓	✓		304	5501 5513 5560 5565 5566 5567 5639 5697	A167 A177 A193 A213 A240 A249 A268 A270 A271 A276 A312 A313 A314 A320 A336 A358 A376 A409 A430 A473 A478 A479 A492 A493	F-20138 P-1144 S-853 S-854 S-862 S-4043 S-5059 S-7720 S-18170 S-18171 S-23195 S-23196	S-763 S766 W-423	B7A17 B7A31

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										AIISI	AMS	*ASTM	MILITARY	FED	CORPORATE	
304-L	✓	✓	✓	✓	✓	✓	✓	✓	✓	304L	5511 5647	A167 A213 A240 A249 A268 A276 A312 A314 A473 A478 A479 A511 A580 A632	S-853 S-854 S-862 S-4043 S-18170 S-18171 S-22216 S-23195 S-23196 T-18063		S-763 S-766	DMS-2050 MBO-160-034
305	✓				✓				✓	305	5514 5685 5686	A167 A176 A240 A249 A276 A313 A314 A473 A478 A492 A493 A511 A580	W-3068 W-17481		S-423 S-763 S-706 W-409 W-423	
309	✓	✓	✓	✓	✓	✓	✓	✓		309		A167 A249 A276 A312 A314 A358 A409 A473 A511 A580	E-19933 R-5031 S-862		S-763 S-766	
309-S	✓	✓	✓	✓	✓	✓	✓	✓		309S	5523 5574 5650	A167 A240 A278 A314 A473 A511 A580			S-763 S-766	
310	✓	✓	✓	✓	✓	✓	✓	✓	✓	310	5521 5572 5577 5651 5694 5695	A167 A182 A213 A249 A264 A276 A298 A312 A314 A336 A358 A409 A473 A511 A580 A632	E-19933 N-15721 R-5031 S-853 S-854 S-862 S22216 W-17481		S-763 S-766 W-423	B50R130 B50R243
314	✓									314	5522 5652	A276 A314 A473 A580				
316	✓	✓	✓	✓	✓	✓	✓	✓	✓	316	5524 5573 5648 5690	A167 A182 A193 A194 A213 A240 A249 A269 A276 A298 A312 A313 A314 A320 A336 A358	E-16715 E-19933 S-854 S-862 S-1144 S-5059 S-7720		S-763 S-766 W-432	B21B69 B50R67
316L	✓	✓	✓	✓	✓	✓	✓	✓	✓	316L	5507 5653	A167 A182 A213 A240 A249 A269 A276 A298 A312 A314 A473 A478	E-19933 E-5031 S-862 S-7720		S-763 S-766	
317-317L	✓	✓	✓	✓	✓	✓	✓	✓	✓	317 317L		A167 A240 A249 A269 A276 A298 A312 A314 A409 A473	E-19933 S-862		S-763	
321	✓	✓	✓	✓	✓	✓	✓	✓	✓	321	5510 5557 5559 5570 5576 5645 5689	A167 A182 A193 A194 A213 A240 A249 A264 A269 A271 A276 A312 A314 A320 A336 A358 A376 A409 A403 A473	E-1993 P-1144 S-853 S-862 S-6721 S-22216 T-6721 T-6737 T-8606 T-8808		S-763 S-766	B7A26 B21B65 B50R142 B50T1182 B50TA100

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	Round	Hexagon	Square	Flat	Strip	Sheet	Plate	Tubing	Pipe	*ASME Same as ASTM With Prefix "S" Used				Others Available		
										AISI	AMS	*ASTM	MILITARY	FED	CORPORATE	
322	✓									322						
329	✓									329		A268 A511				
330	✓	•	•	✓	✓	✓	✓	✓	✓	330	5592 5716	B511 B512 B535 B536				
333	✓	•	•	✓	✓	✓	✓	✓	✓		5593 5717					
347	✓	✓	✓	✓	✓	✓	✓	✓	✓		5512 5556 5558 5571 5575 5646 5654 5674 5680 5681	A167 A182 A193 A213 A240 A249 A269 A271 A276 A312 A314 A320 A336 A358 A376 A409 A430 A473 A479 A493	E-16715 E-199933 R-5031 S-853 S-862 S-6721 S-18063 S-18170 S-18171 S-23195	S-763 S-766	B7A18 B21B17 B21B30 B50R137 B50R227 PWA767 PWA770 PWA776	
348	✓	✓	✓	✓						338		A167 A182 A213 A240 A249 A269 A276 A312 A314 A358 A376 A409	S-6721 S-18171 S-23195 S-23196	S-766		
403	✓	•	✓	✓	✓	✓	✓	✓	✓	403	5611 5612	A176 A276 A314 A473 A511 A580	S-861 S-862	S-763	B50R207 B50T1132 C50T43 B7B20	
405	✓	•	✓	✓	✓	✓	✓	✓	✓	405	5628	A176 A240 A268 A276 A314 A473 A511 A580	S-861 S-862	S-763	B7B19	
409					✓	✓	✓			409		A176 A268 A651				
410	✓	✓	✓	✓	✓	✓	✓	✓	✓	410	5504 5505 5591 5612 5613 5776 5777 5821	A176 A182 A193 A240 A268 A276 A314 A336 A473 A493 A511 A579 A580	E-19933 S-854 S-861 S-862 W-17481	S-763 S-766 W-423	B7B1 B7B2 B7B21 B21B77 B50R226 B50R236 DMS1612	
414	✓	•	•	•						414	5615	A276 A314 A473 A511 A580	S-862	S-763		
416	✓	✓	✓	✓			✓			416	5610 5611	A193 A276 A314 A473 A581 A582	S-853 S-854 S-861 S-862 W-52263 W-52263	S-763 S-764	B5A B7A5 B7B5	
416-SE	✓	✓	✓	✓						416-SE	5610	A276 A324 A473 A581 A582		S-763 S-764		
418 (Greek Ascoloy)	✓	•	•	•							5616	A565				
420	✓		✓	✓	✓	✓	✓	✓	✓	420	5506 5619 5621	A276 A314 A473 A580	S-853 S-862 S-8142 W-17481	S-763 S-764 S-766 W-409 W-423	B7B25	
420-F	✓									420-F	5620	A276 A314 A473		S-764		
422	✓	•	•	•						422	5655	A437 A565 A579	S-861		B50AM422 B50A125	
429	✓				✓	✓	✓	✓		429		A179 A240 A268 A276 A314 A473 A493	S-763 S-766			
430	✓	✓	✓	✓	✓	✓	✓	✓	✓	430	5503 5627	A176 A240 A263 A268 A276 A314 A473 A493 A511 A580	S-853 S-854 S-862 W-17481	S-763 S-766 W-423	B7B6 B7B10 B50R52	
430-F	✓	✓	✓	✓						430-F	5620	A276 A314 A473 A581 A582	S-862 W-52263	S-763 S-764		

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										AISI	AMS	*ASTM	MILITARY	FED	CORPORATE
431	✓	✓	✓	✓						431	5628	A276 A314 A473 A493 A579 A580	S-18732 S-86213	S-763	DMS-1565
434					✓	✓				434		A651			
439												A268			
440-A	✓	✓	✓	✓	✓					440-A	5631	A276 A314 A331 A473 A511 A580	S-862	S-763	B7B17
440-B	✓	✓	✓							440-B		A276 A314 A473 A580	S-862	S-763	
440-C	✓	✓	✓	✓			✓			440-C	5818 5630	A276 A314 A473 A493 A580	S-862	S-763	B7B11 PWA765 LBO-160-151 MBO-160-021
440-F	✓	✓	✓	✓						440-F			S-862	S-763	B50R250
442					✓	✓	✓			442		A176		S-763	B50A125
446	✓	✓	✓	✓	✓	✓	✓	✓	✓	446		A176 A268 A276 A314 A473 A511 A580	S-862 S-13336	S-766	B7B3
501-502	✓				✓	✓	✓			501	5502 5602 5614	A182 A193 A314 A473 A357			
D6AC	✓	•	✓	✓							6431		S-8949		FMS-1-11 LCM-05-2190
H-11 (Vascojet 1000)	✓	✓	✓	•						610	6437 6437 6485 6487 6489	A681		T-570	HBO-160-001 MMS-260 EMS-642 PWA726
Hy-Tuf	✓			✓							6418		S-7108		DMS-1841
4130- Commercial & Aircraft	✓	✓	✓	✓	✓	✓	✓	✓	✓	4130	6350 6351 6361 6362 6370 6371 6373	A274 A304 A322 A331 A372 A505 A519 A646	S-6758 S-16974 S-18729 T-6731 T-6736	S-624 S626 S-627 S629 S-671 T-825	B5F16 B50R141
4140- Commercial & Aircraft	✓	✓	✓	✓	✓	✓	✓	✓	✓	4140	6378 6379 6381 6382 6390 6395	A193 A274 A304 A320 A322 A331 A434 A505 A519 A547 A646	S-5626 S-13040 S-16974	S-624 S-627 S-671	B50R42
4150	✓	✓								4150		A322	S-11595		
4330 MOS. Commercial & Aircraft	✓		✓	✓							6411 6427	A292 A293	S-8699		BMS-7-7 BMS-7-122 EMS-96242 FMS-1012 GM-1010 CE-0906
4340-Commercial & Aircraft	✓	✓	✓	✓	✓	✓	✓	✓	✓	4340	6359 6414 6415	A274 A304 A320 A322 A331 A505 A519 A547 A646	S-5000 S-8699 S-8844 S-16974 S-21515	S-624 S-627 S-671	B50R210 B50T1041 B50T1133 B50TA306 BMS-7-28 DMS-1555 EMS-641 STM -05-502
4617	✓									4617	6292	A519	S-7493		
4620	✓									4620	6294	A274 A304 A322 A331 A505 A535	S-866 S-7493	S-624 S-671	
4820	✓									4820		A322	S-8503		
6150	✓	✓	✓	✓	✓	✓				6150	6448 6450 6455	A160 A231 A232 A274 A304 A322 A331	S-16410 S-18731 S-20145 S-46033 W-22826	S-624 S-627 S-671 S-625 W-412	
8615	✓									8615	5333	A322	S-866		
8620	✓	•	•	•				✓		8620	6274 6276 6277	A274 A304 A322 A331	S-8690 S-16974	S-624 S-626 S-671	B50R168

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										AIISI	AMS	*ASTM	MILITARY	FED	CORPORATE
8740	✓	•	•	•					8740	6322 6323 6325 6327 6358	A274 A304 A322 A331	S-6049	S-624 S-629	B50R160	
9310-Commercial & Aircraft	✓	•	✓	✓					9310	6260 6265	A274 A304 A322 A331	S-7393	S-624	B50R183 B50A315	
9315	✓	•	•	•					9315					B50R173 PWA723	
52100-GR1 & GR2	✓								52100	6440 6441 6444	A274 A295 A322 A505 A519 A535 A642	S-980 S-7420	S-624 S-771 S-788		
A2-A10	✓		✓	✓					A2		A681		T-570		
D2-D3-D5	✓		✓	✓					D2		A681		T-570		
D6	✓		✓	✓					D6		A682		T-570		
H11	✓	✓	✓	✓					610	6437 6485 6487 6488	A681		T-570	HBO-A60-001 MMS-260 EMS-642 PWA726	
H12	✓		✓	✓					H12		A681		T-570		
H13	✓		✓	✓					H13		A681		T-570		
M2	✓		✓	✓					611		A681	S-15046	T-590		
M50	✓		✓	✓				✓	M50	6490	A681				
O1	✓		✓	✓					O1		A681	S-15853	T-570		
P4-P5-P6	✓		✓	✓					P4		A681				
P20	✓		✓	✓						A681					
S1-S5-S7	✓		✓	✓					S1		A600				
T1	✓		✓	✓				✓	T1	5626			T-590		
W1-W2	✓		✓	✓					W1				T-580		

ALUMINUM	SHAPES									PARTIAL LIST OF SPECIFICATIONS			
	Round	Hexagon	Square	Flat	Strip	Sheet	Plate	Tubing	Pipe	FEDERAL	AFNOR/FRENCH	ASTM	AMS
2014 Bare & Alclad	✓	✓	✓			✓	✓	✓		QQ-A-200/2 QQ-A-225/4	A-U4SG A-U4GL	B-211 B-209	A121
2024 Bare & Alclad	✓	✓	✓			✓	✓	✓		QQ-A-225/6 QQ-A-250/5	A-U4GL	B-211 B-209	4120
2219 Bare & Alclad	✓	✓	✓							QQ-A-367	A-U6MT	B-211 B-209	4031
5052	✓	✓	✓		✓	✓	✓	✓		QQ-A-250/8	A-G2	B-209	4015
5083	✓	✓	✓		✓	✓	✓	✓		QQ-A-200/4 QQ-A-250/6	A-G5	B-221	4056
5086	✓	✓	✓		✓	✓	✓	✓		QQ-A-200/5 QQ-A-250/7	A-G5	B-211	
5154	✓	✓	✓		✓	✓	✓	✓			A-G3	B-221	4018
5252	✓	✓	✓		✓	✓	✓	✓			A-G2	B-209	
5254	✓	✓	✓		✓	✓	✓	✓				B-221	
5454	✓	✓	✓		✓	✓	✓	✓		QQ-A-200/6 QQ-A-250/10	A-G2	B-221	
5456	✓	✓	✓		✓	✓	✓	✓		QQ-A-200/7 QQ-A-200/9		B-221	
6061 Bare & Alclad	✓	✓	✓		✓	✓	✓	✓		QQ-A-200/8 QQ-A-250/11	A-G5UC	B-211	
6063	✓	✓	✓		✓	✓	✓	✓		QQ-A-200/9	A-G5	B-211	4129 4156
6151	✓	✓	✓		✓	✓	✓	✓		QQ-A-367			4125
7075 Bare & Alclad	✓	✓	✓		✓	✓	✓	✓		QQ-A-250/12 QQ-A-225/9	A-25GU	B-209	4038
7175 Bare & Alclad	✓	✓	✓		✓	✓	✓	✓		QQ-A-250/12 QQ-A-225/9	A-25GU	B-209	4038
7079 Bare & Alclad	✓	✓	✓		✓	✓	✓	✓		QQ-A-250/17 QQ-A-250/12		B-209	4024
7178 Bare & Alclad	✓	✓	✓		✓	✓	✓	✓		QQ-A-200/13 QQ-A-200/13		B-209	4051

**MAGNESIUM ALLOY**

AZ80	✓	✓	✓	✓		✓	✓					B-275	
AZ61A	✓	✓	✓	✓		✓	✓			QQ-A-M31A		B-275	
ZK60A	✓	✓	✓	✓		✓	✓					B-275	
AZ31B	✓	✓	✓	✓		✓	✓			QQ-A-M31A		B-275	

✓ IN STOCK • CUSTOM PRODUCED



## Specialty Steel Wire In Stock

### WIRE FEET PER LB. CHART

DIAMETER INCHES	FEET PER POUND	DIAMETER INCHES	FEET PER POUND	DIAMETER INCHES	FEET PER POUND
.060	103.7	.079	59.2	.098	38.2
.061	99	.080	57.7	.099	37.7
.062	96	.081	56.3	.100	36.9
.063	93	.082	54.9	.104	34.1
.064	90	.083	53.6	.109	31.3
.065	88	.084	52.3	.125	23.6
.066	85	.085	51.1	.140	18.8
.067	82	.086	49.9	.156	15.1
.068	80	.087	48.8	.171	12.643
.069	78	.088	47.7	.187	10.572
.070	75	.089	46.6	.203	8.971
.071	73	.090	45.6	.218	7.779
.072	71	.091	44.6	.234	6.752
.073	59	.092	43.6	.250	5.915
.074	68	.093	42.7	.265	5.264
.075	65.7	.094	41.8	.281	4.682
.076	64.0	.095	40.9		
.077	62.3	.096	40.1		
.078	60.7	.097	39.2		

AMS 4162 B 5056 Aluminum  
 AMS 4184 B 4145 Aluminum  
 AMS 4190 C 4045 Aluminum  
 AMS 4191 A 2319 Aluminum  
 AMS 4395 B AZ-92 A  
 AMS 4396 A EZ-33 A  
 AMS 4951 D Commercial Pure Titanium  
 AMS 4953 A 5AL-2.5SN  
 AMS 4954 C 9AL-4V  
 AMS 4955 A 8AL-1MO-AV  
 AMS 1956 A 6AL-4V (EL1)  
 AMS 5555 Nickel 205  
 AMS 5660 E Alloy 901  
 AMS 5675 A Inconel 92  
 AMS 5676 A Nichrome V  
 AMS 5679 C Inconel 62  
 AMS 5680 D 347 Stainless  
 AMS 5682 B Nichrome V  
 AMS 5689 A 321 Stainless  
 AMS 5690 G 316 Stainless  
 AMS 5694 D 310 Stainless  
 AMS 5698 B Inconel X-750 #1 Temp.  
 AMS 5699 B Inconel X-750 Spring Temp.  
 AMS 5774 A AM-350  
 AMS 5776 A 41D Stainless

AMS 5778 A Inconel 69  
 AMS 5780 AM-355  
 AMS 5782 B 19-9 W Mo  
 AMS 5786 A Hastelloy W  
 AMS 5789 Stellite 31  
 AMS 5794 A N-155  
 AMS 5796 Haynes 25  
 AMS 5798 B Hastelloy X  
 AMS 5800 B Rene 41  
 AMS 5801 A Haynes 188  
 AMS 5804 B A-286  
 AMS 5805 B A-286 (vacuum melted)  
 AMS 5812 B 15-7 Mo (vacuum melted)  
 AMS 5813 A 15-7 Mo  
 AMS 5817 A Greek Ascology  
 AMS 5824 A 17-7 Stainless  
 AMS 5825 C 17-4 Stainless  
 AMS 5828 B Waspalloy  
 AMS 5832 B Inconel 718  
 AMS 5837 B Inconel 625  
 AMS 5840 13-8 Mo  
 AMS 6458 E 17-22 ASBM  
 AMS 6461 F 6130 (vacuum melted)  
 AMS 6462 E 6130  
 AMS 6466 B 502

**Other Alloys Available**

# All Metals & Forge

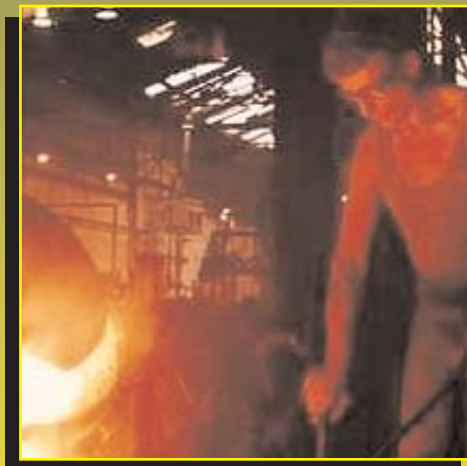
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# Forgings





## Open-Die Forgings & Rolled Rings

### FORGING - THE TECHNIQUE THAT PARALLELS THE DEVELOPMENT OF MAN

As with the cultural history of man, the history of metals springs from the land between the Tigris and the Euphrates, one called Mesopotamia. The earliest signs of metalworking date back to about 4500 B.C.

The inhabitants of this fertile valley were the Sumerians. These people, a mixture of many ethnic backgrounds, were the true founders of metallurgy as we know it today.

The art of forging, shaping metal using heat and pressure, progressed until the Dark Ages; the same time that most industrial, scientific and cultural advancements halted. Before this time, possession of metals

was highly regarded as a sign of wealth. The Romans even had gods dedicated to the forge, the most notable being Vulcan.

During the Dark Ages the production of weapons flourished. European culture and industry was severely set back due to constant wars. Yet the Iron industry remained much intact due to the need for weapons.

One of the most significant developments came from the combination of the Roman discovery of water power and the forging of metals. Water power was used to operate bellows and mechanical hammers. This significant discovery came into

use between the 10th and 12th century A.D. Some water operated hammers were still being used into the 20th century.

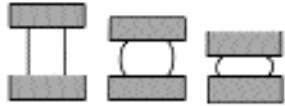
The 19th century invention of the steam engine brought us to the doorstep of modern forging as we know it. Of course, to follow was the harnessing of electrical power and the development of explosive forming, which truly brought forging out of the dark ages.

Forging as an art form started with the desire to produce decorative objects from precious metals. Today, forging is a major world-wide industry that has significantly contributed to the development of man.

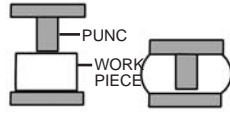




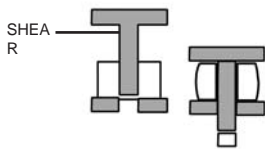
## How Forgings Are Made



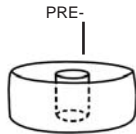
1. The ring rolling process typically begins with upsetting of the starting stock on flat dies at its plastic deformation temperature...in the case of grade 1020 steel, approximately 2200 F.



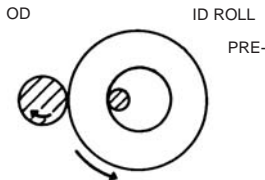
2. Piercing involves forcing a punch into the hot upset stock causing metal to be displaced radially, as shown by the illustration.



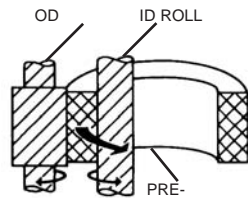
3. A subsequent operation, shearing serves to remove the small punchout



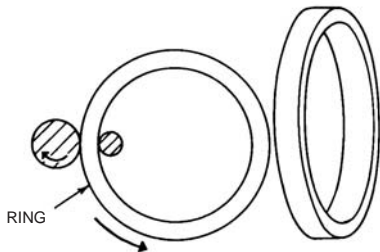
4. ...producing a completed hole through the stock, which is now ready for the ring rolling operation itself. At this point the stock is called a preform.



5. The doughnut-shaped preform is slipped over the ID roll shown here from an "above" view.

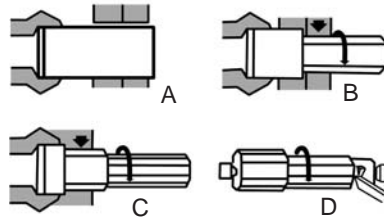


6. A side view of the ring mill and preform workpiece, which squeezes it against the OD roll which imparts rotary action...



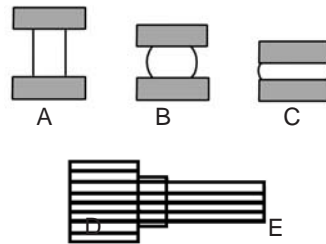
7....resulting in a thinning of the section and correspondence increase in the diameter of the ring. Once off the ring mill, the ring is then ready for secondary operations such as close tolerance sizing, parting, heat treatment and test/inspection.

### SHAFTS



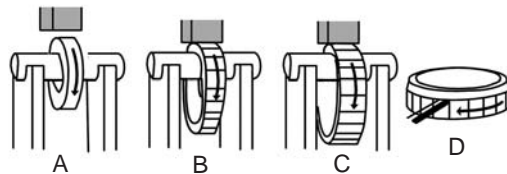
A. Starting stock, held by manipulator  
 B. Open-die forging  
 C. Progressive forging  
 D. Lathe turning to near net shape

### DISCS



A. Starting stock  
 B. Preliminary upsetting  
 C. Progressive upsetting/forging to disc dimensions  
 D. Pierced for saddle/mandrel ring preform

### SADDLE-MANDREL RINGS



A. Preform mounted to saddle/mandrel  
 B. Metal displacement reduce preform wall thickness to increase diameter  
 C. Progressive reduction of wall thickness to produce ring dimensions  
 D. Machining to near net shape



## How To Buy Forgings

Close cooperation between buyers and producers of forgings has always been a vital part of achieving the best possible product at the best possible cost. With recent major advances in forging methods and materials improvements, this collaboration is more critical than ever before. By keeping abreast of these advances, and working closely with the forger, the engineer or buyer can ensure delivery of high-quality products with important cost savings.

Despite its long history and the many technological developments that have taken place in recent years, forging still involves a good deal of artistry. Even as product designers and industrial buyers learn more about shaping of metals, there is still much to be gained from bringing the forger into the design and specification phases of product development.

Of course, such basic questions as whether a given part can or should be forged must be addressed at an early stage. There are many instances when any of several processes can be used to produce the component in question.

Once it has been determined that a product or component requires the strength, toughness, dimensional accuracy and overall integrity of forging, there is still the question of which forging process - open die, impression die, ring rolling, etc. - is most appropriate. Usually, this decision is straightforward, based on part size, configuration and quantity required. However, to help in those situations when the choice is not so clear cut, the forging buyer should have at least a general knowledge of methods and equipment used in the industry.

Besides a general knowledge of forging, the buyer should also have a clear idea of what he or she specifi-

cally requires and how readily his or her needs can be met by individual forgers. Capabilities can vary dramatically from one company to another. For instance:

--Does the forger have experience in applications similar to the one being considered?

--Is design assistance offered?

--Does the forger have the equipment required to produce the part?

--Is the forger able to provide related services like heat treating, machining, testing and so on?

--Is the forger accustomed to producing the volume required?

--Does the company specialize in long runs, short runs or quick delivery?

The answer to these and other questions will help narrow the field to a few qualified forgers. Then, the buyer can begin to take advantage of the valuable technical and design assistance available from these forging experts.

### THE DESIGN CONFERENCE

An experienced and capable forging company engineer should be able to make design suggestions to consolidate components, simplify processing, reduce required machining, speed delivery and so on. It may be possible to achieve forging's high-level performance benefits without significantly increasing material or production costs over those associated with other processes.

The key is to get the forger involved early. The benefit derived from consultation will vary with the complexity of the part and the forging process involved. For instance, impression die forgings may benefit somewhat more dramatically than open die products. However, the ideal first step toward getting the most from a forged part is to form a team consisting of the product designer, the purchasing manager and, possibly, a quality-control or manufacturing rep-

resentative. Then this team should sit down with a technical representative of the forging company while the product or component design is still being evaluated.

The focal point in these early meetings with candidate forgers should be an engineering drawing. The part print should be fully detailed, showing finished dimensions and tolerances. If the forging is to be delivered in a rough-machined or as-forged state, the required machining envelope should be clearly specified. In many cases, it can be advantageous to provide a drawing that shows how the forged part will mate with other components in the finished assembly.

Another critical part of these early design meetings should be the service requirements of the application. The forger needs complete information on how the forging will be used, the operating environment, and critical mechanical properties. A thorough understanding of service stresses - load-bearing, power transmitting, impact, hydraulic pressure, high or low temperatures, corrosive conditions - and the stress location can allow the forging engineer to make design and process suggestions that can result in an improved product and reduced manufacturing costs. For instance:

--*Material Selection...* Often, alternative carbon- and alloy-steel grades can produce similar mechanical properties, depending on forging design, heat treatment, and so forth. Specifying property levels beyond those actually required by the application can significantly increase costs. The best economy is achieved when tensile, hardness, impact and other mechanical properties are realistically based on the service requirements of the component being designed. Once these realistic prop-



## How To Buy Forgings (continued)

erty levels are established, the forger can help select one material from among the alternatives to achieve the optimum combination of performance, forgeability, heat treatability, machinability and economy.

--*Part Configuration...*Special pre-forming operations, reheats or additional dies and equipment may or may not be required to achieve the specified part configuration and the desired grain flow pattern. Almost always, a knowledgeable forger can work with a product design and achieve material and production economies with no loss of part performance. Sometimes, slight changes in part shapes can simplify forging requirements, reduce die costs, and speed production.

The forging engineer studies a new design from the standpoint of its tooling and processing requirements. Reduced draft angles or sharper radii, for instance, can sometimes reduce machining requirements without affecting part function. If a simpler die can be used or if the parting line can be adjusted to allow use of a flat top die, it may be possible to produce the part more economically.

--*Dimensional Tolerances...*The ability of forgers today to produce as-forged shapes to tight tolerances is improving, and most companies are striving to develop their net- and near-net-shape forging capabilities. At present, however, there is some considerable cost involved in holding tight as-forged tolerances. The wise buyer will ask the forger to help evaluate the trade-offs between reduced machining and increased die and processing costs.

In open die forging, particularly nearly all forgings require some machining. Determining where and how much machining stock "envelope" should be specified is a complex decision best made in concert with the forger.

But no matter what tolerances are set, it is important to include them along with all dimensions of the part drawing given to the forging engineer. Based on this information, and on his or her experience and the experience of the supplier, the forger can accept or request modification to the specifications to achieve more cost-effective production.

--*Applying Guidelines...*Over the years, the forging industry has developed a system of dimensional tolerance guidelines that set limits on size (length, width and thickness), die match and straightness. Guidelines for impression die applications, for instance, are found in the Forging Industry Association's *Tolerances for Impression Die Forgings, Hammer, Press and Upsetter*.

Standards also have been developed to apply to such material considerations as chemistry, strength, ductility, impact resistance, conductivity, soundness and grain flow. These have been published by such organizations as ASTM, SAE, and the American Standards Association. Unless there is a good reason to specify a special material or tighter tolerance controls, it is best to follow the established standards to avoid additional costs.

--*Surface Finishing...*Most forging companies have machining capabilities and some offer extensive finishing services. Many buyers specify that rough machining be done by the forger so that any surface imperfections will be discovered before the parts are shipped. And there is a growing trend toward specifying that the forger also do finish machining, for reasons of economy and to isolate responsibility. The buyer gets a finished, ready-to-install component. Intermediate steps in production are left to the forger.

With the added responsibility, the

forger gains some flexibility that can result in overall savings for the buyer. Armed with a drawing showing finished dimensions and tolerances, the forger can design an ideal forging around the finished part. The parting line can be positioned for maximum efficiency. The chief benefit, however, is that the machining envelope can sometimes be reduced to save material and machining time.

--*Inspection and Testing...*Only those tests needed to establish the mechanical properties and quality required for reliable performance should be specified to minimize the costs involved. While the buyer will normally specify the type of test and acceptance levels required for a forging, the forger can offer good advice on appropriate testing. Tests on representative bar samples are relatively simple. When the specification requires that additional tests be made on the forging itself, costs increase. Non-destructive testing - ultrasonic and magnetic particle inspection - is becoming increasingly important for critical service applications like generator or turbine rotor shafts. Because these tests can be time-consuming and expensive, however, they should be required only when absolutely necessary.

Statistical process/quality control techniques are being applied in many forge shops. Such capabilities may reduce the need for some of the costly testing of individual forgings.

--*Delivery...*While not necessarily important in early design discussions, it is helpful to discuss production volumes and anticipated shipping schedules with the prospective forger. This information allows him or her to take these factors into consideration when making tooling decisions.

In addition, production-run setup and material acquisition requirements will vary with anticipated volume.



## How To Buy Forgings (continued)

Substantial reductions in material and production costs are attainable through advance planning. And it is almost always more economical to forge and ship a quantity of parts at one time, rather than shipping to a monthly, weekly or daily schedule. However, any economies realized through bulk handling must be achieved through Just-In-Time material-control programs. The forger usually can help reconcile these conflicting objectives.

### ADVANCING TECHNOLOGY

Even in an industry as mature and well-established as forging, there are continual advances in processing technology and techniques. Some of the developments underway in the industry today may have an impact on the production of many forgings, while others may affect only a narrow segment of the business.

No matter, it is important for the forging buyer to stay abreast of developments so as to be aware of options becoming available through advancing technology. This is another good reason to get the candidate forger involved early in product development discussions. The competent forging engineer will be able to identify situations where new technology and processing techniques can benefit the buyer's particular project. And because capabilities vary so widely from one forging plant to another, only the forger can determine how cost-effectively a particular new or more advanced procedure can be applied in that plant.

Here are some areas where technology is changing the way forgings are made:

--*Net-Shape Forging* has been getting a lot of attention primarily because of the potential to dramatically reduce finishing costs. Not only should it be possible to reduce the amount of stock machined away after forging, but the costs associated with machining time will be

reduced. In the industry as a whole, however, net-shape forming techniques require further refinement before they become a real alternative for the average forging buyer.

That does not mean there are no benefits to be achieved by studying net-shape techniques. Given a certain latitude in material selection and in forging design, the knowledgeable forger should be able to keep machining and associated costs to a minimum. The more input the forger has in the early stages of product development, the more likely near-net shapes can be achieved.

--*Microalloyed Steels* have been used to reduce the need for heat treatment after forging. Small additions of vanadium, columbium and other ingredients can greatly strengthen plain carbon grades of steel. These materials can be used to forge such parts as crankshafts, connecting rods and front axles for trucks - without the need for heat treatment.

This technology is still in its infancy and not all forgers will be able to take advantage of it. But under certain circumstances, and for certain components, it may be possible to reduce or eliminate the costs associated with heat treatment. Close cooperation between forging producer and forging buyer is required to ensure that the performance properties of the finished product suit the application.

--*CAD/CAM and Computer Control* are having a dramatic effect on many industries. Forging is no exception. From quoting, to die design and production, to billet handling and presses, to heat treating and machining, the computer is affecting the way forgings are produced.

### A SERVICE INDUSTRY

The custom forge plant is essentially a service organization. One of the

most important aspects of the service provided is the assistance the forger can give in the design and development of a product to be forged. Today, competition among forgers in the global marketplace is allowing the buyer to demand - and get - ever higher levels of service from the companies vying for the business.

As materials and process technologies advance, it is increasingly important for the forging buyer to involve the forger in decisions that ultimately affect the cost and performance of the part. Through close collaboration with forgers, buyers can gain the greatest benefits from forging industry innovation and can help spur further progress.

*This article is adapted from the Forging Industry Association's booklet "How to Buy Forgings." FIA, formed in 1913, is the trade association for U.S. and Canadian producers of forgings. Headquartered in Cleveland, it serves 150 forging company members operating more than 200 plants. Its members account for 79% of the custom forged products produced in North America.*

# All Metals & Forge

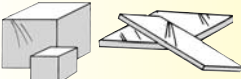



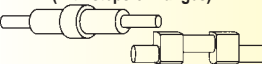
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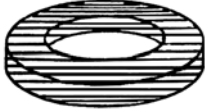
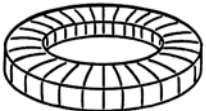

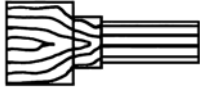


## Forging Materials & Capabilities

SHAPE	SIZE/ WEIGHT	FERROUS ALLOYS		NICKEL, COBALT & SPECIAL ALLOYS	NON-FERROUS ALLOYS								
		Carbon, Alloy & Tool	Stainless		Aluminum, Copper, Magnesium	Titanium							
<b>FLAT BAR BLOCKS</b> 	MAX. WIDTH=72"	72"	60"	27"	60"	65"							
	MAX. WEIGHT= 40,000#	40,000#	25,000#	15,000#	10,000#	15,000#							
<b>CYLINDERS / SLEEVES</b> 	MAX. O.D.=72"	72"	72"	50"	72"	52"							
	MAX. LENGTH= 96"	96"	96"	65"	96"	65"							
<b>DISCS / HUBS</b> 	MAX. DIA.=80"	80"	80"	50"	80"	65"							
	MAX. WEIGHT= 40,000#	40,000#	40,000#	20,000#	15,000#	10,000#							
<b>RINGS, ROLLED OR HAND FORGED</b> 	MAX. O.D.=160"	160"	160"	84"	80"	80"							
	MAX. LENGTH= 65"	65"	65"	40"	65"	65"							
<b>ROUNDS / SHAFTS</b> (with steps or flanges) 	MAX. LENGTH= 220"	220"	220"	144"	220"	144"							
	MAX. WEIGHT= 40,000#	40,000#	40,000#	20,000#	10,000#	10,000#							
<b>Carbon</b> 4115 1020 1022 1023 1025 1026 1029 1030 1035 1040 1045 1055 1070 <b>Alloy</b> 2315 2340 2515 3140 3145 3150 3310 3312 3315 4015 4017 4020 4023 4085 4112		7290 8140 8150 8160 8615 8617 8620 8630 8640 8642 8645 8720 8735 8740 8750 9115 9260 9310 9315 9317 9430 9840 9850 <b>Tool</b> A2 A6 A10 D2 D3		D5 D6 H11 H12 H13 H21 H26 H43 M2 P20 S1 S5 S7 T1 W1 W2  <b>Special Grades</b> D6AC HY80 • HY100 F-11(1 1/4 CR-1/2 MO) F-22(2 1/4 CR-1 MO) F-5(5CR-1/2MO)		<b>Stainless Steel</b> 409 410 300 Series 302 303 304L 309 310 314 316L 317L 321 322 329 330 333 347 348 400 & 500 Series 403 405		<b>Nickel, Cobalt, Special Alloys</b> A-286 • AM-355 Cust. 450, 455 Ferralium 255 Hastelloy B2, C276, N, W, X Haynes 188 Haynes 230 Incoloy 800, 825, 901 Inconel 600, 601, 617, 625, 690, 702, 706, 718, 722, 725, 750, 751, 800, 825, 903 Invar 36, 42 Jethete M152 Kovar, Rodar L605 (Haynes 25) Maraging 250, 300, 350 Monel 400 (reg.) Monel 500 (K) Nickel 200, 201 Nitronic 40 • 50 • 60 N155 Nimonic 75 • 80 • 90 Rene 41 • 125 Udimet 500, 700 Vascojet 1000 Waspalloy Zirconium 20 CB		<b>Aluminum Alloys</b> 2014 2024 2219 5083 5086 6061 6063 7049 7050 7075 7079 7175 <b>Copper Alloys</b> Alum Brz C613 Ni Alum Brz C623, C624 C630, C632 Copper Ni C706(90/10) C715(70/30) <b>Magnesium Alloys</b> AZ80 AZ61A ZK60A AZ31B		<b>Titanium Alloys</b> Commercially Pure 4AL-3MO-1V 4AL-4MN 5AL-2.5SN 6AL-2SN-4ZR-2MO 6AL-2SN-4ZR-6MO 6AL-4V 6A1-6V-2SN 7AL-4MO 8AL-1MO-1V 13.5V-11CR-3AL Ti17	

**GRADES OF BILLET MATERIAL INSTOCK OR AVAILABLE FROM MILL DEPOT  
 (If your required grade is not shown, call for assistance)**



## Cost Saving Tips

<b>PROBLEM</b>	<b>+</b>	<b>SOLUTION</b>	<b>=</b>	<b>\$ SAVINGS</b>
<p><b>RINGS</b> Flame cutting a ring from plate is not economical when meeting material requirements.</p> <ul style="list-style-type: none"> <li>• Flame cutting, all corner stock and the full center slug is lost even though you pay for it.</li> <li>• As desired thickness of the ring increases, availability of plate sizes and grades drastically decreases.</li> <li>• Uni-directional grain flow of plate increases susceptibility of ring to fatigue failure.</li> </ul> 	<b>+</b>	<p>A custom forged ring allows greater versatility and improved quality while reducing material cost.</p> <ul style="list-style-type: none"> <li>• The forging process moves and shapes material to ordered ring size with minimal material waste.</li> <li>• Required ring thickness has no effect on the virtually limitless combinations of sizes and grades available.</li> <li>• The porosity and laminations sometimes encountered in plates is eliminated with a custom forged ring.</li> <li>• Contoured grain flow within forged ring yields combination of strength, toughness and fatigue resistance.</li> </ul> 	<b>=</b>	<p><b>30% MATERIAL SAVINGS</b> Material=4340 Finished Size=46 5/8" O.D. X 26 1/4" I.D. X 4 1/8" FACE Materials Needed to Produce= Forging=2,015 lbs. Plate=2,865 lbs.</p> <p><b>56% MATERIAL SAVINGS</b> Material=1021 Finished Size=22 5/8" O.D. X 17" I.D. X 9" FACE Materials Needed to Produce= Forging=700 lbs. Plate=1,580 lbs.</p>
<p><b>BARS &amp; SHAFTS</b> Matching a solid bar to form a step down causes expensive use of material, labor and time.</p> <ul style="list-style-type: none"> <li>• When machining the step down, all excess material, as shown here, is lost.</li> <li>• Machining time, tool life and freight costs are expensive.</li> <li>• Grain flow within the bar is exposed when machined, thus making the material more susceptible to fatigue failure.</li> </ul> 	<b>+</b>	<p>Custom forging the bar to form a step down lowers the cost for a value added part.</p> <ul style="list-style-type: none"> <li>• Forging requires less starting material, thus saving cost on excess material waste.</li> <li>• Less machining saves money, time and tool life while producing a closer-to-finish shape</li> <li>• Freight and handling costs are lowered because the forged step down weighs less than the bar</li> <li>• Contoured grain flow within forged step down yields greater impact and directional strength.</li> </ul> 	<b>=</b>	<p><b>64% SAVINGS</b> Forged Sizes=18 1/4" O.D. X 16 1/2" Long, Step 11 1/4" O.D. X 8" Long, Step 6 3/4" O.D. X 48" Long Weight=1,935 lbs. Bar Size=18 1/4" O.D. X 72 1/2" Long Weight=5,375 lbs.</p> <p><b>49% SAVINGS</b> Forged Sizes=4" O.D. X 13 1/16" Long, Step 6 1/2" O.D. X 9 3/4" Long, Step 4" O.D. X 19 13/16" Long Weight=205 lbs. Bar Size=6 1/2" O.D. X 42 1/4" Long Weight=400 lbs.</p>
<p><b>HUBS</b> When hub shapes are achieved through machining solid bar stock or flame cutting plate, waste is an expensive part of the process.</p> <ul style="list-style-type: none"> <li>• When machining a shape from solid bar or flame cutting plate, all excess material is lost. See the illustration below.</li> <li>• Machining or flame-cutting means costly machine time, lowered tool life, and increased freight costs.</li> <li>• Most importantly, the uni-directional grain flow of both bar and plate increases the likelihood of fatigue</li> </ul> 	<b>+</b>	<p>Custom forging of hub shapes improves quality, lowers material costs and offers maximum flexibility.</p> <ul style="list-style-type: none"> <li>• As it requires less material from the start, forging saves on both material and freight</li> <li>• The forging process requires simple tooling yet can produce virtually limitless combinations of single or double hub sizes.</li> <li>• Reduces machining saves time, labor, and tooling costs and forging produces a nearer net shape.</li> <li>• The optimum combination of strength, toughness, and fatigue resistance in the hub is achieved by the continuous grain flow which comes through forging.</li> </ul> 	<b>=</b>	<p><b>59% MATERIAL SAVINGS</b> Forged Sizes=4" O.D. X 20" Face, Hub on side 9" O.D. X 4 1/2" Projection Weight=346 lbs. Plate Size=20" Square X 7 1/2" Thick Weight=850 lbs.</p> <p><b>43% MATERIAL SAVINGS</b> Forged Sizes=18 1/4" O.D. X 3 7/8" Face, Hub on side 10 5/8" O.D. X 6 1/8" Projection with a 3" I.D. through Weight=421 lbs. Bar Size=18 1/4" O.D. X 10" Long Weight=741 lbs.</p>

# All Metals & Forge

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## FORGING GLOSSARY

**Age**-An operation in which forgings are subjected to low temperature treatment for specific periods of time to effect the complete or partial precipitation of the solutes in the alloy, resulting in controlled hardening of the metal.

**Age hardening (aging)**-The latter part of a two-step heat treating operation applied to certain alloys for strengthening and hardening (See also *Solution heat treatment*). Aging involves heating to a relatively low temperature for a specified period of time, and results in controlled precipitation of the constituent dissolved during the solution heating treatment.

**Aging**-The change in the properties of a metal that occurs at relatively low temperature following a final heat treatment or a final cold working operation: aging tends to restore equilibrium in the metal and eliminate any unstable condition induced by a prior operation.

**Aircraft quality**-Denotes stock of sufficient quality to be forged into highly stressed parts for aircraft or other critical applications. Such materials are of extremely high quality, requiring closely controlled, restrictive practices in their manufacture in order that they may pass rigid requirements, such as magnetic particle inspection (Ref: Aerospace Material Specification 2301).

**Air-lift hammer**-A type of gravity drop hammer where the ram is raised for each stroke by an air cylinder. Because length of stroke can be controlled, ram velocity and thus energy delivered to the workplace can be varied.

**Alloy**-A material having metallic properties and composed of two or more chemical elements of which at least one is a metal. In practice, the word is commonly used to denote relatively high-alloy grade of material - for example, "alloy" steels as differentiated from "carbon" steels. Materials are alloyed to enhance physical and mechanical properties such as strength, ductility, and hardenability.

**Annealing, full**-A heat-treating operation wherein metal is heated to a temperature above its critical range, held at the temperature long enough to allow full recrystallization, then slowly cooled through the critical range. Annealing removes working strains, reduces hardness, and increases ductility.

**Auxiliary operations**-Additional processing steps performed on forgings to obtain properties, such as surface conditions or shapes, not obtained in the regular processing operation.

**Axial rolls**-In ring rolling, vertically displaceable, tapered rolls, mounted in a horizontally displaceable from opposite from but on the same centerline as the main roll and rolling mandrel. The axial rolls control the ring height during the rolling process.

**Backward extrusion**-Forcing metal to flow in a direction opposite to the motion of a punch or die.

**Backing arm**-A device for supporting the ring rolling mill mandrel from above during the roll process.

**Bar**-A section hot rolled from a billet to a form, such as round, hexagonal, octagonal, square, or rectangular, with sharp or rounded corners or edges, with a cross-sectional area of less than 16"; a solid section that is long in relation to its cross-sectional dimensions, having a completely symmetrical cross section and whose width or greatest distance between parallel faces is 3/8" or more.

**Bed**-Stationary platen of a press to which the lower die assembly is attached.

**Bend**-Operation to preform (bend) stock to approximate shape of die impression for subsequent forging; also includes final forming. Bend or twist (defect)-Distortion similar to warpage, but resulting from different causes; generally caused in the forging or trimming operations. When the distortion is along the length of the part, it is called "bend"; when across the width, it is called "twist". Low-draft and no-draft forgings are more susceptible to bending, as they must be removed from the dies by some form of mechanical ejection. Dull trimming tools and improper nesting will cause bending in the trimming operation. When bend or twist exceeds tolerances, it is considered a defect. Corrective action entails either hand straightening, machine straightening, or cold restriking.

**Bending**-A preliminary forging operation to give the piece approximately the correct shape for subsequent forming.

**Billet**-(1) A semi-finished section hot rolled from a metal ingot, with a rectangular cross section usually ranging from 16-36", the width being less than twice the thickness. Where the cross section exceeds 36", the term "bloom" is properly but not universally used. Sizes smaller than 16" are usually termed "bars"; a solid semi-finished round or square product

which has been hot worked by forging, or extrusion. (2) A semi-finished, cogged, hot-rolled, or continuous-cast metal product of uniform section, usually rectangular with radiused corners. Billets are relatively larger than bars.

**Blank**-A piece of stock (also called a "slug" or "multiple") from which a forging is to be made.

**Blast cleaning (blasting)**-A process for cleaning or finishing metal objects by use of an air jet or centrifugal wheel that propels abrasive particles (grit, sand, or shot) against the surfaces of the workpiece at high velocity.

**Block**-The forging operation in which metal is progressively formed to general desired shape and contour by means of an impression die (used when only one block operation is scheduled).

**Blow**-The impact or force delivered by one workstroke of the forging equipment.

**Boss**-A relatively short protrusion or projection on the surface of a forging, often cylindrical in shape.

**Box annealing**-A heat-treating process whereby metal to be annealed is packed in a closed container to protect its surfaces from oxidation. Sometimes used to describe the process of placing forgings in a closed container immediately after forging operations are completed, permitting forgings to cool slowly.

**Brinell hardness**-The hardness of a metal or part, as represented by the number obtained from the ratio between the load applied on and the spherical area of the impression made by a steel ball forced into the surface of the material tested.

**Brinell hardness testing**-Method of determining the hardness of materials; involves impressing a hardened ball of specified diameter into the material surface at a known pressure (10mm ball, 500kg load for aluminum alloys). The Brinell hardness number results from calculations involving the load and the spherical area of the ball impression. Direct-reading testing machines designed for rapid testing are generally used for routine inspection of forgings, and as a heat treat control function.

**Carbonitriding**-A process of case hardening a ferrous material in a gaseous atmosphere containing both carbon and nitrogen.

**Case**-The surface layer of an alloy that has been made substantially harder than the interior by some form of hardening operation.

**Case hardening**-A heat treatment or combination of processes in which the surface layer of a ferrous alloy is made substantially harder than the interior. Carburizing, cyaniding, nitriding, and heating and quenching techniques are commonly used. Case hardening can provide a hard, wear-resistant surface on a forging, while retaining a softer, tougher core.

**Centering arm**-in ring rolling, externally mounted rolls, adjusted to the outside diameter of the ring during rolling. The rolls maintain and guide the ring in a centerline position to achieve roundness.

**Charpy test**-A pendulum type impact test where the specimen is supported as a simple beam and is notched opposite the point of impact. The energy required to break the beam is used as an index of impact strength measurement.

**Chop**-A die forging defect; metal sheared from a vertical surface and spread by the die over an adjoining horizontal surface.

**Cleaning**-The process of removing scale, oxides, or lubricant acquired during heating for forging or heat treating from the surface of the forging. (See also *Blasting, Pickling, Tumbling*).

**Cogging**-The reducing operation in working the ingot into a billet by the use of a forging hammer or a forging press.

**Coining**-The process of applying necessary pressure to all or some portion of the surface of a forging to obtain closer tolerances or smoother surfaces or to eliminate draft. Coining can be done while forgings are hot or cold and is usually performed on surfaces parallel to the parting line of the forging.

**Cold coined forging**-A forging that has been restruck cold in order to hold closer face distance tolerances, sharpen corners or outlines, reduce section thickness, flatten some particular surface, or, in on-heat-treatable alloys, increase hardness.

**Cold inspection**-A visual (usually final) inspection of the forgings for visible defects, dimensions, weight, and surface condition at room temperature. The term may also be used to describe certain non destructive tests, such as magnetic particle, dye penetrant, and sonic inspection.

**Cold shut**-A defect characterized by a fissure or lap on the surface of a forging that has been closed without fusion during the forging operation.



## FORGING GLOSSARY (continued)

**Conventional forging**-A forging characterized by design complexity and tolerances that fall within the broad range of general forging practice.

**Core**-The softer interior portion of an alloy piece that has been surface (case) hardened; or, that portion of a forging removed by trepanning or punching.

**Critical point**-The temperature in metal at which recrystallization or other phase transformation takes place.

**Critical (temperature) range**-Temperatures at which changes in the phase of a metal take place. Changes are determined by absorption of heat when the metal is heated, and liberation of heat when it is cooled.

**Decarburization**-The loss of carbon from the surface of steel by heating above lower critical temperature or by chemical action. Decarburization is usually present to a slight extent in steel forgings. Excessive decarburization can result in defective products.

**Descaling**-The process of removing oxide scale from heated stock prior to or during forging operations, using such means as extra blows, wire brushes, scraping devices, or water spray.

**Drawing**-A forging operation in which the cross section of a forging stock is reduced and the stock lengthened between flat or simple contour dies. (See also *Fuller*).

**F.A.O.**-An abbreviation of "finish all over", it designates that a forging must have sufficient size over the dimensions given on the drawing so that all surfaces may be machined in order to obtain the dimensions shown on the drawing. The amount of additional stock necessary for machining allowance depends on the size and shape of the part, and is agreed on by the vendor and the user.

**Flat die forging (open-die forging)**-Forging worked between flat or simple contour dies by repeated strokes and manipulation of the workpiece. Also known as "hand" or "smith" forging.

**Forging quality**-Term describing stock of sufficiently superior quality to make it suitable for commercially satisfactory forgings.

**Fuller (fullering impression)**-Portion of the die that is used in hammer forging primarily to reduce the cross section and lengthen a portion of the forging stock. The fullering impression is often used in conjunction with an edger (or edging impression).

**Grain**-The characteristic crystalline structural unit or metals and alloys.

**Grain flow**-Fiber-like lines appearing on polished and etched sections of forgings that are caused by orientation of the constituents of the metal in the direction of working during forging. Grain flow produced by proper die design can improve required mechanical properties of forgings.

**Grain size**-The average size of the crystals or grains in a metal as measured against an accepted standard.

**Gravity hammer**-A class of forging hammer wherein energy for forging is obtained by the mass and velocity of a freely falling ram and the attached upper die. Examples are board hammers and air-lift hammers.

**Grinding**-Process of removing metal by abrasion from bar or billet stock to prepare stock surfaces for forging. Occasionally used to remove surface irregularities and flash from forgings.

**Hammer forging**-A forging that is made on the flat die of a steam hammer. A forged piece produced in a forging hammer, or the process of forming such a piece. (See also *Board hammer*, *Power-drive hammer*, *Rope hammer*).

**Hand forge (smith forge)**-The forging operation in which the forming is accomplished on dies that are generally flat. The piece is shaped roughly to the required contour with little or no lateral confinement; operations involving mandrels are included.

**Hand forging**-A forging made by hand on an anvil or under a power hammer without dies containing an exact finishing impression of the part. Such forgings approximate each other in size and shape but do not have the commercial exactness of production die forgings. Used where the quantity of forgings required does not warrant expenditure for special dies, or where the size or shape of the piece is such as to require means other than die forging. A forging worked between flat or simply shaped dies by repeated strokes and manipulation of the piece. Also known as smith forging or flat die forging.

**Hardening**-A heat treatment consisting of heating an alloy to a temperature within or above the critical range, maintaining that temperature for the prescribed time (usually 15-30 min.), then quenching or otherwise rapidly cooling. For age-hardening alloys, a two-stage process consisting of solution heat treatment and aging.

**Heat (forging)**-Amount of forging stock placed in a batch-type furnace

at one time.

**Heat treatment**-A combination of heating, holding, and cooling operations applied to a metal or alloy in the solid state to produce desired properties.

**Hub**-A boss that is in the center of the forging and forms a part of the body of the forging.

**Impact testing**-Tests that determine the energy absorbed in fracturing a test bar at high velocity. (See also *Charpy test*, *Izod test*).

**Impression die forging**-A forging that is formed to the required shape and size by machined impressions in specially prepared dies that exert three-dimensional control on the workpiece.

**Inclusion**-Impurities in metal, usually in the form of particles in mechanical mixture.

**Izod test**-A pendulum-type impact test in which the specimen is supported at one end as a cantilever beam and the energy required to break off the free end is used as a measure of impact strength.

**Jominy**-A hardenability test for steel to determine the depth of hardenability obtainable by a specified heat treatment.

**Lap**-A surface defect appearing in a seam, caused by the folding over of hot metal, fins, or sharp corners and by subsequent rolling for forging (but not welding) of these into the surface.

**Loose material**-During forging operations, pieces of flash often break loose necessitating cleaning of the dies between forging blows; this is usually accomplished by lubricating the die while air is blown on it. Insufficient cleaning results in pieces of flash becoming imbedded in the surface of the forging. Such forgings are often salvaged by removing the loose pieces and hot reworking to fill out the depressions.

**Macrotech**-A testing procedure for conditions such as porosity, inclusions, segregations, carburization, and flow lines from hot working. After applying a suitable etching solution to the polished metal surface, the structure revealed by the action of the reagent can be observed visually.

**Magnetic particle testing**-A non-destructive test method of inspecting areas on or near the surface of ferromagnetic materials. The metal is magnetized, then iron powder is applied. The powder adheres to lines of flux leakage, revealing surface and near surface discontinuities.. Magnetic particle testing is used for both raw material acceptance testing and product inspection. Quality levels are usually agreed on in advance by the producer and purchaser.

**Magnaglo**<sup>®</sup>-A type of magnetic particle testing where the magnetic powder is fluorescent and the inspection is performed under black light. (See also *Magnetic particle testing*). Trade name of Magnaflux Corp.

**Mandrel forging**-The process of rolling and forging a hollow blank over a mandrel in order to produce a weldless, seamless ring or tube.

**Mechanical properties**-Those properties of a material that reveal the elastic and inelastic reaction when force is applied, or that involve the relationship between stress and strain; for example, the modulus are dependent on chemical composition, forging, and heat treatment.

**Microstructure**-The structure and internal condition of metals as revealed on a ground and polished (and sometimes etched) surface when observed at high magnification (over 10 diameters).

**Nonferrous**-Metals or alloys that contain no appreciable quantity of iron; applied to such metals as aluminum, copper, magnesium, and their alloys.

**Normalizing**-A heat treatment in which ferrous alloys are heated to approximately 100°F above the critical range, holding that temperature for the required time, and cooling to room temperature in air.

**Overheating**-Can occur in preheat furnaces prior to forging or in the heat-treating operation. The condition results when metal temperature exceeds the critical temperature of the alloy involved and a change in phase occurs; this is also known as the transformation temperature. Externally, overheated material will often form blisters or a web of fine cracks; internally, overheating causes precipitation of melted constituents around grain boundaries and the formation of rounded pools of melted constituents often called "rosettes".

**Pickling**-The process of removing oxide scale from forgings by treating in a heated acid bath.

**Pierce**-In ring rolling, the process of providing a through hole in the center of an upset forging as applied to ring blank preparation.

**Plane, forging**-The plane that includes the principal die face and that is perpendicular to the direction of the ram stroke; when the parting is flat, the forging plane coincides with the parting line.

**Power-driven hammer**-A forging hammer with a steam or air-cylinder for raising the ram and augmenting its downward blow.



## FORGING GLOSSARY (continued)

**Precision forging**-A forging produced to closer tolerances than normally considered standard by the industry.

**Preform**-The forging operation in which stock is preformed or shaped to a predetermined size and contour prior to subsequent die forging operations; the operation may involve drawing, bending, flattening, edging, fullering, rolling, or upsetting. The preform operation is not considered to be scheduled operation unless a separate heat is required; usually, when a preform operation is required, it will precede a forging operation and will be performed in conjunction with the forging operation and in the same heat. In ring rolling, a term generally applied to ring blanks of a specific shape to be used for profile (contour) ring rolling.

**Preheating**-A high-temperature soaking treatment used to change the metallurgical structure in preparation for a subsequent operation, usually applied to the ingot.

**Prepierce**-In ring rolling, a vertically mounted piercing (punching) tool used for preparation of ring blanks on the ring blank press. A tapered tool of various diameters and lengths.

**Press forging**-The shaping of metal between dies by mechanical or hydraulic pressure. Usually this is accomplished with a single work stroke of the press for each die station.

**Punch**-A shearing operation to remove a section of metal as outlined by the inner parting line in a blocked or finished forging; the operation is generally performed on a trim press using a punch die, a tool used in punching holes in metal. The movable die in a press or forging machine.

**Radial ring rolling mill (RW)**-A type of ring forging equipment for producing seamless rolled rings by controlling only the outside and inside diameters.

**Radial roll (main roll, king roll)**-The primary driven roll of the rolling mill for rolling rings in the radial pass. Roll supported at both ends.

**Radial rolling force**-The action produced by the horizontal pressing force of the rolling mandrel acting against the ring and the main roll. Usually expressed in metric tons.

**Ram**-The moving or falling part of a drop hammer or press to which one of the dies is attached; sometimes applied to the upper flat die of a steam hammer.

**Reduction of area (contraction of area)**- The difference in a tension specimen, between the size of the original sectional area and that of the area at the point of rupture. It is generally stated as the percentage of decrease of cross sectional area of a tension specimen after rupture.

**Ring rolling**-The process of shaping weldless rings from pierced disks or thick-walled, ring-shaped blanks between rolls that control wall thickness, ring diameter, height, and contour.

**Rockwell hardness testing**-A method of determining the relative hardness value of a material by measuring the depth of residual penetration by a steel ball or diamond point under controlled loading.

**Roller (roller impression)**-The portion of a forging die where cross sections are altered by hammering or pressing while the workpiece is being rotated.

**Rolling**-The forging operation of working a bar between contoured dies while turning it between blows to produce a varying circular cross section.

**Rolling mandrel**-In ring rolling, a vertical roll of sufficient diameter to accept various sized of ring blanks and exert rolling force on an axis parallel to the main roll.

**Sand blasting**-The process of cleaning forgings by propelling sand against them at high velocity. (See also *Blast cleaning*).

**Shearing**-A process of mechanically cutting metal bars to the proper stock length necessary for forging the desired product.

**Shoe**-A holder used as a support for the stationary portions of forging and trimming dies.

**Shot blasting**-A process of cleaning forgings by propelling metal shot at a high velocity by air pressure or centrifugal force at the surface of the forgings. (See also *Blast cleaning*).

**Shrinkage**-The contraction of metal during cooling after forging. Die impressions are made oversize according to precise shrinkage scales to allow forgings to shrink to design dimensions and tolerances.

**Sizing**-A process employed to control precisely a diameter of rings or tubular components.

**Smith hammer**-Any power hammer where impression dies are not used for the reproduction of commercially exact forging.

**Solution heat treatment**-A process in which an alloy is heated to a suitable temperature, held at this temperature long enough to allow a

certain constituent to enter into solid solution, then cooled rapidly to hold the constituent in solution. The metal is left in a supersaturated, unstable state and may exhibit age hardening.

**Spheroidizing**-A form of annealing consisting of prolonged heating of iron base alloys at a temperature generally slightly below the critical range, followed by a relatively slow cooling. Causes the graphite to assume a spheroidal shape.

**Steam hammer**-A type of drop hammer where the ram is raised for each stroke by a double-action steam cylinder and the energy delivered to the workpiece is supplied by the velocity and weight of the ram and attached upper die driven downward by steam pressure.

**Stress relieving**-A process of reducing residual stresses in a metal object by heating it to a suitable temperature and holding for a sufficient time. This treatment may be applied to relieve stresses induced by quenching, normalizing, machining, cold working, or welding.

**Swage**-operation of reducing or changing the cross-sectional area by revolving the stock under fast impact of blows. Finishing tool with concave working surface; useful for rounding out work after its preliminary drawing to size.

**Table mill**-In ring rolling, a type of ring forging equipment employing multiple mandrels with a common main roll. Usually used in high volume production of small-diameter rolled rings.

**Tensile properties**-The property data obtained from tensile test on a specimen, including tensile strength, elongation, reduction of area, and yield strength.

**Tensile strength**-The maximum load per unit of initial cross-sectional area obtained before rupture in a tension test.

**Tonghold**-The portion of the stock by which the operator grips the stock with tongs. A small portion of metal projecting from the forging used to manipulate the piece, usually trimmed off.

**Tongs**-Metal holder used to handle metal pieces.

**Tumbling**-The process for removing scale from forgings in a rotating container by means of impact with each other and abrasive particles and small bits of metal. A process for removing scale and roughness from forgings by impact with each other, together with abrasive material in a rotating container.

**Ultrasonic testing**-A non-destructive test applied to sound-conductive materials having elastic properties for the purpose of locating inhomogeneities or structural discontinuities within a material by means of an ultrasonic beam.

**Upset forging**-A forging in which the metal is placed in the die so that the direction of the fiber structure is at right angles to the faces of the die.

**Upset**-Working metal in such a manner that the cross-sectional area is increased, and length is decreased.

**Upset forging**-A forging obtained by upset of a suitable length of bar, billet, or bloom; formed by heading or gathering the material by pressure upon hot or cold metal between dies operated in a horizontal plane.

**Upsetter (forging machine)**-A machine with horizontal action, used for making upset forgings.

**Warpage**-Term generally applied to distortion that results during quenching from the heat-treating temperature; hand straightening, press straightening, or cold restriking is employed, depending on the configuration of the part and the amount of warpage involved. The condition is governed by applicable straightness tolerances; beyond tolerances, warpage is a defect and cause for rejection.

**Yield point**-The load per unit of original cross section at which a marked increase in the deformation of the specimen occurs without increase of load. It is usually calculated from the load determined by the drop of the beam of the testing machine or by the use of dividers. The stress in material at which there occurs a marked increase in strain without an increase in stress.

**Yield strength**-Stress corresponding to some fixed permanent deformation, such as 0.1 or 2.0% offset from the modulus slope.

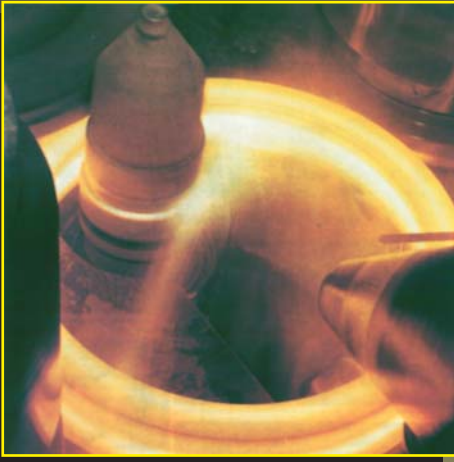
**Zygro**®-A method for nondestructive surface inspection of primarily non-magnetic materials using fluorescent penetrants. Trade name of Magnaflux Corp.

# All Metals & Forge

A SERVICE CENTER & FORGE FACILITY

**Ferrous & Non-Ferrous Materials**

239 New Road, Parsippany, New Jersey 07054 USA 973-276-5000 Fax: 973-276-5050  
www.steelforge.com E-mail: sales@steelforge.com or info@steelforge.com



# Reference Manual



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## WEIGHT CONVERSION FACTORS

*(For Estimating Purposes Only)*

To obtain theoretical weights of metals & alloys . . . calculate the weight of the required size from the weight reference tables that follow. Then multiply by the appropriate factor as shown.

Aluminum	.364
Aluminum Alloys	.356
Columbium (Niobium)	1.107
Copper	1.148
Copper Alloys	1.120
Hastelloy B	1.187
Hastelloy C	1.139
Hastelloy X	1.058
Haynes 25 (L-605)	1.172
Haynes 188	1.183
Incoloy 800	1.025
Inconel 600	1.074
Inconel 625	1.082
Inconel 718	1.029
Inconel X-750	1.053
Magnesium	.223
Molybdenum	1.321
Monel 400	1.127
Monel 405	1.127
Monel 500	1.078
Multimet (N-155)	1.056
Nickel 200	1.134
Rene 41	1.057
Tantalum	2.142
Titanium	.582
Titanium Alloys	.576
Tungsten	2.464
Waspalloy	1.057
Zirconium	.835
<b>Tool Steels:</b>	
Tungsten-Moly	1.040
Tungsten-Hi-Speed	1.120

## METRIC EQUIVALENTS: MEASURES OF LENGTH

1 millimeter(mm)=0.03937 inch=0.00328083 ft.  
 1 meter(m)=39.37 inches=3.28083333 ft.  
 1 inch=0.083333 foot=25.400508 mm  
 12 inches=1 foot=0.30480061 meter

## METRIC EQUIVALENTS: MEASURES OF WEIGHT

1 kilogram(kg)=2.20462234 avoirdupois lbs.  
 1000 kilograms=1 metric ton  
 =.96420640 long ton =1.10231117 short tons  
 1 avoirdupois pound=453.5924277 grams(g)  
 =0.45359234 kg  
 1 long ton=2240 lbs.=1.01604704 metric tons  
 1 short ton=2000 lbs.=0.90718485 metric tons

## CHEMICAL ELEMENTS & THEIR RESPECTIVE SYMBOLS

Actinium	Ac	Mendelevium	Md
Aluminum	Al	Mercury, hydrargyrum	Hg
Americium	Am	Molybdenum	Mo
Antimony, Stibium	Sb	Neodymium	Nd
Argon	A	Neon	Ne
Arsenic	As	Neptunium	Np
Asatine	At	Nickel	Ni
Barium	Ba	Niton, see Radon	
Berkelium	Bk	Nitrogen	N
Beryllium, Glucinum	Be	Nobellium	No
Bismuth	Bi	Osmium	Os
Boron	B	Oxygen	O
Bromine	Br	Palladium	Pd
Cadmium	Cd	Phosphorus	P
Calcium	Ca	Platinum	Pt
Californium	Cf	Plutonium	Pu
Carbon	C	Polonium	Po
Cassiopeiium, See Lutetium		Potassium Kalium	K
Cerium	Ce	Praseodymium	Pr
Cesium	Cs	Promethium	Pm
Chlorine	Cl	Protactinium	Pa
Chromium	Cr	Radium	Ra
Cobalt	Co	Radon, Nitron	Rn
Columbium, Niobium	Cb	Rhenium	Re
Copper	Cu	Rhodium	Rh
Curium	Cm	Rubidium	Rb
Dysprosium	Dy	Ruthenium	Ru
Einsteinium	Es	Samarium	Sm, Sa
Erbium	Er	Scandium	Sc
Europium	Eu	Selenium	Se
Fermium	Fm	Silicon	Si
Fluorine	F	Silver, Argentum	Ag
Fransium	Fr	Sodium, Natrium	Na
Gadolinium	Gd	Strontium	Sr
Gallium	Ga	Sulfur	S
Germanium	Ge	Tantalum	Ta
Gold, Aurum	Au	Technetium	Tc
Hafnium, Celtium	Hf	Tellurium	Te
helium	He	Terbium	Tb
Holmium	Ho	Thallium	Tl
Hydrogen	H	Thorium	Th
Indium	In	Thulium	Tm
Iodine	I	Tin, Stannum	Sn
Iridium	Ir	Titanium	Ti
Iron, Ferrum	Fe	Tungsten	W
Krypton	Kr	Uranium	U
Lanthanum	La	Vanadium	V
Laurencium	Lw	Xenon	Xe
Lead, Plumbum	Pb	Ytterbium	Yb
Lithium	Li	Yttrium	Y
Lutetium	Lu	Zinc	Zn
Magnesium	Mg	Zirconium	Zr
Manganese	Mn		

## FORMULA FOR CALCULATING WEIGHTS OF TUBING

Round Tubing:  $W=20.68 (D-T)T$   
 Square Tubing:  $W=13.5984 (D-T)T$

W=weight in pounds per foot  
 D=outside dimension in inches  
 T=wall thickness in inches

## HARDNESS RANGES

1/4 Hard TS-125,000 psi min or Rc-25 min	1/2 Hard TS-150,000 psi min or Rc-30 min
3/4 Hard TS-175,000 psi min or Rc-35 min	Full Hard TS-185,000 psi min or Rc-40 min



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## DISTANCES ACROSS CORNERS of Hexagons & Squares



d	D	E	F	d	D	E	F	d	D	E	F
1/16	.0721	.0884	.0361	1 1/4	1.4434	1.7677	.7213	2 1/2	2.8867	3.5355	1.4425
1/8	.1443	.1767	.0721	1 9/32	1.4794	1.8119	.7393	2 9/16	2.9583	3.6239	1.4786
3/16	.2164	.2651	.1082	1 5/16	1.5155	1.8561	.7573	2 5/8	3.0311	3.7123	1.5147
1/4	.2886	.3535	.1443	1 11/32	1.5516	1.9003	.7754	2 11/16	3.1032	3.8007	1.5507
9/32	.3247	.3977	.1623	1 3/8	1.5877	1.9445	.7934	2 3/4	3.1754	3.8891	1.5868
5/16	.3608	.4419	.1803	1 13/32	1.6238	1.9887	.8114	2 13/16	3.2476	3.9794	1.6229
11/32	.3968	.4861	.1983	1 7/16	1.6598	2.0329	.8295	2 7/8	3.3197	4.0658	1.6589
3/8	.4329	.5303	.2164	1 15/32	1.6959	2.0771	.8475	2 15/16	3.3919	4.1542	1.6950
13/32	.4690	.5745	.2344	1 1/2	1.7320	2.1213	.8655	3	3.4641	4.2426	1.7310
7/16	.5051	.6187	.2524	1 17/32	1.7681	2.1655	.8836	3 1/6	3.5362	4.3310	1.7671
15/32	.5412	.6629	.2705	1 9/16	1.8042	2.2097	.9016	3 1/8	3.6084	4.4194	1.8032
1/2	.5773	.7071	.2885	1 19/32	1.8403	2.2539	.9196	3 3/16	3.6806	4.5078	1.8392
17/32	.6133	.7513	.3065	1 5/8	1.8764	2.2981	.9377	3 1/4	3.7527	4.5962	1.8753
9/16	.6494	.7955	.3246	1 21/32	1.9124	2.3423	.9557	3 5/16	3.8249	4.6846	1.9114
19/32	.6855	.8397	.3426	1 11/16	1.9485	2.3865	.9742	3 3/8	3.8971	4.7729	1.9474
5/8	.7216	.8839	.3606	1 23/32	1.9846	2.4306	.9918	3 7/16	3.9692	4.8613	1.9835
21/32	.7576	.9281	.3787	1 3/4	2.0207	2.4708	1.0098	3 1/2	4.0414	4.9497	2.0196
11/16	.7937	.9723	.3967	1 25/32	2.0568	2.5190	1.0278	3 9/16	4.1136	5.0381	2.0556
23/32	.8298	1.0164	.4147	1 13/16	2.0929	2.5632	1.0459	3 5/8	4.1857	5.1205	2.0917
3/4	.8659	1.0606	.4328	1 27/32	2.1289	2.6074	1.0639	3 11/16	4.2579	5.2149	2.1277
25/32	.9020	1.1048	.4508	1 7/8	2.1650	2.6516	1.0819	3 3/4	4.3301	5.3033	2.1638
13/16	.9380	1.1490	.4688	1 29/32	2.2011	2.6958	1.1000	3 13/16	4.4023	5.3917	2.1999
27/32	.9741	1.1932	.4869	1 15/16	2.2372	2.7400	1.1180	3 7/8	4.4744	5.4801	2.2359
7/8	1.0102	1.2374	.5049	1 31/32	2.2733	2.7842	1.1360	3 15/16	4.5466	5.5684	2.2720
29/32	1.0463	1.2816	.5229	2	2.3094	2.8284	1.1540	4	4.6188	5.6568	2.3080
15/16	1.0824	1.3258	.5410	2 1/32	2.3455	2.8726	1.1720	4 1/8	4.6910	5.7452	2.3441
31/32	1.1184	1.3700	.5590	2 1/6	2.3815	2.9168	1.1901	4 1/4	4.7631	5.8336	2.3801
1	1.1545	1.4142	.5770	2 3/32	2.4176	2.9610	1.2081	4 3/8	4.8352	5.9220	2.4161
1 1/32	1.1907	1.4584	.5950	2 1/8	2.4537	3.0052	1.2261	4 1/2	4.9073	6.0104	2.4522
1 1/6	1.2268	1.5026	.6131	2 5/32	2.4898	3.0494	1.2442	4 3/4	4.9794	6.0988	2.4883
1 3/32	1.2629	1.5461	.6311	2 3/16	2.5259	3.0936	1.2622	5	5.0515	6.1872	2.5244
1 1/8	1.2990	1.5910	.6491	2 1/4	2.5620	3.1378	1.2803	5 1/4	5.1236	6.2756	2.5605
1 5/32	1.3351	1.6352	.6672	2 5/16	2.5981	3.1820	1.2983	5 1/2	5.1957	6.3640	2.5966
1 3/16	1.3712	1.6793	.6852	2 3/8	2.6342	3.2262	1.3164	5 3/4	5.2678	6.4524	2.6327
1 7/32	1.4073	1.7235	.7032	2 7/16	2.6703	3.2704	1.3344	6	5.3400	6.5408	2.6688

## FRACTIONAL INCHES Converted to Decimal Inches & Millimeters

FRACTION OF INCH	DECIMAL OF INCH	DECIMAL MILLIMETERS	FRACTION OF INCH	DECIMAL OF INCH	DECIMAL MILLIMETERS	FRACTION OF INCH	DECIMAL OF INCH	DECIMAL MILLIMETERS	FRACTION OF INCH	DECIMAL OF INCH	DECIMAL MILLIMETERS
1/64	.015625	0.39688	9/32	.27559	7	35/64	.546875	13.89065	13/16	.8125	20.63754
				.28125	7.14376		.5518	14		.82677	21
1/32	.03125	0.79376	19/64	.296875	7.54064	9/16	.5625	14.28753	53/64	.828125	21.03442
	.03937	1									
3/64	.046875	1.19063	5/16	.3125	7.93752	37/64	.578125	14.68440	27/32	.84375	21.43129
				.31496	8		.59055	15			
1/16	.0625	1.58750	21/64	.328125	8.33439	19/32	.59375	15.08128	55/64	.859375	21.82817
										.86614	22
5/64	.078125	1.98438	11/32	.34375	8.73127	39/64	.609375	15.47816	7/8	.875	22.22504
	.07874	2		.35433	9						
3/32	.09375	2.38125	23/64	.359375	9.12814	5/8	.625	15.87503	57/64	.890625	22.62192
							.62992	16		.90551	23
7/64	.109375	2.77813	3/8	.375	9.52504	41/64	.640625	16.27191	29/32	.90625	23.01880
	.11811	3									
1/8	.125	3.17501	25/64	.390625	9.92189	21/32	.65625	16.66878	59/64	.921875	23.41567
				.3937	10		.66929	17			
9/64	.140625	3.57188	13/32	.40625	10.31877	43/64	.671875	17.06566	15/16	.9375	23.81255
										.94488	24
5/32	.15625	3.96876	27/64	.421875	10.71565	11/16	.6875	17.46253	61/64	.953125	24.20942
	.15748	4		.43307	11						
11/64	.171875	4.36563	7/16	.4375	11.11252	45/64	.703125	17.85941	31/32	.96875	24.60630
							.70866	18		.98425	25
3/16	.1875	4.76251	29/64	.453125	11.50940	23/32	.71875	18.25629	63/64	.984375	25.00318
	.19685	5									
13/64	.203125	5.15939	15/32	.46875	11.90627	47/64	.734375	18.65316	1	1	25.4005
				.47244	12		.74803	19			
7/32	.21875	5.55626	31/64	.484375	12.30315	3/4	.750	19.05004			
15/64	.234375	5.95314	1/2	.500	12.70003	49/64	.765625	19.44691			
	.23622	6									
1/4	.250	6.35001	33/64	.5118	13	25/32	.78125	19.84379			
				.515625	13.09690		.7874	20			
17/64	.265625	6.74689	17/32	.53125	13.49378	51/64	.796875	20.24067			

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## ROUNDS ... Weights

SIZE IN INCHES			EST. WEIGHT LBS.			SIZE IN INCHES			EST. WEIGHT LBS.			SIZE IN INCHES			EST. WEIGHT LBS.			SIZE IN INCHES			EST. WEIGHT LBS.			
PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		
1/16	.010	.12	27/64	.475	5.70	27/32	1.901	22.81	17/32	6.261	75.13	1/4	28.21	338.5	3/4	88.29	1059.0	15/16	94.14	1130.0				
5/64	.016	.19	7/16	.511	6.13	7/8	2.044	24.53	9/16	6.520	78.24	3/20	28.551	342.61	15/16	94.14	1130.0	1	96.13	1153.5				
3/32	.023	.28		.4425	5.225	6.27	.880	2.067	24.81	5/8	7.051	84.61	5/16	29.30	351.6	6	96.13	1153.5	1/8	100.2	1202.4			
7/64	.032	.38		.4475	5.35	6.42	.885	2.091	25.09	11/16	7.604	91.25	3/8	30.42	365.0	1/8	100.2	1202.4	1/4	104.3	1252.0			
1/8	.042	.50	29/64	.548	6.576	57/64	2.118	25.42	3/4	8.178	98.14	7/16	31.55	378.6	1/4	104.3	1252.0	1/2	112.8	1353.8				
.130	.0451	.54	15/32	.587	7.04	29/32	2.193	26.32	1.770	8.365	100.38	1/2	32.71	392.5	3/4	112.8	1353.8	3/2	121.7	1460.0				
9/64	.053	.64	31/64	.626	7.51	15/16	2.347	28.16	13/16	8.773	105.30	3.520	33.085	397.02	1/2	121.7	1460.0	7	130.9	1570.8				
5/32	.065	.78	1/2	.668	8.02	.9425	2.372	28.46	7/8	9.388	112.70	3.530	33.273	399.28	1/4	130.9	1570.8	1	140.4	1684.8				
11/64	.079	.95		.505	6.80	8.16	31/32	2.506	30.07	15/16	10.02	120.20	5/8	35.09	421.1	7	140.4	1684.8	1/2	150.2	1802.0			
3/16	.094	1.13	.510	.694	8.33	1	2.670	32.04	2	10.68	128.2	11/16	36.31	435.7	1/2	150.2	1802.0	3/4	160.4	1924.8				
.1925	.0989	1.186	33/64	.710	8.52	1.005	2.696	32.38	2.020	10.896	130.75	3/4	37.55	450.6	3/4	160.4	1924.8	1	170.9	2051.0				
.1975	.104	1.248	17/32	.754	9.05	1.010	2.723	32.67	1/6	11.36	136.3	3.770	37.951	455.41	8	170.9	2051.0	1/4	182.7	2180.0				
13/64	.110	1.32	9/16	.845	10.14	1/64	2.750	33.00	1/8	12.06	144.7	7/8	40.10	481.2	1/4	182.7	2180.0	1/2	192.9	2315.0				
7/32	.128	1.54		.5675	8.60	10.32	1.020	2.778	33.34	3/16	12.78	153.4	15/16	41.40	496.8	1/2	192.9	2315.0	3/4	204.5	2454.0			
15/64	.147	1.76		.5725	8.75	10.50	1/16	3.014	36.17	1/4	13.52	162.2	4	42.73	512.8	3/4	204.5	2454.0	9	216.3	2596.0			
1/4	.167	2.00		.5775	8.91	10.69	3/32	3.194	38.33	2.270	13.76	165.12	4.020	43.153	517.84	1	216.3	2596.0	1/4	228.5	2742.8			
.255	.1736	2.083	37/64	.892	10.70	1/8	3.379	40.55	5/16	14.28	171.4	4.030	43.366	520.39	1/4	228.5	2742.8	3/2	241.0	2892.0				
.260	.1805	2.166	19/32	.941	11.29	1.135	3.440	41.28	3/8	15.06	180.7	1/8	45.40	544.8	1/2	241.0	2892.0	1/4	253.8	3045.6				
17/64	.188	2.256	5/8	1.043	12.52	9/64	3.470	41.64	7/16	15.87	190.4	1/4	18.23	578.7	3/8	267.0	3204.0	1/2	295.2	3542.4				
9/32	.211	2.53	.630	1.06	12.72	1.145	3.50	42.00	1/2	16.69	200.3	3/8	51.11	613.3	1/2	295.2	3542.4	1/2	324.0	3888.0				
19/64	.235	2.82	.635	1.076	12.91	5/32	3.570	42.84	2.520	16.957	203.48	7/16	52.58	631.0	1/2	324.0	3888.0	1/2	354.0	4248.0				
5/16	.261	3.13	.640	1.093	13.12	3/16	3.766	45.29	9/16	17.53	210.4	1/2	54.08	648.9	1/2	354.0	4248.0	1/2	385.56	4626.7				
3.175	.269	3.228	41/64	1.096	13.15	1/4	4.173	50.08	5/8	18.40	220.8	4.530	54.795	657.54	1/2	385.56	4626.7	1/2	420.0	5025.0				
.3225	.277	3.32	21/32	1.150	13.80	1.260	4.240	50.88	11/16	19.29	231.5	5/8	57.12	685.4	1/2	420.0	5025.0	1/2	451.29	5414.5				
21/64	.287	3.44	11/16	1.262	15.14	17/64	4.276	51.31	3/4	20.20	242.4	3/4	60.25	723.0	1/2	451.29	5414.5	1/2	482.7	5812.0				
11/32	.316	3.79	.6925	1.280	15.37	1.275	4.34	52.08	2.770	20.489	245.87	7/8	63.48	761.8	1/2	482.7	5812.0	1/2	512.9	6132.0				
23/64	.287	3.44	23/32	1.379	16.55	9/32	4.384	51.60	13/16	21.12	253.4	15/16	65.10	781.2	1/2	512.9	6132.0	1/2	543.32	6279.8				
11/32	.316	3.79	3/4	1.502	18.02	5/16	4.600	55.20	7/8	22.07	264.8	5	66.76	801.1	1/2	543.32	6279.8	1/2	601.0	7212.0				
23/64	.345	4.14	.755	1.522	18.26	3/8	5.049	60.59	15/16	23.04	276.5	1/8	70.10	841.2	1/2	601.0	7212.0	1/2	684.0	8208.0				
3/8	.376	4.51	.760	1.54	18.48	1.385	5.218	62.62	3	24.03	288.4	1/4	73.60	883.2	1/2	684.0	8208.0							
.380	.3855	4.62	49/64	1.565	18.78	13/32	5.279	63.35	3.020	24.354	292.25	3/8	77.15	925.8										
.385	.395	4.74	25/32	1.630	19.56	7/16	5.518	66.22	1/16	25.05	300.6	7/16	78.95	947.4										
25/64	.407	4.88	13/16	1.763	21.16	1/2	6.008	72.10	1/8	26.08	312.9	1/2	80.78	969.4										
13/32	.441	5.29	.8175	1.784	21.42	1.510	6.21	74.52	3/16	27.13	325.6	5/8	84.48	1013.8										

## HEXAGONS ... Weights

## SQUARES ... Weights

SIZE IN INCHES			EST. WEIGHT LBS.			SIZE IN INCHES			EST. WEIGHT LBS.			SIZE IN INCHES			EST. WEIGHT LBS.			SIZE IN INCHES			EST. WEIGHT LBS.		
PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR	
1/8	.046	.55	3/4	1.656	19.87	3/4	9.018	108.20	1/8	.053	.640	1	3.400	40.80	1/2	21.25	255.0	1/2	25.71	308.5			
5/32	.072	.864	13/16	1.944	23.33	13/16	9.673	116.1	5/32	.083	.996	1/16	3.840	46.08	3/4	30.6	367.2	3	30.6	367.2			
3/16	.104	1.25	7/8	2.254	27.05	7/8	10.35	124.2	3/16	.120	1.440	1/8	4.303	51.64	1/2	41.65	500.0	1/2	41.65	500.0			
7/32	.140	1.68	15/16	2.588	31.06	2	11.78	141.4	1/4	.213	2.560	3/16	4.795	57.54	1/2	54.4	652.8	1/2	68.85	826.2			
1/4	.184	2.21	1	2.945	35.34	1/8	13.30	159.6	5/16	.332	3.980	1/4	5.313	63.76	1/2	68.85	826.2	1/2	85.0	1020.0			
9/32	.232	2.79	1/16	3.324	39.89	3/16	14.09	169.1	3/8	.478	5.740	5/16	5.857	70.28	1/2	102.9	1234.0	1/2	102.9	1234.0			
4/16	.288	3.26	1/8	3.727	44.72	1/4	14.91	178.9	7/16	.651	7.810	3/8	6.428	77.14	1/2	122.4	1469.0	1/2	122.4	1469.0			
11/32	.348	4.14	3/16	4.152	49.82	3/8	16.61	199.3	1/2	.850	10.200	1/2	7.650	91.80									
3/8	.414	4.97	1/4	4.601	55.21	1/2	18.40	220.8	9/16	1.076	12.910	5/8	8.980	107.80									
13/32	.4857	5.828	5/16	5.072	60.86	5/8	20.29	243.5	5/8	1.328	15.940	3/4	10.41	124.90									
7/16	.564	6.77	3/8	5.567	66.80	3/4	22.27	267.2	11/16	1.607	19.280	7/8	11.95	143.40									
1/2	.736	8.83	7/16	6.085	73.02	7/8	24.33	292.0	3/4	1.913	22.960	2	13.600	162.20									
9/16	.932	11.18	1/2	5.525	79.50	3	26.50	318.0	13/16	2.245	26.940	1/8	15.350	184.20									
5/8	1.150	13.80	5/8	7.775	93.30	1/2	36.07	432.8	7/8	2.603	31.240	1/4	17.21	206.6									
11/16	1.392	16.70	11/16	8.385	100.60	4	47.11	565.0	15/16	2.988	35.856	3/8	19.18	320.2									

## STAINLESS SHEETS Pounds Per Square Foot

## STAINLESS PLATES Pounds Per Square Foot

Thickness Ordering Range in Inches	Gauge Number	Approx. Decimal Parts of an Inch	Avg. Wt./Sq. Ft. in Lbs for Chrome Iron Alloys	Avg. Wt./Sq. Ft. in Lbs for Chrome Nickel Boiled Alloys	Gauge Number	Approx. Decimal Parts of an Inch	Approx. Fractions of an Inch	Avg. Wt./Sq. Ft. in Lbs for Straight Chrome Alloys	Avg. Wt./Sq. Ft. in Lbs for Chrome Nickel Alloys
.161 - .176	8	.171875	7.0813	7.2187		1.000	1	40.478	41.342
.146 - .160	9	.15625	6.5375	6.5625		.9375	15/16	37.949	38.759
.131 - .145	10	.120625	5.7937	5.9062		.8750	7/8	35.419	36.175
.115 - .130	11	.125	5.1500	5.2500		.8125	13/16	32.889	33.591
.099 - .114	12	.109375	4.5063	4.5937		.7500	3/4	30.359	31.007
.084 - .098	13	.09375	3.8625	3.9375		.6875	11/16	27.829	28.423
.073 - .083	14	.078125	3.2187	3.2812		.6250	5/		

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## FLATS ... Weights

SIZE IN INCHES	EST. WEIGHT LBS.		SIZE IN INCHES	EST. WEIGHT LBS.		SIZE IN INCHES	EST. WEIGHT LBS.		SIZE IN INCHES	EST. WEIGHT LBS.		SIZE IN INCHES	EST. WEIGHT LBS.	
	PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR		PER FT.	12 FT. BAR
1/8 x 3/16	.072	.864	5	4.250	51.00	1	1.700	20.40	8	20.400	244.80	12	51.000	612.00
1/4	.106	1.27	5 1/2	4.680	56.20	1 1/8	1.920	23.00	9	22.920	275.04	14	59.520	714.24
5/16	.133	1.60	6	5.100	61.20	1 1/4	2.125	25.50	10	25.500	306.00	1 3/8 x 1 1/2	7.010	84.12
3/8	.159	1.91	7	5.950	71.40	1 3/8	2.340	28.00	12	30.600	367.20	2	9.348	112.18
7/16	.186	2.23	8	6.800	81.60	1 1/2	2.550	30.60	14	35.760	429.12	3	14.040	168.48
1/2	.213	2.56	10	8.500	102.00	1 5/8	2.760	33.12	7/8 x 1	2.975	35.70	1 1/2 x 1 3/4	8.92	107.10
5/8	.266	3.19	12	10.200	122.40	1 3/4	2.975	35.70	1 1/8	3.350	40.20	2	10.20	122.40
3/4	.319	3.83	14	11.900	142.80	2	3.400	40.80	1 1/4	3.719	44.63	2 1/4	11.48	137.80
7/8	.372	4.46	5/16 x 3/8	.398	4.78	2 1/4	3.825	45.90	1 3/8	4.090	49.00	2 1/2	12.75	153.00
1	.425	5.10	7/16	.460	5.52	2 1/2	4.250	51.00	1 1/2	4.463	53.56	2 3/4	14.04	168.48
1 1/8	.480	5.76	1/2	.531	6.37	2 3/4	4.675	56.10	1 3/4	5.206	62.47	3	15.30	183.60
1 1/4	.531	6.37	5/8	.664	7.97	3	5.100	61.20	2	5.950	71.40	3 1/4	17.50	198.90
1 3/8	.588	7.06	3/4	.797	9.56	3 1/4	5.524	66.24	2 1/4	6.696	80.35	3 1/2	17.85	214.20
1 1/2	.638	7.66	7/8	.930	11.16	3 1/2	5.920	71.40	2 1/2	7.438	89.26	4	20.40	244.80
1 5/8	.696	8.35	1	1.063	12.76	4	6.800	81.60	2 3/4	8.180	98.16	4 1/2	22.92	275.04
1 3/4	.744	8.93	1 1/8	1.200	14.40	4 1/2	7.650	91.80	3	8.925	107.10	5	25.50	306.00
2	.850	10.20	1 1/4	1.328	15.94	5	8.500	102.00	3 1/2	10.410	124.90	5 1/2	28.08	336.96
2 1/4	.956	11.47	1 1/2	1.594	19.13	5 1/2	9.350	112.20	4	11.900	142.80	6	30.60	367.20
2 1/2	1.063	12.76	1 3/4	1.859	22.31	6	10.200	122.40	4 1/2	13.440	161.28	7	35.70	428.40
2 3/4	1.160	13.90	2	2.125	25.50	6 1/2	11.052	132.62	5	14.880	178.60	8	40.80	489.60
3	1.275	15.30	2 1/4	2.390	28.65	7	11.904	142.84	6	17.850	214.20	10	51.00	612.00
3 1/4	1.380	16.56	2 1/2	2.656	31.86	8	13.600	163.20	7	20.880	250.56	12	61.20	734.40
3 1/2	1.488	17.86	2 3/4	2.930	36.16	9	15.360	184.32	8	23.800	285.60	1 3/4 x 2	11.90	142.80
4	1.700	20.40	3	3.188	38.26	10	17.000	204.00	10	29.750	357.00	2 1/4	13.44	161.28
4 1/2	1.913	22.96	3 1/2	3.719	44.63	12	20.400	244.80	12	35.700	428.40	2 1/2	14.88	178.60
5	2.125	25.50	4	4.250	51.00	9/16 x 5/8	1.200	14.40	14	41.760	501.12	2 3/4	16.32	195.80
6	2.550	30.60	4 1/2	4.776	57.31	3/4	1.440	17.28	1 x 1/8	3.828	45.93	3	17.85	214.20
3/16 x 1/4	.160	1.92	5	5.313	63.76	1	1.910	22.90	1 1/4	4.250	51.00	3 1/2	20.88	250.60
5/16	.199	2.39	6	6.375	76.50	1 1/4	2.390	28.70	1 3/8	4.680	56.16	4	23.80	285.60
3/8	.239	2.87	8	8.500	102.00	1 1/2	2.870	34.44	1 1/2	5.100	61.20	5	29.76	357.20
7/16	.279	3.35	10	10.630	127.50	2	3.830	45.96	1 5/8	5.523	66.27	6	35.70	428.40
1/2	.319	3.83	12	12.750	153.00	5/8 x 3/4	1.594	19.13	1 3/4	5.950	71.40	8	47.60	571.00
5/8	.398	4.78	3/8 x 7/16	.576	6.91	7/8	1.859	22.31	2	6.800	81.20	10	59.52	714.24
3/4	.478	5.74	1/2	.638	7.66	1	2.125	25.50	2 1/4	7.650	92.33	12	71.40	856.80
7/8	.558	6.70	9/16	.720	8.64	1 1/8	2.390	28.60	2 1/2	8.500	102.00	2 x 2 1/4	15.36	184.30
1	.638	7.66	5/8	.797	9.56	1 1/4	2.565	31.87	2 3/4	9.350	112.20	2 1/2	17.00	204.00
1 1/8	.717	8.60	3/4	.956	11.47	1 3/8	2.930	35.16	3	10.200	122.40	2 3/4	18.72	224.60
1 1/4	.797	9.56	7/8	1.116	13.39	1 1/2	3.188	38.26	3 1/4	11.050	132.60	3	20.40	244.80
1 3/8	.877	10.52	1	1.275	15.30	1 5/8	3.454	41.45	3 1/2	11.900	142.80	3 1/2	23.80	285.60
1 1/2	.956	11.47	1 1/8	1.430	17.16	1 3/4	3.719	44.63	4	13.600	163.20	4	27.20	326.00
1 3/4	1.116	13.39	1 1/4	1.594	19.13	2	4.250	51.00	4 1/2	15.300	183.60	4 1/2	30.60	367.00
2	1.275	15.30	1 3/8	1.750	21.00	2 1/4	4.781	57.37	5	17.000	204.00	5	34.00	408.00
2 1/4	1.440	17.28	1 1/2	1.913	22.96	2 1/2	5.313	63.76	5 1/2	18.720	224.64	5 1/2	37.44	449.28
2 1/2	1.594	19.13	1 5/8	2.080	24.96	2 3/4	5.840	70.00	6	20.400	244.80	6	40.80	489.60
2 3/4	1.750	21.00	1 3/4	2.231	26.77	3	6.375	76.50	6 1/2	22.080	264.96	7	47.60	571.20
3	1.913	22.96	2	2.550	30.60	3 1/2	7.438	89.26	7	23.800	285.60	8	54.40	652.80
3 1/2	2.231	26.77	2 1/4	2.869	34.43	4	8.500	102.00	8	27.200	326.40	9	61.20	734.40
4	2.550	30.60	2 1/2	3.188	38.26	4 1/2	9.560	114.70	9	30.600	361.20	10	68.00	816.00
4 1/2	2.870	34.40	2 3/4	3.500	42.00	5	10.630	127.60	10	34.000	408.00	12	81.60	979.20
5	3.188	38.26	3	3.825	45.90	5 1/2	11.690	140.30	12	40.800	489.60	2 1/4 x 2 1/2	19.07	228.84
6	3.825	45.90	3 1/4	4.140	49.68	6	12.750	153.00	14	47.600	571.20	3	22.90	274.80
8	5.100	61.20	3 1/2	4.463	53.56	7	14.880	178.56	1 8/16 x 1 1/4	4.780	57.36	4	30.60	367.20
10	6.380	76.56	4	5.100	61.20	8	17.000	204.00	1 3/8	5.260	63.12	4 1/2	34.42	413.00
12	7.660	91.92	4 1/2	5.738	68.86	9	19.080	228.96	1 1/2	5.740	68.90	5	38.28	459.36
1/4 x 5/16	.266	3.19	5	6.375	76.50	10	21.250	255.00	1 3/4	6.696	80.35	6	45.80	549.60
3/8	.319	3.83	5 1/2	7.010	84.10	12	25.500	306.00	2	7.640	91.68	2 1/2 x 3	25.50	306.00
7/16	.372	4.46	6	7.650	91.80	3/4 x 7/8	2.230	36.77	2 1/4	8.596	103.15	3 1/2	29.75	357.00
1/2	.425	5.10	7	8.928	107.13	1	2.550	30.60	2 1/2	6.56	114.70	4	34.00	408.00
9/16	.480	5.76	8	10.200	122.40	1 1/8	2.880	34.56	3	11.470	137.66	4 1/2	38.25	459.00
5/8	.531	6.37	10	12.750	153.00	1 1/4	3.188	38.26	4	15.280	183.36	5	42.50	510.00
3/4	.628	7.66	12	15.300	183.60	1 3/8	3.500	42.00	1/4 x 1 3/8	5.860	70.32	6	51.00	612.00
7/8	.744	8.93	14	17.856	214.27	1 1/2	3.825	45.90	1 1/2	6.375	76.50	8	68.00	816.00
1	.850	10.20	7/16 x 1/2	.744	8.93	1 5/8	4.140	49.68	1 5/8	6.900	82.80	12	102.00	1224.00
1 1/8	.956	11.47	5/8	.929	11.15	1 3/4	4.463	53.56	1 3/4	7.438	89.26	3 x 3 1/2	35.76	429.12
1 1/4	1.063	12.76	3/4	1.116	13.39	2	5.100	61.20	2	8.500	102.00	4	40.80	489.60
1 3/8	1.160	13.90	7/8	1.344	16.13	2 1/4	5.738	68.86	2 1/4	9.563	114.80	4 1/2	45.90	551.00
1 1/2	1.275	15.30	1	1.488	17.86	2 1/2	6.375	76.60	2 1/2	10.630	127.60	5	51.00	612.00
1 5/8	1.380	16.56	1 1/4	1.859	22.31	2 3/4	7.000	84.00	2 3/4	11.690	140.00	6	61.20	734.40
1 3/4	1.488	17.86	1 1/2	2.231	26.77	3	7.650	91.80	3	12.750	153.00	8	81.60	979.20
2	1.700	20.40	1 3/4	2.600	31.20	3 1/4	8.2908	99.48	3 1/4	13.800	165.60	3 1/2 x 4	47.60	571.00
2 1/4	1.913	22.96	2	2.975	35.70	3 1/2	9.25	107.00	3 1/2	14				

# All Metals & Forge

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Stainless Carbon & Alloy		PIPE SCHEDULES																Aluminum Nickel		
PIPE SIZE	O.D. IN INCHES	5s	5	10s	10	20	+	30	40s & STD	40	+	60	80s & E.H.	80	100	120	140	160	DBL E.H.	
1/8	.405		.035 .1383	.049 .1863	.049 .1863				.068 .2447	.068 .2447			.095 .3145	.095 .3145						
1/4	.540		.049 .2570	.065 .3297	.065 .3297				.088 .4248	.088 .4248			.119 .5351	.119 .5351						
3/8	.675		.049 .3276	.065 .4235	.065 .4235				.091 .5676	.091 .5676			.126 .7388	.126 .7388						
1/2	.840		.065 .5383	.065 .5388	.083 .6710	.083 .6710			.109 .8510	.109 .8510			.147 .1088	.147 .1088					.187 1.304	.294 1.714
3/4	1.050		.065 .6838	.065 .6838	.083 .8572	.083 .8572			.113 1.131	.113 1.131			.154 1.414	.154 1.414					.218 1.937	.308 2.441
1	1.315		.065 .8678	.065 .8678	.109 1.404	.109 1.404			.133 1.679	.133 1.679			.179 2.172	.179 2.172					.250 2.844	.358 3.659
1 1/4	1.660		.065 1.107	.065 1.107	.109 1.801	.109 1.801			.140 2.273	.140 2.273			.191 2.997	.191 2.997					.250 3.765	.382 5.214
1 1/2	1.900		.065 1.274	.065 1.274	.109 2.085	.109 2.085			.145 2.718	.145 2.718			.200 3.631	.200 3.631					.281 4.859	.400 6.408
2	2.376		.065 1.605	.065 1.604	.109 2.638	.109 2.638			.154 3.653	.154 3.653			.218 5.022	.218 5.022					.344 7.462	.436 9.029
2 1/2	2.875		.083 2.475	.083 2.475	.120 3.531	.120 3.531			.203 5.793	.203 5.793			.276 7.661	.276 7.661					.375 10.01	.552 13.70
3	3.500		.083 3.020	.083 3.029	.120 4.332	.120 4.332			.216 7.576	.216 7.576			.300 10.25	.300 10.25					.438 14.32	.600 18.58
3 1/2	4.000		.083 3.472	.083 3.472	.120 4.937	.120 4.937			.226 9.109	.226 9.109			.318 12.51	.318 12.51					.318 12.51	.636 22.85
4	4.500		.083 3.915	.083 3.915	.120 5.613	.120 5.613			.237 1.079	.237 1.079			.337 14.98	.337 14.98		.438 19.00			.531 22.51	.674 27.54
4 1/2	5.000								.247 12.54				.355 17.61							
5	5.563		.109 6.349	.109 6.349	.134 7.770	.134 7.770			.258 14.62	.258 14.62			.375 20.78	.375 20.78		.500 27.04			.625 32.69	.750 38.55
6	6.625		.109 7.585	.109 7.585	.134 9.289	.134 9.289			.280 18.97	.280 18.97			.432 28.57	.432 28.57		.562 36.39			.719 43.35	.864 53.16
7	7.625								.301 23.54				.500 38.04							.875 63.08
8	8.625		.109 9.914	.109 9.914	.148 13.40	.148 13.40	.250 22.34	.175 5.463	.277 24.70	.277 24.70		.406 35.64	.500 43.39	.500 43.39	.594 5.095	.719 60.71	.812 67.76	.906 74.79	.875 72.42	
9	9.625								.342 33.91				.500 48.73							
10	10.75		.134 15.19	.134 15.19	.165 18.65	.165 18.65	.250 28.04	.279 1.079	.307 34.24	.307 34.24		.590 54.76	.500 54.74	.594 64.43	.719 77.03	.844 82.29	1.000 104.1	1.125 115.6	1.000 104.1	
11	11.75								.375 45.56				.500 60.08							
12	12.75		.156 21.07	.165 22.18	.180 24.16	.180 24.16	.250 33.38	.375 17.14	.330 43.77	.330 43.77	.500 22.63	.562 73.15	.500 65.12	.688 68.63	.844 107.3	1.000 125.5	1.125 136.7	1.312 160.3	1.000 125.5	
14	14.00		.158 23.07		.188 27.73	.250 36.71	.312 45.61		.375 54.57	.375 54.57		.594 85.05	.500 72.09	.750 106.1	.938 130.9	1.094 150.8	1.250 170.2	1.406 189.1		
16	16.00		.165 27.90		.188 35.76	.250 42.05	.312 52.27		.375 62.58	.375 62.58		.656 107.5	.500 82.77	.844 136.6	1.031 164.8	1.219 192.4	1.438 223.6	1.594 245.3		
18	18.00		.165 31.43		.188 35.76	.250 47.39	.312 58.94		.438 82.15	.375 70.59		.750 138.2	.500 93.45	.988 170.9	1.156 208.0	1.375 244.1	1.562 274.2	1.781 308.5		
20	20.00		.188 39.78		.218 46.05	.250 52.73	.375 78.60		.500 104.1	.375 48.60		.812 166.4	.500 104.10	1.031 206.9	1.281 256.1	1.500 296.4	1.750 341.1	1.969 379.2		
24	24.00		.260 68.37		.260 63.41	.250 63.41	.375 96.42		.562 140.7	.375 94.62		.969 238.4	.500 125.5	1.219 296.6	1.631 367.4	1.812 429.4	2.062 483.1	2.344 542.1		
26	26.00				.312 85.60	.500 136.17			.375 102.63				.500 136.17							
28	28.00				.312 92.26	.500 146.85			.625 182.73	.375 110.64										
30	30.00		.250 79.43		.312 98.93	.500 157.53			.625 196.08	.375 118.65			.500 157.53							
32	32.00				.312 105.59	.500 168.21			.625 209.43	.375 126.66			.500 168.21							
34	34.00				.312 112.25	.500 178.89			.625 222.78	.375 134.67			.500 168.21							
36	36.00				.312 118.92				.625 236.13	.375 142.68			.500 189.57							

BLACK: Wall thickness in inches  
 RED: Steel weight per foot in pounds  
 GREEN: Aluminum weight per foot in pounds

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Please copy, fill out and fax to 973-276-5050. Retain this original for future use.

### WAREHOUSE AND MILL PRODUCTS

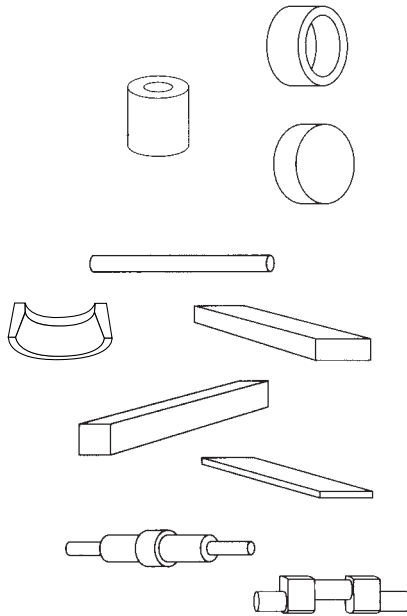
GRADE \_\_\_\_\_ SPECIFICATION \_\_\_\_\_

SIZE \_\_\_\_\_

QUANTITY \_\_\_\_\_ DELIVERY REQUIREMENT \_\_\_\_\_

SHEET  STRIP  PLATE  ROUND  SQUARE  FLATS  HEX  TUBING  PIPE  WIRE

### FORGINGS



	FINISHED SIZES		
	Outside Diameter	Inside Diameter	Thickness/Face Length
<b>RING</b>			
<b>SLEEVE</b>			
<b>DISC</b>			
<b>ROUND BAR</b>	Diameter _____ Length _____		
	Width	Length	Thickness
<b>BLOCK</b>			
<b>BAR</b>			
<b>PLATE</b>			

**STEP DOWNS AND SPECIAL SHAPES (Please Include print or drawing)**

FORGINGS ARE TO BE ROUGH MACHINED WITHIN ALLOWANCE TO FINISH.

**SPECIAL INSTRUCTIONS/COMMENTS:** \_\_\_\_\_

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

NAME \_\_\_\_\_ TITLE \_\_\_\_\_ DATE \_\_\_\_\_

COMPANY \_\_\_\_\_ TELEPHONE \_\_\_\_\_

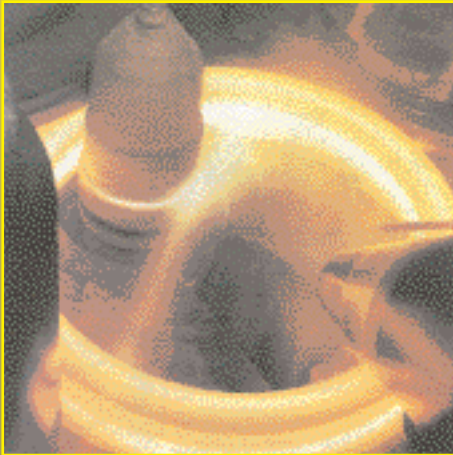
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