VERSA BAR®
american iron & alloys corporation

To: The Machinist (or anyone concerned with machining costs)

RE: VERSA−BAR Machinist Guide

Dear Machinist:

We at American Iron & Alloys Corporation have felt for some time that there were many misconceptions and a general lack of information available for machining continuous cast iron. Therefore, we thought it would be helpful to you, the machinist, if we put together a guide which would address commonly asked questions and provide a basis for improved machining.

In compiling this information, we knew that not all processes of machining and their many variations could be covered. Also, it was not our intent to re−write the machinist handbook. Therefore, we concentrated on the basic operations and equipment most commonly found.

To give this guide more practical merit, all of out tests were done on machines in the field, rather than in a laboratory type situation. The field tests were arraigned by Mr. Gene Bournique of G.T. Enterprises in Seattle, Washington. It was through Gene's 33 years of experience at Continental Can, Boeing Corporation, and close association with the Society of Mechanical Engineers that allowed us access on equipment used in daily operations. We feel fortunate to have had Gene Bournique's assisstance and commentary on these tests.

We hope you'll find the VERSA−BAR Machinist Guide helpful, and that through it you too can reduce your machining costs. Again, it is a base to start from. So don't be afraid to improve on our recommendations. Even though your results may vary from ours, we are confident you will find that VERSA−BAR is *the* high performance, low cost, machinable material, best suited to your needs. If you have any special problems or questions, please feel free to give us a call. After all, it was from your questions that prompted American Iron & Alloys to gather this information.

Thank you,
American Iron & Alloys Corp.

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American Iron & Alloys' *Machinist Guide*
for **Versa Bar** Continuous Cast Iron

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VERSA BAR VS. SAND CASTING

What is the difference between Versa Bar Continuous Cast Iron and the iron I've machined for years?

We need to understand that iron castings and sand cast iron bars are not the same products as **Versa Bar** continuous cast iron bars. While sand cast iron, man's second oldest metal, has been around for a long time, continuous cast iron technology was only developed recently.

So, what;s the big difference? Simply put, **Versa Bar** con−cast iron bars are metallurgically superior to conventional sand castings.

The **Versa Bar** continuous casting process virtually eliminates rejections due to porosity and center line shrinkage. These internal flaws usually show themselves after the last bit of expensive machining has been completed. Therefore **Versa Bar** can significantly reduce the risk of machining unusable material.

REASONS TO USE VERSA BAR

VERSA BAR saves you money in three important areas!

Lower Material Cost:

Versa Bar is a lower cost alternative when compared directly to aluminum, brass, bronze and many grades of alloy and carbon steel.

(G.B.): "For example: in our tests we machined for direct comparison both **Versa Bar** and two popular grades of aluminum. Including any machining cost differences, the finished part cost of the **Versa Bar** hydraulic cylinder piston was **45% less expensive** than the least expensive grade of aluminum.

(G.B.): Gene Bournique

Improved Machinability:

Versa Bar's fine grained microstructure offers a consistent soundness and uniformity previously unknown to the machinist who might already be working with sand cast iron.

The well dispersed graphite in **Versa Bar** con−cast iron acts as a self−contained chip breaker which reduces horsepower requirements. Improved turning speeds of 30% or more can be achieved with American Iron and Alloys' **Versa Bar.** The result is increased tool life and decreased tool life and decreased man hour expense.

Improved Performance:

The high graphite flake content of con−cast **Versa Bar** offers two very important advantages.

First, these microscopic flakes or spheres of graphite feature tiny recesses that promote the retention of oil. So lubricated parts stay oily longer.

Second, this well dispersed graphite acts as a self lubricant in the event of oil loss. A part made of **Versa Bar** will have better chance of survival.

The naturally occurring non−abrasive quality gives the **Versa Bars** and **tubes** extremely high wearability. We believe it can be said that **Versa Bar** con−cast iron is the true hydraulic metal.

Versa Bar can be supplied with very high physical properties. As cast our ductile iron is available from 60,000 to 80,000 psi tensile strength. Through heat treatment, **Versa Bar** ductile iron can provide up to 100,000 psi tensile strength.

These **Versa Bar** products offer excellent compression strength and high vibration dampening capability. Good dampening capacity reduces machinery noise and thus helps to control fatigue caused by vibration.

MATERIAL GRADES OF VERSA BAR

What are the differences in the three major grades of Versa Bar Continuous Cast Iron?

There are three main grades of **Versa Bar:**

V−2 (Class 40) Gray Iron has a tensile strength of 40,000 psi with a compression strength of 150,000 psi. Its hardness will range from 187 to 269 bhn. The microstructure is essentially pearlitic. **V−2** is ideally suited for straight wear applications. It is widely used for bearing and bushing applications in the hydraulics industry. Yet like any gray iron casting it has many other applications, within the available shapes and sizes.

V−3 (65−45−12) Ductile Iron has a tensile strength of 65,000 psi, yield strength of 45,000 psi, with a 12% elongation. The hardness ranges from 131 to 220 bhn. The microstructure as cast is ferritic. This fine ferritic structure makes the **V−3** ductile iron the easiest machining of the three grades of **Versa Bar.** It offers high spindle speeds, less tool wear and better finishes. It is widely used for pistons in the hydraulics industry. This grade provides high strength and excellent wear resistance in metal−to−metal applications.

(When compared directly to 1144 steel, including material cost, out machining tests showed the **V−3** ductile iron cost 15 to 20% less to produce the same part.)

V−4 (80−55−06) Ductile Iron has a tensile strength of 80,000 psi, yield strength of 55,000 psi and elongation of 6%. It is the highest strength of the three grades, as cast. As mentioned earlier this grade can be heat treated to 100,000 psi tensile strength. The **V−4** material can be expected to machine 10 to 15% below the rates of **V−3,** due to its pearlitic structure. The **V−4** material is most often chosen when steel physicals are needed. Even with its higher strength and the corresponding hardness of 187 to 269 bhn, it should also yield a positive cost comparison to other materials.

TURNING AND MILLING

What do you recommend as a staring point for Turning and Milling Versa Bar products?

(G.B.): "The machinist's handbook recommends turning and milling sand cast iron at 300 sfm. In our field tests, on a conventional lathe with carbide inserts, we found that **Versa Bar** con−cast bars easily attained **800 sfm** and showed improved performance and greater economy."

Speeds and Feeds: We recommend starting with 800 sfm with a .015" feed rate. rpm 1100, (depending on available horsepower.)

Tooling could be any of the recommended inserts discussed later. Our speeds and feed recommendations were based on normal carbide inserts. If coated or the newer high tech inserts are used, the machining rates will be dramatically higher. Examples of these higher rates are shown later. Whatever type of cutting material you use; **we urge you to: increase your feed if you think you are experiencing excessive tool wear. Don't turn down!** Cast iron has a tendency to build up on the tooling, making it perform as if it were dull. Our tests clearly showed that insert choice and proper placement angle to be critical in achieving the best machining results. Your local tool saleman can be very helpful in making the best tool selection.

(G.B.); Gene Bournique

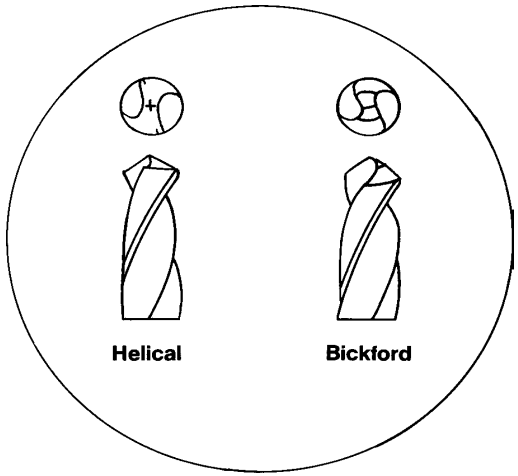
DRILLING

What would you recommend for parts requiring drilling?

We must again acknowledge that the metallurgy of cast iron and other metals are not the same. When drilling steels, for instance, chips form as a spiral that tends to self clean the hole. With cast iron, the chips may remain in the hole and the drill then works against its own chips. If left unattended, these chips can weld themselves to the drill which dulls the bit and can cause the hole to become oversize. Thus, we would recommend **coolant fed drills** whenever possible.

The problem can also be relieved by grinding a **1/8" thick double cutting edge point** to your existing drill. You should see vastly improved tool wear over conventional drill bit shapes.

Another solution is to use commercially available bits with a **"Helical"** or **"Bickford" point,** shown below. The Bickford point has excellent centering ability. It **increases speeds and feed by 25%** over standard drill bits and decreases tool wear.



SAW CUTTING

What recommendations can you make for saw cutting Versa Bar?

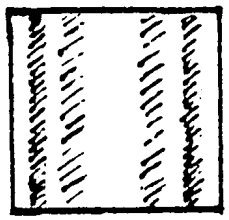
At American Iron & Alloys Corp., we use the cutting chart shown below. The high graphite content of **Versa Bar** allows us to cut dry or wet at all the speeds we require.

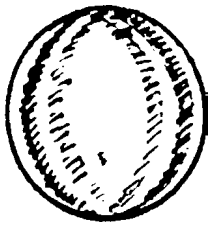
Break in blades at 1/2 feed and 2/3 speed (about 75 in). Coarser blades tend to wander because of decreased back strength. Wander cuts usually indicate worn or defective blades or too fast of feed.

The cut face should show a regular pattern, course for small sizes of **V−2,** finer for larger sizes. **V−4** will show a somewhat finer pattern, while **V−3** will give a coarser appearance. These patterns run parallel to the direction of the saw blade. The face of the cut should show regular shadows echoing the shape of the cut edge. Shadows should be more pronounced near the edge, fainter toward the center of the face, as the sketch below indicates.

Sawing Recommendations for Cast Iron Versa Bar

Grade	Diameter Range	Best Pitch	Type	Recommended Tooth Material	Ft/Min Speed	In^2/Min Feed	Coolant
V−2	½"−3"	4/6	Variable	Cobalt	145−200	4	Dry & Wet
V−2	2"−6"	3/4	Posi−Tooth	Cobalt	120−165	4	Dry & Wet
V−2	6"−16"	2/3	(all types)	Cobalt	110−135	5	Dry & Wet
V−3	½"−6"	4/6		Cobalt	250−350	5−6	Dry & Wet
V−3	4"−10"	3/4		Cobalt	200−250	6−7	Dry & Wet
V−3	8"−16"	2/3		Cobalt	180−210	6	Dry & Wet
V−4	½"−6"	4/6		Cobalt	150−210	4−5	Dry & Wet
V−4	4"−10"	3/4		Cobalt	120−160	5	Dry & Wet
V−4	8"−16"	2/3		Cobalt	100−130	5	Dry & Wet





SURFACE GRINDING

What recommendations can you make regarding Surface Grinding, Blanchard Grinding, O.D./I.D. Grinding?

In many cases, the first operation for **Versa Bar** round con−cast bars is grinding. This is required where close tolerances are needed on the O.D. American Iron & Alloys provides centerless ground bars up to 5 inches in diameter. We usually can take at least .025" per pass while holding a plus or minus .003" tolerance.

As a general statement on grinding, we would recommend following the machinist handbook rates to start. Then increase the rate at least 20%. Of course the type of grinding and the equipment being used will determine how much more you can advance the recommended rates.

TOOLING TECHNOLOGY

What effects have the latest developments in Ceramic, Carbide and other cutting tool technology has on machining rates for Versa Bar?

The impact of the new tooling technology now available in the machining of cast iron is very
significant. However, as we've stated earlier, the improved metallurgy of **Versa Bar** alone will yield far better rates than the machinist handbook recommends. We did test some of these advanced **ceramic inserts** and achieved feed rates as high as **1,500 sfm.** This again was on a conventional 7 hp lathe. (G.B.) "It was our opinion, both the operator and mine, that if we had been using a high speed, high horsepower CNC machine, we could have run as high as 3,000 sfm."

In the past few years tremendous advances have been made in cutting tools. Of these new materials, two seem to show the **most significant improvement** in machining cast iron, These are: **silcon**
nitride and **cubic boron nitride** (CBN). This CBN material is also referred to as polycrystalline tools. As you can see from the chart on the next page, the machining rates for **cast iron** published by NGK Cutting Tool, with their SX8, silicon nitride insert, **meets and exceeds the sfm of aluminum.** These types of inserts should be considered for high volume production and/or extended tool life. (Other manufactures, such as Valenite also offer a similar line of cutting tool.)

So by matching the metallurgical advantages of **Versa Bar** and the **superior tooling** now available:: today's machinist can run at much **higher sfm** than ever in the past.

(G.B,); Gene Bournique

NGK's Recommendation Chart for Turning

Material	Hardness (HB)	Depth of Cut	Black Ceramic CX3	White Ceramic HC2	Composite Ceramic HC6	Silicon Nitride SX8	Titanium Nitride T3N	XT3	XN4
Carbon Steels 1000 Series Alloy Steels 4000 5000 6000 8000 9000 Series	130	~.020	2500		2000		1000	1100	
		~.180	2000		1800		900	950	750
		~.150							650
	180	~.020	2500		2000		80	900	
		~.080	2000		1800		780	800	650
		~.150							580
	220	~.020	2000		1800		800	800	
		~.080			1500		700	700	580
		~.150							530
	260	~.020	1800		1500		700	700	
		~.060			1300		600	600	540
		~.020							500
	300	~.020	1500		1500		600	600	
		~.060			1200		500	500	420
		~.120							350
	350	~.020		1300	1200		550	550	
		~.040		1000	1000		450	450	350
		~.080							270
	40 RC	~.020		1000			450	400	
		~.040		800			350	300	
		~.080		700					
	50 RC	~.010		600					
		~.020		550					
		~.060		500					
	60 RC	~.010		420					
		~.020		370					
		~.040		340					
	65 RC	~.010		350					
		~.020		300					
		~.040		250					
Gray Cast Iron	180	~.020	3000	2000	2000	5000			
		~.080	2500	2000		5000			
		As Cast	2000	1500		3500			
	230	~.020	2500	1800	1800	3000			
		~.060	2500	1800		3000			
		As Cast	1800	1200		2500			
Ductile & Malieable Iron (Nodular Iron)	180	~.020			1500			800	
		~.060			1500			650	
		As Cast			1200				
	250	~.020			1200			500	
		~.060			1200			450	
		As Cast			1000				
Aluminum Alloys (Low Si content)		~.040					3500		
		~.150					3000		
Non Ferrous (copper, zinc, brass)		~.040					3500		
		~.150					3000		

RECOMMENDED TOOLING

Based on your testing, what types of cutting tools would you recommend for Increased Productivity?

(G.B) "The following can be used as a guide or starting point. We used both Kennametal and Valenite brands for our testing. In our side−by−side material comparison, the insert of choice became the Valenite, VC 67 432 2B, 55 degree, negative rake. It machined at a feed rate between .006−.026 ipr with chip control on both sides. Its ability to both rough turn and finish allowed for much less down time during the tests."

Regardless of the geometry for tool placement or shape of insert used, it is our opinion that an insert with a **negative rake performs best** when machining **Versa Bar.**

(G.B.): "Generally speaking, ceramic tooling will machine beyond carbide by two to three times the speed. However, ceramics are designed to be run dry. If you are running hot, literally red hot, and you apply coolant, it will crack the insert. Therefore, in very high speed operations, we recommend using a polycrystalline insert or silicon nitride. The Sumitomo's BN 100 or NGK's SX8 shown on our chart are of this type and might be considered." (Since our list was originally published, Valenite has offered their Quantum 6 "Iron Eater." This insert is specially designed for high speed machining cast iron.)

Inserts Used in Test and Others Recommended for Versa Bar

Mfg. Or Trade Name	Roughing	Finishing
Carboloy	820	999
Carmet	CA 310	CA8
Greenleaf	G−10	G−40
Kennametal	KC 950	KC 850
Newcomer	N−10	N−40
Sandvik	H−20 H−13A	H05
Valentine	VC 67	VC 67
NTK (NGK)	SX8	CX3 HC2 SX8
Sumitomo	BN 100	BN 100

(G.B.); Gene Bournique

COOLANT AND MACHINE MAINTENANCE

How much of an effect does Coolant play in the machining of Versa Bar?

(G.B.): "Usually forgotten in any discussion of machining practices are coolants. Yet their impact can be enormous. The proper use of coolant in the machining of cast iron will lead to decrease in the horsepower required and increased tool life. It will also improve the surface finish due to less graphite pullout; which is significant in terms of total machine productivity. We attributed a 20% increase in productivity in our test when using a semi−synthetic coolant like the ones listed below."

Coolants Used in Our Tests and Their Equivalents:

Ore−Lube 108, Polar−Chip, Cim Cool, Blaze−Kut, Cool−Lube 220.

What recommendation can be made regarding machine and coolant maintenance?

Proper maintenance of your machine as everyone knows is sound advice for optimum performance. This is especially true when machining cast iron. The chips tend to be small which can build up quickly if left unattended.

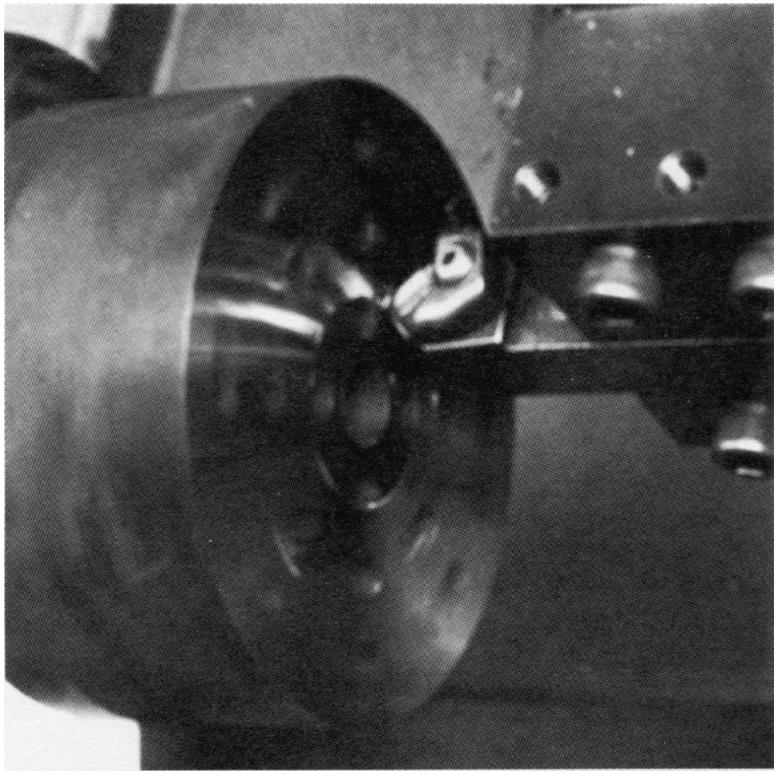
Also, any metals simply by the nature of chemistry, will interact with that of the coolant and foul. If you are experiencing a high amount of coolant fouling, it is more likely that an unacceptable amount of lube oil is finding its way into the coolant. This can be controlled by use of a skimmer in the coolant tank or absorbent pickup pad.

Will coolants help control the fumes and smoke that can generate from machining?

Yes, but keep oil away from cutting surface. It contaminates coolant and leads to excessive smoke and fumes. When cut dry the high graphite content in cast iron will show itself as smoke. Especially during deep or rough cuts involving a very hot tool.

(G.B.): "The answer is to use coolant. This will greatly reduce any tendency to smoke. Be careful to use "non−oil base" coolants. This should eliminate the problem. However steam may still be
generated at the point of contact if the tool is extremely hot.

(G.B.); Gene Bourmique



MACHINING COMPARISON

What kind of machine cost comparison can be made between Versa Bar con−cast bar and other metals such as aluminum, bronze or steel?

This is a difficult question to answer because machining is such a relative subject. Surface roughness is often looked at as a common denominator. However, an O.D. finish considered rough in one application may be too smooth for another. Often machinists will look first to speed and feed rates as the bottom line determinate. Yet as we have shown earlier this is greatly affected by the tooling used and the capability of the machine.

We feel it is the end use application versus cost per pound that determines the material used. As such, where **Versa Bar** fits the physical requirements, it should be used...pound for pound against aluminum, bronze, and most steel, it will be the **low cost material.** Even against engineered sand castings it will often be lower, if you consider tooling pattern cost and losses from scrap.

FIELD TEST COMPARISON CHART

The chart below shows the speeds and feeds for aluminum, bronze and steel as well as the comparable rates for **Versa Bar**. The rates for aluminum, bronze and steel were those used by the field test operator for normal production requirements on the machine being used. (The machine used was a 7 hp lathe, set up for production of hydraulic cylinder pistons. The cutting tools used for this analysis was a Valenite VC 67 Carbide Insert.)

The operators were asked to reach the optimum sfm (surface feed per minute) on the **Versa Bar** and still maintain comparable depth of cut and surface roughness with the other three materials. As you can see, the chart shows that all three grades of **Versa Bar** far exceeded the recommendations of conventional machinist handbooks for sfm on cast iron. Again, these tests were with conventional tooling and equipment. The results of the **Versa Bar** sfm are very conservative. If you were to run the same test on a CNC type machine or use one of the new high tech inserts, rates comparable to those shown on the NGK chart would be possible.

	CAST IRON										ALUMINUM			BRONZE		STEEL	
	V−2 GREY (CLASS 40)			V−3 DUCTILE (65−45−12)				V−4 DUCTILE (80−55−06)			6061−T6		2024 T−3	SAE 660		C−1045	
R.P.M.	1100	1500	1500	1100	1500	1500	1100	1100	1500	550	1100	1500	1100	1100	1500	1100	1500
FEED	.011	.013	.008	.009	.013	.013	.011	.009	.013	.006	.009	.013	.009	.009	.011	.009	.013
DEPTH OF CUT	.150	.150	.125	.125	.250	.060	.050	.125	.060	.180	.125	.250	.125	.125	.125	.125	.125
LENGTH OF CUT	4"	4"	3"	4"	4"	4"	4"	4"	4"	4"	4"	4"	4"	3¼"	3¼"	5"	5"
R.M.S.	63FS	90FS	63FS	63FS	150FS	63FS	63FS	63FS	63FS	80FS	60FS	125FS	60FS	80FS	80FS	63FS	150FS
WITH COOLANT	YES	NO	YES	YES	NO	NO	NO	YES	NO	NO	YES	YES	YES	YES	YES	YES	YES
MACHINE HORSEPOWER	7HP	7HP	7HP	7HP	7HP	7HP	7HP	7HP	7HP	7HP	7HP	7HP	7HP	7HP	7HP	7HP	7HP
TAPER	.0007	.0015	.0005	.001	.003	.0008	.001	.001	.001	.001	.001	.001	.0005	.0005	.0005	.001	.001
S.F.M.	625	825	825	550	775	775	550	575	800	270	575	800	575	950	1200	800	900

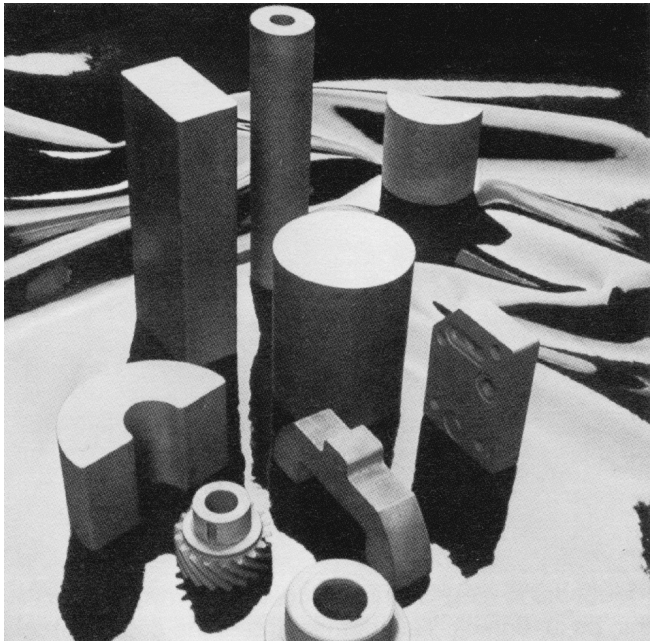
CONCLUSION

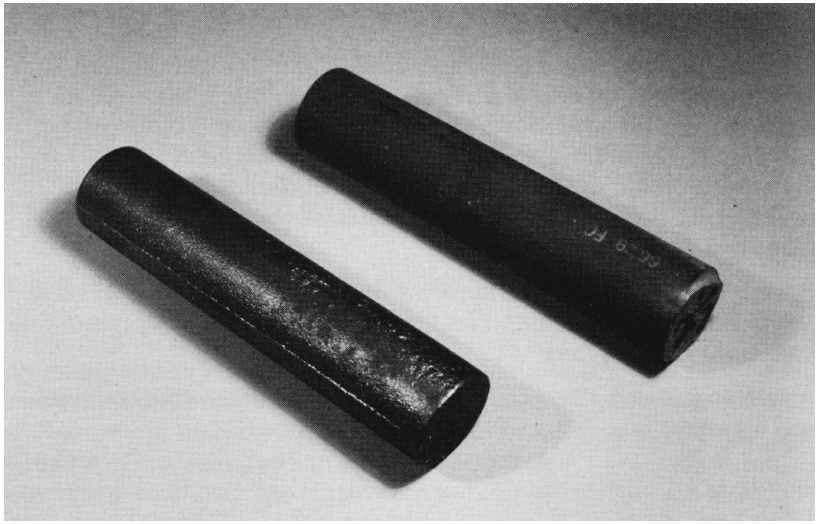
The main purpose of this guide was to address the misconceptions on machinability of cast iron, and in particular **Versa Bar,** continuous cast iron. We hope we have shown that through the unique **metallurgical make−up** of **Versa Bar** alone, much **better machining rates** can be achieved. Further, with the **new tooling and coolant technologies** available, it's now possible to **machine at rates** equal to or **better than aluminum, bronze and steel.**

It is our firm belief that if you apply the recommendation of this guide and select **Versa Bar**, continuous cast iron, you will see improvements in your total finish machine cost.

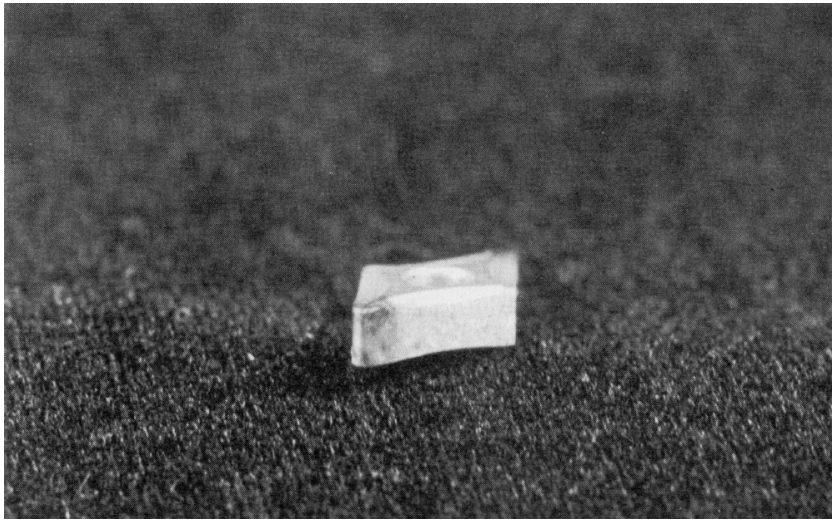
American Iron and Alloys Corp. welcomes any questions or comments you may have.

(800) 544-4800 or FAX (262) 544-4137

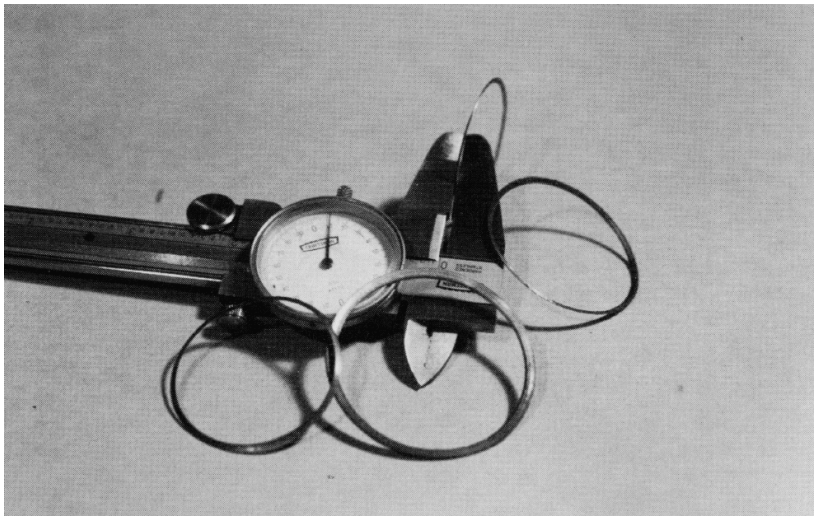




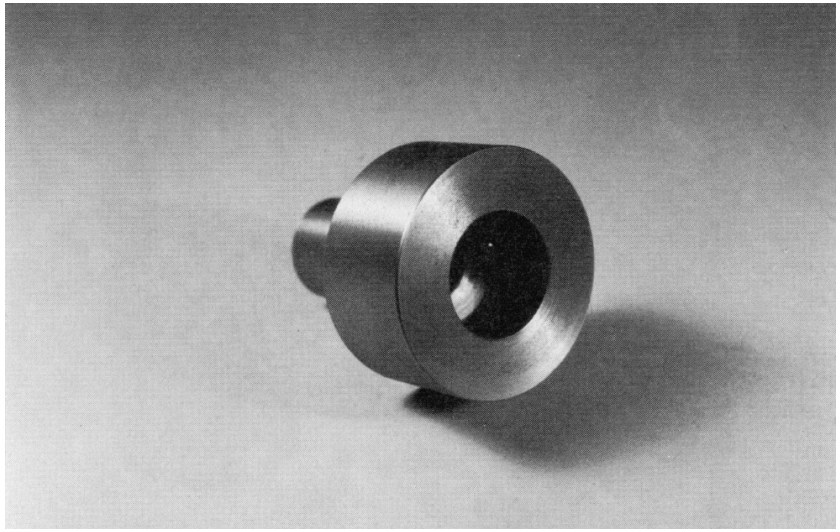
A side by side comparison of both a sand cast bar and a Versa con−cast bar shows why machinist prefer the as cast finish of the VERSA−BAR product. The continuous casting method offers a superior surface finish and virtually eliminates internal porosity and centerline shrinkage.



This Valenite VC 67 carbide insert has had over 15 hours of machine time. It was used to test the full range of VERSA−BAR cast iron. It’s surface shows how "insert friendly" VERSA−BAR products can be given proper setup and machining practice.

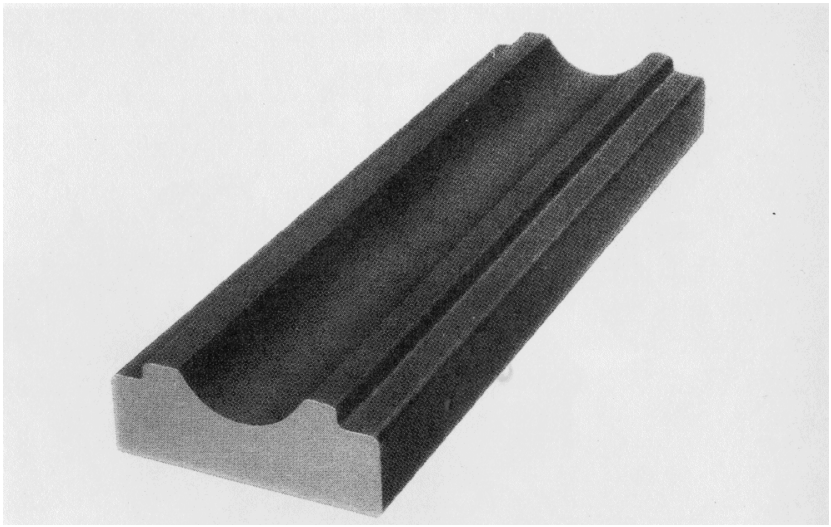


During our machine testing for this guide, sample rings were routinely parted as thin as .010 thick. This demonstrates the superior metallurgical integrity of the VERSA−BAR con−cast product.

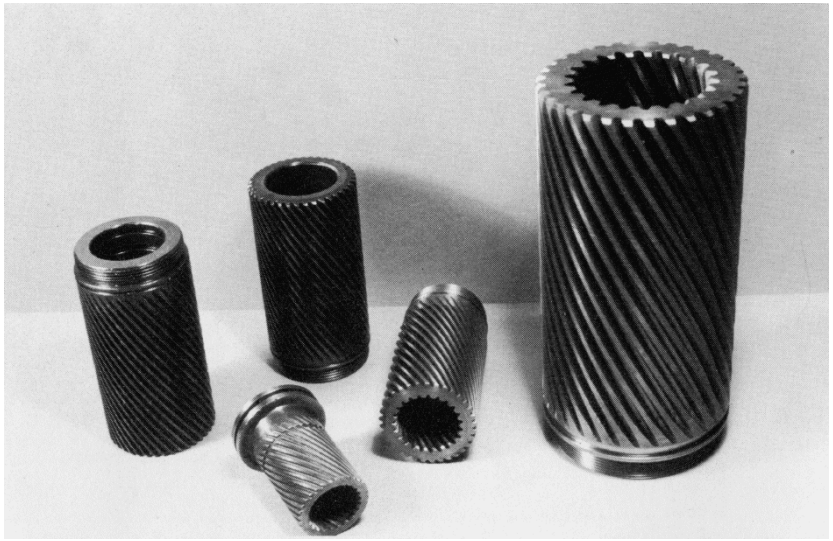


The part pictured above was made from a solid piece of round VERSA−BAR, V−3 (65−45−12) ductile iron. The customer machined the spindle in a one pass operation which took less than 30 seconds. We feel this demonstrates the versatility and integrity of the material under heavy machinery demands.

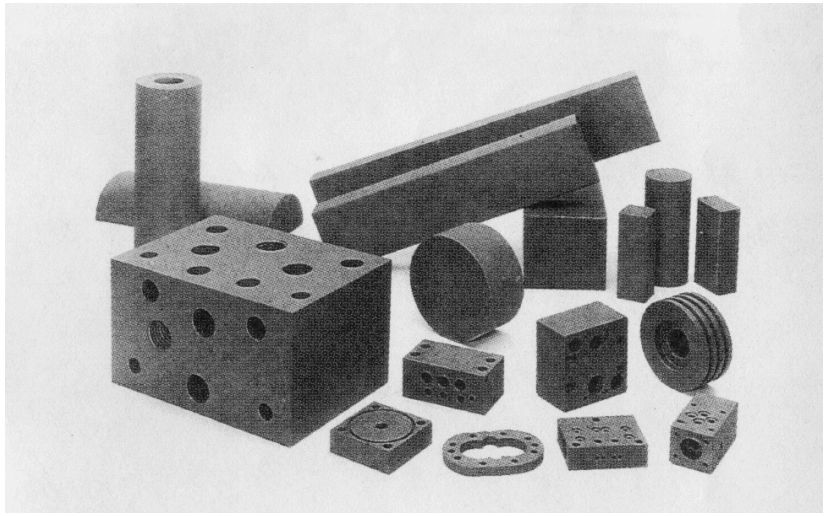
These stepped hydraulic seal rings are double−parted from the same bar. VERSA−BARS' homogeneous matrix allowed the customer the necessary yield per bar to utilize this economical process.



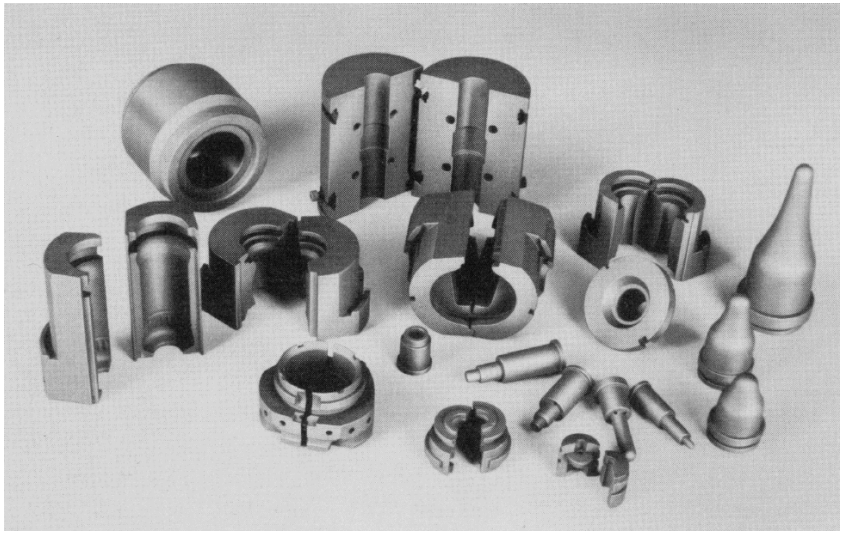
The machine tool industry has been a traditional user of VERSA−BAR continuous cast iron. The near net shapes attainable through continuous casting and the excellent metal to metal wearability, makes VERSA−BAR the right choice in this industry.



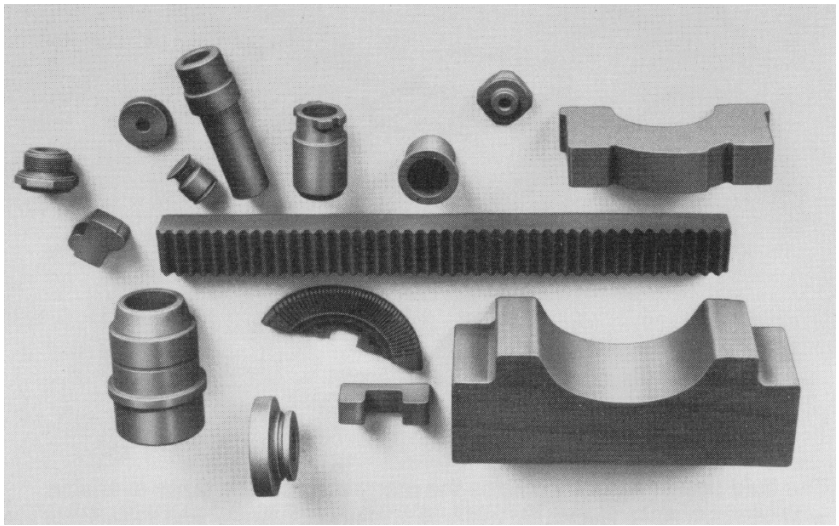
These are rotary actuator piston sleeves made of V−4 (80−55−06) ductile iron. These worm gears are grooved on the O.D. and I.D. The O.D. is then threaded with ring grooves placed on both O.D. and I.D. This part shoes how VERSA−BAR fits even in the most complex machining application.



The fluid power industry utilizes the many shapes and sizes available with VERSA−BAR. Hydraulic cylinders, pistons, glands, and manifolds are a few of the more common applications. More and more this industry is finding that higher cost materials, such as Aluminum, offer no benefits over VERSA−BAR.



The fine grain structure and the machinability of VERSA−BAR makes for a perfect fit in production of glass molds.



Versatility is the first word in VERSA−BAR. American Iron and Alloys and our customers are finding new applications every day.

A complete inventory is maintained at American Iron and Alloys' central operations in Waukesha, Wisconsin as well as at our distributors throughout the united States and Canada.

GRAY IRON
VERSA−BAR® (40,000 PSI) V−2
SOLID ROUND BARS−6 FOOT LENGTHS

CENTERLESS GROUND BARS
TOLERANCE +.010 −.000"

FINISH DIAMETER IN INCHES	EST. POUNDS PER INCH	EST. POUNDS PER BAR
.625	.08	6
.750	.13	9
.875	.17	12
1.000	.21	15
1.125	.28	20
1.250	.33	24
1.375	.40	29
1.500	.49	35
1.625	.53	38
1.750	.63	45
1.875	.72	52
2.000	.82	59
2.125	.93	67
2.250	1.04	75
2.375	1.17	84
2.500	1.29	93
2.625	1.42	102
2.750	1.58	114
2.875	1.71	123
3.000	1.88	135
3.125	2.03	146
3.250	2.19	158
3.375	2.36	170
3.500	2.56	184
3.625	2.74	197
3.750	2.92	210
3.875	3.13	225
4.000	3.33	240
4.250	3.78	272
4.500	4.24	305

A.I.A DESIGNATION

GRADES OF IRON	
V−1A	Glass Mold Iron
V−1	30,000 psi Gray Iron
V−2	40,000 psi Gray Iron
V−3	65−45−12 Ductile Iron
V−4	80−55−06 Ductile Iron
V−5	100−70−03 Ductile Iron
V−6	35,000 psi Gray Iron

AS CAST BARS

FINISH DIAMETER IN INCHES	AVG. STOCK ALLOW.	EST. POUNDS PER INCH	EST. POUNDS PER BAR	FINISH DIAMETER IN INCHES	AVG. STOCK ALLOW.	EST. POUNDS PER INCH	EST. POUNDS PER BAR
.625	.085	.10	8	7.000	.170	10.71	771
.750	.085	.15	11	7.250	.190	11.53	830
.875	.085	.19	14	7.500	.190	12.35	889
				7.750	.190	13.13	945
1.000	.085	.25	18				
1.125	.085	.31	22	8.000	.190	13.96	1005
1.250	.085	.38	27	8.250	.216	14.92	1074
1.375	.085	.44	32	8.500	.216	15.82	1139
1.500	.085	.53	38	8.750	.216	16.74	1205
1.625	.085	.61	44				
1.750	.085	.71	51	9.000	.216	17.68	1273
1.875	.085	.81	58	9.250	.254	18.76	1351
				9.500	.254	19.81	1426
2.000	.085	.90	65	9.750	.254	20.83	1500
2.125	.110	1.04	75				
2.250	.110	1.17	84	10.000	.254	21.89	1576
2.375	.110	1.29	93	10.250	.400	23.61	1700
2.500	.110	1.42	102	10.500	.400	2427	1781
2.625	.110	1.56	112	10.750	.400	25.88	1863
2.750	.110	1.71	123				
2.875	.110	1.86	134	11.000	.400	27.06	1948
				11.500	.582	30.38	2187
3.000	.110	2.01	145				
3.125	.125	2.21	159	12.000	.582	32.94	2372
3.250	.125	2.38	171	12.500	.582	35.63	2565
3.375	.125	2.56	184				
3.500	.125	2.74	197	13.000	.582	38.40	2765
3.625	.125	2.93	211				
3.750	.125	3.13	225	14.000	.582	44.25	3186
3.875	.125	3.33	240				
				15.000	.582	50.54	3689
4.000	.125	3.54	255				
4.250	.140	4.01	289	16.000	.582	57.24	4121
4.500	.140	4.49	323				
4.750	.140	4.97	358	17.000	.762	65.67	4728
5.000	.140	5.50	396	18.000	.762	73.26	5275
5.250	.155	6.08	438				
5.500	.155	6.67	480	19.000	.762	81.29	5853
5.750	.155	7.26	523				
				20.000	.762	89.74	6461
6.000	.155	7.89	568				
6.250	.170	8.58	618				
6.500	.170	9.26	667				
6.750	.170	9.97	718				

FORMULA:
As Cast Round Weight:
Length in inches x Weight per inch
= Total Weight

DUCTILE IRON
VERSA−BAR® (65−45−12) V−3 · (80−55−06) V−4
SOLID ROUND BARS−6 FOOT LENGTHS

CENTERLESS GROUND BARS
TOLERANCE +.010 −.000"

FINISH DIAMETER IN INCHES	EST. POUNDS PER INCH	EST. POUNDS PER BAR
1.500	.49	35
1.625	.53	38
1.750	.63	45
1.875	.72	52
2.000	.82	59
2.125	.93	67
2.250	1.04	75
2.375	1.17	84
2.500	1.29	93
2.625	1.42	102
2.750	1.58	114
2.875	1.71	123
3.000	1.88	135
3.125	2.03	146
3.250	2.19	158
3.375	2.36	170
3.500	2.56	184
3.625	2.74	197
3.750	2.92	210
3.875	3.13	225
4.000	3.33	240
4.250	3.78	272
4.500	4.24	305

FORMULA:
As Cast Round Weight:
Length in inches x Weight per inch
= Total Weight

DUCTILE IRON PROPERTIES	VERSA−BAR® (65−45−12) V−3	VERSA−BAR® (80−55−06) V−4
Tensile Strength	65,000 psi	80,000 psi
Yield Strength	45,000 psi	55,000 psi
Elongation, % min.	12%	6%
Brinell Hardness Range	131/220	187/269
Microstructure, As Cast	Ferritic	Pearlitic
Machinability	Good	Good
Heat Treatment	Full Anneal or Normalize	Normalize or Oil Quench and Tempered
ASTM Specification	A−536	A−536

*** NOTE:** Material can be furnished in cut to length pieces on request.

AS CAST BARS

FINISH DIAMETER IN INCHES	AVG. STOCK ALLOW.	EST. POUNDS PER INCH	EST. POUNDS PER BAR	FINISH DIAMETER IN INCHES	AVG. STOCK ALLOW.	EST. POUNDS PER INCH	EST. POUNDS PER BAR
1.500	.085	.53	38	5.000	.140	5.50	396
1.625	.085	.61	44	5.250	.155	6.08	438
1.750	.085	.71	51	5.500	.155	6.67	480
1.875	.085	.81	58	5.750	.155	7.26	523
				6.000	.155	7.89	568
2.000	.085	.90	65	6.250	.170	8.58	618
2.125	.110	1.04	75	6.500	.170	9.26	667
2.250	.110	1.17	84	6.750	.170	9.97	718
2.375	.110	1.29	93				
2.500	.110	1.42	102	7.000	.170	10.71	771
2.625	.110	1.56	112	7.250	.190	11.53	830
2.750	.110	1.71	123	7.500	.190	12.35	889
2.875	.110	1.86	134	7.750	.190	13.13	945
				8.000	.190	13.96	1005
3.000	.110	2.01	145	8.250	.216	14.92	1074
3.125	.125	2.21	159	8.500	.216	15.82	1139
3.250	.125	2.38	171	8.750	.216	16.74	1205
3.375	.125	2.56	184				
3.500	.125	2.74	197	9.000	.216	17.68	1273
3.625	.125	2.93	211	9.250	.254	18.76	1351
3.750	.125	3.13	225	9.500	.254	19.81	1426
3.875	.125	3.33	240	9.750	.254	20.83	1500
4.000	.125	3.54	255	10.000	.254	21.89	1576
4.250	.140	4.01	289	10.250	.400	23.61	1700
4.500	.140	4.49	323	10.500	.400	24.27	1781
4.750	.140	4.97	358	10.750	.400	25.88	1863
				11.000	.400	27.06	1948
				11.500	.582	30.38	2187
				12.000	.582	32.94	2372
				12.500	.582	35.63	2565
				13.000	.582	38.40	2765
				14.000	.582	44.25	3186
				15.000	.582	50.54	3689
				16.000	.582	57.24	4121
				17.000	.762	65.67	4728
				18.000	.762	73.26	5275
				19.000	.762	81.29	5853
				20.000	.762	89.74	6461

GRAY IRON
VERSA−BAR® (40,000 PSI) V−2
SOLID SQUARE, RECTANGLE, AND PLATE BARS−6 FOOT LENGTHS

AS CAST SQUARES

ACTUAL SIZE IN INCHES	EST. POUNDS PER INCH	EST. POUNDS PER BAR
1.250 x 1.250	.42	30
1.500 x 1.500	.60	43
1.625 x 1.625	.69	50
1.750 x 1.750	.81	58
2.000 x 2.000	1.04	75
2.250 x 2.250	1.32	95
2.500 x 2.500	1.63	117
3.000 x 3.000	2.35	169
3.250 x 3.250	2.75	198
4.250 x 4.250	4.69	338
5.250 x 5.250	7.17	516
6.250 x 6.250	10.17	732
7.250 x 7.250	13.67	984
8.250 x 8.250	17.71	1275
9.250 x 9.250	22.25	1602
10.250 x 10.250	27.32	1967
12.250 x 12.250	39.03	2810

*** NOTE:**
Dimensions shown are actual.
Material will finish to .250" (¼") under dimensions shown.

EXAMPLE:

Actual size: 2.250" x 2.250"
Finish size: 2.000" x 2.000"

SAW CUT PLATES

ACTUAL SIZE IN INCHES	EST. POUNDS PER INCH	EST. POUNDS PER BAR
.500 x 1.250	.17	12
.625 x 1.250	.21	15
.750 x 1.250	.24	18
.500 x 2.250	.29	22
.625 x 2.250	.37	27
.750 x 2.250	.44	32
.500 x 3.250	.43	31
.625 x 3.250	.53	39
.750 x 3.250	.64	46
.500 x 4.250	.56	40
.625 x 4.250	.70	50
.750 x 4.250	.83	60

AS CAST RECTANGLES

ACTUAL SIZE IN INCHES	EST. POUNDS PER INCH	EST. POUNDS PER BAR
.750 x 1.500	.29	.21
1.250 x 2.250	.74	53
1.250 x 3.250	1.06	76
1.250 x 4.250	1.39	100
1.250 x 5.250	1.71	123
1.250 x 6.250	2.04	147
1.250 x 10.250	3.33	240
1.500 x 2.250	.89	64
1.500 x 3.250	1.28	92
1.500 x 4.250	.167	120
1.500 x 5.250	2.06	148
1.500 x 6.250	2.44	176
1.750 x 2.000	.92	66
1.750 x 4.500	2.06	148
1.750 x 6.250	2.85	205
2.000 x 2.500	1.31	94
2.250 x 3.250	1.90	137
2.250 x 4.250	2.49	179
2.250 x 5.250	3.08	222
2.250 x 6.250	3.67	264
2.250 x 8.250	4.84	348
2.500 x 6.250	4.07	293
2.500 x 7.250	4.72	340
2.500 x 8.250	5.36	386
3.000 x 8.250	6.44	464
3.250 x 4.250	3.60	259
3.250 x 10.250	8.67	624
4.250 x 5.250	5.81	418

*** NOTE:**
Dimensions shown are actual.
Material will finish to .250" (¼") under dimensions shown.

EXAMPLE:

Actual size: 2.250" x 4.250"
Finish size: 2.000" x 4.000"

*** NOTE:** Dimensions shown are representative of square, rectangle, and plate sizes available. For sizes or materials not listed, please ask for price and delivery. Cut to length pieces are available on request.

GRAY & DUCTILE IRON
VERSA−TUBE®
HOLLOW BARS−6 FOOT LENGTHS or CUT PIECES

AS CAST O.D. − MACHINED I.D.

FINISH OUTSIDE DIA. IN INCHES		ACTUAL INSIDE DIA. IN INCHES	EST. POUNDS PER INCH	EST. POUNDS PER BAR
3.500	x	1.250	2.42	174
4.500	x	1.250	4.15	299
5.500	x	1.250	6.33	456
4.000	x	1.750	2.91	209
5.000	x	1.750	4.86	350
6.000	x	1.750	7.25	522
4.500	x	2.250	3.43	247
5.500	x	2.250	5.59	403
6.500	x	2.250	8.21	591
7.500	x	2.250	11.25	810
6.000	x	2.750	6.32	455
7.000	x	2.750	9.13	657
8.000	x	2.750	12.38	892
5.250	x	3.000	4.20	302
6.250	x	3.000	6.71	483
7.250	x	3.000	9.65	695
8.250	x	3.000	13.04	939
5.500	x	3.250	4.46	321
6.500	x	3.250	7.07	509
7.500	x	3.250	10.10	727
8.500	x	3.250	13.61	980
5.750	x	3.500	4.71	339
6.750	x	3.500	7.42	534
7.750	x	3.500	10.55	760
8.750	x	3.500	14.18	1021
6.000	x	3.750	4.96	357
7.000	x	3.750	7.77	560
8.000	x	3.750	11.02	794
9.000	x	3.750	14.75	1062
6.500	x	4.250	5.50	396
7.500	x	4.250	8.54	615
9.500	x	4.250	16.02	1154
7.000	x	4.750	6.00	432
8.000	x	4.750	9.25	666
9.000	x	4.750	12.97	934

FINISH OUTSIDE DIA. IN INCHES		ACTUAL INSIDE DIA. IN INCHES	EST. POUNDS PER INCH	EST. POUNDS PER BAR
7.500	x	5.250	6.57	473
8.500	x	5.250	10.06	725
8.000	x	5.750	7.08	510
9.000	x	5.750	10.79	777
9.000	X	6.750	8.18	589

*** NOTE:**

Inside diameters are actual sizes.
Inside diameter will finish to .250" (¼") over dimensions show.

EXAMPLE:
Actual Size: 3.500" O.D. X 1.250" I.D.
Finish Size: 3.500" O.D. X 1.500" I.D.

FORMULA:
$(O.D.^2 - I.D.^2) \times .208 \times$ length in inches = VERSA−TUBE® weight

GRAY IRON PROPERTIES	VERSA−BAR® (40,000 PSI) V−2
Tensile Strength Min.	40,000 psi
Compressive Strength Min.	150,000 psi
Transverse Strength: Average lbs. Load on 1.2" dia. Bar on 18" span	4,000 psi
Deflection − inches	0.25 − 0.34
Brinell Hardness Range	183/285
Microstructure, As Cast	Essentiall pearlitic
Heat Treatment	Can be oil−quench hardened from 1575 °F to attain Rockwell C−50 min. Surface hardness
Machinability	Very Good
Applicable Specification	ASTM A 48 Class 40

*** NOTE:** Dimensions shown are representative of tube sizes available. For sizes or materials not listed, please ask for price and delivery.

AMERICAN IRON & ALLOYS
CORPORATION

Continuous Cast Iron Process