



STAINLESS STEEL UNIVERSITY

PENN STAINLESS PRODUCTS, INC.



Understanding Material Availability

Structural Products

- Laser-Fused Shapes
- Square / Rectangular Tubes
- Processed Flat Bars

Flat Rolled Products

- Plate Coil vs Plate Mill Plate Options
- Non-Standard Widths / Gauges

Bar Products – Machine Shops

- Plate for Machining Applications
- Bar Lengths
- PM 2000 Bar

Mill Production Capabilities

Flat Rolled Products

- Understanding differences in Plate Products
- Plate From Coil vs Plate Mill Plate
- Plate Thickness Options
- Non-Standard Widths / Gauges
- Price Differentiations between coil and plate mill plate

2 Methods for Manufacturing Stainless Plate = 3 Distinct Products

Why does this matter?

Identifying the capabilities of the 2 methods and the 3 products produced can significantly impact:

Cost

Delivery Time

Service Center
Availability

Product
Customization



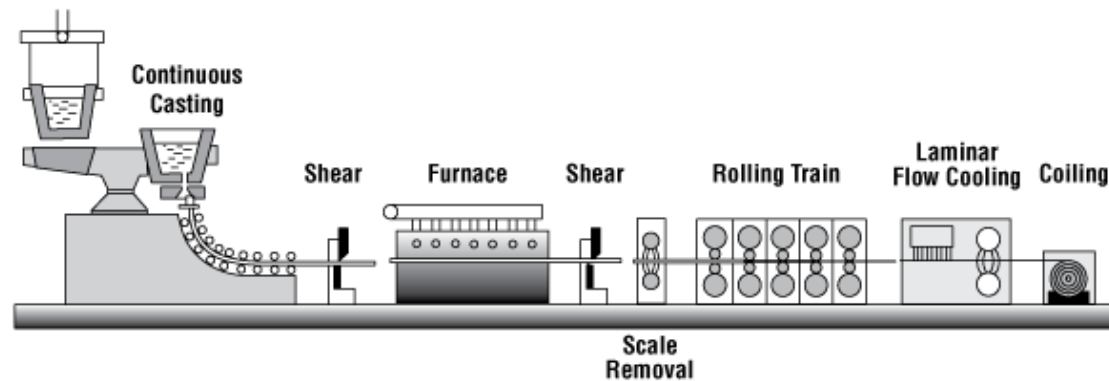
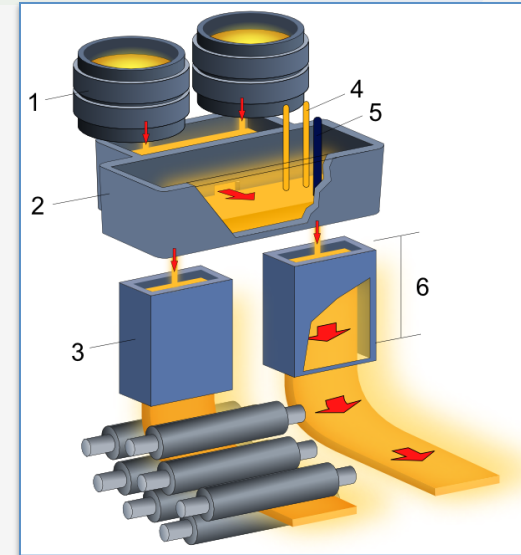
Continuous Casting of Stainless Steel Plate = 2 Product Types

Reduces number of steps required to roll stainless steel plate or sheet.

Significantly reduces the cost to manufacture stainless steel plate and sheet

Recent innovations such as Allegheny's DRAP line Direct Roll, Anneal and Pickle

2 Products from Casting = 1) Plate Coil 2) Rougher Plate / Plate Mill Plate



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Plate Products Produced from Continues Casting

Coil Plate in 304, 304/L & 316/L produced through ½” thick from continuous casting production.



Plate Mill Plate in 304, 304/L & 316/L produced from ½” thick to 2-1/2”.



Plate Products Produced from Traditional Rolling Methods

Plate Mill Plate: 3/16" – 6" Thick. 304, 304/L & 316/L most common but allows for the manufacture numerous other grades.

Utilized typically for plates over 78.74" wide

Largest width typically 120"

Plate from Coil (CMP)

CMP Advantage –

- Low Price - (48" & 60" wide most common)
- Flexibility - Level from coil = length customization
- High Availability in 304, 304/L and 316/L
- Short Lead-times

Examples of Custom Lengths: ¼" x 60" x 108 or ¼" x 60" x 456"

Plate from Coil (CMP)

CMP Limitations –

- Limited in widths: (36" – 48" – 60" – 72" – 78.74")
- Limited standard thickness options 3/16" – ¼" – 5/16" – 3/8"
 - ½" some availability
- More “memory” than PMP – Flatness
- Little availability or large order minimums for non commodity grades:
 - 309/S, 310/S, 317L, 321, Duplex 2205, 410

½" Coil = 304/L & 316/L = Cross over thickness – Typically have to level entire coil – Not easy to “back the coil off.” May have significant memory

Continues Cast Plate Mill Plate

PMP Advantages

- Low Price Product!
- High service center availability in 304, 304/L and 316/L
- Ample Domestic production – Short lead times 4-8 weeks
- Workhorse of plate fabrication

May not be the low cost solution....?

Continues Cast Plate Mill Plate

PMP Limitations

- Typically 48" & 60" wide
- Produced from 480" & 432"
- Non-standard thickness difficult to achieve
- Limited to 304, 304/L or 316/L – Non commodity grades such as 309, 310, 321, 347, Duplex involve significant mill minimums



Non-Continues Cast Plate Mill Plate

PMP Advantages

- Plate widths are highly flexible produced from about 50” through 120”
- Plate lengths are highly flexible produced to 400” + long
- Plate thicknesses are highly flexible – MM size thicknesses can be produced.
- Low order minimums – About 4,000 lbs
- Many grades produced: 304, 304/L, 304H, 309, 310, 316/L, 321, 347, 410, 410S, Duplex 2205, Duplex 2507 and more
- Lead times 6-10 weeks for domestic production

Important – You are not stuck with a 96” wide width



Non-Continues Cast Plate Mill Plate

PMP - Limitations

- Highest priced plate product
- Not generally produced under 50" wide



Estimated Price Differentials between 304/L CMP & PMP

Size	Width	Price	Total \$ based on 5,000lbs
¼"	36" wide	\$1.12	\$5,600
¼"	48" & 60" wide	\$1.00	\$5,000
¼"	72" wide	\$1.24	\$6,200
¼"	78.74" (2M) wide	\$1.38	\$6,900
¼"	84" wide	\$2.10	\$10,500
¼"	96" wide	\$2.05	\$10,250
¼"	120" wide	\$2.16	\$10,800

Other Options – 70" Wide Coil Product ?

For ease of calculations using \$1.00 lbs. Not actual pricing! Penn Stainless does not offer this as a quotation.

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Raw Material Price vs Total Cost

Case: Fabricator requested the “standard” wide plate width for 316/L material. Customer consultation resulted in significant savings:

Size	Weight	Price LBS	Total	Savings
6 pcs ¾” x 96 x 270”	32,765	2.50/lbs	\$81,912	\$ 12,797
6 pcs ¾” x 81” x 270”	27,646	2.50/lbs	\$69,115	18.5%

This is not a quote – Example Only

Raw Material Price vs Total Cost

Case: Fabricator requested the “standard” wide plate width for 316/L material. Delivery required stock to 1 week. Customer consultation resulted in significant savings:

Size	Weight	Price per LBS	Total	Savings
11 PCS ¼” x 96 x 240”	19,645	2.60/lbs	\$51,977	\$21,363
11 PCS ¼” x 78.74” x 228”	15,307	2.00/lbs	\$30,614	Nearly 70% Savings

This is not a quote – Example Only



Raw Material Price vs Total Cost

Case: OEM Requested ½" (12.7MM) plate in 304 assuming this was a "standard thickness." Through customer discussions we discovered the plate was to be milled to 10MM (.394"). PSP proposed 11MM thickness allowing for weight savings and reduced machining costs

Size	Weight	Price per LBS	Total	Savings
18 PCS ½" (12.7mm) x" 50" x 82"	11,102	\$1.50/lbs	\$16,653	TBD
18 PCS .433" (11MM) x 50" x 82"	9,547	\$2.15/lbs	\$20,526	Significantly less machining!

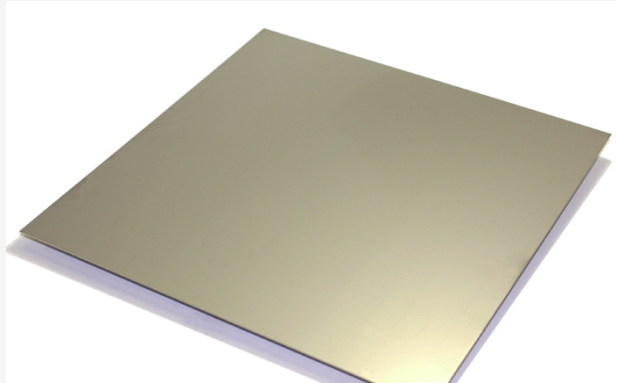
This is not a quote – Example Only



Other Cost Saving Options?

Hot Rolled Coil Product in Gauge Material?

- Sheet Metal Gauges typically produced with a 2B finish
- Plate product is produced with a mill finish HR&P



Other Cost Saving Options?

Hot Rolled Coil Product in Gauge Material?

- .078 through .120 (11 Gauge) can be produced as a hot rolled product
- Typically, Hot Rolled base pricing is about 20% to 25% less than Cold Rolled Pricing
- The offering is manufactured domestically

Large Price Savings – But there are drawbacks



Other Cost Saving Options?

Hot Rolled Coil Product in Gauge Material?

- High Order Minimums – 54,000 lbs – Need a larger job
- Limited Service Center Inventory?
- Not ideal for polishing applications
- Read your specs – Sheet gauges are typically specified with a 2B finish

Large Price Savings – But there are drawbacks



Other Cost Saving Options?

304H Grade – Use Plate from Coil or Plate Mill Plate?

CHEMICAL PROPERTIES

Type	C	Mn	Si	P	S	Cr	Ni	N
304	0.08 max	2.0 max	0.75 max	0.045 max	0.03 max	min: 18.0 max: 20.0	min: 8.0 max: 10.5	-
304L	0.03 max	2.0 max	0.75 max	0.045 max	0.03 min	min: 18.0 max: 20.0	min: 8.0 max: 12.0	0.10 max
304H	min: 0.04 max: 0.10	2.0 max	0.75 max	0.045 max	0.03 min	min: 18.0 max: 20.0	min: 8.0 max: 10.5	0.10 max

MECHANICAL PROPERTIES

Grade	Tensile Strength ksi (MPa) min	Yield Strength 0.2% offset ksi (MPa) min	Elongation (% in 50mm) min	Hardness (Brinell) MAX	Hardness (Rockwell B) MAX
304	75 (515)	30 (205)	40	201	92
304L	70 (485)	25 (170)	40	201	92
304H	75 (515)	30 (205)	40	201	92

A grain size of 7 or courser must also be reported by the manufacture

Other Cost Saving Options?

PRODUCT DESCRIPTION:

STAINLESS STEEL COIL, HRAP; UNS 30400
 ASTM A240/16a,A480/16b,A666/15;ASME SA240/15,SA480/15,SA666/15
 CHEM ONLY ON FOLLOWING ASTM: A276/17,A479/17,A484/16,A312/16
 CHEM ONLY ON FOLLOWING ASME: SA312/13,SA479/13
 AMS 5513J XMRK; MIL-S-5059D AMEND3 (X CROWN MEAS)
 NACE MR0175/ISO 15156-3:2009 A. MR0103/07;QCS766D-A X MAG PERM
 MIN. SOLUTION ANNEAL TEMP 1900F, WATER QUENCHED
 ASTMA262/02PR A
 ASME Sect. II, 1995 Edition, 1996 & 1997 Addenda

REMARKS:

Mat'l is Free of Mercury Contamination. No weld repairs.
 EN 10204:2004 3.1; RoHS 1 & 2 Compliant
 Material is Free of Radioactive Contamination
 Steel Making Process: EAF, AOD, & Cont. Casting
 Product Mfg.by a Quality Mgt.Sys. in Conf. w/ISO 9001
 Annealing Temp did not exceed 2100F
 *Melted & Manufactured in the USA; Mat'l is DPFRs Compliant

Product ID #	Coil #	Thickness	Width	Weight	-----Length-----	Mark	Pieces
04324Y C	* 04324Y C	.3750	60.0000	14,440	COIL	191.70	41

Lab Accreditation Bureau, ISO/IEC 17025, Certificate# L2323

CHEMICAL ANALYSIS CM(Country of Melt) ES(Spain) US(United States) ZA(South Africa) JP(Japan) Chemical Analysis per ASTM A751/14a

HEAT	CM	C %	CO %	CR %	CU %	MN %	MO %	N %	NI %	P %
324Y	US	.0469	.1185	18.2680	.4070	1.8275	.3465	.0607	8.0870	.0270
		S %	SI %							
		.0010	.2280							

MECHANICAL PROPERTIES

Product ID #	Coil #	l d c r	UTS KSI	20C .2% YS KSI	20C ELONG %-2"	% Hard RB	Tail Hard	A 262 'E' Pr E
04324Y C	04324Y C	F T	92.70	49.32	55.23	90.00	92.00	OK

NAS hereby certifies that the analysis on this certification is correct. Based upon the results and the accuracy of the test methods used, the material meets the specifications stated. These results relate only to the items tested and this report cannot be reproduced, except in its entirety, without the written approval of NAS.

Technical
 Dept. Mgr.

Kris Lark
 KRIS LARK 7/17/2017



Other Cost Saving Options?

The MTR meets the Chemical and Mechanical requirements for 304H - less the grain structure. What can we do?

- Option 1: In some instances, customers will accept the .04 min carbon without the grain structure
- Option 2: Send sample piece to independent lab to have the grain size identified and produce an independent test report.
 - Typical Coupon size 1 or 2 pcs 3" x 3"
 - Typical Time for Testing 5-10 Working Days
 - Minimal cost – Less than \$300.00



Other Cost Saving Options?

So why offer the product as .04 min carbon OR sent out a sample for testing?

- Reduced Cost: In the example, the product is coming from coil. Remember, plate from coil is the low cost option
- Availability: Coil is readily available

Limitations

- Testing: The product may not pass independent testing. With current technologies the annealing process is accelerated increasing the likelihood that the grain will not meet the 7 or courser requirements.

Other Cost Saving Options?

302 Stainless at times is specified, particularly in government funded applications. Typically, 302 is not stocked at the service center. The current “equivalent” to 302 is 304/L Stainless.

In some cases, customers will accept 304 as a replacement. How is this done? And sometimes the customer wants what is organically specified



Other Cost Saving Options?

Element	Percent by Weight Maximum Unless Range is Specified			
	302	304	304L	305
Carbon	0.15	0.08	0.03	0.12
Manganese	2	2	2	2
Phosphorus	0.045	0.045	0.045	0.045
Sulfur	0.03	0.03	0.03	0.03
Silicon	0.75	0.75	0.75	0.75
Chromium	17	18	18	17
	19	20	20	19
Nickel	8	8	8	10.5
	10	10.5	12	13
Aluminum	0.1	0.1	0.1	--

Typically this holds true for round bar too

Step: Call Mill and ask that the MTR be re-certified to 302

Other Cost Saving Options?

Machining Stainless Steel Plate?

- Its estimated that between 15% - 20% of stainless steel plate requires machining.
- Unlike bar products, the manufactures typically do not refine or process stainless steel plate with the machinist in mind.
- Conclusion: Machining stainless steel plate, particularly 316/L is not a fun process!

Other Cost Saving Options?

PRODEC Advantages:

- PRODEC Plate is refined and manufacturing specifically for machining applications.
- PRODEC meets all the standard ASTM specifications associated with common stainless plate
- PRODEC plates are pre-tested for machinability
- PRODEC enables the machinist on average to increase their feeds & speeds typically 20% to 25%.
- PRODEC typically produces longer tool life



Other Cost Saving Options?

PRODEC Plate – Field Test Results

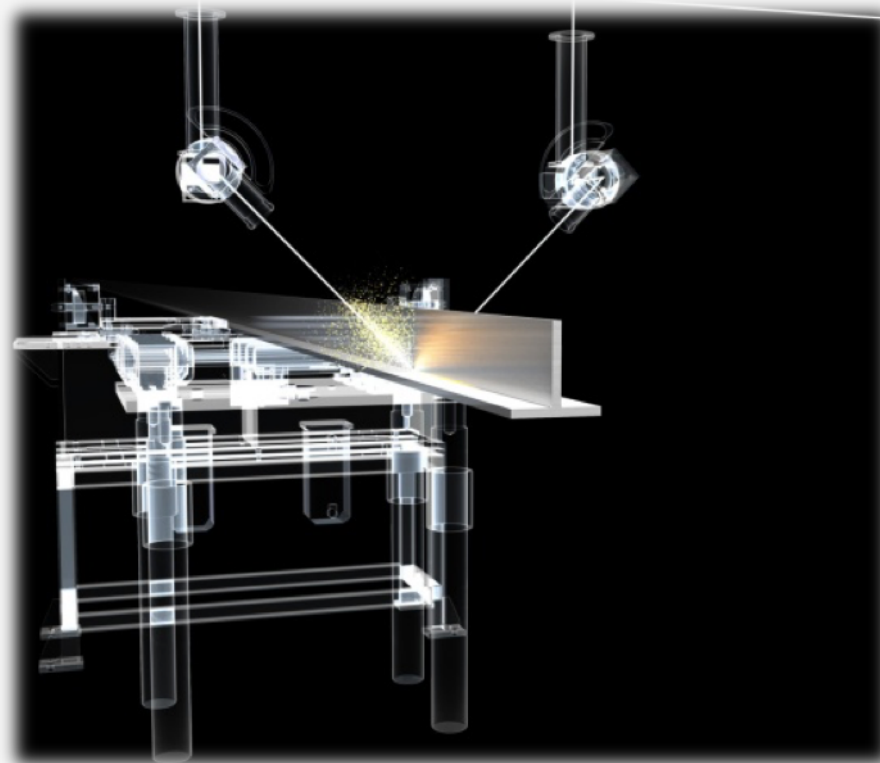
	Trial One			Trial Two			Trial Three			
Procedure	Standard shop drilling of 1" (actual 1-1/16") diameter hole in 1" thick 304 Prodec and 304 standard grade.			Same as Trial One			Standard shop milling of 1" 304 and 304 Prodec.			
Setup	Standard setup for 304 stainless with no increase in speeds or feeds.			Standard setup for 304 stainless with no increase in speeds or feeds.			Standard setup for 304. Optimum set up for Prodec.			
Equipment	A Carlton drill press that was old but sufficiently fast and strong enough to optimize Prodec. A standard, non-chip breaking, high-speed steel twist drill ground to 118 degrees included angle was used.			Cincinnati boring mill. Drill bit was a standard, non-chip breaking, high-speed steel twist type ground to 118 degrees included angle.			Cincinnati horizontal milling machine with multi-purpose carbide inserts.			
Results		304 Standard Grade Parameter	304 Prodec		304 Standard Grade Parameter*	304 Prodec		304 Standard Grade Parameter	304 Prodec	
	Feed (In/Turn)	.008	.025	Feed (In/Turn)	.007	.015	Cut	.157	.400	
	Speed (RPM)	141	192	Speed (RPM)	150	220	Speed (RPM)	500	895	
	Time	1:50	0:19	Time	1:13	0:23	Feed	6.125 ipm	16 ipm	
					*Does not include time to drill pilot hole.			Chip Load	.0053	.041
								SFPM	520 sfpm	950 sfpm
Notes	Prodec chips were heavy and broken even though a chip breaker was not used in the drill bit. The drill bit used on the Prodec showed no apparent tool wear.			No tool wear was apparent on the drill bit used on Prodec.			Prodec exhibited no excessive vibration and no noticeable tool wear.			

Mill Production Capabilities

Structural Sections

- Laser-Fused Structural Products
- Welded Structural Products
- Optimizing lengths

Laser-Fused Structural

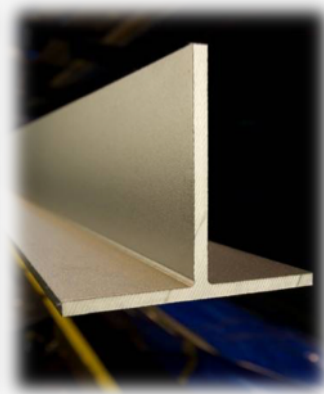
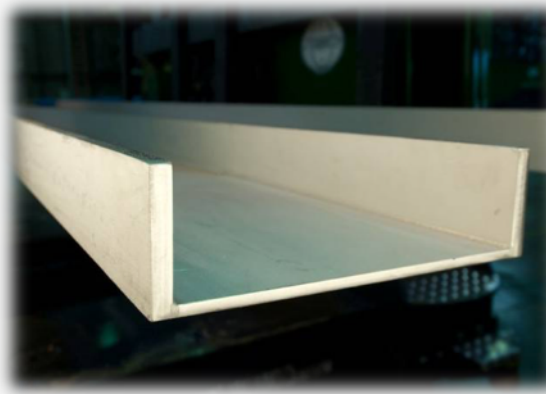
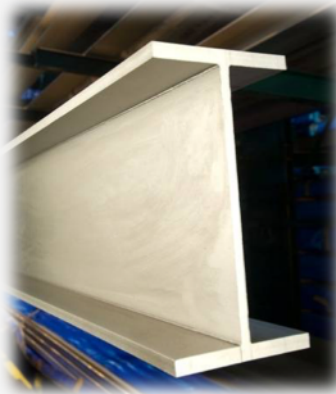


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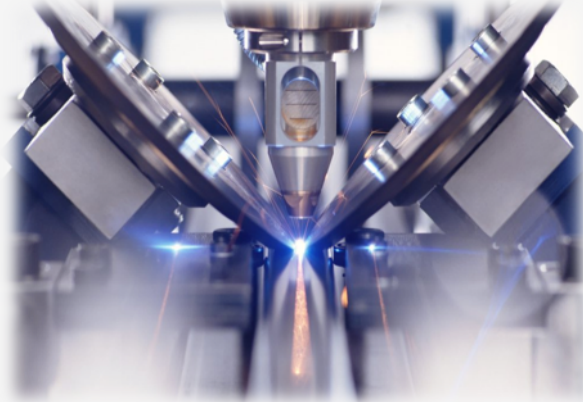
Laser Fused Structurals

- Full Penetration Weld = Homogenous monolithic structure
 - No Filler Metal
- Significant design capabilities...what can you design in a 20" - 36" box?
- Low minimums for non-standard shapes (500 to 2,000 lbs)
- Customized lengths available to reduce scrap – more flexibility with coil fed product.

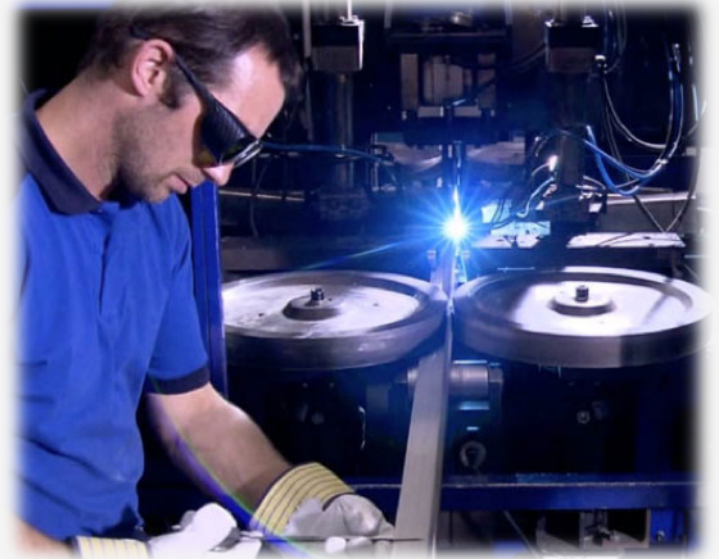


Laser Fusion / Conventional Welding

Controlled, Automated and
Consistent



Conventional Weld – With Filler Metal



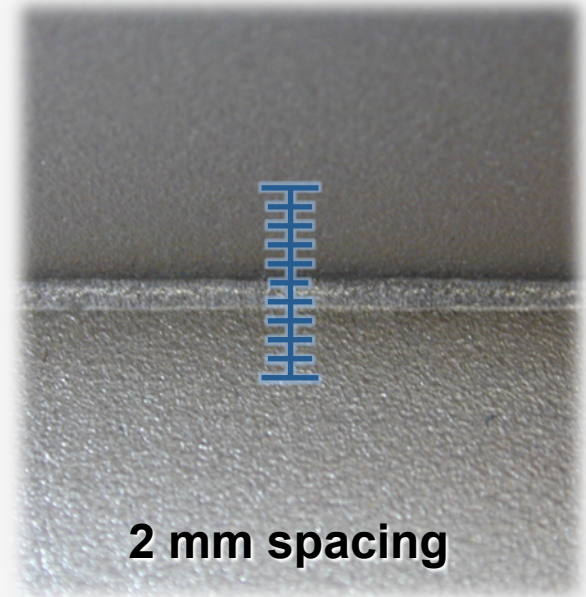
No Filler Metal

Laser Fusion / Conventional Welding

Laser fusing = High degree of accuracy, small weld area



Conventional Weld – With Filler Metal

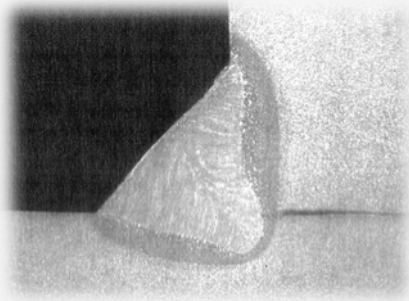


2 mm spacing

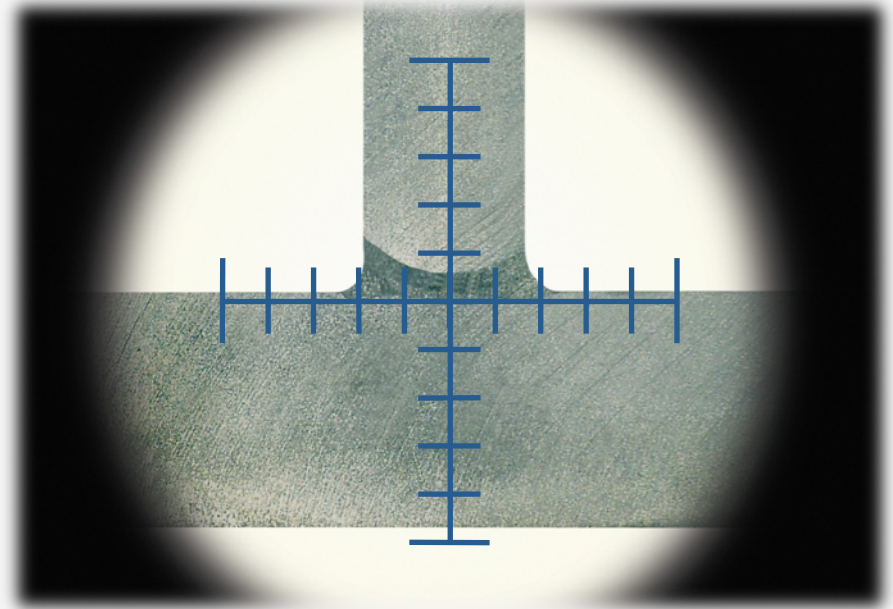
No Filler Metal

Laser Fusion / Conventional Welding

- Monolithic Structure
 - No filler material
 - No filler material
 - Full penetration up to .800" thick
 - No weld correction factor
- Square Corners, Smooth Lines



Conventional Weld – Filler Metal



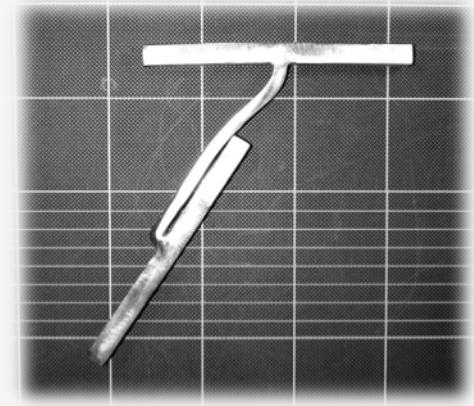
No Filler Metal

Laser Fusion Specifications



ASTM A1069

- Achieved official product standard

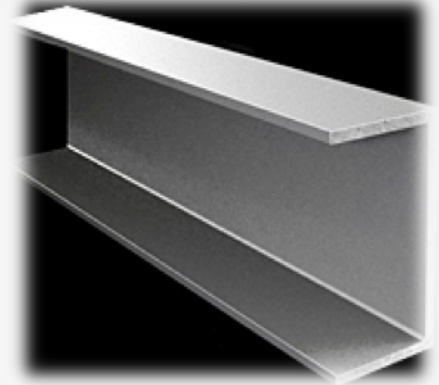
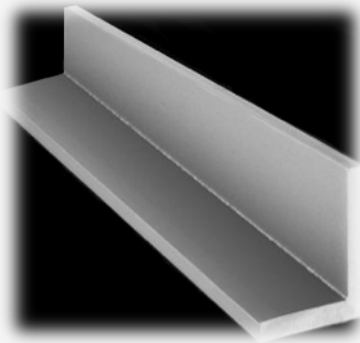
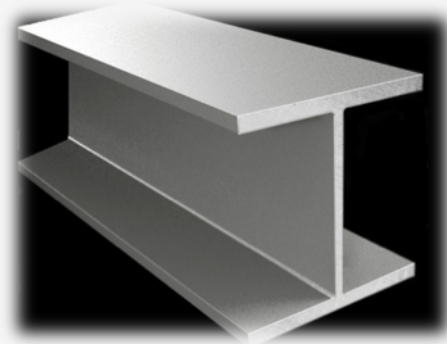
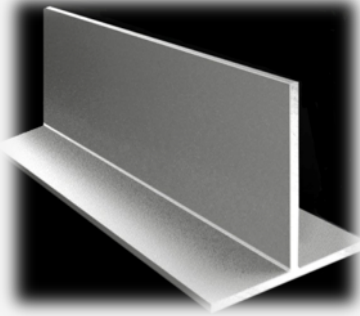


- **Destruction Test on Laser Fused H-Beam**

- Standard specification for laser-fused stainless steel bars, plates, and shapes
- ISO 13919-1: Welding and laser welded joints, quality levels
- ISO 15609-4: Specification and qualification of welding procedures
- ISO 15614-11: Specification and qualification of welding (laser)

Exotic Alloys

- 409
- 317L
- 904L
- 254 SMO
- 321
- 309
- 310s
- 330
- C276
- Nickel Alloys
- Duplex



Square & Rectangular Tubes



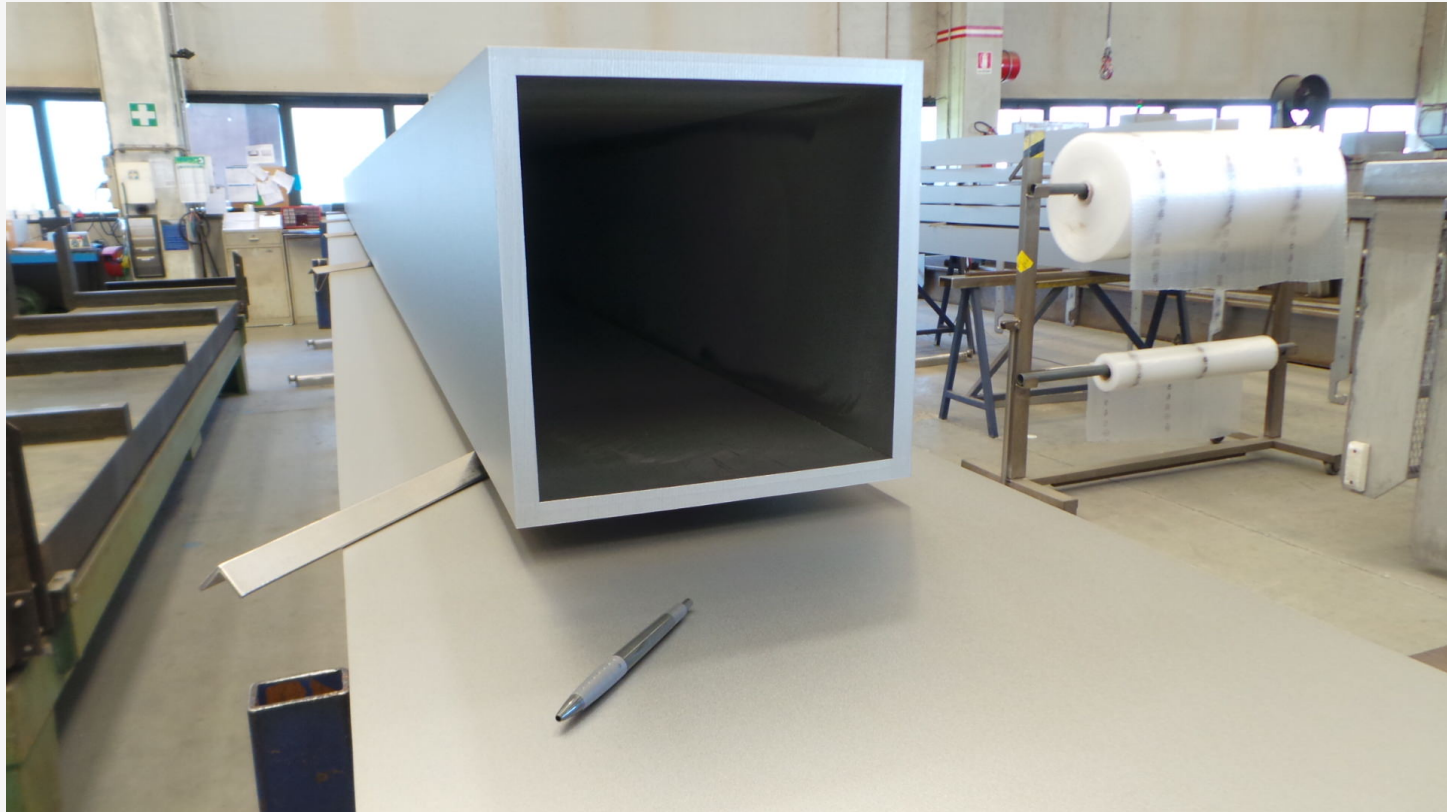
Meets ASTM A 554
Requirements



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Square & Rectangular Tubes



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Availability of Custom Lengths- Structural Products

Product Category	Dimensional Flexibility	Tolerance Flexibility	Length Flexibility	Manufacturing Variation
Standard Ornamental Tube	Limited – Dies Required	Limited	Flexible	Flexible on weld method
Rolled Angled	Limited	Limited	Limited	Limited
Laser-Fused Angle	Flexible	Flexible	Flexible	Flexible
Laser-Fused Tees, Beam, Channel	Flexible	Flexible	Flexible	Flexible
Non-Standard Ornamental Tube (Formed & Welded)	Flexible	Flexible	Flexible	Flexible
Laser-Fused Structural Tube	Flexible	Flexible	Flexible	Flexible



Mill Production Capabilities

Long
Product
Bar

- Machining
- Optimizing lengths

Mill Production Capabilities

Round Bar: The Challenges

- Tends to have longer mill lead times. Can make customization & special orders somewhat challenging
- Domestically, NAS & Valbruna offer better delivery times ranging from 8 – 15 weeks.



Mill Production Capabilities

Round Bar: Cold Finish Opportunities for length flexibility

- NAS will customize product length.
 - 300 series: Cold Rolled Production: 3/16" – 1.1875"
 - 416: 3/8" thru 7/8"
 - Lengths: 144" is standard.
 - Custom Lengths: from 84" min to 240" max
 - Typically can specify a tolerance of +2" / -000"

Mill Production Capabilities

Round Bar: Hot Finished Opportunities for length flexibility

- NAS will customize product length.
 - 300 series: 1.1875" thru 5"
 - 416: .9375" thru 5"
 - 17-4PH: 7/8" thru 5"
 - Lengths: 144" is standard with tol +/- 12"
 - Minimum Lengths: 114" with tol +6" / -000
 - Maximum Length 246" with tol +/- 6"



Mill Production Capabilities

Round Bar: Opportunities for length flexibility

- Valbruna Fort Wayne – Domestic
- Round Bar from 7/16" – 8"
- Square Bar 7/16" up to 2-1/2" (no 2-1/4" currently)
- Hex Bar 7/16" up to 2-1/2" (no 2-1/4" currently)
- Size Customization:
 - Over 2-1/2" can hold +2" / -0
 - Over 2-1/2" can produce up to 28' long bars
 - Will consider non-standard OD sizes
 - Will consider non-standard – customized tolerances



Round Bar – PM 2000

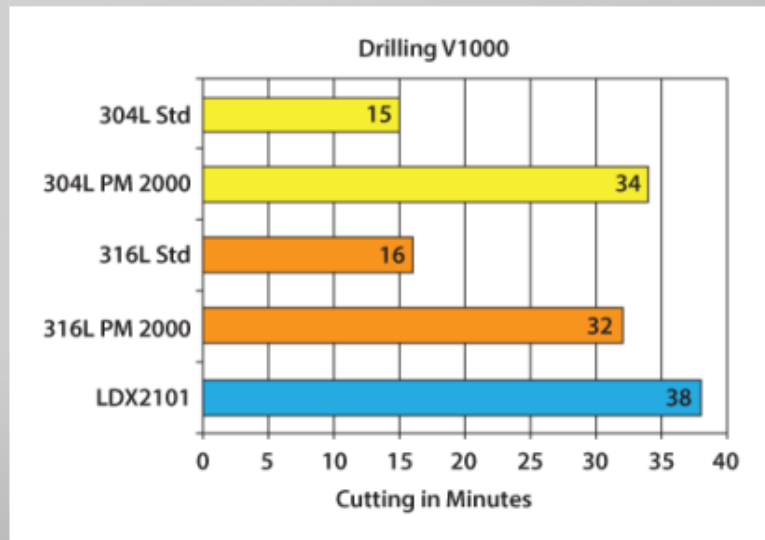
Round Bar: Opportunities for reduced costs

- PM 2000 / PRODEC Round Bar
 - Melted and refined specifically to improve machinability

PennMet 2000

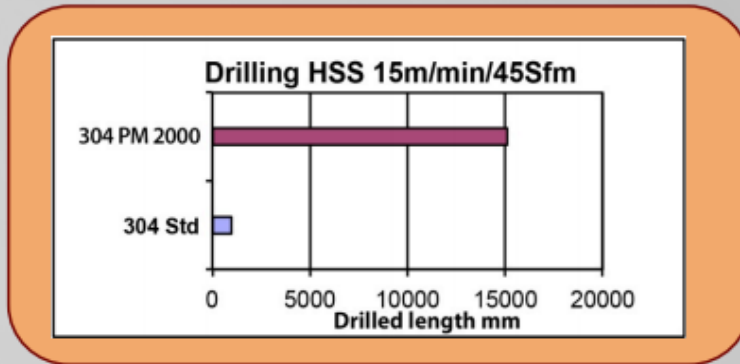
A SPECIAL PROCESS FOR A SPECIAL STEEL QUALITY

- Ladle metallurgy to control **composition, amount, size, shape and distribution of nonmetallic inclusions.**
- Can machine at higher speeds and feeds – increase size of machining window.

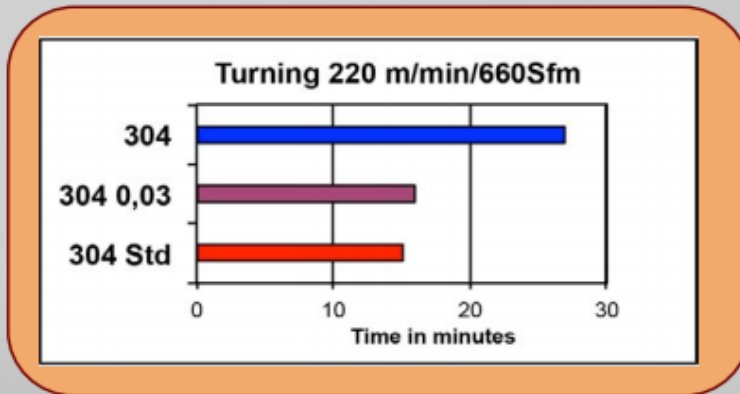


V1000 – Machining test showing cutting speed that gives a tool lifetime of 1000mm drilled length.

Results of PennMet 304 vs Standard 304



PennMet works for drilling



**0.030% Sulfur content helps but...
Pre-treatment is more important**

Sample Test B Report: Rough TURN OD

Common 316/316L vs PennMet 316/316L

Penn Stainless Test Report – Date: 7/18/2014			
Turning	Outside Diameter	Issued by: DNL	
Machine: Okuma LB 25	Machine #: 2	Test # 1	
Component: Housing	Material: PennMet 316/316L	Material: Common 316/316L	
Operation: Rough Turn OD	Hardness, hB: 180 - 240	Hardness, hB : 180 - 240	% of Increase
Cutting speed	450	300	67%
RPM	215	145	67%
Feed/rev.	0.011	0.008	73%
Depth of cut	0.15	0.1	67%
Length of cut	10	15	150%
Criterion tool change	Flank	Flank	
Machine cost/hour	\$100.00	\$100.00	
Cutting time/component (mins)	4.23	12.93	306%
Non cutting time/component (mins)	3	3	
No. of components/set of edges	4	2	
Tool changing time (mins)	2	2	
Total time/component (mins)	7.73	16.93	54%
Machine cost/component	\$12.05	\$26.55	55%
Total machining cost/component	\$12.05	\$26.55	55%
Productivity Increase %	54%		
Savings/component	\$14.50		



Sample Test Report: Housing, Rough Turn OD

Common 316/316L vs PennMet 316/316L

Penn Stainless Test Report – Date: 7/18/2014			
Turning	Outside Diameter	Issued by: DNL	
Machine: Okuma LB 25	Machine #: 2		
Component: Housing	Material: PennMet 316/316L		<u>% improvement</u>
Operation: Rough Turn OD	Hardness, hB: 180 - 240		
Cutting speed	450	Cutting Speed:	67%
RPM	215	RPM:	67%
Feed/rev.	0.011	Feed/rev:	74%
Depth of cut	0.15		
Length of cut	10		
Criterion tool change	Flank	Cutting time/component:	306%
Machine cost/hour	\$100.00	Total machining cost/component:	55%
Cutting time/component (mins)	4.23		
Non cutting time/component (mins)	3		
No. of components/set of edges	4	Productivity increase:	54%
Tool changing time (mins)	2	Savings/component:	\$14.50
Total time/component (mins)	7.73		
Machine cost/component	\$12.05		
Total machining cost/component	\$12.05		
Productivity Increase %	54%		
Savings/component	\$14.50		





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