

MARSHALLOY MQ[®]



PRECISION
MARSHALL
The Deluxe Company

MARSHALLOY MQ[®]

Technical Bulletin

Dear Industry Colleagues,

Precision Marshall Steel Company's primary mission is to provide higher value in the products and services we provide than can be found from our competitors. When it comes to meeting and exceeding your service and product quality needs, our goal is not to be the best in our industry, but rather to be the best there ever has been in our industry. This is what it means to be *The Deluxe Company*.

For over 70 years, we have been making substantial investments in operating systems, plant facilities, equipment and personnel. The end result is to keep improving our performance so that you can keep pace with your competition. We know that we must earn your business every day, and with continuous improvement, we all succeed. Despite our longevity, our eye is on the future and not the past.

We also know that without strong relationships our business will falter. We believe that "Companies Don't Succeed, People Do." Part of our continuing effort is to build relationships inside and outside of our organization that are productive and will stand the stresses of a dynamic global business environment.

Finally, we know you have many choices of suppliers and we appreciate your business. Remember, when you deal with *The Deluxe Company*, you should always expect the best.

Respectfully,



Jackson Milhollan
President and Chief Executive Officer

Applications & General Features

Prehardened Alloy Steel

MARSHALLOY MQ[®], exclusively by Precision Marshall Steel, is a mold quality steel supplied in the prehardened condition. Special melting and refining practices are utilized to produce a uniform product with exceptional cleanliness. These characteristics allow MARSHALLOY MQ[®] to be polished to an extremely high finish required for plastic molding. The material is tested to rigorous standards to ensure uniformity of structure and exceptionally low inclusion levels. MARSHALLOY MQ[®] is supplied prehardened to 280/320 BHN. The balanced composition of MARSHALLOY MQ[®] ensures uniform cross-sectional hardness and is guaranteed to maintain the specified hardness throughout the plate.

MARSHALLOY MQ[®] provides superior machinability while demonstrating outstanding cleanliness and soundness. It may be successfully substituted for P20 in plastic injection molding applications. MARSHALLOY MQ[®] is also useful in a wide range of mechanical applications, including short run tools and dies.

MARSHALLOY MQ[®]

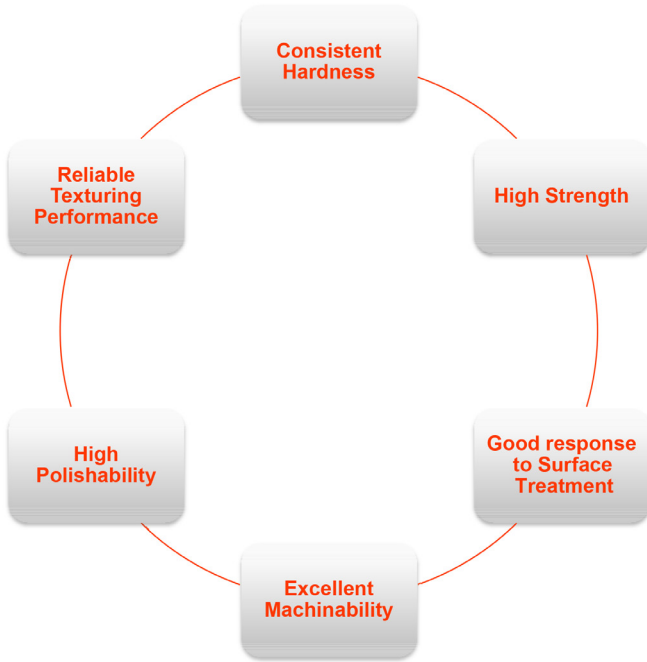
Marshallloy MQ is a very versatile grade

APPLICATIONS	COMPARED TO 4140/4142	COMPARED TO P20
Tool Frames	<ul style="list-style-type: none"> • Improved hardenability • Through thickness consistency even for thick pieces 	<ul style="list-style-type: none"> • Better machinability (tooling cost, machining cost)
Holder Blocks		
Mold Cavities		
Mechanical Engineering	<ul style="list-style-type: none"> • Improved machinability • Suitable for etching • Suitable for polishing (A2 finish) 	<ul style="list-style-type: none"> • Superior cleanliness & polishability

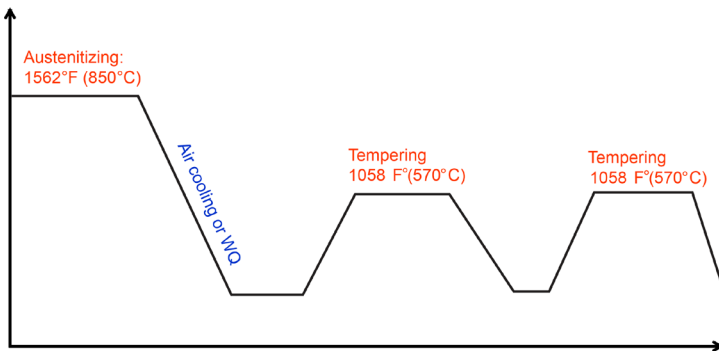
As a mold quality steel made with a proprietary melting and refining process, Marshallloy MQ[®] offers superior:

- ◆ Machinability
- ◆ Hardness
- ◆ Tensile Strength
- ◆ Uniformity
- ◆ Cleanliness
- ◆ Polishability

Marshallloy MQ is a versatile steel for mold cavities, holder blocks and engineering



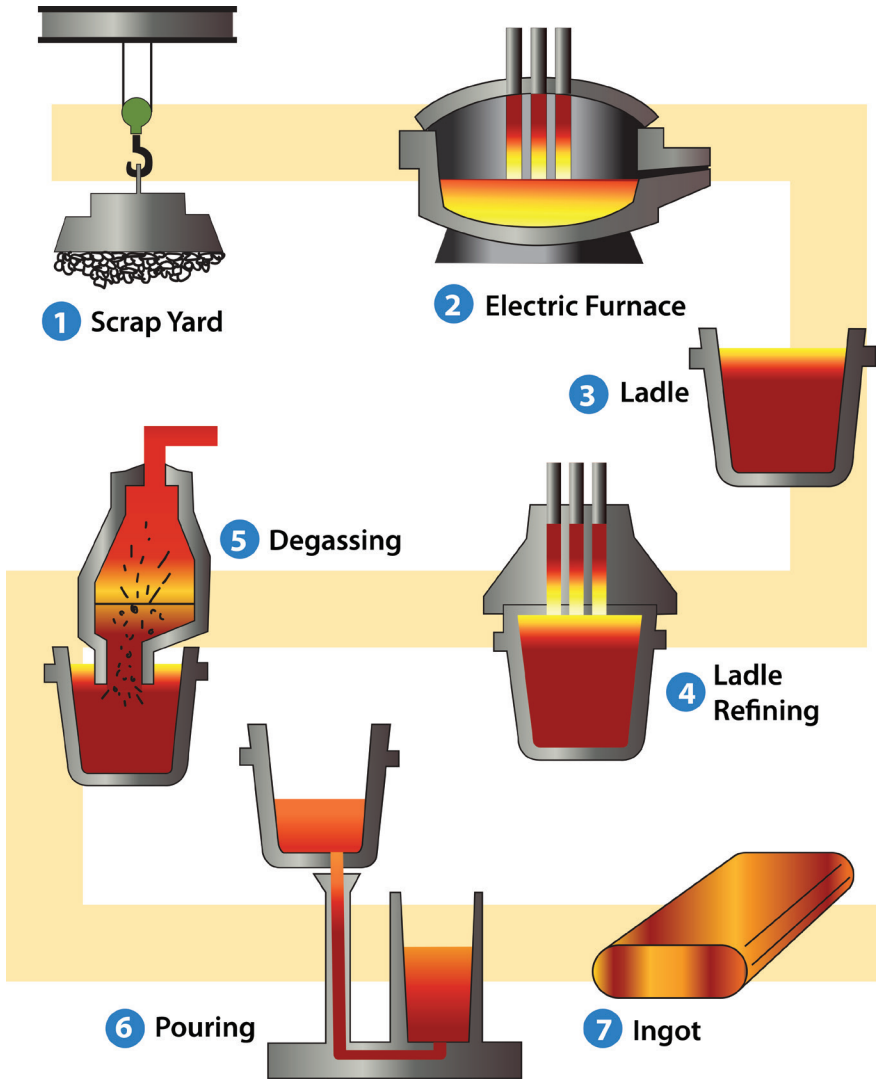
A lean manufacturing process with key control operations (UT, flatness, hardness)



Marshallloy MQ® is made using a lean manufacturing process that controls ultra-toughness, flatness & hardness. The result is double-tempered, stress-relieved plates delivered from the mill.

MARSHALLOY MQ®

Steelmaking Process



Electric furnace

- ◆ Rigorous scrap selection
 - > **High Quality** > **Low Impurities**
- ◆ Removal of Phosphorus (<0.007%)
- ◆ Ultra low carbon liquid steel

Heated ladle refining

- ◆ Removal of sulfur (<0.002%)
- ◆ Chemical balance of alloying elements (C,Mo,Cr,Ni...)

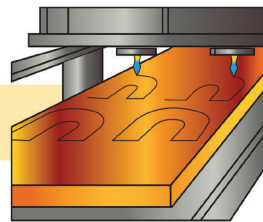
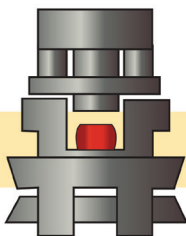
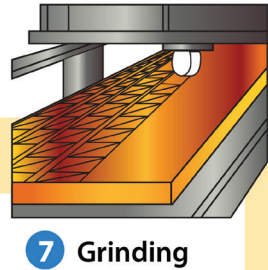
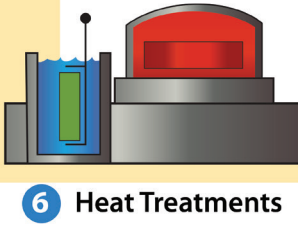
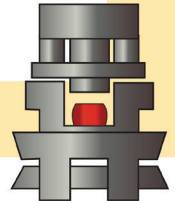
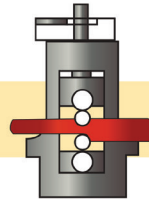
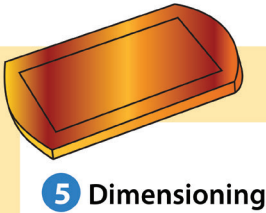
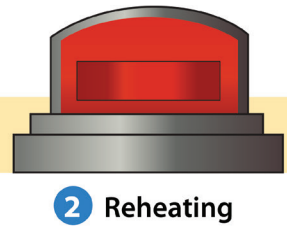
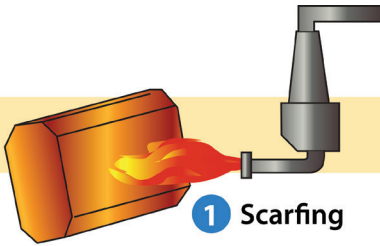
Special degassing unit

- ◆ RH type, new investment and
- ◆ Low Hydrogen content < 1 ppm

Ingot casting

- ◆ Bottom-poured heavy ingots up to 130T
- ◆ Inverse mold for improved homogeneity

Manufacturing Process for Plates & Blocks



Chemistry

	Mass weight %	C	S	P	Mn	Ni	Cr	Mo
Marshallloy MQ	Aim	0.39	0.015	<0.010	1.25	0.35	1.15	0.24
	Sample	0.40	0.017	0.008	1.24	0.37	1.16	0.27
AISI 4140	Aim	0.43	≤0.040	≤0.035	0.85	-	0.95	0.21
	Sample 1	0.40	0.003	0.014	0.87	0.03	0.86	0.17
	Sample 2	0.39	0.001	0.033	1.13	0.02	0.99	0.18
	Sample 3	0.42	0.001	0.010	0.73	0.22	0.94	0.14

In contrast, AISI 4140 is manufactured by many companies, resulting in chemistry variations and inconsistent performance. (High phosphorous (P) content can make steel brittle!)

	C	S	Mn	Ni	Cr	Mo	V
P20	0.35	0.005	0.9	/	1.8	0.38	/
4142 (typical)	0.42	0.005	0.8	/	1.1	0.2	0.03
MMQ (guarantee)	0.36/ 0.42	0.010/ 0.025	1.10/ 1.30	0.25/ 0.50	1.00/ 1.20	0.15/ 0.35	/
MMQ (typical)	0.39	0.015	1.25	0.35	1.15	0.24	/

- Better Machinability
- Compatible with polishing & texturing

- Good hardenability, through thickness consistency

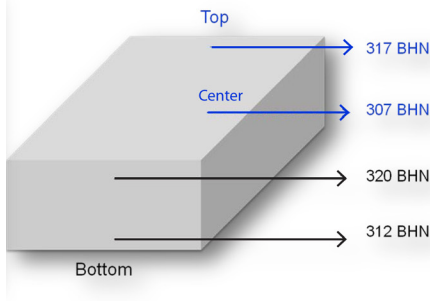
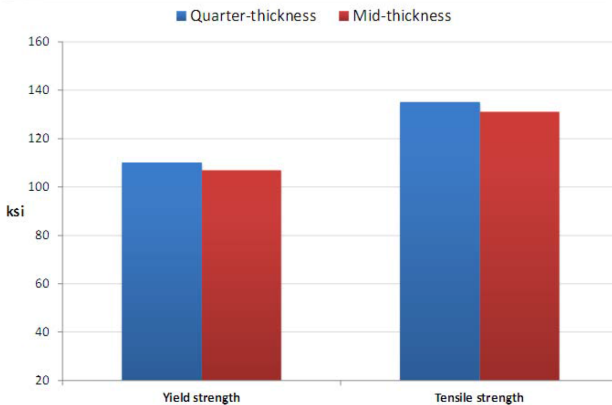
Mechanical Properties

HARDNESS		TYPICAL TENSILE PROPERTIES			
Typical (BHN)	Guarantee (BHN)	UTS MPa (KSI)	YS MPa (KSI)	Elongation (%)	Red. of Area (%)
295	280/321	950 (138)	750 (109)	15/16	55

Hardness & Tensile properties similar to P20

Hardness & Tensile Strength

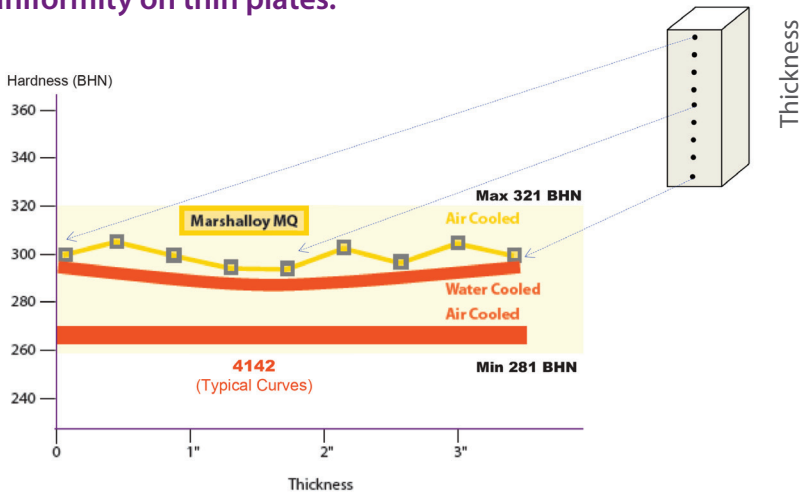
Mill data for a 8.50"-thick plate



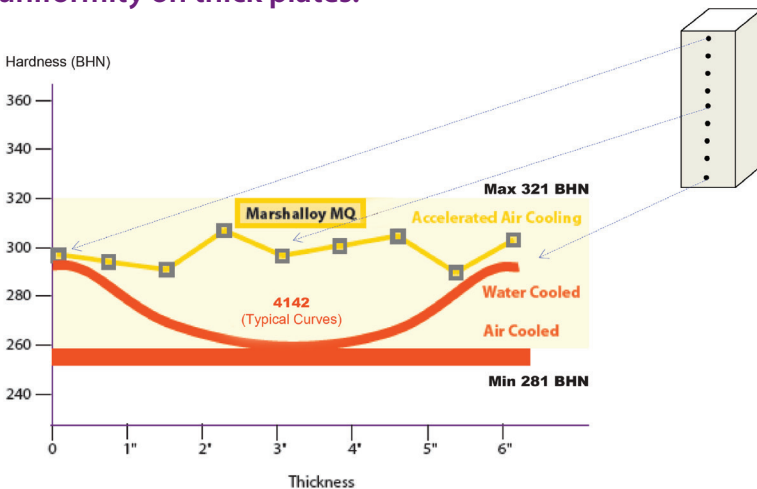
Every Marshalloy MQ[®] plate features high hardness consistency, resulting in uniform tensile properties.

Hardenability

Marshallloy MQ[®] offers excellent hardness uniformity on thin plates.



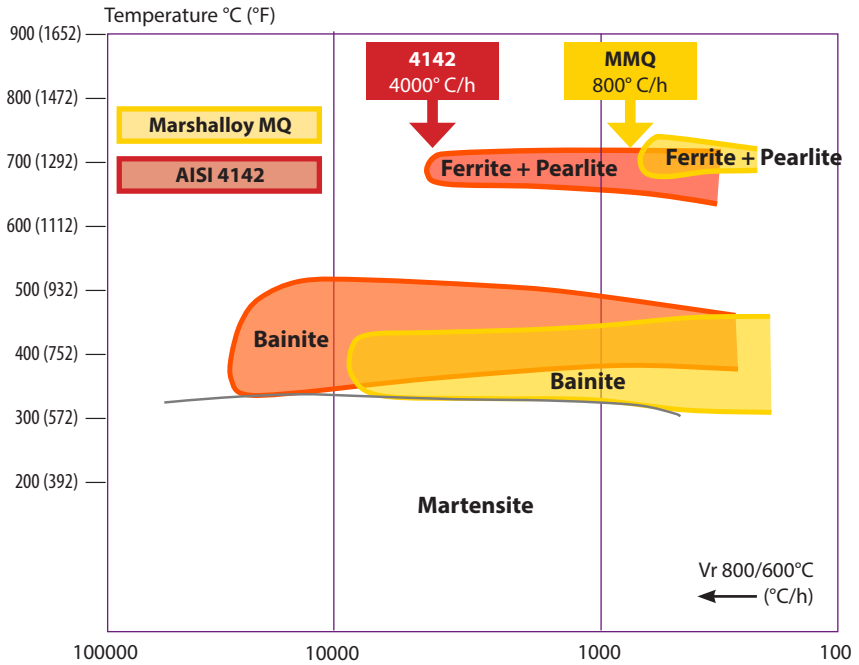
Marshallloy MQ[®] also offers excellent hardness uniformity on thick plates.



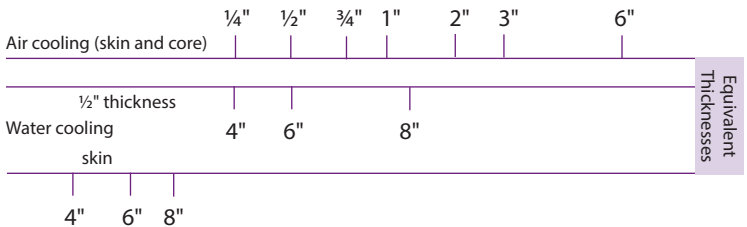
Marshallloy MQ[®]'s homogeneity on thick pieces is superior to that of P20 & 4142 steel.

Hardenability

CCT diagram 4142 versus Marshalloy MQ[®]



Equivalent Thicknesses



Hardening Process

Hardening

- ◆ Preheating and homogenization at 1250°F (680°C)
- ◆ Final heating to 1550/1600°F (840/870°C)
(Holding time 1H/inch)

Quenching

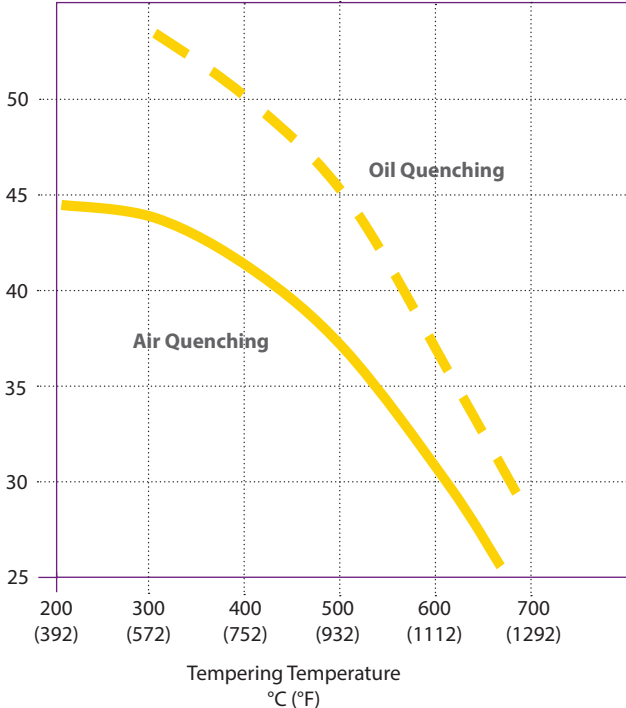
- ◆ Air / oil quenching down to 150°F (70°C)
(avoid oil quenching on pieces with complex shapes)

Tempering

- ◆ Temperature chosen according to required hardness level

MMQ — Tempering Curve

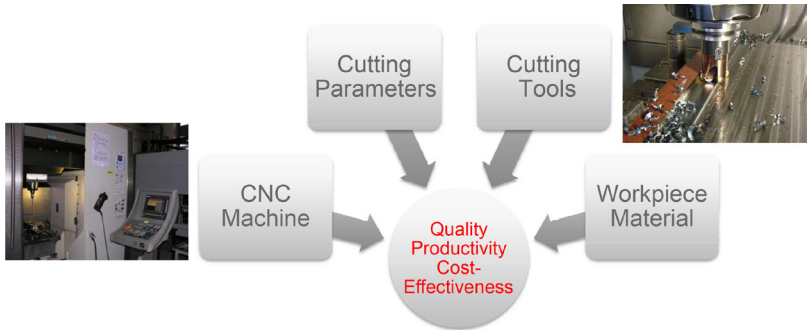
Hardness (HB)



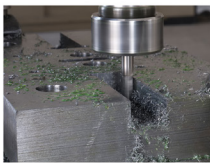
Machining Performance

Steel quality plays a significant role in machinability.

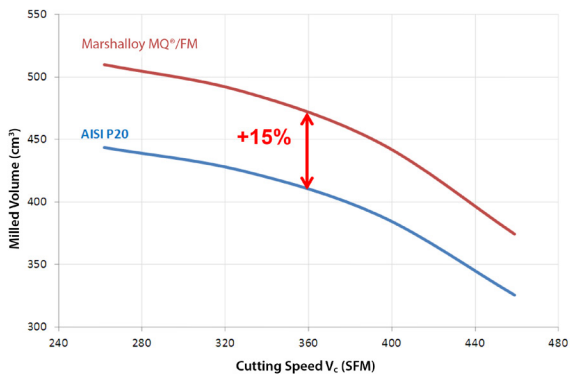
Marshallloy MQ[®]'s superior chemistry (including added sulfur content) and uniform hardness make it easier to machine than other materials, without compromising cleanliness.



Marshallloy MQ[®]'s optimized chemistry gives the material superior machinability.

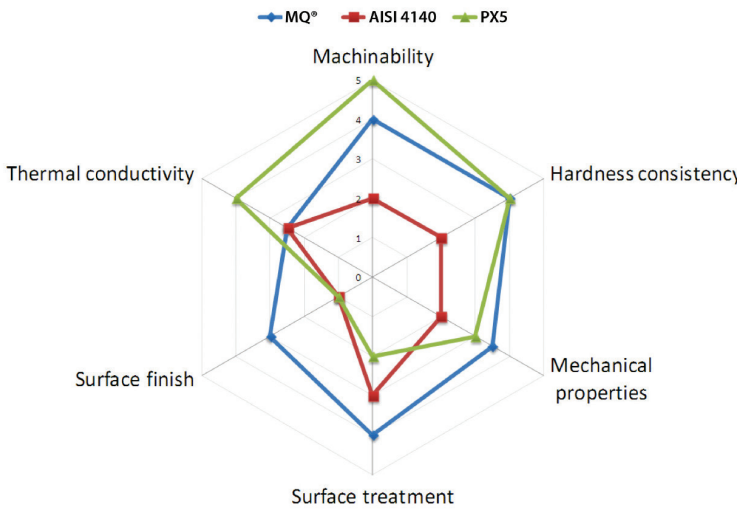


Tool holders (Ø 40)
Feed per tooth: 0.1 mm
Depth for cut: 4 mm



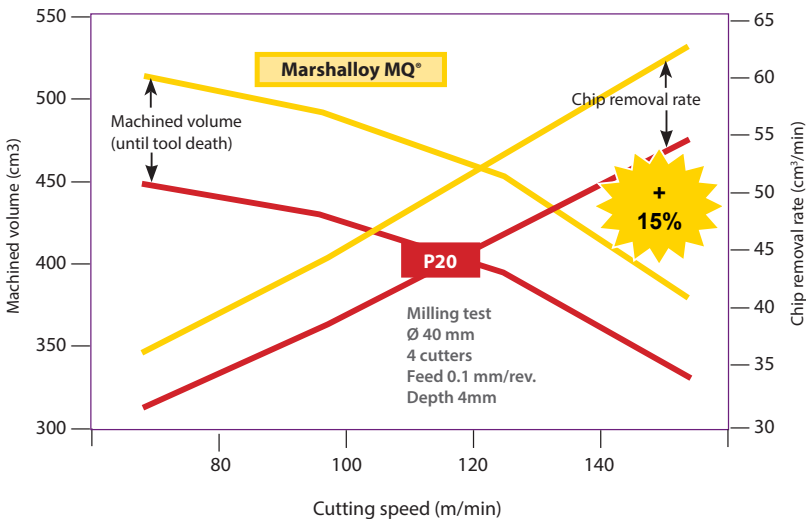
Superior Machinability

Marshallloy MQ® offers the best combination of hardness consistency, mechanical properties and surface finish. Its machinability is far better than that of conventional P20 types.



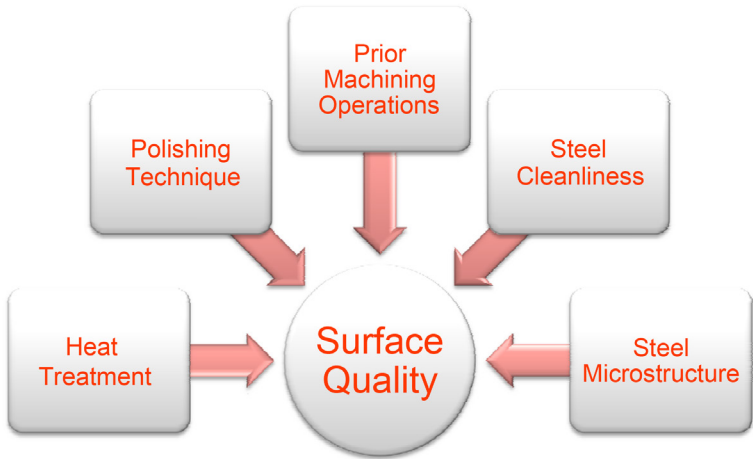
Machinability

Superior machinability compared to P20



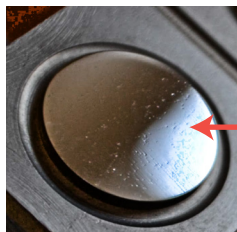
Cleanliness & Polishability

Steel cleanliness has a major effect on polishability and surface quality. For maximum luster, Marshalloy MQ[®] can be polished like SRI A2.



Too Many Sulfides = Too Many Pits

When a grade contains too many sulfides, poor cleanliness results and leads to pitting on polished surfaces. High-sulfur grades like P20+S, PX5 and NAK55 are examples of this phenomenon.

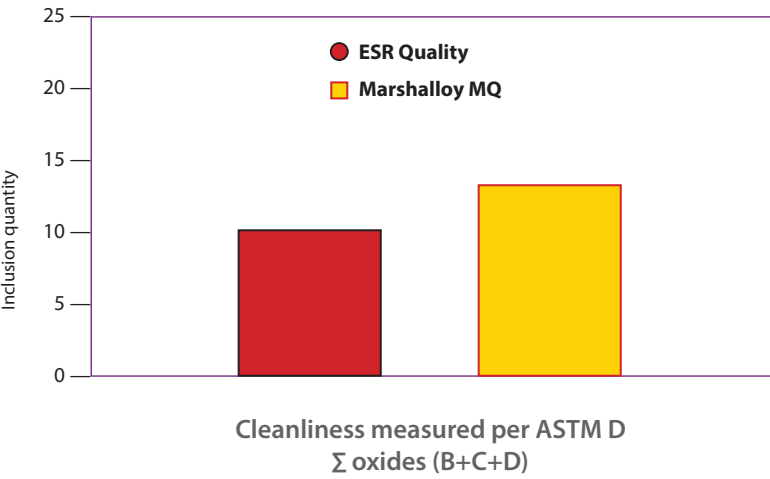
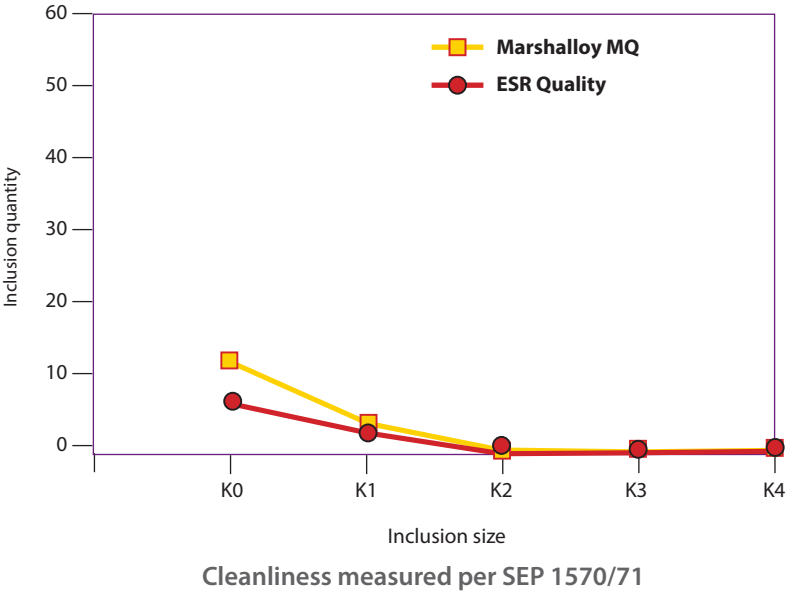


Too many sulfides (MnS) on a surface undergoing SPI A2 polishing can lead to the pitting shown here.

	Chemistry (mass weight %)			
Grade	C	S	Mn	Cr
P20+S	0.37	0.077	1.61	1.78

Cleanliness & Polishability

Marshallloy MQ[®] offers a microcleanliness (similar to ESR) ensuring excellent polishability and improved machinability warranted to an A2 finish.



Comprehensive Technical Support

When it comes to using Marshalloy MQ[®] Precision Marshall provides full metallurgical support.



Technical Assistance

- Field Support
- Applications
- Metallurgical Analysis

Welding

- Metallurgy
- Customized Process Development
- Other Considerations

Process Optimization

- Hot Working Processes
- Heat Treatment Parameters
- Other Considerations

ADDITIONAL DELUXE PLATE AND BAR PRODUCTS*

PRESCO O-1: Basic cold work tool steel for general purpose applications. Meets ASTM A-681 and W 2510.

AIRTRUE A-2: Most versatile cold work tool steel combining an excellent combination of wear resistance, toughness, ease of heat treatment and minimal distortion. Meets ASTM A-681.

ARISTOCRAT D-2: High Carbon/High Chrome tool steel for applications requiring superior wear resistance and medium toughness. Meets ASTM A-681 and W2379.

SUPER 7 S-7 MQ: Premium shock resistant tool steel known for its exceptional toughness. Also suitable for plastic molds and zinc die casting dies due to superior cleanliness and minimal segregation. Meets ASTM A-681.

FIRECHROME H-13: General purpose hot work tool steel designed for use as die casting dies, die holder blocks, hot forging and extrusion dies, and hot work punches. Meets ASTM- A-681 and W2344.

MARSHALLOY STANDARD PH: Premium 4142 alloy steel pre-hardened to 262-321 Brinell. Exceptionally versatile for use in short run tools and dies, non critical molds, guide rails, back up and support tooling, and holder blocks.

MARSHALLOY ANNEALED: High quality 4140 alloy steel intended for a wide range of mechanical applications. Hardness is typically 200 Brinell and can be heat treated after machining where required.

**Most Deluxe Products available from ¼" through 8"*

We Stand Behind Our Products *Guarantee of Quality*

Our conformance to specifications sets the industry standard.

At Precision Marshall, we assume complete liability for any costs directly related to a deviation from our published specifications.

Any such costs, properly documented, will be reimbursed.



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