

# DAMASTEEL® DS93X™ MARTENSITIC DAMASCUS PATTERNED STEEL

## PRODUCT INFORMATION

Damasteel's stainless Damascus patterned steel is a powder based steel with the two alloys RWL34™ and PMC27™. They are both variations of the martensitic stainless steel 420 type with a minimum of 13 percent chromium content. These alloys may be considered for a wide variety of applications where one or more of the following properties are important:

- High hardness after hardening and tempering
- High corrosion resistance
- Easy grinding and polishing
- High purity and cleanliness

Each alloy represents a good combination of corrosion resistance and hardenability. This combination of properties is a reason for its impressive suitability as knife material. Some examples of other applications are flatware cutlery, jewelries, and any other products where corrosion resistance and hardness are important.

Grade	Etch color	C	Si	Mn	Cr	Mo	V
RWL34™	Bright	1,05	0,50	0,50	14	4	0,2
PMC27™	Dark	0,60	0,50	0,50	13	-	-

Table 1. Nominal chemical compositions in wt-% of the constituent alloys

## Mechanical and physical properties

Bar and plate material delivered from Damasteel has the following approximate mechanical and physical values at 20°C.

Yield strength, Rp 0,2	270	MPa	Young's modulus	200	GPa
Tensile strength, Rm	<700	MPa	Poisson's ratio	0,3	-
Elongation, A5	45	%	Thermal conductivity	15	W/m·K
Hardness	<300	HV	Heat capacity	460	J/kg·K
Density	7,8	kg/dm <sup>3</sup>	Electrical resistivity	0,73	μ·Ω·m

Table 2. Mechanical and physical properties of Damasteel martensitic Damascus patterned steel (DS93X™) in annealed condition.

## Corrosion resistance

The martensitic stainless steels have a moderate to good corrosion resistance and are therefore suitable for a wide range of applications. The addition of Molybdenum in RWL34™ as one of the alloys gives our Damascus patterned steel a higher corrosion resistance compared to standard martensitic stainless steels.

## Hot working

Hot working temperature 1050-1160 °C (1920-2120 F)

Compared to low alloyed steels, martensitic stainless steels has higher, almost doubled deformation resistance. Hand forging can therefore only be performed on relatively small dimensions. Melting starts at 1220°C (2230 F) which means that the material is very sensitive to overheating. A good control of the heating temperature is needed. An electric or gas fired furnace is recommended.

Long soaking times above 850°C (1560 F) leads to decarburization and scale formation.

After the hot working process, a slow cooling is recommended due to the risk of cracks when the material phase transforms to martensite at around 200 °C (390 F). Usage of vermiculite or other heat insulating material is recommended.

## Heat treatment

Because of the risk of cracking; no grinding, cutting or machining should be done after hot working until the material is annealed. The recommendation is to have the material fully transformation annealed which means one hour at 900 °C (1650 F), then cool to 750°C (1380F) during two hours and finally hold at 750°C for four hours. All martensitic material supplied from Damasteel is soft annealed to 230 – 280 HV (20 – 28 HRC).

## Cold working

Martensitic stainless steel does not cold work as easily as the conventional austenitic stainless steels but can be formed and fabricated by a full range of cold working operations. The ductility is good and any cold working process will increase the strength and the hardness of the material.

## Welding

When cooling martensitic stainless steel after any hot process the martensitic phase transformation occur at around 200 °C and can lead to cracking. This can be avoided either by preheating the piece or do a post-weld heat treatment.

Our stainless Damascus patterned steel can be welded by a full range of conventional welding methods.

## Machining

The martensitic stainless steels are generally easier to machine than other stainless steel grades. The machining characteristics for our stainless Damascus patterned steel are:

### Soft annealed

- HSS or carbide tools (drilling, tapping, reaming, milling and turning)
- Tendencies for buildup of material on the tool edge
- Tough and stringy chips

### Hardened and tempered (56-61 HRC)

- Ceramic or CBN inserts (milling and turning)

## Grinding and polishing

Normal grinding and polishing procedures for austenitic stainless can be used also for the martensitic stainless steel.

### Grinding wheel recommendation:

Silicon Carbide, 46 grit, soft, open density, ceramic bonded. (C46J6V)

- Speed: 35 m/sec
- Feed: 0.01-0.05 mm/stroke

Speed of the work piece may be 1/60 of the grinding speed.

# Hardening

For knife applications the following heat treatments can be recommended for a 3,2 mm thick piece.

	Hardening temperature (A)	Tempering temperature (T)	Tempering time	Hardness RWL34™	Hardness PMC27™
I	1050 °C / 1920 F	220 °C / 430 F	2 h	59 HRC	53 HRC
II	1050 °C / 1920 F	175 °C / 345 F	2 h	62 HRC	54 HRC
III	1080 °C / 1980 F	220 °C / 430 F	2 h	58 HRC	56 HRC
IV	1080 °C / 1980 F	175 °C / 345 F	2 h	63 HRC	58 HRC
V	1100 °C / 2010 F	175 °C / 345 F	2 h	64 HRC	60 HRC

Table 3. Hardening and tempering suggestions for a 3,2 mm thick piece with corresponding hardness of the alloys

The suggested heat treatment processes IV and V includes deep freezing (DF) at -80°C (-110 F) for 15 minutes.

To ensure that best corrosion properties are achieved we recommend a low tempering temperature. The following time temperature curve can act as a guide, see fig. 1 below.

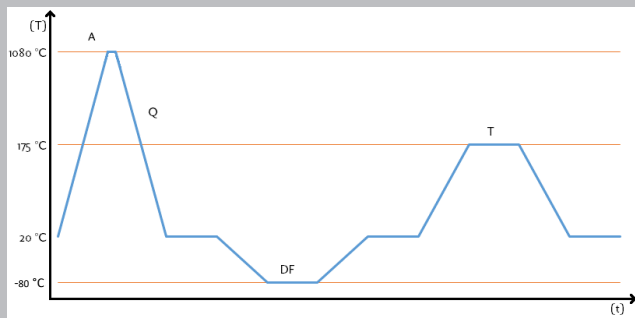


Figure 1: Schematic hardening and tempering curve

A Austenitizing. Holding time 8 min on a 3,2 mm thick piece. Increase or decrease that holding time with one minute per half mm of thickness

Q Rapid cooling to room temperature. We suggest quenching in oil and that the piece reaches room temperature within two min. Apply some pressure on the piece if cooling in air so it will not bend due to uneven cooling

DF Deep freezing is not necessary but completes the martensite transformation and increases hardness. Hold for approx. one and a half hour

T Tempering. Holding time two hours

# Etching

To make the pattern in our steel visible, an etching has to be made. Depending on desired result, different acids and acids mixtures can be used. The surface finish is also influencing the result. In the below table below are a few suggestions.

	Acid	Chem. comp.	Blend (%)	Time (min)	Color RWL34™	Color PMC27™
I	Hydrochloric acid 37 %	HCl	100	2-5	Bright grey	Light grey
II	Sulfuric acid 30 %	H <sub>2</sub> SO <sub>4</sub>	100	5-10	Light grey	Grey
III*	Hydrochloric acid 37 % Vinegar / Ferro chloride 30 %	HCl Vinegar/FeCl <sub>3</sub>	100 50/50	5 5	Bright grey	Dark grey

Table 4. Etching suggestions with corresponding colors and relief of the different alloys

1. Grind the piece progressively up to desired grit, 600 or higher. Finish off with polishing if desired.
2. Clean and degrease the piece carefully.
3. Mix the etching acid in the recommended ratios and remember to always pour the acid into the water.
4. Immerse the piece in the mix and leave it in for the time you choose. Longer soaking time will give deeper etch.
5. Neutralize the piece by dipping it into water with bicarbonate.

Beware of noxious fumes. Acids must be handled with great care.

\* Method number III is a high-contrast etching which requires two steps. First, etch in HCl then neutralize then directly afterwards etch in the mix of Vinegar and FeCl<sub>3</sub>. A light buff at the end can help to make the tops bright.

## Products and dimensions

Damasteel has a standard product program that can be found on our website [www.damasteel.com](http://www.damasteel.com).

We supply martensitic Damascus patterned steel in following formats

- Round bars in selected sizes
- Flat bars in dimensions shown in below chart, see fig. 2.

BESPOKE PRODUCTS CAN BE SUPPLIED WITHIN THE LIMITS SHOWN IN CHART.

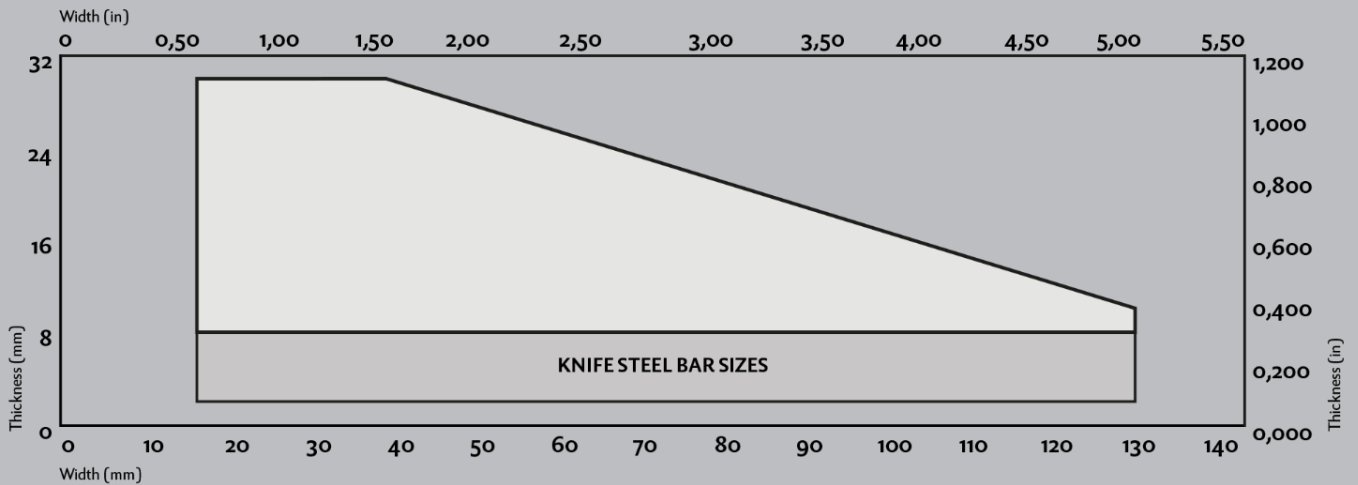


Figure 2: Size range

Even if it comes to creating customized patterns on our Damascus products or if you like dimensions outside our standard range either on our Damascus patterned steel grades (DS93X™, DS95X™, DS92X™, DS96X™) or our martensitic steels RWL34™ or Nitrobe77™ – do not hesitate to contact us.

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