DATA SHEET
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 martensitic stainless steel 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

Distinctive feature

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.

Mechanical and physical properties

Grade	C	Si	Mn	Cr	Mo	V	S	P	N
RWL34™	1,05	0,50	0,50	14	4	0,2	<0,03	<004	<0,1
PMC27™	0,60	0,50	0,50	13	-	-	<0,03	<0,04	<0,1

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

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/dm3	Electrical resistivity	0,73	µ·Ω·m

Table 2. Mechanical and physical properties of Damasteel martensitic Damascus patterned steel (DS93XTM) in annealed condition at 20°.

Hot working

Forging or rolling temperature 1050-1160 °C (1920-2120 F). Compared to low alloyed steels, martensitic stainless steels have 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. Because of the risk of cracking, no grinding, cutting, machining, should be done after hot working until the material is annealed. All material from Damasteel is in annealed condition.

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, any cold working process will increase the strength and the hardness of the material.

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, 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 can be used 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.

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.

Heat treatment

Annealing: The recommendation is to have the material fully transformation annealed which means two hours at 910 °C (1670F), then cool in furnace to 750°C (1380F) with a ramp of 15° per hour. Hold for two hours at 750°C (1380F) then air cool to room temperature. Achieved hardness <250 HV (23HRC).
Austenitizing: Holding time at austenitizing temperature 15 min.
Rapid cooling to 50°C. We suggest quenching in oil and that the piece reaches 50°C within two min.
Tempering. Between 150°C to 450°C without losing corrosion resistant and for knife applications the following heat treatments can be recommended, se table 3 below. Deep freezing is not necessary but completes the martensite transformation and increases hardness. Hold for 2h in temperature below -100°C(-148F) or in Liquidized Nitrogen -198°C (-324F) a half an hour.

	Austenitizing temperature (A)	Tempering temperature (T)	Tempering time (h)	HardnessRWL34™ (HRC)	Hardness PMC27™ (HRC)
I	1050 °C / 1920 F	220 °C / 430 F	2	59 HRC	53 HRC
II	1050 °C / 1920 F	175 °C / 345 F	2	62 HRC	54 HRC
III	1080 °C / 1980 F	220 °C / 430 F	2	58 HRC	56 HRC
IV	1080 °C / 1980 F	175 °C / 345 F	2	63 HRC	58 HRC
V	1100 °C / 2010 F	175 °C / 345 F	2	64 HRC	60 HRC

Table 3. Hardening and tempering suggestions with corresponding hardness of the alloys.

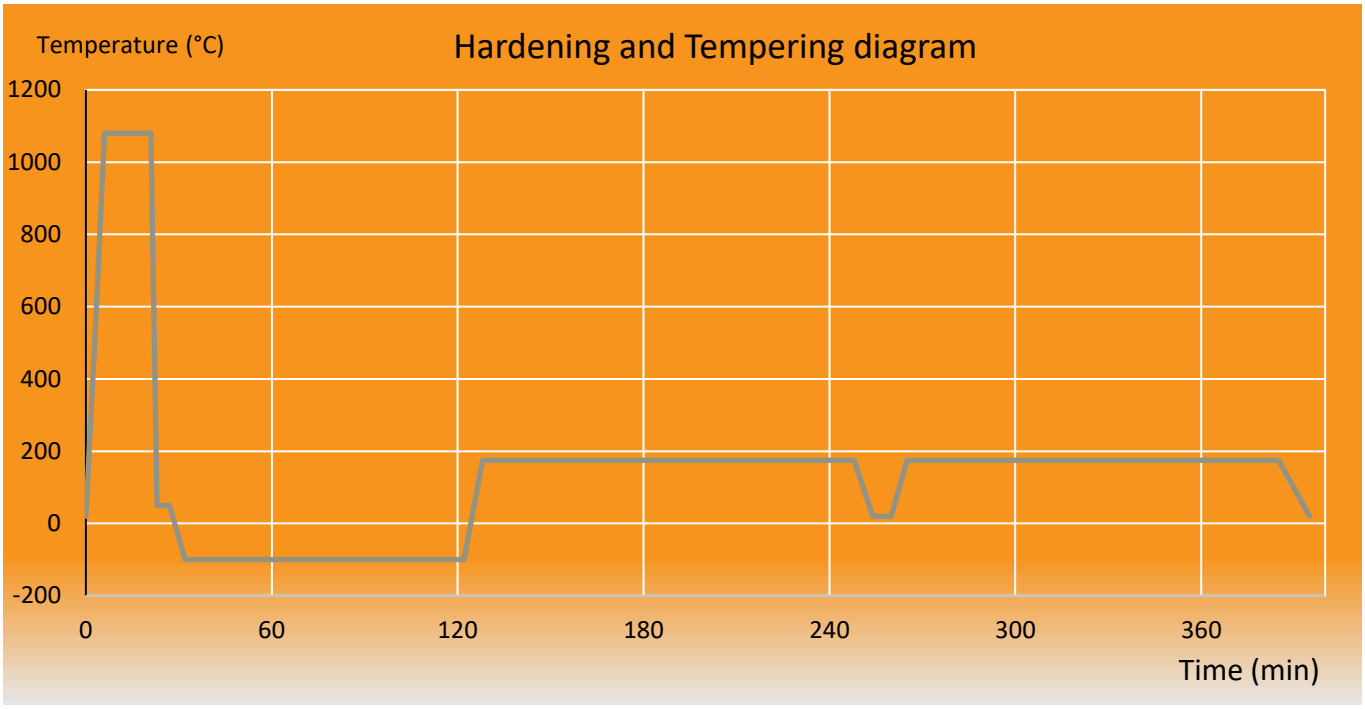

Diagram 1. Schematic hardening and tempering diagram for martensitic material including a deep-freezing treatment with liquified Nitrogen.

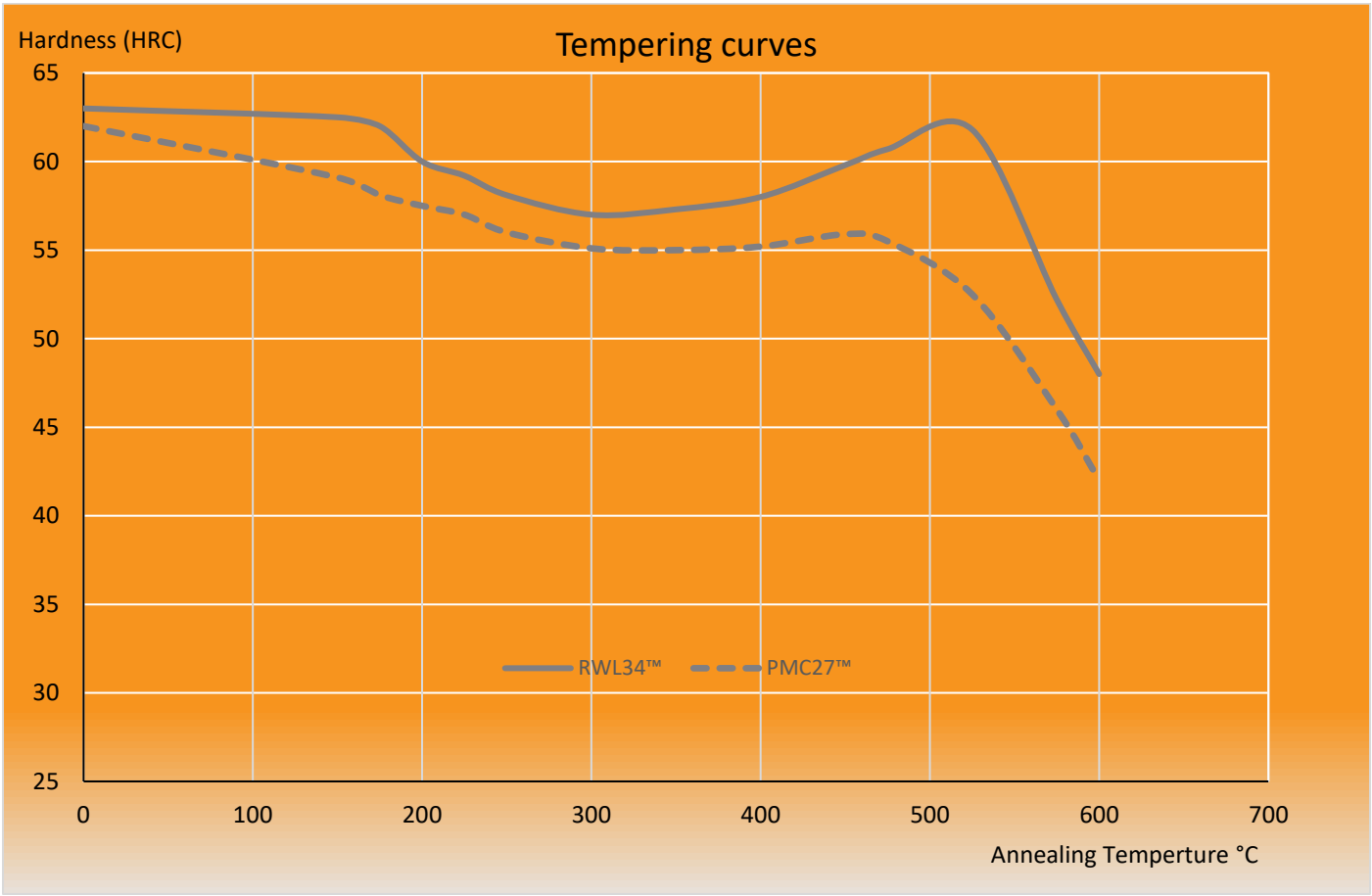

Diagram 2. Annealing temperature for the grades RWL34™ and PMC27™ in DS93X, austenitzing temperature 1080°C (1976F).

Etching

The pattern will be visible after etching. Depending on desired result, different acids and acids mixtures can be used. The surface finish strongly affects the result. In table 4 is a recommended recipe for hardened and tempered material.

	Etching Solution	Chem. comp.	Blend (%)	Time (min)	Temp (°C/ °F)	Color RWL34™	Color PMC27™
I	Hydrochloric acid 37% Ferrochloric acid 47%	HCl, $FeCl_3$	95 5	2-5	45-50/ 113-122	Bright	Dark Grey

Table 4. Etching suggestion with corresponding colors of the different alloys.

Etching procedure:

1. Grind the piece progressively up to desired grit, 600 or higher. Finish off with polishing if desired.
2. Degrease the piece carefully and finish off using glass cleaner.
3. Mix the etching acid in the recommended ratios and remember to always pour the acid into the water.
4. Heat the acid mixture in a water bath.
5. Immerse the piece in the mix and leave it in for the time you choose. Longer soaking time will give deeper relief.
6. Neutralize the piece by dipping it into water with bicarbonate.
7. A light buff with 2500 grit or more, after etching, can help to make the tops bright.

Beware of noxious fumes. Etching must be performed in a well-ventilated area. All acids are highly corrosive and must be handled with great care.

Products dimensions and delivery conditions.

Damasteel has a standard product program that can be found on our website www.damasteel.com.
We supply martensitic Damascus patterned steel in following features.

- Round bars in selected sizes. Ranging from 15-65 mm, length 500-1100mm
- Flat bars in dimensions shown in chart below, see diagram 3, length 500-1100 mm.
- All martensitic material supplied from Damasteel is soft annealed, hardness < 25 HRC

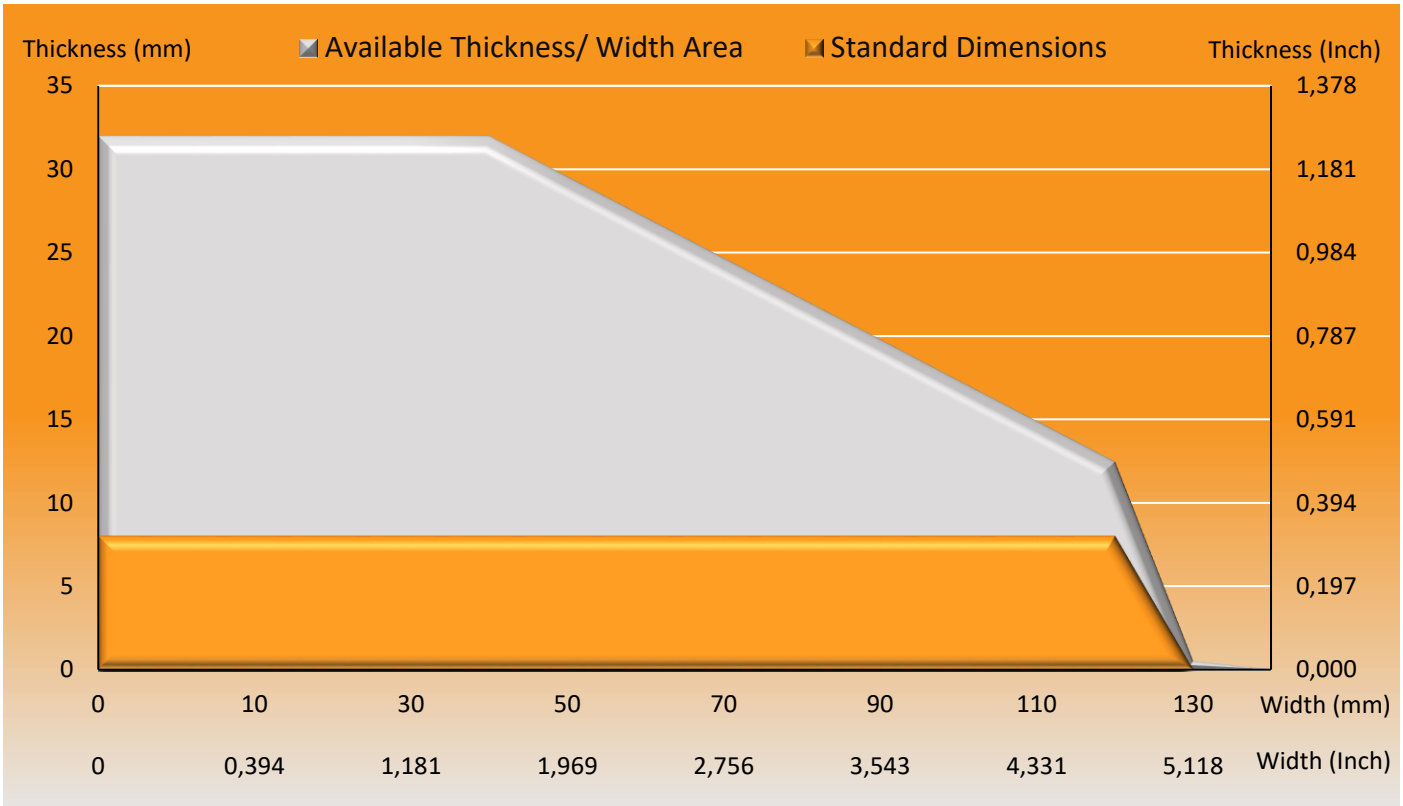

Diagram 3: Size range.

Even if it comes to creating customized patterns on Damascus products or if you like dimensions outside standard range contact us.

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