DATASHEET

DAMACORE® DC18N

Product information

Damasteel's stainless Damascus patterned steel, Damacore® DC18N, is a powder metallurgy-based steel with three different alloys. The center core consists of N11X™, a high-nitrogen steel with distinctive properties. Through a process route based on powder metallurgy, a high nitrogen steel is produced, most of the carbon is substituted by nitrogen, modifying the traditional chromium carbides into vanadium nitrides. This gives N11X™ unique properties, a combination of hardness, wear resistance, ductility, and corrosion resistance. This combination of properties is a reason for its impressive suitability as a knife material.

The Damascus-patterned outer layers consist of RWL34™ and PMC27™. These three alloys combined in Damasteel's process give the Damacore® DC18N unique and exceptional properties that combine beauty and function that until now was impossible to produce.

Distinctive Features

- Excellent corrosion resistance
- Good wear resistance
- Good ductility

Mechanical and physical properties

Grade	C	Si	Mn	Cr	Mo	V	N	S	P
N11X™	0,36	0,3	0,3	18,2	1,1	3,5	1,55		
RWL34™	1,05	0,50	0,50	14	4	0,2	0,1	<0,03	<0,05
PMC27™	0,60	0,50	0,50	13			0,1	<0,03	<0,05

Table 1. Nominal chemical compositions in wt-% of the constituent alloys in DC18N.

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	<25	HRC	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 Damascus patterned steel (DC18N™) in annealed condition at 20°.

SWEDEN: STALLGATAN 9, SE-815 76 SÖDERFORS | OFFICE SWEDEN: +46 293 306 00 | SALES@DAMASTEEL.SE | WWW.DAMASTEEL.SE

Hot working

Forging or rolling temperature is in the range 1050-1160 °C (1920-2120°F). Melting starts at 1220°C (2230°F), which means that the material is very sensitive to overheating, so good control of the heating temperature is needed. Compared to low-alloyed steels, martensitic stainless steels have higher, almost doubled deformation resistance.
Long soaking times above 850°C (1560°F) lead 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, or machining should be done after hot working until the material is annealed. All material delivered from Damacore is annealed.

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 easy to machine.
The machining characteristics for our stainless Damascus patterned steel are:

Soft annealed, <25 HRC:

- Use HSS or carbide tools.
- Tendencies for buildup 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. The speed of the workpiece may be 1/60 of the grinding speed.

Welding

When cooling martensitic stainless steel after any hot process, the martensitic phase transformation occurs 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

It is recommended that hardening operations, heating, cooling, cryogenic and tempering operations should be performed before grinding or machining the bevel to protect the core from loss of nitrogen if operations are not done in a vacuum furnace with a partial pressure of nitrogen.

Annealing:
The recommendation is to have the material fully transformation annealed, which means two hours at 980 °C (1796°F), then cool in the furnace to 850°C (1562°F) with a ramp of <15° per hour. Hold for 10 hours at 850°C (1562°F), then cool slowly, ~10°C/h, to 750°C (1382°F), then cool to room temperature, see Diagram 1. Achieved hardness <280 HV (28HRC). All material from Damasteel is in an annealed condition.

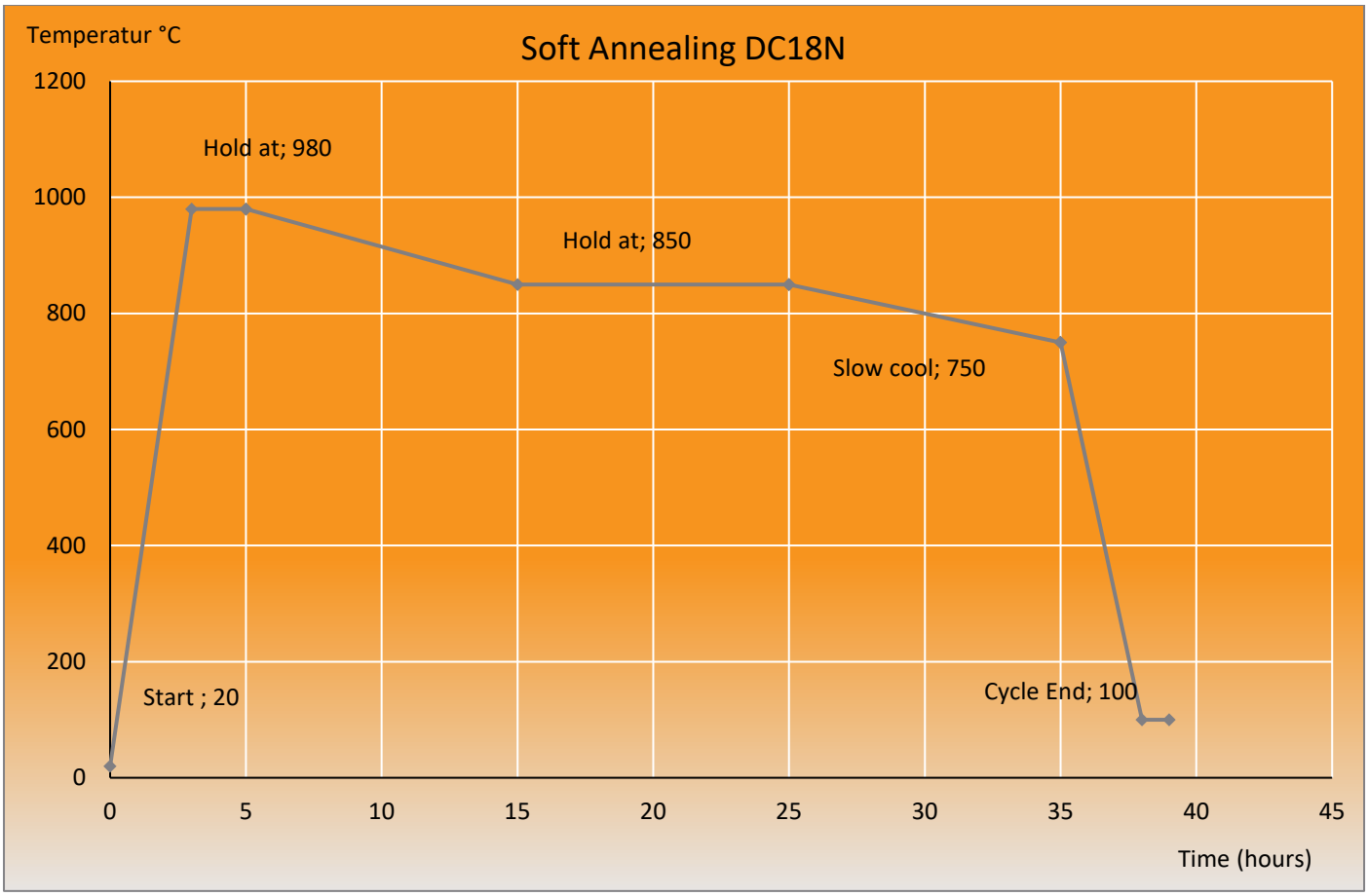

Diagram 1. Soft annealing cycle for DC18N.

Hardening/ Tempering:

Austenitizing:

Temperature 1080°C (1976°F), holding time at austenitizing temperature 30 min. This temperature includes a deep-freezing treatment to fulfill the transformation to martensite. An alternative austenitizing temperature is 1010°C (1850°F). Hardening can be performed in a normal atmosphere with the use of heat treatment foil wrap, see Diagram 2. To counteract the loss of Nitrogen, perform the hardening using a vacuum furnace and with a Nitrogen partial pressure of 150-200 mbar.

Quenching:

We suggest cooling in **oil** and the piece reaches 50°C within two min. **Cooling in the air also works**. Apply some pressure on the piece if cooling in air, so it will not bend due to uneven cooling. Followed by deep cooling between -100°C (148°F) and -196°C (-320°F) to minimize the amount of retained austenite.

Deep Freezing:

Necessary for DC18N and completes the martensite transformation. Without DF, the retained austenite will be around 60% with a hardness of around 50 HRC. Hold for one and a half hours in a temperature below -100°C (-148°F) or use liquid Nitrogen -198°C (-324°F).
If there are no possibilities to deep freeze use an austenitizing temperature of 1010°C (1850°F). Hold for 30 min and then temper at 200° (390F) 2x 2h. Achieved hardness will be around 57-58 HRC. See diagram 3.

Tempering:
For the best corrosion properties, low temperature tempering at 200°C (390°F)/2 x 2h is recommended. If the product application conditions require a higher tempering temperature, Damacore® DC18N can be tempered up to 450°C (840°F) without significant loss of corrosion properties, see diagram 4. The hardenability is adequate to ensure good through hardening properties when quenching in vacuum furnaces.

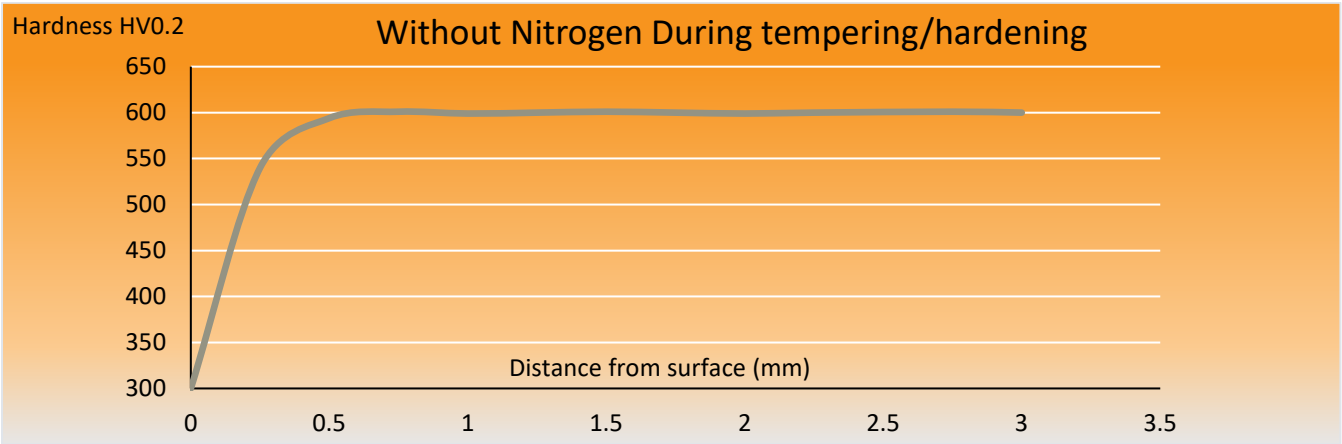

Diagram 2. Hardness profile without Nitrogen during tempering/hardening.

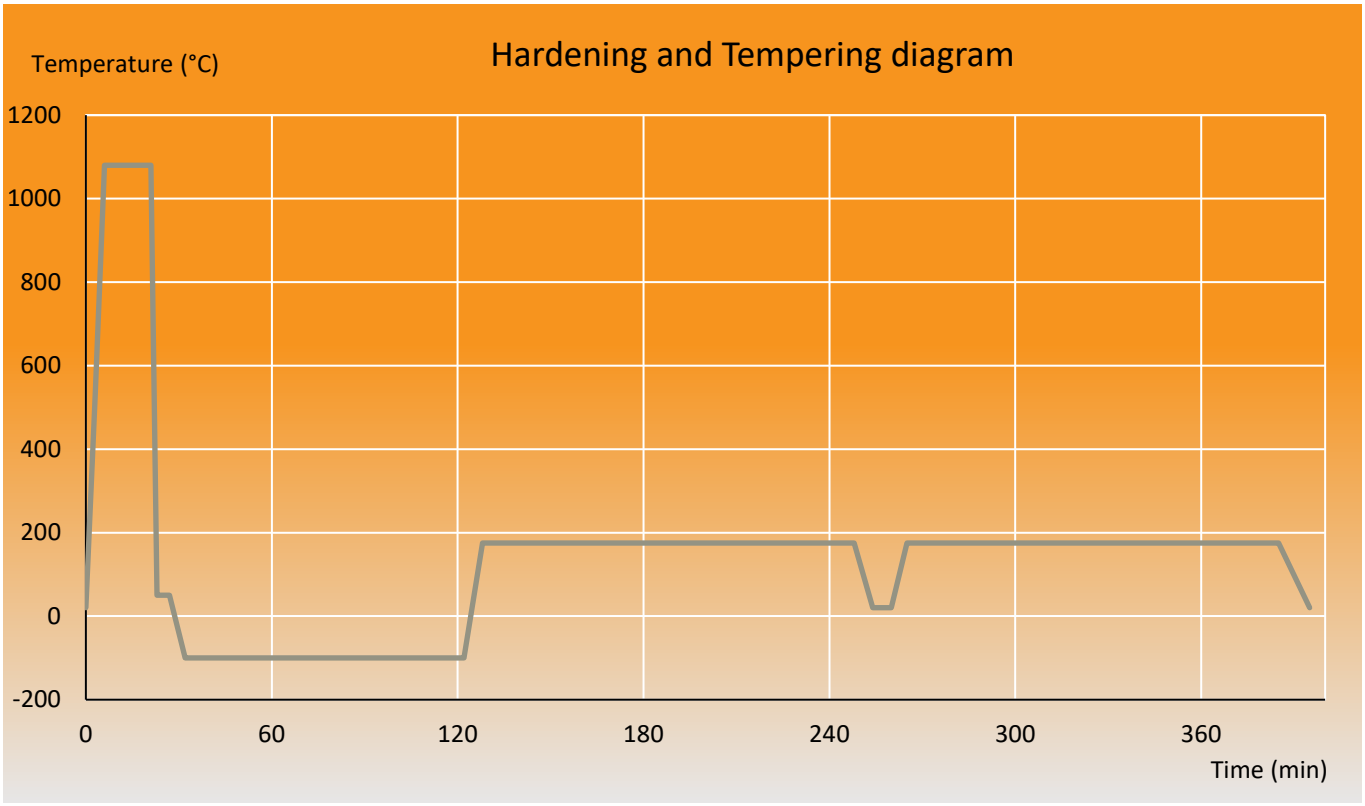

Diagram 3. Schematic hardening and tempering diagram for martensitic material including a deep-freezing treatment with liquified Nitrogen.

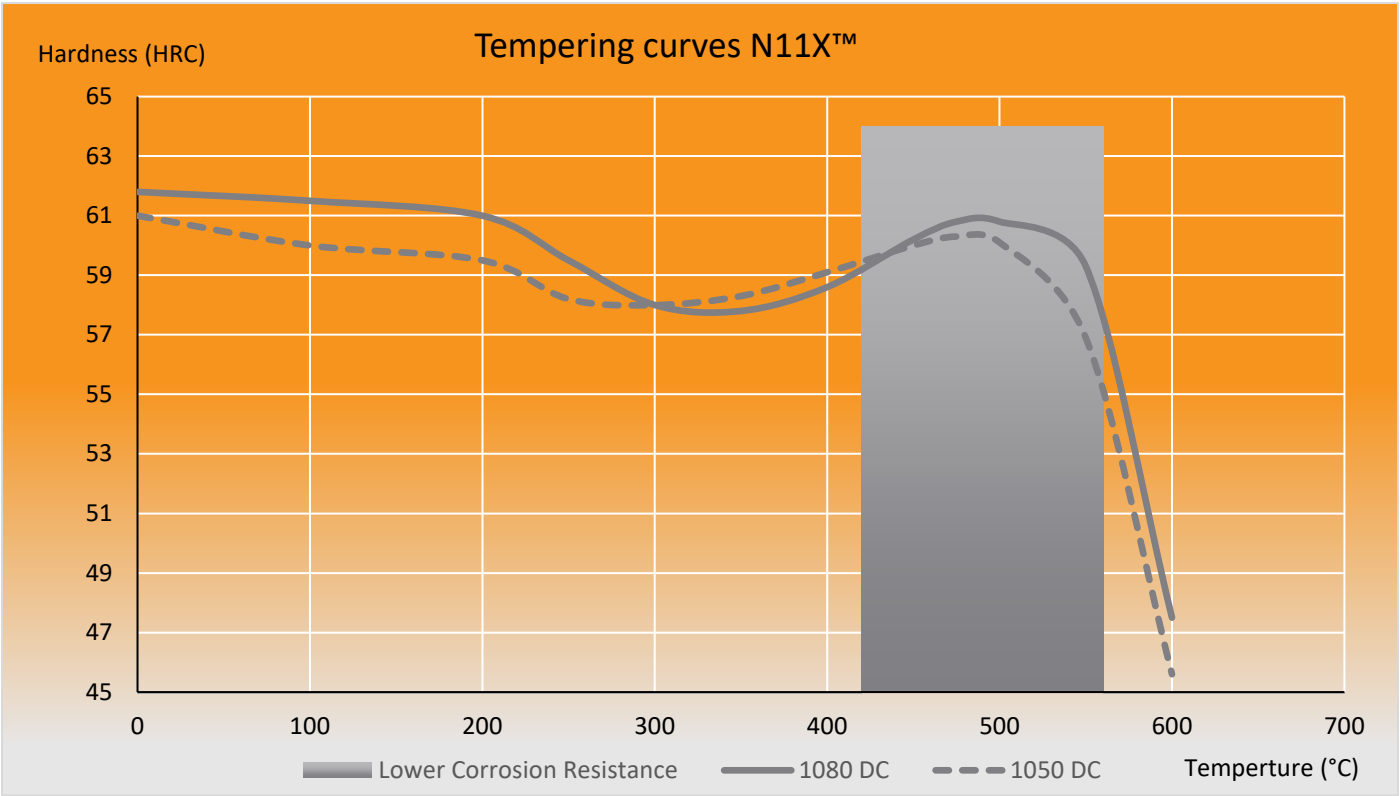

Diagram 4. Tempering and corresponding hardness in HRC for two austenitizing temperatures, material subzero treated before.

Etching

The pattern will be visible after etching. Depending on the desired result, different acids and acid mixtures can be used. The surface finish strongly affects the result. Table 2 is a recommended recipe for etching hardened and tempered material.

	Etching Solution	Chem. comp.	Blend (%)	Time (min)	Temp (°C/ °F)	Color RWL34™	Color PMC27™	Color N11X™
I	Hydrochloric acid 37% Ferro Chloric acid 40%	HCl, $FeCl_3$	95 5	2-5	45-50/ 113-122	Bright	Dark grey	Grey

Table 2. Etching suggestions with corresponding colours and relief of the different alloys.

Etching procedure:

1. Grind the piece progressively up to the 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 always to 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. A longer soaking time will provide 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.

Product dimensions and delivery conditions.

Available width on Damacore® DC18N is 38, 51 and 63,5 mm (1.5" , 2" and 2.5").
Thicknesses ranging between 2,5 mm to 6,3 mm (0.100" to 0.248"), depending on pattern, all thicknesses are not available, see Table 3.
Length between 305-610 mm.
Annealed to hardness <28 HRC.
For more details, visit our website.

Patterns	Thickness available for a specific pattern						
	.100" 2,5mm	.118" 3,0mm	.125" 3,2mm	.138" 3,5mm	.156" 4,0mm	.190" 4,8mm	.248" 6,3mm
Odins Eye™					x	x	x
Grosserosen™					x	x	x
Thor™				x	x	x	
Hugin™	x	x	x	x	x	x	
Rose™	x	x	x	x	x	x	
Hakkapella™	x	x	x	x	x	x	x
Baldur™		x	x	x	x	x	x

Table 3. Available patterns for a specific thickness.

Information given in this datasheet may be subject to alterations without notice. Care has been taken to ensure that the contents of this publication are accurate, but Damasteel ® and its affiliated companies do not accept responsibility for errors or for information which is found to be misleading. Suggestions for or descriptions of the end use or application of products or methods of working are for information only, and Damasteel ® and its affiliated companies accept no liability in respect thereof. Before using products supplied or manufactured by the company, the customer should satisfy themselves of their suitability.

STALLGATAN 9, SE-815 76 SÖDERFORS | OFFICE SWEDEN: +46 293 306 00 | SALES@DAMASTEEL.SE | WWW.DAMASTEEL.SE