Technical Data Sheet
UGIMA® 4116N

Chemical analysis (%)

C	Si	Mn	Cr	Mo	N	V	P	S
0,45 - 0,55	≤ 1,0	≤ 1,0	14,0 - 15,0	0,50 - 0,80	0,05 - 0,15	0,10 - 0,20	≤ 0.040	0,02 - 0,03

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General presentation

UGIMA® 4116N is a martensitic stainless steel. This grade is similar to UGI® 4116N in that, thanks to its high carbon (C) + nitrogen (N) content, it provides a greater compromise between corrosion resistance and hardness than grades 1.4112 (440B) and 1.4125 (440C), which it can replace in many applications. In addition, it can be used in much the same way as a 1.4034 (420) and is therefore much easier to handle than a 4112/4125.

Finally, unlike UGI® 4116N, UGIMA® 4116N is a grade containing 0.020 to 0.030% sulphur, making it much easier to machine. Although its chip breakability is similar to that of a 1.4112 with controlled sulphur content, its productivity for equivalent tool wear is markedly higher (+ 50% in terms of $VB_{15/0.15}$ for rough turning).

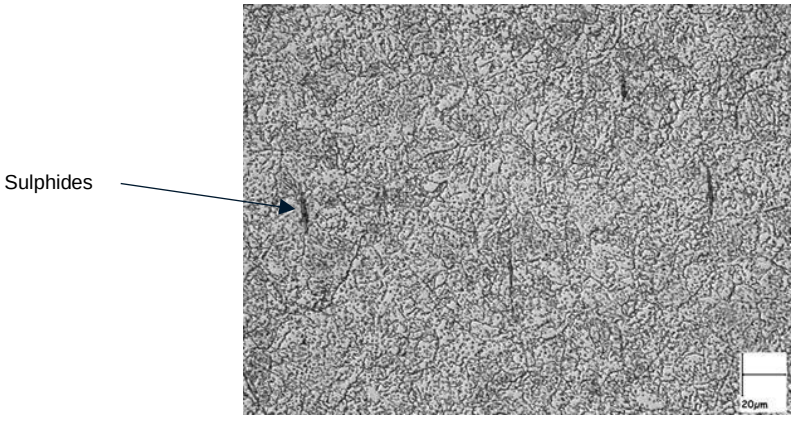
Classification

Martensitic stainless steel with the addition of nitrogen.

Designation

Material No.	
EN 10088 - 3	NF A-36-711
1.4116 – X50CrMoV15	1.4116 – X50CrMoV15

Microstructure



Microstructure of UGIMA® 4116N in the softened state (longitudinal micrograph of 73 mm ∅ bar)

Swiss Steel Group

Production sites: Ugitech SA
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Mechanical properties

The following table summarizes, for information only, the hardness and resilience values that can be achieved at ambient temperature with UGIMA® 4116N for different heat treatments.

State	Hardness	KCV resilience
Maximum softening	< 280 HBW *	-
Air quenching 1050°C + tempering 200°C/1 h	57 HRC	5 J/cm²
Air quenching 1050°C + sub-zero treatment (- 80°C/1 h) + tempering 200°C/1 h	59 HRC	4 J/cm²

* for information only

Comparison with martensitic grades with higher C content

	UGIMA® 4116N	1.4112 (440B)	1.4125 (440C)
% C + N	0.6	0.9	1.0
% Cr min / max	14.0 / 15.0	17.0 / 19.0	16.0 / 18.0
% Mo min / max	0.5 / 0.8	0.9 / 1.3	0.4 / 0.8
Maximum hardness (quenching T°)	59 HRC (1050°C)	60 HRC (1050°C)	61 HRC (1030°C)
Hardness (quenching + tempering 200°C / 1 h)	57 HRC	55.5 HRC	60 HRC
Impact strength (quenching + tempering 200°C / 1 h)	5 J/cm²	4 J/cm²	1.5 J/cm²

Physical properties

Temperature	Density	Elasticity modulus	Thermal conductivity	Expansion coefficient	Specific heat	Electrical resistivity
(°C)	(g/cm³)	(GPa)	(W/m.K)	(10^{-6}/K)	(J/kg.K)	(µΩ.mm)
20	7.7	215	30		460	650
100		212		10.5		
200		205		11.0		
300		200		11.0		
400		190		11.5		

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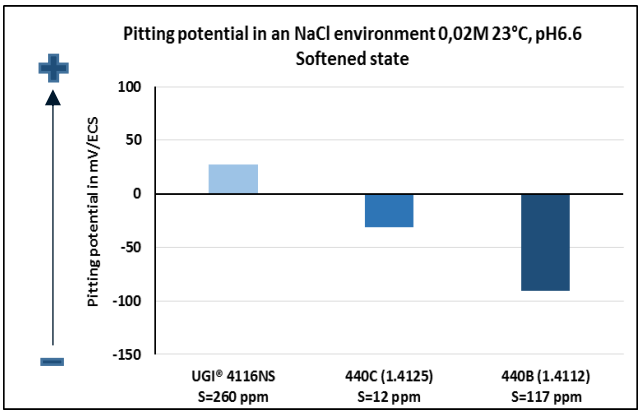
Corrosion resistance

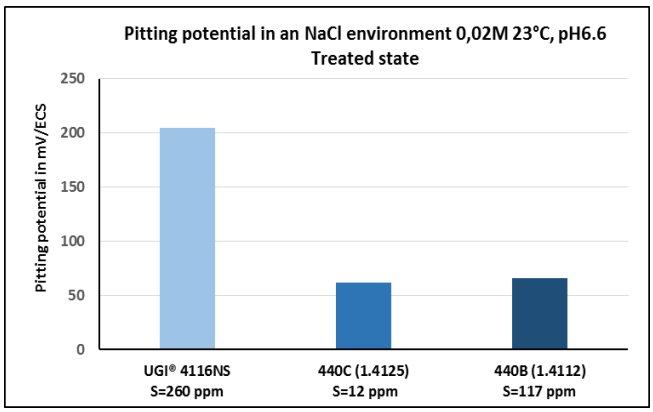
UGIMA® 4116N is one of the martensitic grades that have good corrosion resistance. It can be used, for example, in the following environments: water, water vapour, petrol and more generally in environments with a low chloride ion content.

Localized corrosion

– Pitting corrosion

UGIMA® 4116N in the quenched state (1050°C 30 min Oil Quenching) + Tempering (200°C 2 h Air Stop) has better resistance to pitting corrosion in a drinking water type environment (0.02M NaCl, pH=6.6 at 23°C) than martensitic grades 1.4112 (440B) and 1.4125 (440C) which have a higher carbon content, despite its higher sulphur level.





In its softened state, the pitting corrosion resistance of UGIMA® 4116N is lower, but remains significantly better than that of 1.4112 (440B) and 1.4125 (440C).

Hot transformation

Forging

UGIMA® 4116N has good forgeability in the 950°C - 1200°C temperature range. It should be heated to 1180°C-1200°C and remain above 950°C during hot forming (return to the furnace if necessary).

After forging, slow cooling is required, followed, after complete cooling to ambient temperature, by softening or quenching and tempering heat treatment according to the following operations.

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Machinability

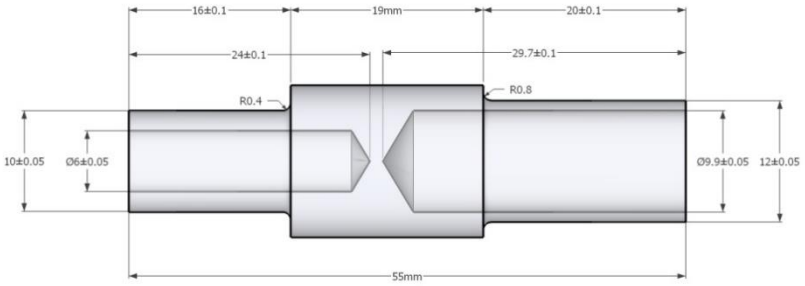
UGIMA® 4116N, like most high-carbon martensitic grades, is best machined in the softened state. The following data summarizes the results obtained on hot-rolled bars and drawn bars that have undergone a softening heat treatment as described in the heat treatment section. If you need advice on machining UGIMA® 4116N in the treated state, please contact us.

Turning

Comparative turning tests on hot-rolled bars were conducted between UGIMA® 4116N, UGI® 4116N and 1.4112 with a sulphur content of 0.13%. These tests show that **the turning productivity of** UGIMA® 4116N **is increased by about 10 to 15% compared to that of UGI® 4116N, which puts it 50% above 1.4112.**
The high sulphur (S) content in UGIMA® 4116N also significantly improved chip breakability during turning, compared to UGI® 4116N, which puts it at almost the same level as 1.4112.

Screw machining

In addition to the turning and drilling tests on hot-rolled bars, a TORNOS SIGMA 32 screw machine was used to perform machining tests on drawn bars. Several series of 1000 parts (see diagram below) from 15 mm ∅ bars were screw machined to determine optimal cutting conditions in terms of productivity for UGI® 4116N and UGIMA® 4116N, allowing these 1000 parts to be machined without changing tools. Once these conditions were determined for each cutting operation, they were revalidated for another two series of 1000 parts using new tools for each grade.



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Straight turning

The table below shows the cutting conditions determined for UGIMA® 4116N and UGI® 4116N, guaranteeing dimensional accuracy and the required part roughness, right up to the thousandth part. The results of a standard $VB_{15/0.25}$ test have been added to this table. **For the three turning operations, potential productivity gains of between 10 and 20% were demonstrated with UGIMA® 4116N, as opposed to those obtained with a standard UGI® 4116N.**

Operations	Tools	Standard UGI® 4116N	UGIMA® 4116N
Rough turning BP (1) (a_p = 2 mm [∅15 to ∅21 mm]; f = 0.25 mm/rev)	SECO TM2000 CCMT09T308-F2	V_c = **205** m/min	V_c = **225** m/min
Finish turning BP (2) (a_p = 0.5 mm [∅21 to ∅20 mm]; f = 0.10 mm/rev)	SECO TM2000 CCMT09T304-F1	V_c = **200** m/min	V_c = **240** m/min
Turning $VB_{15/0.25}$ CB (3) (a_p = 1.5 mm [∅15 to ∅12 mm]; f = 0.25 mm/rev)	SECO TM2000 CCMT09T308-F2	V_c = **205** m/min	V_c = **225** m/min

BP: Main spindle, CB: Counter spindle
(1) cutting conditions resulting in tool relief wear of approximately 0.25 mm
(2) cutting conditions resulting in tool relief wear of approximately 0.30 mm and guaranteeing roughness < 1.6 µm
(3) $VB_{15/0.25}$: cutting speed for which relief wear of 0.25 mm for 15 min of effective machining is observed

Drilling

For drilling tests, only the 6 mm ∅ one-piece carbide drill bit was tested on the Main Spindle (BP). These tests show that **the optimal cutting conditions guaranteeing 1000 holes at 4D without reaming with the same drill bit were improved by more than 30% with UGIMA® 4116N, compared to the conditions obtained with UGI® 4116N**.

Operations	Tools	Standard UGI® 4116N	UGIMA® 4116N
BP Drilling	GÜHRING RT100F DK460UF ∅ 6 mm	V_c = **140** m/min f = **0.15** mm/rev	V_c = **140** m/min f = **0.20** mm/rev

BP: Main spindle, CB Counter spindle

Cross-cutting

The table below shows, for a cross-cutting operation, the cutting conditions that can be obtained to produce 1000 parts without having to change tool for each grade. **In cross-cutting, a productivity increase of more than 15% was observed with UGIMA® 4116N, compared to that obtained with the standard UGI® 4116N.**

Operations	Tools	Standard UGI® 4116N	UGIMA® 4116N
Cross-cutting	SANDVIK C3-QD-RFG25C22055A	V_c = **75** m/min f = **0.10** mm/rev	V_c = **90** m/min f = **0.10** mm/rev

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Welding

UGIMA® 4116N can only be welded by taking very special precautions. It is therefore not recommended and, where possible, should be avoided.

Heat treatment

Softening

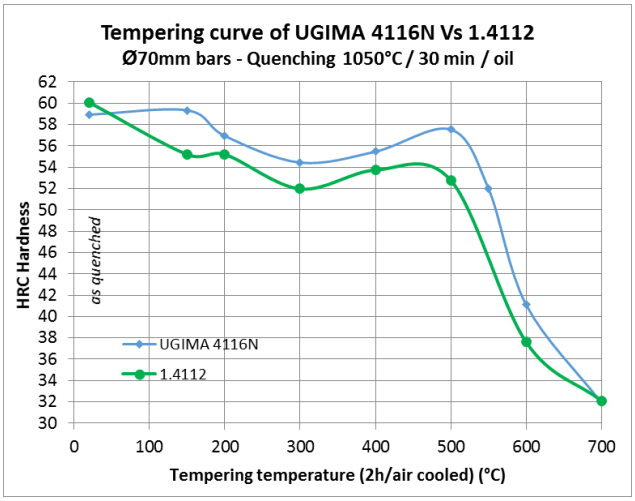
For maximum softening, UGIMA® 4116N should be treated at approximately 840°C for several hours and then cooled very slowly in the furnace. Hardness of about 210-220 HV_{1kg} is then obtained.

Quenching

Oil or air quenching is preferably performed at 1050°C.

Tempering

The curve below shows the hardness levels available for UGIMA® 4116N compared to those available for 1.4112 for different tempering temperatures between 150 and 700°C (from a quenched state, from 1050°C).



Surface treatment

Pickling / Passivation / Electropolishing

The surface treatment conditions of UGIMA® 4116N remain identical to those of the martensitic family containing 12 to 14% chromium and S ≤ 0.030%.

We recommend using a hydrochloric acid bath to strip the hot-formed oxides (for example, 4 moles/litre - 40°C - time to be adjusted according to the layers to be removed). They must then be rinsed with water (preferably by immersion, then spraying).

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Passivation is traditionally carried out in a nitric acid bath (50% Vol.; 50°C; 30 minutes to adjust), followed by rinsing with water (preferably by immersion, then spraying).

Available products

Product	Form	Finish	Tolerance	Dimensions	
Hot-rolled bar	round	black		∅ 23 – 115	mm
		rolled descaled	K12 and K13	∅ 22 – 115	mm
	hexagonal	rolled descaled		∅ 22 – 58	mm
Cold-rolled bar	round	turned polished	ISO 9 - 10	∅ 22 – 115	mm
		drawn	ISO 9 - 10	∅ 2.0 – 30	mm
		ground	ISO 6 – 7 – 8 - 9	∅ 1.8 – 70	mm
	hexagonal	drawn		∅ 3.0 – 60	mm

Other: contact us

Applications

- Mechanical parts subject to wear: pins, nozzles
- Replacement wear parts for 1.4112 (440B) or 1.4125 (440C)
- Components with a cutting or sharp edge and a machined part

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