Technical Data Sheet
UGIMA® 4509

Chemical analysis (%)

C	Si	Mn	Cr	P	S	N	Nb	Ti
≤ 0.03	≤ 1.0	≤ 1,0	17.5 - 18.5	≤ 0.030	≤ 0.015	≤ 0.03	0.30+(3xC) - 0.7	0.1 - 0.3

18-02-2016 – REV01

General presentation

UGIMA® 4509 is an improved machinability ferritic stainless steel containing approximately 18% chromium and stabilised with niobium and titanium.

Apart from good corrosion resistance, this grade is characterised by its high suitability for different methods of working, such as machining, cold heading and welding:

This UGIMA® version of 4509 makes it possible to achieve significantly greater machining productivity than that obtained with a standard 4509, thanks to slower tool wear and better chip breakability.

Stabilisation with niobium eliminates the risk of sensitisation during welding and the titanium limits the grain size in welded areas.

It has excellent cold-heading properties.

For some applications, it is an economical replacement for certain austenitic grades such as 1.4307 or 1.4305.

Its ferritic structure ensures excellent ferromagnetic properties, good oxidation resistance (in particular to thermal cycles) and an expansion coefficient similar to that of carbon steel.

Classification

Stabilised ferritic stainless steel

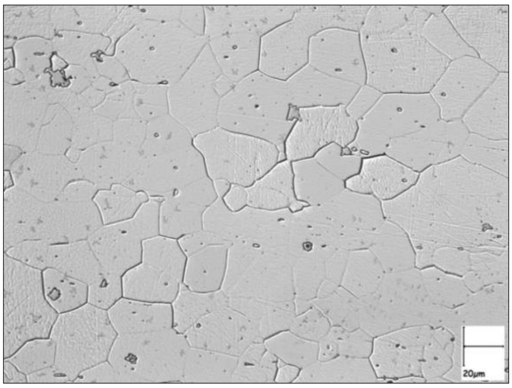
Designation

Material No

Europe EN		**USA ASTM**	**Japan SUS**	**International ISO**	
10088-3		**A959**		**ISO 15510**	
Number	Name			Number	Name
1.4509	X2CrNbTi18	S43940	SUS430LX	4509-439-40-X	X2CrNbTi18

Microstructure

The structure of UGIMA® 4509 is entirely ferritic in the as-delivered condition. The main precipitates are Nb-carbonitrides, Ti-nitrides and Ti-sulphides or Ti-carbosulphides.



Microstructure of UGIMA® 4509 (transverse micrography x 500)

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Mechanical properties:
Traction data

Metallurgical condition	Temperature (T)	Tensile strength (UTS)	Yield strength (YS0.2)	Elongation (E)	Brinell hardness (HB)
	(C°)	(MPa)	(MPa)	(%)	
softened	20	420 – 620	> 200	> 18	< 200
∅ ≤ 10 mm work-hardened by drawing	20	500 – 750	> 320	> 8	
10 mm < ∅ ≤ 16 mm work-hardened by drawing	20	480 – 750	> 300	> 10	
16 mm < ∅ ≤ 50 mm work-hardened by drawing	20	400 – 700	> 240	> 15	

Physical properties

Temperature	Density	Elasticity modulus	Thermal conductivity	Expansion coefficient	Specific heat	Electrical resistivity
(°C)	(kg/dm^3)	(GPa)	(W/m.K)	(10^{-6}/K)	(J/kg.K)	(µΩ.cm)
20	7.7	220	25		460	60
100		215		10.0		
200		210		10.0		
300		205		10.5		
400		195		10.5		

Corrosion resistance
Localized corrosion

– Pitting corrosion

We assessed this type of corrosion by testing the pitting potential: the higher its mV/SCE, the greater the pitting corrosion resistance; a neutral, slightly chlorinated pH environment (0.02 moles/litre of sodium chloride) of municipal drinking water was chosen (at 23°C).

The following table gives the pitting potential values measured on samples from bars turned in the transverse direction:

Grade	Pitting potential (mV/SCE)	Standard deviation
UGI® 4509	484	3
UGIMA® 4509	447	8
UGIMA® 4511	360	20

The pitting corrosion resistance behaviour of UGIMA® 4509 is therefore similar to that of UGI 4509.

Neutral salt spray test to ISO 9227 operating standard

Although, on stainless steels, this test greatly depends on the surface condition tested (presence of scratches, etc.), it was carried out on 15 mm diameter bars in their longitudinal direction, after mechanical polishing with SIC 1200 paper. After both UGIMA® 4509 and UGI® 4509 grades were tested for 500 hours, 90% of their surfaces were free from corrosion pitting. In this respect too, the salt spray resistance of UGIMA® 4509 is identical to that of UGI® 4509.

High-temperature oxidation resistance

A cyclic oxidation test was performed in air at 900°C which was maintained for 20 minutes, followed by air cooling for 300 cycles; the following table shows that **the thicknesses of the oxide layers formed (fine and adhesive) are similar for both UGIMA® 4509 and UGI® 4509 grades.**

Grade	Thickness of oxide layers in mg/cm^2 after 300 x 20 minute cycles at 900°C
UGI® 4509	1,9
UGIMA® 4509	1,7
UGIMA® 4511	1,2

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Hot transformation

UGIMA® 4509 has excellent forgeability at all temperatures, due to its entirely ferritic structure. It can be hot formed by forging or rolling at between 800°C and 1150°C. The heating temperature must not exceed 1150°C to prevent excessive grain growth.

Cold transformation

UGIMA® 4509 can easily be used for conventional cold-working processes: cold drawing, shaping, forming, cold heading, etc. As it is moderately work-hardened, there is less force on the tools.

Machinability

Compared to a standard 1.4509, UGIMA® 4509 provides significant productivity increases in machining, thanks to slower tool wear and, above all, better chip breakability for the same cutting conditions.

Turning

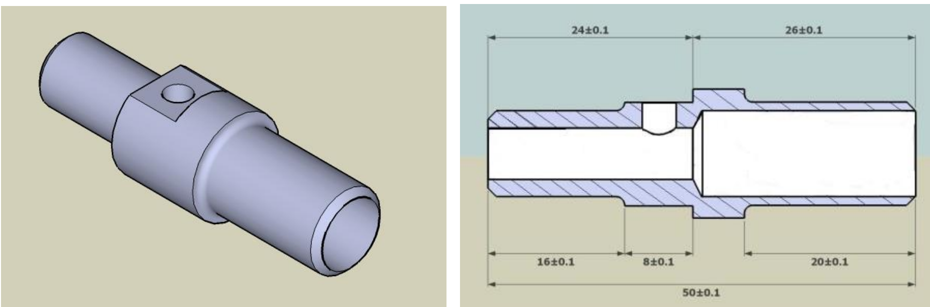
Standard $VB_{15/0.15}$ tests were performed dry on a numerically controlled lathe and Chip Breaking Zones (CBZ) were determined. **For equivalent tool wear, they revealed (see table below) a potential increase in productivity of approximately 6% with UGIMA® 4509, compared to a standard 1.4509, as well as improved chip breakability, reducing the risk of machine stoppage (to remove balls of chips that might form and break tools or scratch machined parts).**

Operations	Tools	1.4509 standard	UGIMA® 4509
Turning $VB_{15/0.15}$ (1) (ap = 1.5 mm; f = 0.25 mm/rev)	SECO TM2000 CNMG 120408 – MF4	Vc = **390** m/min	Vc = **415** m/min
Turning CBZ (2) (Vc = 150 m/min)	SECO TM2000 CNMG 120408 – MF4	**38** correct chip breaking conditions out of 56 tested	**43** correct chip breaking conditions out of 56 tested

(1) $VB_{15/0.15}$: cutting speed at which 0.15 mm flank wear is noted in 15 minutes of actual machining;
(2) CBZ: forward sweeping (0.1 to 0.4 mm/rev in increments of 0.05 mm/rev) and depth of cut (0.5 to 4 mm in increments of 0.5 mm) at a constant cutting speed, to determine the number of correct chip breaking conditions out of 7 x 8 = 56 tested.

Screw machining

Tests were performed on a TORNOS SIGMA 32 industrial screw machine to compare UGIMA® 4509 with a standard 1.4509 and quantify the differences in machinability. For each grade, the test consisted in defining the optimum cutting conditions for different operations to produce 1000 components (see the diagram below) without having to change tool.



Typical component made during the test (without chamfer and radial drilling)

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Turning (roughing and finishing)

The table below shows the cutting conditions that can be achieved to produce 1000 components without having to change tool for each grade according to the operations (roughing and finishing) and the tools used. The results of a standard $VB_{15/0.25}$ test have been added to this table.

For the three turning operations, potential productivity increases up to 30% were revealed with UGIMA® 4509 compared to a standard 1.4509.

Operations	Tools	Standard 1.4509	UGIMA® 4509
Rough turning (ap = 2 mm; f = 0.30 mm/rev)	SECO TM2000 CCMT09T308-F2	V_c = **150**(1) m/min	V_c = **195** m/min
Finish turning (2) (ap = 0.5 mm; f = 0.10 mm/rev)	SECO TM2000 CCMT09T304-F1	V_c = **275**(3) m/min	V_c = **275**(3) m/min
Turning $VB_{15/0.25}$ (4) (ap = 1.5 mm; f = 0.25 mm/rev)	SECO TM2000 CCMT09T308-F2	V_c = **220**(5) m/min	V_c = **265** m/min

(1) for f = 0.3 mm/rev, the standard 1.4509 chips are not well-broken, thus inducing lots of machine stops; for f = 0,35 mm/rev and V_c = 130 m/min, 1000 parts are obtained in the standard 1.4509, their chips are well-broken but the Ra roughness of parts are over the 3.2 µm limit;
(2) cutting conditions ensuring roughness Ra < 1.6 µm on the 1000 machined parts, thanks to limited tool wear;
(3) maximal cutting speed of the TORNOS SIGMA 32 machine, making the differentiation between both grades;
(4) $VB_{15/0.25}$: cutting speed at which 0.25 mm flank wear is noted in 15 minutes of actual machining;
(5) at these extreme cutting conditions for standard 1.4509, bad surface roughness due to excessive tool wear.

Cutting-off

The table below shows, for a cross-cutting operation, the cutting conditions that can be achieved to produce 1000 components without having to change tool for each grade.

In parting-off, a very important increase in productivity (more than 80%) was noted with UGIMA® 4509 compared to a standard 1.4509.

Operations	Tools	1.4509 standard	UGIMA® 4509
Cross-cutting	SANDVIK QD-NG-0300-0001-CF 1105	Vc = **100** m/min f = **0,07** mm/tr	Vc = **130** m/min f = **0,10** mm/tr

Welding

Thanks to its niobium and titanium bi-stabilisation, UGIMA® 4509 can be welded in the same way as a standard 1.4509 by most arc welding processes (MIG/TIG, with or without filler metal, coated electrodes, plasma, etc.) by laser, resistance (spot or seam), friction or electrode beam welding, etc.
No heat treatment must be carried out before or after welding so as to prevent ferritic grain growth in the grade.

If a welding filler material is used, a homogeneous (stabilised ferritic) filler metal such as EXHAUST® F1 (18LNb) is preferred to ensure that the welded area (weld metal zone) [WZ] and heat-affected zone [HAZ]) is a 100 % homogeneous ferritic structure; for thick welds (≥ 3mm), an austenitic filler metal such as ER308L(Si) (1.4316) is preferred, in order to eliminate the risk of weakening the WZ through excessive grain growth.
In MIG, as in TIG, the shielding gas must not contain hydrogen or nitrogen. In MIG, welds will be made under Ar (+ possibly He) + 1 to 3% O_2 or CO_2. In TIG, welds will be made under Ar (+ possibly He).

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Heat treatment

Softening

To restore ductility after cold deformation, UGIMA® 4509 can be treated at a temperature between 750 and 900°C and air cooled.

Available products

Product	Form	Finition	Tolerance	Dimension
Bars	Round	Rolled descaled	k13 – k12	∅ 22 to 71 mm
		Turned	10 + 11	∅ 22 to 70 mm
		Ground	7+8+9+options	∅ 2 to 70 mm
		Drawn	9	∅ 2 to 30 mm
		Black	± 1% ∅	∅ 23 to 73 mm

Other contact us.

Applications

- Energy, process (solenoid valves)
- Automotive: lambda sensor support, injection, solenoid valves, magnetic applications (solenoids)

Usage limitations: cryogenic applications (insufficient resilience), applications requiring non-magnetic properties