Technical Data Sheet
UGIMA® 4541

Chemical analysis (%)

C	Si	Mn	Ni	Cr	Mo	Ti	P	S
≤ 0,08	≤ 1,0	≤ 2,0	9,0 – 12,0	17,0 – 19,0	≤ 0,5	5x(C+N) – 0,7	≤ 0.045	≤ 0,030

08-04-2013 – REV00

General presentation

The main property of UGIMA® 4541 is its resistance to intergranular corrosion. It uses titanium as a stabilising element to avoid the formation of chromium carbides in the grade when it is used at high temperature.

The mechanical properties of this stainless steel are better than those of 1.4307.

UGIMA® 4541 is specifically designed for machining and bar turning and provides increased productivity for these operations. UGIMA® 4541 has excellent oxidation and corrosion resistance and good creep behaviour. It is particularly recommended for applications requiring heat resistance at continuous or cyclic operating temperatures (400 – 850°C).

Classification

Austenitic stainless steel

Designation

Material No.

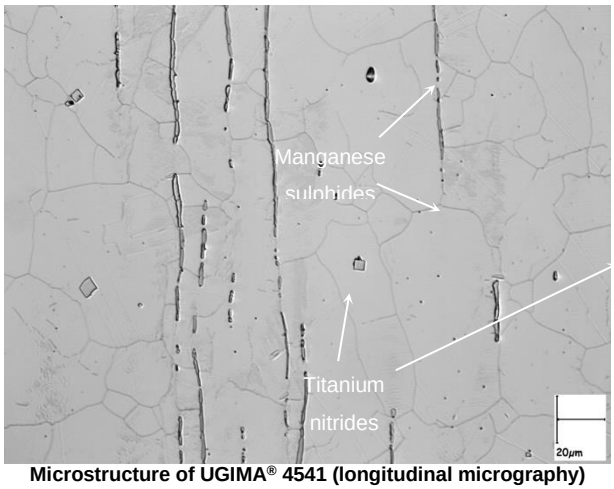
Europe	USA		Japan	ISO (ISO15510)
EN	**ASTM**	**AISI**	**JIS**	
1.4541 X6CrNiTi18-10	UNS S32100	321	SUS321	4541-321-00-I X6CrNiTi18-10

UGIMA® 4541 conforms to the following standard:

– EN 10088-3

Microstructure

UGIMA® 4541 has a mainly austenitic microstructure with elongated sulphides in the hot-rolling direction and some titanium nitrides.



Microstructure of UGIMA® 4541 (longitudinal micrography)

Swiss Steel Group

Production sites: Ugitech SA
www.swisssteel-group.com

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Mechanical properties
Traction data and hardness

Condition	Temperature T (°C)	Tensile strength UTS (MPa)	Yield strength $YS_{0.2\%}$ (MPa)	Elongation E (%)	Brinell hardness (BH)
not work-hardened by drawing	20	500 to 700	≥ 190	≥ 45	< 215
work-hardened by drawing ∅ ≥ 16 mm	20	500 to 850	≥ 190	≥ 30	-
work-hardened by drawing 10 < ∅ ≤ 16 mm	20	580 to 950	≥ 380	≥ 25	-
work-hardened by drawing ∅ ≤ 10 mm	20	600 to 950	≥ 400	≥ 25	-

Physical properties

Temperature (°C)	Density ($kg.dm^{-3}$)	Elasticity modulus (GPa)	Thermal conductivity ($W.m^{-1}.K^{-1}$)	Expansion coefficient ($10^{-6}.K^{-1}$)	Electrical resistivity (µΩ.mm)	Specific heat ($J.kg^{-1}.K^{-1}$)
20	7.9	200	15	-	730	500
100		194		16.0		
200		186		16.5		
300		179		17.0		
400		172		17.5		
500		165		18.0		

Corrosion resistance

It has excellent corrosion resistance in natural environments (drinkable water, rural and urban environments) and in food processing and agri-food environments (but with reservations in some specific cases, such as white wines, mustards, etc.).

UGIMA® 4541 is resistant to intergranular corrosion even after welding; it complies with the ASTM A262 Practice E standardised test.

UGIMA® 4541 can be used in mineral and organic acids, for example nitric acid. Precautionary measures are however required when it is used in other acids, for example phosphoric and sulphuric acids.

UGIMA® 4541 can be salt spray tested (ISO 9227 standardised test). It is difficult for us to give an accurate value in terms of the number of hours after which traces of corrosion will appear, because such resistance to salt spray depends not only on the composition of the grade, but also on the geometry of the component tested, the surface finish (roughness, machining scratches), the presence or absence of pollution (iron particles, cutting oils, etc). Finished components can be tested in our laboratory.

UGIMA® 4541 has excellent high-temperature chemical resistance; estimated continuous use limit temperatures are given below (the limit temperature must take into account the exact nature of the atmosphere and the amplitude and frequency of mechanical and thermal stresses):

Oxidizing atmosphere	850°C
Oxidizing sulphur atmosphere	750°C

Hot transformation
Forging

UGIMA® 4541 can be forged at between 950°C and 1250°C without taking special precautions. As for all austenitic stainless steel grades, the force required to deform metals is high (far higher than that required for carbon steels).
Components can be air- or water-cooled.

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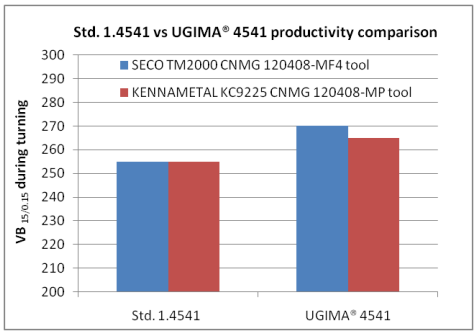
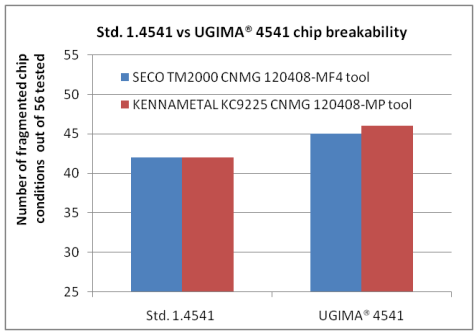
Machinability

Turning

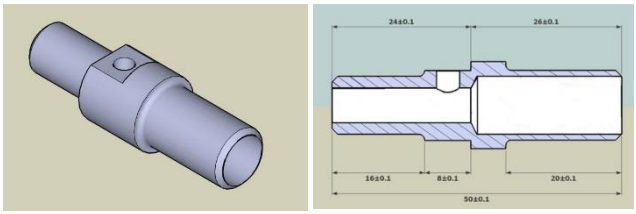
Not only does UGIMA® 4541 **reduce tool wear** (see the graph below for improvements in terms of potential turning productivity), it also provides **better chip breakability** (see graph below for the number of cutting conditions with fragmented chips in turning).





Bar turning

To compare UGIMA® 4541 with a standard 1.4541, tests were carried out on a TORNOS SIGMA 32 screw machine. For each grade, the test consisted in defining the optimum cutting conditions for making, for example, 1000 components without having to change tools.



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

The table below shows the cutting conditions that can produce 1000 components without having to change tools for each grade according to the operations and tools used. **Improved productivity that can exceed 10% was noted.**

Operations	Tools	UGI® 4541	UGIMA® 4541
Rough straight turning	SECO TM2000 CCMT 09T308-F2	V_c = **170** m/min *ap = 2 mm; f = 0.30 mm/rev*	V_c = **190** m/min *ap = 2 mm; f = 0.30 mm/rev*
Finish straight turning	SECO TM2000 CCMT 09T304-F1	V_c = **240** m/min *a_p = 0.5 mm; f = 0.10 mm/rev*	V_c = **250** m/min *ap = 0.5 mm; f = 0.10 mm/rev*
Axial drilling	GÜHRING RT100F ∅ 6 mm – DK460UF	V_c = **70** m/min *f = 0.10 mm/rev*	V_c = **80** m/min *f = 0.10 mm/rev*
	ISCAR IC908 ∅ 9.9 mm – ICM099	V_c = **120** m/min *f = 0.15 mm/rev*	V_c = **130** m/min *f = 0.15 mm/rev*
Cross-cutting	SANDVIK 2135 N132E2-0300-0002-CM	V_c = **60** m/min *f = 0.06/0.03 mm/rev*	V_c = **60** m/min *f = 0.06/0.03 mm/rev*

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Welding

UGIMA® 4541 can be welded by all types of arc processes (MIG, TIG with or without filler metal, coated electrodes, submerged arc welding, etc.), resistance (spot or seam), friction, electron beam or LASER welding.

Thanks to the correct analytical balance and despite a slightly higher percentage of S than UGI® 4541, there is no increased risk of thermal cracking for UGIMA® 4541 during arc and LASER welding.

In MIG welding, the Ar (+ possibly He) based shielding gas will have to contain 2 to 3% CO_2 or O_2 to make it easier to stabilise the welding arc; in TIG welding, the filler gas will be pure Ar (+ possibly He). H_2 and N_2 can be added to the shielding gas if required.

If filler metal is used, ER347 wire should be preferred, particularly in the case of welds used at high temperatures.

Heat treatment

Annealing

UGIMA® 4541 heat treatment involves maintaining a high temperature of between 1000°C and 1100°C, followed by air- or water-cooling. This treatment, which is called annealing, removes all trace of hardening, while giving the steel its lowest level of mechanical properties.

Surface treatment

The conditions generally used for austenitic grades apply to UGIMA® 4541.

Products available

Product	Shape	Finishing	Tolerance	Dimensions	
Rolled and descaled bars	Round		12 to 13	22 to 130	mm
Cold-finished drawn, turned, ground bars	Round		6 to 11	2 to 130	mm
Drawn bars	Hexagonal		11	3 to 60	mm

Others, please contact us

Applications

- Automotive: turbochargers, exhaust manifolds, sensor supports.
- Aeronautics: turboprop engines, jet engines.
- Process, chemical and oil industry: fittings and expansion joints, components for high-temperature equipment, furnaces, heat exchangers.