Technical Data Sheet
UGIMA® 4598

Chemical composition (%)

C	Si	Mn	Ni	Cr	Mo	Cu	P	S
≤ 0.030	≤ 1.0	≤ 2.0	11.0 - 13.0	16.5 - 18.5	2.0 - 2.5	1.3 - 1.8	≤ 0.040	0.10 - 0.18

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General presentation

UGIMA® 4598 uses the base stainless steel type 1.4404 / 316L with the addition of sulphur (>0.1%) and copper (1.5%) to significantly improve its machinability. In addition, UGIMA® 4598 benefits from the UGIMA® manufacturing process that ensures even better machinability. The addition of copper partly compensates for the reduced corrosion resistance which can be expected from the higher sulphur level.

Classification

Resulphurised austenitic stainless steel.

Designation

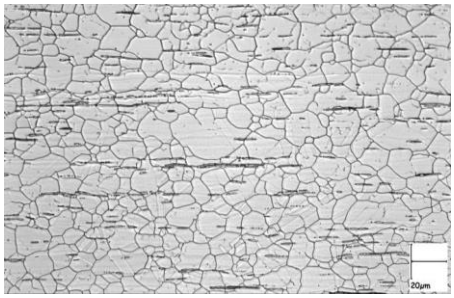
Material no.

Europe	USA	Japan
EN 10088-3	**ASTM**	**SUS**
1.4598	-	-

Microstructure

In the as-delivered condition, the microstructure of UGIMA® 4598 is austenitic with elongated sulphides in the hot-rolling direction and traces of residual ferrite (<1%).

Microstructure of UGIMA® 4598 (longitudinal bar micrography)



Mechanical properties

Tensile data

Condition	Diameter d (mm)	Temperature T (°C)	Tensile strength Rm (MPa)	Yield strength $Rp_{0.2}$ (MPa)	Ultimate elongation A (%)
Solution-annealed	d ≤ 130	20	500 - 700	≥ 200	≥ 40
		100		≥ 165	
		200		≥ 137	
		300		≥ 119	
		400		≥ 108	
		500		≥ 100	
Cold work-hardened	d ≤ 10	20	600 – 930	≥ 400	≥ 15
	10 < d ≤ 16	20	600 – 900	≥ 400	≥ 20
	d > 16	20	500 – 850	≥ 400	≥ 25

Impact data

Temperature	Absorbed energy
T	KV
(°C)	(J)
20	≥ 100

Swiss Steel Group

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

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Physical properties

Temperature	Density	Elasticity modulus	Thermal conductivity	Expansion coefficient (between 20°C and T°)	Electrical resistivity	Specific heat	Magnetism
(°C)	(kg/dm^3)	(GPa)	(W.m^{-1}.K^{-1})	(10^{-6}.K^{-1})	(µΩ.mm)	(J.kg^{-1}.K^{-1})	no *
20°C	8.0	200	15	-	0.70	500	
100°C		194		16.5			
200°C		186		17.3			
300°C		179		17.7			
400°C		172		18.1			
500°C		165		18.4			

*: UGIMA® 4598 may exhibit weak residual ferromagnetism due to the presence of ferrite (≤ 1%) and, on significantly cold work-hardened products, strain-induced martensite.

Corrosion resistance

General corrosion

General corrosion is defined as uniform corrosion of the entire surface; it is particularly found in mineral acid media such as sulphuric acid or phosphoric acid. The applications concerned are those of the chemical industry where the 316 family is sometimes used. This corrosion can be expressed as an annual thickness loss.

In our laboratory, experiments carried out in sulphuric acid at a concentration of 2 moles/litre and at 23°C indicated that the corrosion rate of UGIMA® 4598 is three times higher than that of UGIMA® 4404, the grade for which the usual thickness loss limit of 1 mm/year is reached in this environment after approximately three months. The use of UGIMA® 4598 for this type of application must therefore be subject to a thorough examination.

Localised corrosion

Localised corrosion is mainly initiated on the surface by chloride ions (found in drinking water, seawater, de-icing salts, chlorinated cleaning products, etc.).

– Pitting corrosion

Pitting corrosion resistance can be assessed by measuring the pitting potential in our laboratory (test standardised to ISO 15158).

- In drinking water containing 600 ppm of chloride ions, at neutral pH and at ambient temperature, the potential pitting of UGIMA® 4598 and UGIMA® 4404 grades is identical.
- In an extremely aggressive environment containing 30,000 ppm of chloride ions, at neutral pH and at 35°C, the pitting potential of UGIMA® 4598 is less than that of UGIMA® 4404, but similar to that of UGIMA® 4307.

The ISO 9227 neutral salt spray test was also applied to bars with drawn and turned surface finishes: after 1000 hours of testing, the surfaces of UGIMA® 4598 and UGIMA® 4404 bars are identical.

Agricultural and food industry applications can be envisaged for UGIMA® 4598; however, it is not recommended for use in applications in the vicinity of the sea.

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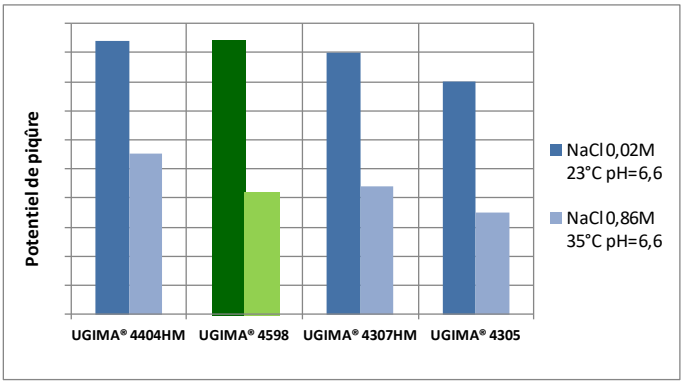
Relative positioning of UGIMA® 4598 with respect to pitting corrosion in two chloride environments



– Crevice corrosion

In acid environments, i.e. environments with a pH between 1 and 4 and which contain chloride ions, the use of UGIMA® 4598 must be limited: under such conditions, the pitting potential of UGIMA® 4598 is effectively less than that of UGIMA® 4404.

The passive film on UGIMA® 4598 is chemically dissolved for pH less than 3.5, whereas UGIMA® 4404 retains its passive film to a pH limit of 2.5.

Hot forming

Forging

UGIMA® 4598 can be forged at between 950°C and 1250°C, preferably between 1050°C and 1250°C where its forgeability is at maximum. As with all austenitic stainless steel grades, the force required to deform the metal is high (far higher than that required for carbon steels). Components can be cooled in air or water.

Cold forming

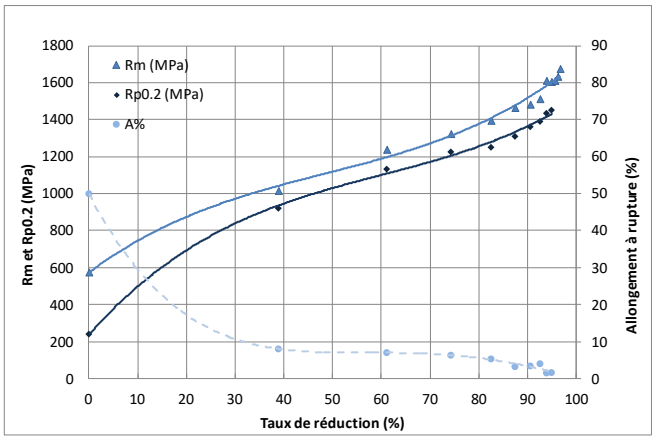
Cold drawing – Roll forming

UGIMA® 4598 is suitable for cold forming by conventional methods.

Cold deformation increases the mechanical properties (Rm and $Rp_{0.2}$) of the grade and reduces its ductility. A solution-annealing heat treatment at between 1020°C and 1120°C can be used to reduce the hardness of UGIMA® 4598 and restore its ductility.

UGIMA® 4598 is less work-hardened than type 1.4404 grades as it exhibits greater stability with respect to strain-induced martensite formation. Thus, for a total section reduction of 95%, UGIMA® 4598 contains less than 5% martensite.

Typical work-hardening curve for UGIMA® 4598 obtained by cold drawing



Machinability

Thanks to the addition of Cu and S and to the UGIMA® manufacturing process, UGIMA® 4598 exhibits machinability levels that are significantly better than those of UGIMA® 4404HM, as a result of a reduction in tool wear under identical cutting conditions and an improvement in chip breakability. Its machinability is even better than that of UGIMA® 4307HM, due mainly to its greatly superior chip breakability.

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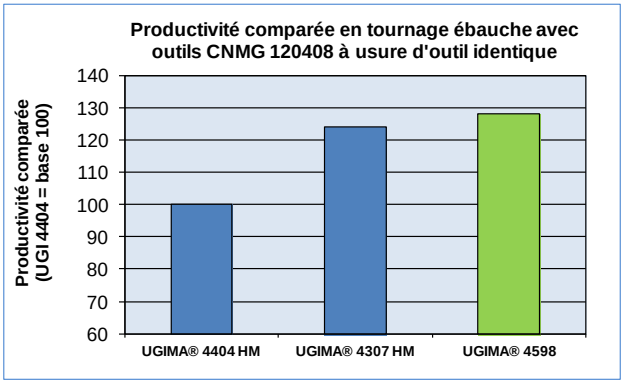
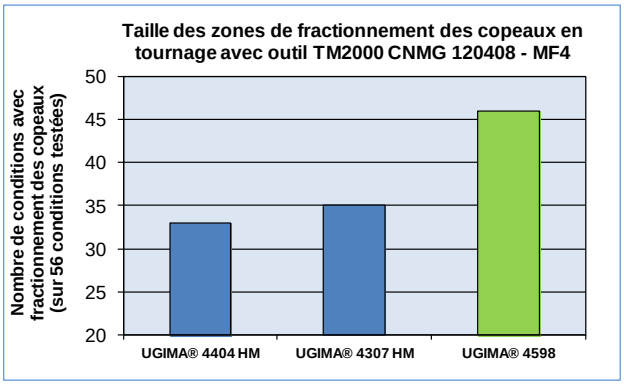
Machinability of bars at high temperature

– Turning

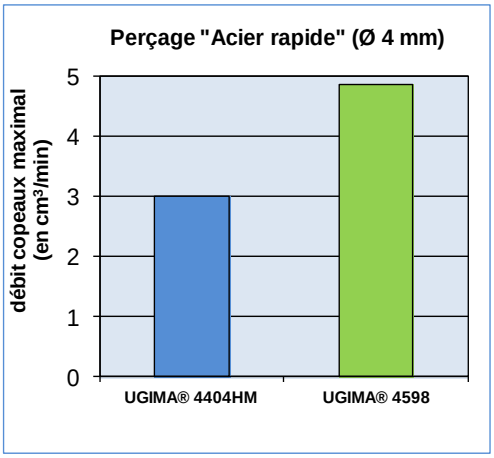
For turning, the tests performed at Ugitech's Research Centre were used to quantify these improvements (see the tables below). The improvement in terms of productivity for equivalent tool wear is almost 30% compared with UGIMA® 4404HM, which gives UGIMA® 4598 a slightly higher productivity rate than that of UGIMA® 4307HM. In terms of chip breakability, the improvement is even more significant, since the gap with UGIMA® 4404HM widens as it does with UGIMA® 4307HM (13 and 11 additional chip breaking conditions out of respectively 56 tested at different cutting feed rates and depths).

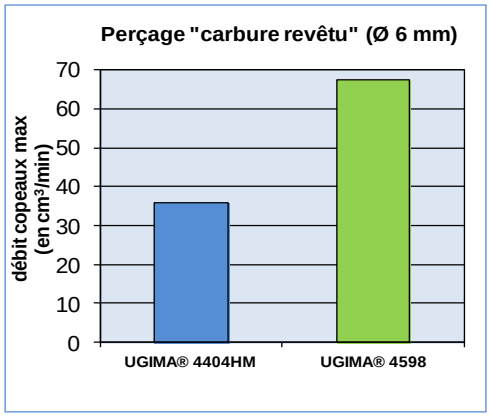




– Drilling

For drilling, the very significant improvement in chip breakability already noted for turning gives UGIMA® 4598 far better machinability than that of UGIMA® 4404HM, with an increase of 50% to 80% in the potential productivity rates expressed in maximum chip flow rates * (see the table below).





* maximum chip flow rates ensuring that a drill bit achieves a total of 18 m of 4D drilled holes [high-speed steel drill bit with external coolant] or a total of 12 m of 4D drilled holes [coated carbide drill bit with internal coolant] without reaming

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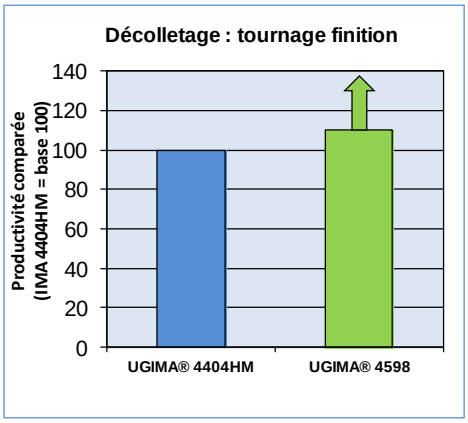
Machinability of bars at cold temperatures for screw machining

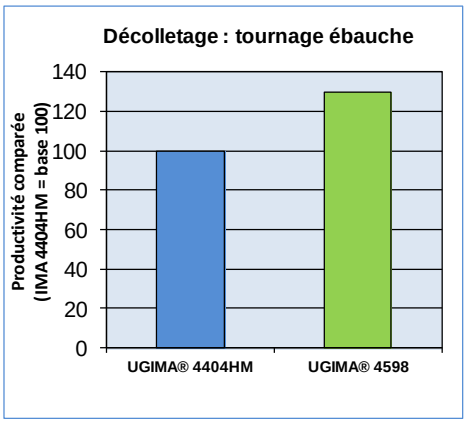
Screw machining tests on drawn bars performed at the Ugitech Research Centre on a TORNOS SIGMA 32 were used to quantify the improvements provided by UGIMA® 4598 as opposed to UGIMA® 4404HM.

– Turning

For a rough turning operation, the improvement in productivity for equivalent tool wear is 30%, compared with UGIMA® 4404HM (see the table below).

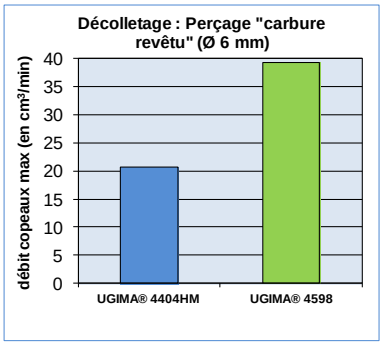
For finish turning, UGIMA® 4598 reached the screw machine limits in terms of bar rotational speed (8000 rpm), giving an increase in productivity of at least 10% compared with UGIMA® 4404HM (and probably distinctly higher if the screw machine limits had not been achieved).

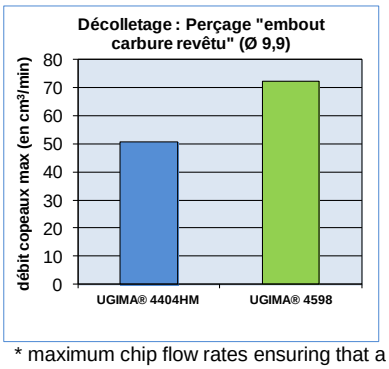




-Drilling

Drilling with a coated carbide drill bit (one-piece or with an end-piece) increases the maximum chip flow rates by between 45% and 90% compared with those of UGIMA® 4404HM.

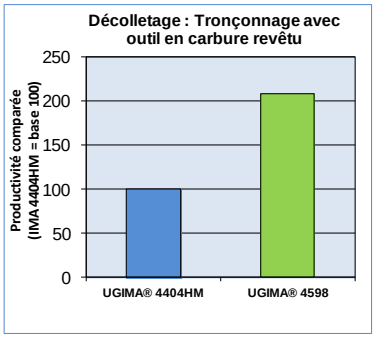




* maximum chip flow rates ensuring that a drill bit drills 1000 3D holes without reaming

– Cross-cutting

For cross-cutting, the increase in productivity noted is 100% greater than that of UGIMA® 4404HM.



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Welding

UGIMA® 4598 can be welded by most arc welding processes (MIG/TIG, with or without filler metal, coated electrodes, plasma, etc.), by laser, resistance (spot or seam), friction or electron beam welding, etc. However, its strong tendency to thermal cracking requires the arc welding linear energies to be reduced as much as possible and the use of laser welding to be limited.

If filler wire is used, it is best to choose a UGIWELD™ 316LM type of wire that will give the welds a corrosion resistance at least equal to that of UGIMA® 4598.

For MIG welding, Argon (Ar) with a maximum of 2% to 5% CO_2 or O_2 should be used as shielding gas to prevent excessive oxidation of the weld seams obtained. Part of the Ar can be replaced with He (< 20%) and a few % of H_2 can be added, if required, depending on the intended applications. The addition of N_2 should be avoided, as it tends to increase the risk of thermal cracking in the weld metal zone.

For TIG welding, pure Argon should be used as a shielding gas to prevent premature oxidation of the tungsten electrode. In the same way as for MIG welding, part of the Ar can be replaced with He (< 20%) and a few % of H_2 can be added, if required, depending on the intended applications. The addition of N_2 should be avoided, as it tends to increase the risk of thermal cracking in the weld metal zone.

Heat treatment

Solution heat treatment (Solution annealing)

UGIMA® 4598 is solution-annealed prior to delivery.

To restore the mechanical properties after hot or cold working, the same heat treatment can be performed. It involves maintaining a temperature of between 1020°C and 1120°C for a long period of time, followed by rapid cooling in air or water. This heat treatment, which is known as solution annealing, removes all trace of hardening; it gives the material its lowest mechanical properties (Rm and $Rp_{0.2}$) and a high ductility, as well as optimum corrosion resistance.

Available products

Product	Shape	Finish	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
Drawn wire	Round				

Other products: please contact us

Applications

- Electronics
- Instruments and probes
- Precision engineering
- Screw machining