Technical Data Sheet
UGI® 4410

Chemical analysis (%)

C	Si	Mn	Ni	Cr	Mo	P	S	N
≤ 0.030	≤ 1.0	≤ 2.0	6.5 - 7.5	25.0 - 26.0	3.3 - 4.0	≤ 0.035	≤ 0.002	0.24 - 0.30

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General presentation

UGI® 4410 is a superduplex stainless steel designed for applications in highly corrosive environments. It has the following advantages:

- very high mechanical properties;
- excellent resistance to different types of corrosion in aggressive environments.

Classification

Austeno-ferritic stainless steel / superduplex family

Designation

Europe EN		USA UNS	Japan JIS	ISO 15510	
1.4410	X2CrNiMoN 25-7-4	S32750		4410-327-50-E	X2CrNiMoN25-7-4

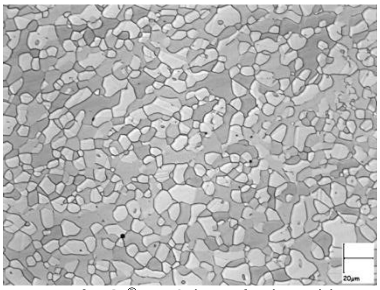
Reference standards

- Europe: EN 10088-3, EN 10272
- USA: ASTM A-479, ASTM A-276

Microstructure

In its delivery condition (solution-annealed), the structure of UGI® 4410 is two-phase: ferrite + austenite. It contains between 45% and 55% ferrite and is free from intermetallic phases (σ, χ) and chromium carbonitrides.

UGI® 4410 is highly susceptible to the precipitation of intermetallic phases that degrade mechanical properties (reduced toughness) and corrosion resistance. The sigma phase (σ) precipitates at between 600°C and 1000°C, after a holding time of a few minutes. The α precipitation phase at between 350°C and 550°C also poses a risk of embrittlement. Consequently, the temperature at which the grade is used must be limited to 300°C.



Microstructure of UGI® 4410 (grey ferrite, white austenite)

Mechanical properties

Tensile data

Temperature	Tensile strength	Yield strength	Ultimate elongation
T	**Rm**	**Rp0.2**	**A**
(°C)	**(MPa)**	**(MPa)**	**(%)**
20	750 - 930	≥ 550	≥ 25
100		≥ 450	
200		≥ 400	

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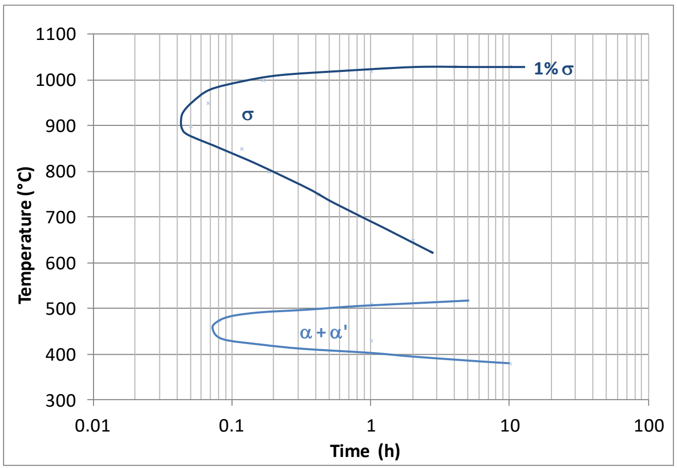

Temperature-Time-Transformation curve for UGI® 4410

Toughness data

On solution-annealed turned bars (Charpy impact test):

Temperature	Absorbed energy
T	**KV**
(°C)	**(J)**
20	≥ 200
- 46	≥ 100
- 60	≥ 50

Physical properties

Temperature	Density	Elasticity modulus	Thermal conductivity	Expansion coefficient (between 20°C and T°)	Electrical resistivity	Specific heat	Magnetism
(°C)	**(kg/dm³)**	**(GPa)**	**(W.m⁻¹.K⁻¹)**	**(10⁻⁶.K⁻¹)**	**(µΩ.mm)**	**(J.kg⁻¹.K⁻¹)**	
20	7.8	200	15	-	0.80	500	Yes
100		194	16	13.0	0.85	530	
200		186	17	13.5	0.90	560	
300		180	18	14.0	1.00	590	

Corrosion resistance

General corrosion

The corrosion resistance properties of UGI® 4410 are very good in this type of corrosion that may be encountered in the mineral acid and organic acid chemical production industry; they include, for example, better resistance of UGI® 4410 compared with that of superaustenitic UGI® 4539/904L in formic acid, hydrochloric acid and sulphuric acid, for concentrations less than 25% by weight.

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Localised corrosion

The localised corrosion resistance initiated by chloride ions is excellent for UGI® 4410.

- Pitting corrosion

  The pitting corrosion resistance can be estimated by using the pitting index formula PREN=%Cr+3.3%Mo+16%N. For UGI® 4410, it gives a PREN of 41 min., which is significantly higher than the PREN of 33 min. for UGI® 4462.

  Tests with 10% by weight ferric chloride (ASTM G48 type test) were used to determine the limit temperature at which pitting corrosion occurs (C.P.T.): we guarantee resistance at 55°C for UGI® 4410, which is far higher than the 35°C measured for UGI® 4462.

- Crevice corrosion

  The critical temperature at which crevices occur can be estimated in a 6% by weight ferric chloride environment (ASTM G48 type test); it is, on average, 35°C for UGI® 4410, as opposed to 25°C on average for UGI® 4462 and 20°C on average for UGI® 4539.

Stress corrosion

The stress corrosion resistance of UGI® 4410 is very good in environments containing chloride ions and/or hydrogen sulphide.

Hot forming

Forging

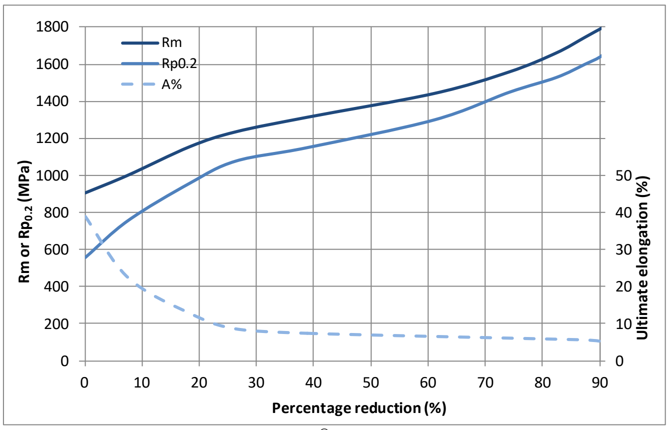
UGI® 4410 can be formed at high temperature (forging, rolling) between 1000°C and 1250°C, preferably between 1100°C and 1250°C, to minimize forces and increase ductility. There is a risk of sigma phase formation if the temperature of the product falls below 1025°C during forming. Solution annealing is therefore strongly recommended for components formed at high temperature, in accordance with the recommendations indicated in the heat treatment section.

Cold forming

Cold drawing – Roll forming

UGI® 4410 is suitable for cold forming by conventional methods. The forces on the tools are high, due to the high mechanical and work-hardening properties of the grade. The austenite is stable and cold deformation therefore does not induce martensitic transformation.

Solution-annealing heat treatment at between 1050 and 1120°C can be used to restore the ductility of UGI® 4410.



Typical work-hardening curve for UGI® 4410 obtained by cold drawing

Machinability

Due to its very high mechanical properties and the high hardenability of its austenite, UGI® 4410 quickly wears out cutting tools. This will consequently limit cutting speeds to levels slightly below those used for 1.4507 stainless steel.

In addition, as for most austeno-ferritic stainless steels, it will be preferable to use harder cutting tools than those used for austenitic stainless steels such as 1.4404 (see, for example, the rough turning possibilities of the STELLRAM SP0819 tool as opposed to those of SECO TM2000).

In addition, as with the most austeno-ferritic stainless steels, during machining, UGI® 4410 generates chips that are difficult to break. Whenever possible, preference should therefore be given to relatively high cutting feed rates that will make it easier to break the chips.

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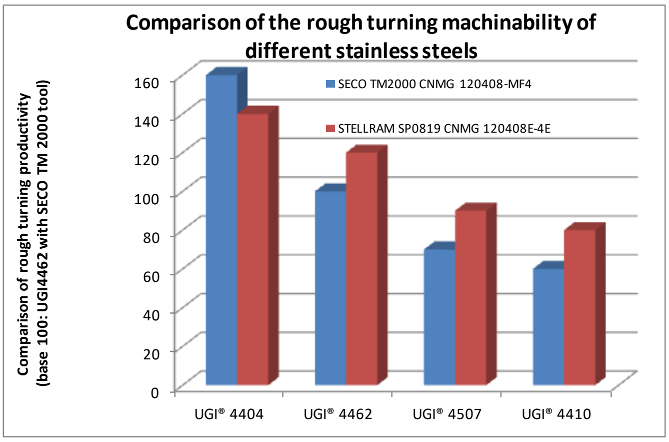
Turning

The following table gives, by comparison with other grades, the cutting speeds that can be accessed by UGI® 4410 during rough turning (base 100: 1.4462 with the SECO TM2000 tool).



Drilling

As with most austeno-ferritic stainless steels, UGI® 4410 is difficult to drill, due to very high cutting forces on the tools, causing them to wear out fast, and poor breakability of the chips created, resulting in random drill breakage.

It is therefore strongly recommended that the drills be lubricated internally using high oil pressures to improve chip breakability and removal. Drilling cycles with reaming can also be used to make UGI® 4410 easier to drill.

Welding

UGI® 4410 can be welded by friction, resistance, arc, with or without filler wire (MIG, TIG, coated electrode, plasma, submerged arc, etc.), LASER beam, electron beam, etc.

However, unlike austenitic stainless steels, UGI® 4410 must be welded in accordance with a welding heat input field to ensure good welded area resilience. If the welding heat input is too high, there is a risk, due to too-slow cooling after welding, of the formation of an embrittling sigma phase in the heat-affected zone (HAZ). If the linear welding energy is too low, there is a risk, due to too-rapid cooling after welding, of the HAZ being too ferritic and, therefore, brittle.

The welding heat input field to be complied with depends mainly on the geometry of the components to be welded, and in particular, their thickness. The thicker the components, the faster the weld cools, shifting the field of linear welding heat input towards high energies. The welding heat input field to be complied with also depends on the welding process used (MIG, TIG, etc.).

In the event of multipass welding, it is important to let the weld cool to below 150°C between each pass. Preheating the components before each welding operation is not advisable and no heat treatment should be carried out after welding, except, if necessary, solution annealing as described in the "Heat treatment" section.

MIG welding

The most suitable filler wire for MIG welding UGI® 4410 is UGIWELD™ 25.9.4 (ISO14343 - A: 25 9 4L). Its more austenitic balance than that of UGI® 4410 limits the percentage of ferrite in the weld metal (WM) and thus the risk of embrittlement in the WM.

A shielding gas of low oxidizing potential (Ar + 1 to 3% O_2 or CO_2) is preferred, to limit the percentage of oxygen in the weld zone and consequently ensure good resilience in the WM. Under no circumstances should hydrogen be added to the shielding gas, to avoid the risks of cold cracking in the weld area. If necessary, a few per cent of N_2 may be added to the shielding gas to compensate for any loss of nitrogen in the weld zone during the welding operation.

TIG welding

A neutral shielding gas MUST be used (Ar, possibly partly substituted by He) to protect the tungsten electrode. As with MIG welding, the shielding gas MUST NOT contain hydrogen.

Due to the absence of oxygen in the protection gas, this process makes it easier to ensure good resilience in the weld zone.

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Heat treatment

Annealing solution

UGI® 4410 bars and wires are supplied solution annealed.

To reduce the hardness and restore the ductility of UGI® 4410 after hot or cold forming, heat treatment can be carried out at between 1050°C and 1120°C, preferably 1100°C, followed by rapid cooling (water) to avoid precipitating embrittling phases (intermetallic or chromium nitride) during cooling.

Available products

Products	Shape	Surface finish	Tolerance	Dimension	
Bars	Round	Rolled descaled	13	71 to 120	mm
		Turned	10 - 11 - 12	71 to 120	mm
Semi-finished products	Square	Ground		80 to 120	mm

Other sizes: contact us

Applications

UGI® 4410 is designed for applications requiring very good corrosion resistance in aggressive environments in the presence of chlorides, as well as high mechanical properties, such as for example:

- The chemical and petrochemical industries
- The sea water desalination industry
- The paper pulp industry