

Technical Data Sheet

UGIMA®-X 4460

Chemical composition (%)

C	Si	Mn	Ni	Cr	Mo	P	S	N
≤ 0.03	≤ 0.75	≤ 1,0	4,5 – 5,0	25,0 – 27,0	1,3 – 1,8	≤ 0,035	0.02 – 0.03	0.05 – 0.20

14-10-2024 – REV 00

General presentation

UGIMA®-X 4460 is an austenitic-ferritic stainless steel, otherwise known as duplex, identical in all respects to the characteristics of 1.4460, with the exception of machinability, which has been significantly improved by the application of the UGIMA-X process :

- Compared with commercially available 1.4460 grades, productivity gains of 20-30% have been achieved, and the chip fragmentation of UGIMA®-X 4460 is significantly better.
- UGIMA®-X 4460's machinability is better than that of austenitic grade 1.4404 / AISI 316L, including UGIMA®-X 4404, thanks in particular its good chip fragmentation.

Classification

Austenitic-ferritic (duplex) stainless steel with sulfur content

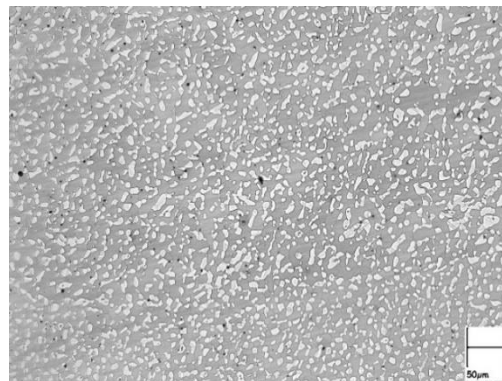
Designation

Europe - EN	USA – AISI – UNS	Japan – JIS
EN 10088-1	AISI	UNS
1.4460	X3CrNiMoN 27-5-2	329
		S32900
		-

Microstructure

UGIMA®-X 4460 has a two-phase structure consisting of a ferritic matrix with austenite islands. In the photo opposite, taken in the transverse direction, the austenite islands are light grey and the ferritic matrix is dark grey.

UGIMA® oxides are the fine black particles distributed throughout the matrix,



Cross-wise micrograph

Mechanical properties

Tensile data

	Yield stress	Tensile strength	Elongation	Reduction of Area	Impact test
	Rp0,2% (MPa)	Rm (MPa)	A (%)	Z (%)	KV (J) at 20°C min.
Solution annealed	530	655	31	77	150
Work-hardened by drawing (10% reduction of section)	810	920	20	64	120



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Temperature (°C)	Density (kg/dm ³)	Elastic modulus (GPa)	Thermal conductivity (W/m.K)	Expansion coefficient from 20 to T° (10 ⁻⁶ /K)	Electrical resistivity (μΩ.mm)
20	7,8	200	15		800
100		194		13,0	
200		186		13,5	
300		180		14,0	

(Indicative values)

The use of UGIMA[®]-X 4460, like all other austenitic-ferritic grades, is not recommended above 300°C due to the formation of brittle phases that deteriorate impact strength and affect corrosion resistance properties (alpha', chi and sigma phases at higher temperatures).

At low temperatures, the impact strength of UGIMA[®]-X 4460 remains good down to -20°C (KV > 120J), and the brittle ductile transition only begins at -40°C.

As UGIMA[®]-X 4460 is an austeno-ferritic grade, it contains around 65% of ferritic phase, which gives it the following magnetic properties:

Relative permeability: $\mu_r = 125$

Remanent field : $B_r = 0.11 \text{ T}$

Saturation field: $J_{\text{sat}} = 0.825 \text{ T}$

Coercive field: $H_c = 450 \text{ A/m}$

Corrosion resistance

UGIMA[®] 4460 is highly resistant to corrosion in chlorinated environments like sea water or in accelerated tests such as salt spray tests according to ISO 9227 (2022) as well as in a wide range environment generating pitting corrosion. The table below gives an indicative scale of behavior in different environments:

Environment	Behaviour
Nitric acid	Good
Phosphoric acid	Good
Sulfuric acid	Moderate
Acetic acid	Good
Soda	Good
NaCl (salt spray)	Excellent
Humidity	Excellent
Sea water	Good
Oil & Gas	Good



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UGIMA®-X 4460's resistance to pitting corrosion in chloride media (NaCl) is significantly better than the grade 1.4404 / AISI 316L. This has been verified by pitting potential measurements according to ISO 15158 (2014) or simply and only for information purposes through the PREN (Pitting Resistance Equivalent Number = Cr % + 3.3 x Mo % + 16 x N %).

	UGIMA®-X 4404	UGIMA®-X 4460
Pitting potential (mV/ECS – (NaCl 0,86 M, pH 6,6 at 35°C) (transverse direction)	305	500
PREN (Calculation of Pitting Resistance Equivalent Number)	24	30

Hot working

The forgeability of UGIMA®-X 4460 is inferior to that of common austenitic steels type 1.4307/1.4404. Practical rules for hot working are :

- **Preheating**: not necessary, except perhaps for large parts for the sole purpose of homogenization ($T^{\circ} > 900^{\circ}\text{C}$).
- **Forging**: can be carried out between 1200 and 900°C, but the best results are obtained between 1200 and 1100°C. At these temperatures, the metal becomes more ferritic and more malleable.
- **Cooling** : rapid cooling with water or oil is recommended to avoid the formation of brittle phases, notably the sigma phase between 900 and 600°C.

Cold forming

The mechanical properties of UGIMA®-X 4460 in the annealed condition are far superior to those of UGIMA®-X 4404, particularly in terms of yield strength, a key factor in part design.

Annealed condition	Tensile strength	Yield stress	Elongation	Reduction of Area	Impact test
	(MPa)	(MPa)	(%)	(%)	KV (J) at 20°C min.
UGIMA-X 4404	550	260	45	75	180
UGIMA-X 4460	650	530	31	75	150

As UGIMA®-X 4460 is a nitrogen-doped grade, its mechanical properties increase significantly during cold forming by drawing or wire drawing. It is a highly work-hardenable grade whose tensile strength after cold working can exceed 900 MPa and yield strength be over 800 MPa.



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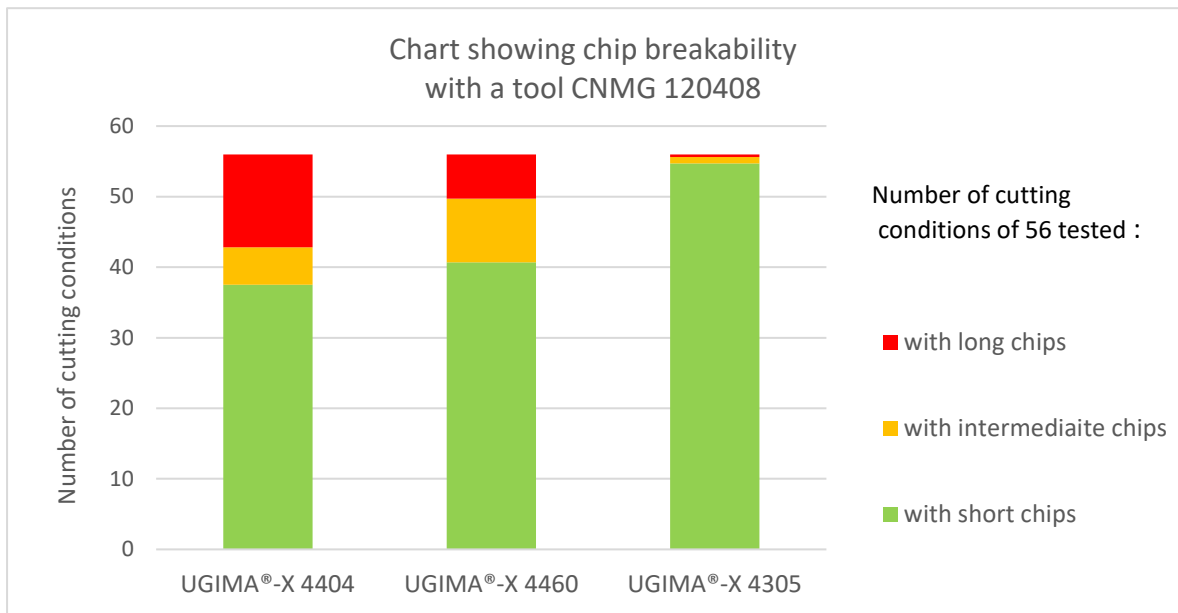
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Machinability

Duplex steels are often considered difficult to machine due to their high mechanical characteristics, the high work hardening of the austenite they contain and their very low sulfur content. But, this is not the case for UGIMA®-X 4460 which benefits from a sulfur level between 0.02 and 0.03% and especially from the UGIMA®-X process which allows machining performances similar or even better than those of austenitic grades 1.4404 / 316L. Thus, the turning productivity of a UGIMA®-X 4460 is at the level of that of a UGIMA®-X 4404.

Furthermore, the chip fragmentation of UGIMA®-X 4460 has been significantly improved. It is better than that of a UGIMA®-X 4404 and tends to be closer to that of a UGIMA®-X 4305 as shown in the graph below.



Heat Treatment

The annealed condition of grade 1.4460 is obtained after heating to around 1030/1100°C, followed by rapid cooling with oil or water. This heat treatment enables to :

- achieve equilibrium between the phases present (ferrite + austenite),
- ensure the absence of undesirable embrittling phases, such as the sigma phase, which would deteriorate impact strength and corrosion resistance properties.

Surface treatment

UGIMA-X 4460 is stripped using fluorine-nitric mixtures whose proportions may vary within the following limits:

- Nitric acid HNO₃ - 20 to 25% by volume - (density of acid before dilution: 1.43)
- Hydrofluoric acid HF - 1 to 4% by volume - (density of acid before dilution: 1.18)



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These baths are best used at temperatures of around 60°C; above this, there are notable risks of hydrofluoric acid evaporation and increased environmental hazards.

At low temperatures, pickling times are considerably increased, to the detriment of industrial line productivity.

Welding

UGIMA®-X 4460 has a higher ferrite content in the Weld Metal (WM) when the filler metal has the same composition as the base metal. This should be taken into account when determining optimum filler metal compositions to avoid too important ferrite content in WM that would let them become brittle. In addition, heat-affected zones are also likely to have more ferrite than the base metal. To limit this difference, high linear welding energies are preferred to induce slower cooling. However, this should be limited to energies that do not induce Sigma phase formation. There is a range of linear welding energies which minimizes the 2 risks mentioned above. The thicker the parts to be welded, the higher the linear energy (to avoid too rapid cooling that could induce a too high ferrite content).

Preheating of workpieces prior to welding is not recommended.

No heat treatment should be carried out after welding, with the exception, if necessary, of a quenching treatment described in the "Heat treatments" paragraph.

In the case of MIG welding, we recommend Nickel-based filler metals such as Ni 6660 to ensure ductility and corrosion resistance in the molten zone.

Available products

Product	Shape	Surface finish	Tolerance	Dimensions
Bar	Round	Hot rolled and descaled	11 to 13	20 to 120 mm
	Round	Turned and polished	9 to 11	20 to 120 mm
	Round	Draw and polished bars	9	5 to 55 mm
	Round	Ground bars	7 to 9	20 to 80 mm
Wire rod	Round	Picked		5,5 to 32 mm

Other sizes: contact us

Applications

- Mechanical industry - cylinder rods
- Chemical industry
- Oil and petrochemical industry



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