UGI® 4462

Chemical analysis	C	Si	Mn	Ni	Cr	Mo	N	P	S
	≤0.03	≤ 0.75	1 – 2	5 – 6	22 – 23	2,5 – 3,5	0,12 – 0,20	≤ 0.035	‹ 0,010

27-09-2010 – Rev 00

General description

Duplex stainless steel with high corrosion resistance and high mechanical performances
UGI 4462 has excellent corrosion resistance in aggressive environments, coupled with high mechanical properties.

Classification

Duplex stainless steel

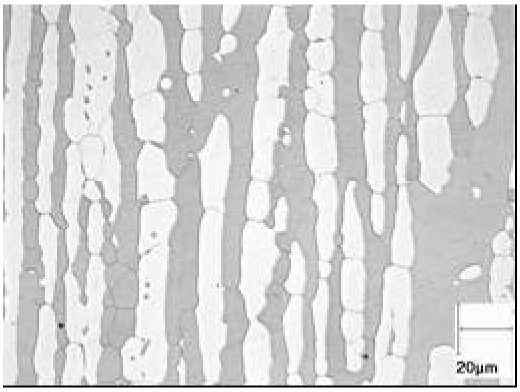
Designation

Material n°						
Europe EN		USA	Japan	ISO 15510	
Number	symbol	UNS	JIS	Number	symbol
1.4462	X2CrNiMoN22-5-3	S31803 / S32205	SUS329J3L	4462-318-03-I	X2CrNiMoN22-5-3

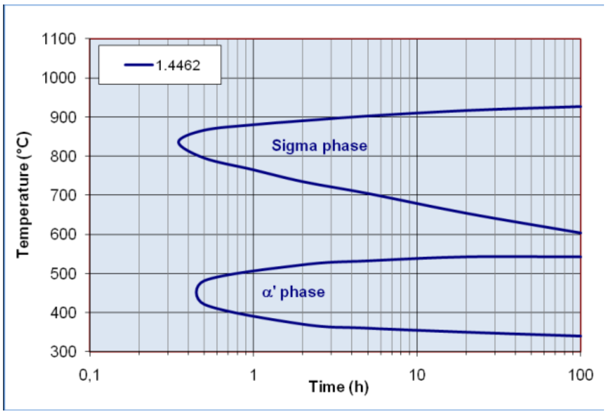
Other designations of material				
USA	France	Germany	UK	Sweden
ASTM – A182	AFNOR	DIN	BS	SS
F51 – F60	Z2CND22.05.03	1.4462	318S13	2377

Microstructure

The chemical composition of UGI 4462 is optimised to obtain, after a solution annealing heat treatment, a two-phase ferrite + austenite structure containing between 40% and 60% ferrite.
The UGI 4462 grade is sensitive to precipitation of inter-metallic phases which degrade the mechanical properties and corrosion resistance. The sigma phase (σ) precipitates between 600°C and 1000°C, after a holding time of a few dozen minutes.
The precipitation phase α' between 350°C and 550°C also presents a risk ofembrittlement.
Consequently the temperature at which the grade is used must be limited to 300°C.



Microstructure of UGI 4462
after rolling + solution annealing
(grey: ferrite; white: austenite)



TTP diagram
(Temperature – Time – Phases)

SCHMOLZ + BICKENBACH GROUP

UGITECH
Providing special steel solutions

UGI® 4462

Chemical analysis	C	Si	Mn	Ni	Cr	Mo	N	P	S
	≤0.03	≤ 0.75	1 – 2	5 – 6	22 – 23	2,5 – 3,5	0,12 – 0,20	≤ 0.035	‹ 0,010

27-09-2010 – Rev 00

Mechanical properties

Tensile data

- Cold drawn bars

Temperature	Tensile strength	Elastic limit	Elongation
T	Rm	Rp 0.2%	A
(°C)	(MPa)	(MPa)	(%)
20	850 / 1050	700 / 900	20 / 30

- Solution annealed turned bars

Temperature	Tensile strength	Elastic limit	Elongation
T	Rm	Rp 0.2%	A
(°C)	(MPa)	(MPa)	(%)
20	680 / 830	480 / 580	35 / 45
280	550 / 650	300 / 450	30 / 40

Impact strength data

- Solution annealed turned bars

Temperature	Energy absorbed
T	KV
(°C)	(J)
20	200
- 46	100
- 60	80

Physical properties

Temperature	Density	Modulus of elasticity	Thermal conductivity	Coefficient of thermal expansion (between 20°C and T°)	Electrical resistivity	Specific heat
(°C)	(g/cm³)	(GPa)	(W/m.°C)	(10^{-6}/°C)	(µΩ.mm)	(J/Kg.°C)
20	7,8	200	15	-	800	500
100	-	194	16	13.0	850	530
200	-	186	17	13.5	900	560
300	-	180	18	14.0	1000	590

For information only

Corrosion resistance

UGI 4462 can be used in applications where corrosion resistance properties are essential:

- the building industry for exposures in maritime or urban atmospheres,
- the pulp industry,
- the desalination industry,
- and the chemistry industry in general.

This is illustrated by the diagrams of corrosion in a sulphuric acid H_2SO_4 medium (general corrosion) and in a sodium chloride NaCl medium (pitting).

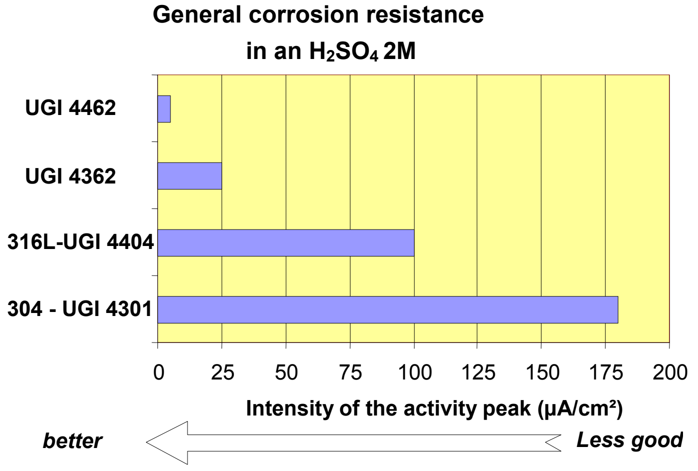
General corrosion

This mode of corrosion is found mainly in the chemical manufacture of sulphuric or phosphoric acid. An accelerated test to simulate this type of corrosion is carried out by measuring the density of dissolution or activity current on a polarization curve in a sulphuric acid environment of 2 moles/litre (200 g/l) at 23°C. The graph below shows the dissolution current values in µA/cm^2 for grades UGI 4462, UGI 4362, UGI 4404 and UGI 4301 on wire rods (after mechanical polishing of the surface with SiC 1200 paper); the lower the values, the better the resistance to this type of corrosion).

UGI® 4462

Chemical analysis	C	Si	Mn	Ni	Cr	Mo	N	P	S
	≤0.03	≤ 0.75	1 – 2	5 – 6	22 – 23	2,5 – 3,5	0,12 – 0,20	≤ 0.035	‹ 0,010

27-09-2010 – Rev 00



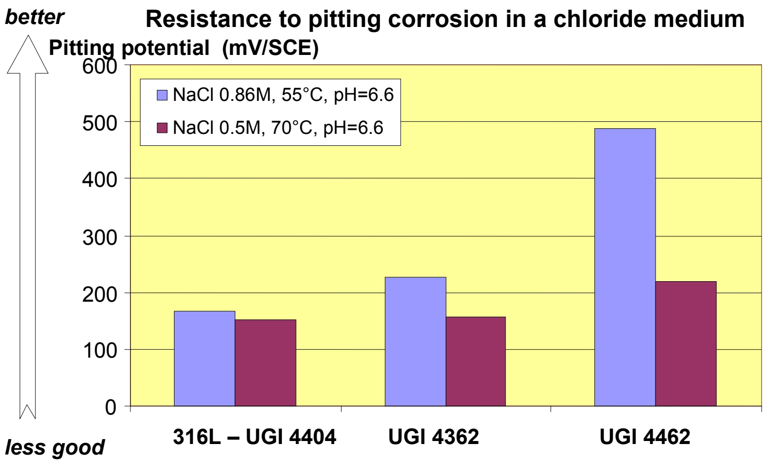
It should be noted that UGI 4462 has the better performance.

Pitting corrosion

This mode of corrosion is the most prevalent. Due mainly to the harmful effects of the chloride ions on the sulphide inclusions, it translates visually into small spots of corrosion.

Our experiment consisted of determining on a polarization curve the potential from which corrosion pits are formed; the higher the potential, the better the corrosion resistance.

The graph below shows the values of pitting potential in mV/SCE (Saturated Calomel Electrode) for wire rods, which have undergone mechanical polishing of their surface with SiC1200 paper, and immersed in 0.86 mol/litre of NaCl (30.4 g/l of chlorides) at 55°C (and also in 0.5 M of NaCl at 70°C).



Note that UGI 4462 yields the best result in this test.

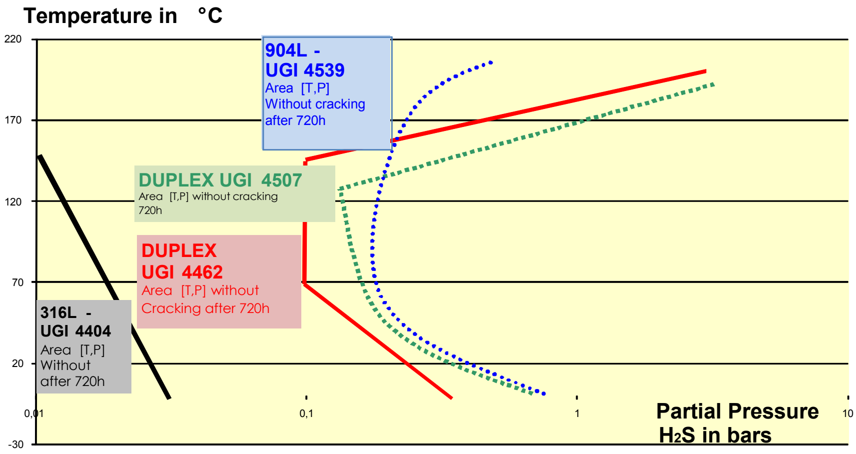
Stress corrosion

Stress corrosion tests in a medium of the "NACE standard" type with application of stresses lower than the limit of elasticity for durations of 720 hours show that the UGI 4462 grade has an area of non-cracking (on the left of the curves) fairly comparable to those of the superaustenitic UGI 4539 and super duplex UGI 4507.

UGI® 4462

Chemical analysis	C	Si	Mn	Ni	Cr	Mo	N	P	S
	≤0.03	≤ 0.75	1 – 2	5 – 6	22 – 23	2,5 – 3,5	0,12 – 0,20	≤ 0.035	‹ 0,010

27-09-2010 – Rev 00



Hot working

Forging

UGI 4462 has satisfactory hot workability between 1220 and 950°C, although lower than that of ordinary austenitic steels (1.4301, 1.4404). Hot ductility is related to the ferrite content of the grade, which increases with temperature; it will therefore be better for high forging temperatures.

At forging temperatures, the mechanical strength of UGI 4462 is lower than that of an austenitic, which gives rise to lower loads on tools, and sometimes it is necessary to take precautions to limit the creep deformation of the parts.

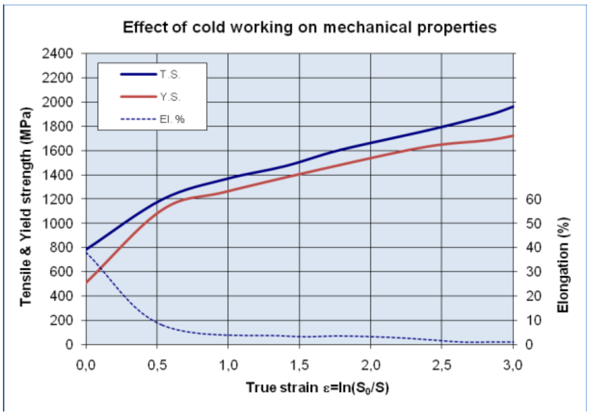
Hot processing must be followed by a solution annealing heat treatment with rapid cooling, in order to restore the ferrite-austenite equilibrium, the mechanical properties and corrosion resistance of the grade.

Cold working

Drawing - forming

Owing to the high limit of elasticity of UGI 4462, its cold working will require strengths greater than those needed to form an austenitic grade of the 1.4404 (316L) type.

Hardening curve of UGI 4462:



Cold heading:
UGI 4462 is not a grade optimised for cold heading. Its high mechanical properties will induce significant forming forces and rapid wear of the forming dies.
However, the surface aspect of the parts formed in UGI 4462 is much better than that observed on austenitic grades (no orange peel phenomenon). Thus UGI 4462 can be used in ordinary cold heading or bending when orange peel phenomena are observed with austenitic grades.
In the cold impact test, the UGI 4462 allows for a 40% expansion deformation before cracking.

Heat treatment

Solution annealing:
The solution annealing heat treatment using must be performed at a temperature between 1020°C and 1100°C followed by rapid cooling in air or water. This treatment restores the ductility of the grade UGI 4462 after hot or cold working.

Welding

General points

UGI 4462 can be welded by friction, resistance, arc, with or without a filler wire (MIG, TIG, coated electrode, plasma, in a stream, ...) by laser beam, electron beam, etc.
However, unlike austenitic stainless steels, UGI 4462 must be welded in accordance with a field of linear welding energy to ensure good toughness of the welded areas. If the linear welding energy is too high, there is a risk - due to too-slow cooling after welding - of an embrittling sigma phase forming in a Heat Affected Zone (HAZ). If the linear welding energy is too low, there is a risk - due to too-rapid cooling after welding - of having too ferritic and, therefore, fragile HAZs.
The field of linear welding energy to be respected depends mainly on the geometry of the pieces to be welded, and in particular on their thickness. The thicker the work pieces are, the faster the cooling of the weld, which shifts the field of linear welding energy towards the high energies. The linear energy field to be respected also depends on the welding process used (MIG, TIG, …).
In the case of multipass welding, it is important to allow the weld to cool to below 150°C between each pass.
Preheating of parts before welding is not desirable and no heat treatment should be performed after welding, except, if necessary, for a solution annealing described in the paragraph on "Heat Treatment" .

MIG welding
The filler wire that is best suited for MIG welding of UGI 4462 is ER2209 - 22.9.3NL - UGIWELD ™ 45N. Its more austenitic balance than that of UGI 4462 limits the proportion of ferrite in the weld zone (WZ) and thereby the risk of fragility in WZ.
We prefer a slightly oxidizing shielding gas (Ar + 1-3% O_2 or CO_2) to limit the oxygen level in WZ and thereby to ensure good toughnessin WZ. Under no circumstances should one add hydrogen to the shielding gas to avoid the risk of cold cracking in WZ. If necessary, one may add a few % of N_2 to the shielding gas to offset any loss of nitrogen in WZ during the welding operation.

TIG welding
It is imperative that the shielding gas to be used be absolutely neutral (Ar, partially substituted or not by He) to protect the tungsten electrode. As in MIG welding, hydrogen is prohibited in the shielding gas.
Due to the absence of oxygen in the gas supply, this process ensures more easily good toughness in WZ.

UGI® 4462

Chemical analysis	C	Si	Mn	Ni	Cr	Mo	N	P	S
	≤0.03	≤ 0.75	1 – 2	5 – 6	22 – 23	2,5 – 3,5	0,12 – 0,20	≤ 0.035	‹ 0,010

27-09-2010 – Rev 00

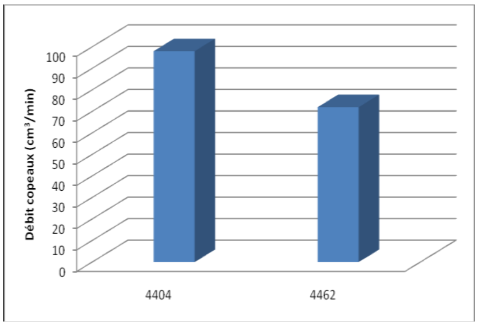
Machinability

Because of its low sulphur content (to preserve its very good corrosion resistance) and strong mechanical properties, UGI 4462 is a difficult-to-machine grade. The absence of sulphides in large quantities prevents good chip breaking in machining operations. The high mechanical properties generate, in turning, high cutting forces which lead to rapid tool wear.

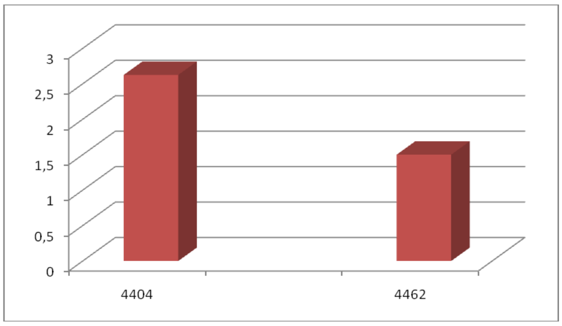
That is why the choice of cutting tools (carbide grade and chip breaker) is essential to machine UGI 4462 correctly.

Moreover, the choice of cutting conditions is more difficult than with grades having lower mechanical properties. It will be necessary to lower cutting speeds compared to austenitic grades, while avoiding taking them too low because one has to be able to maintain temperatures high enough at the tool tip to limit the cutting forces. As for cutting feed rates, they must be maintained at a level that allows the chips to be broken successfully.

The graphs below give an idea of the decreases in cutting conditions that may be carried out on UGI 4462 compared to those of a 1.4404 for turning with a coated carbide tool and for drilling with a high-speed steel tool.



Turning with a coated carbide tool



Drilling with high speed steel (HSS)

Our technical support department will be pleased to answer any questions on the subject.

Products available

Product	Form	Finish	Tolerance	Dimensions (mm)
Bars	Round	Drawn	9	5 - 28
	Round	Turned	10 – 11 – 12	22 – 120
	Round	Rolled	13	22 - 120
	Round	Ground	8 - 9	22 - 115
Wire rod	Round	Pickled		5,5 - 32

For others, please consult us.

Applications

- Parts for the nautical industry
- Chemical and pulp manufacturing industry
- Oil & Gas industries
- Construction

Ugitech SA
Avenue Paul Girod
CS90100
73403 Ugine Cedex – France
www.ugitech.com