Technical Data Sheet
UGI® 446

Chemical composition (%)

C	Si	Mn	Cr	Ni	Mo	N	P	S
≤ 0,06	≤ 0,7	≤ 1,0	23.0 – 24,0	≤ 0,50	≤ 0,50	≤ 0,10	≤ 0,030	≤ 0,030

02-06-2016 – REV 00

General presentation

UGI® 446 is a ferritic stainless steel with more than 23% of chromium content. Thus its corrosion resistance is among the best within the ferritic stainless grades. As UGI® 446 stands well thermal oxidation with a good behavior against scaling off phenomena, it is commonly used for applications where temperature range is in between 800 and 1150°C.

Thermal expansion coefficient of UGI® 446 being close to special glasses ones so it is often used in metal-glass sealed junctions.

UGI® 446 is a ferritic stainless steel grade which stands well liquid metal contact like copper or brass. Thus it is well adapted to electrical applications where there are close contacts between stainless steel, copper and brass.

Long exposure to temperature in between 350 and 800°C leads to an evolution of the metallurgical structure of the material which may become brittle (sigma phase or ferrite de-mixing).

Classification

Heat resistant ferritic stainless steel (not stabilized)

Designation

Material Nº

Europe		USA		Japan
DIN	France	AISI	UNS	SUS
1.4763	X8Cr24	446	S44600	

Compliant with norms ASTM A 276 Condition A and ASTM A 276 Condition S.

Mechanical properties

Tensile data in annealed condition

Temperature	Tensile strength	Yield strength	Elongation
T	Rp0,2%	Rm	A
(°C)	(MPa)	(MPa)	(%)
20°C	≥ 280	≥ 480	20

UGI® 446 exhibits a transition temperature (ductile – brittle) close to ambient temperature. On that ground, it is advisable not to use it in great thicknesses, for example larger than 80 mm for plain bar.

Physical properties

Temperature	Density	Elastic modulus	Thermal conductivity	Specific heat	Electrical resistivity
(°C)	(g/cm^3)	(GPa)	($W.m^{-1}.K^{-1}$)	($J.kg^{-1}.K^{-1}$)	(µΩ.cm)
20	7,5	220	17	500	110

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Microstructure

UGI® 446 has a structure 100% ferritic when annealed. This metallurgical condition ensures that the material will not be subjected to intergranular corrosion. A too long holding time at temperature into the 350-750°C range may lead to an embrittleness of the material due to the growth of brittle phases in the structure (α+ ά ferrite de-mixing around 475°C and Sigma phase at higher temperature). It has to be avoided.

Corrosion resistance

Localized corrosion

– Pitting corrosion

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

In lightly salted aqueous solution containing NaCl 0,02 M, the table below gives the pitting potential for majors ferritic stainless steel grades. Measured samples were polished in the rolling direction of the rod or the wire. Surfaces of the samples were naturally aged for 24 h after mechanical polishing and before pitting corrosion tests.

Ferritic grades	Pitting potential in mV/ECS
AISI 430 - 1.4016	350 mV
AISI 434 - 1.4113	400 mV
AISI 446 - 1.4763	**420 mV**
1.4511 / 1.4509	470 mV
AISI 445 - 1.4621	550 mV

Pitting corrosion potential of UGI® 446 is greater than the one of standard ferritic UGI® 430 but not as high than the ones of ferritic Titanium or Niobium stabilized grades as 4511, 4509 or 4621 due to a light intergranular corrosion sensitivity

Thermal oxidation

UGI® 446 stands well thermal oxidation; it is commonly used for applications where temperature is into the range 800 and 1150°C. Especially it stands well against scaling off effect during cycling tests.

Hot transformation

Forging

UGI® 446 can be easily forged at between 800°C and 1130°C where its forgeabilty is at maximum. Components can be quickly cooled. This can be done either in air or in water.

Cold transformation

Cold heading

Due to a good ductility, UGI® 446 is well adapted to cold heading. It is sensitive to scratch lines coming either from hot rolling or from cold drawing. This can lead to surface cracks after severe cold deformations.

Bending – Forming

UGI® 446, being ductile, is well adapted to bending and forming. Its transition temperature (ductile / brittle) being close to ambient temperature, slow deformation speed is recommended. Depending on the thermo-mechanical transformation before bending, stretched surfaces may show lumpy surface (so called ‘orange skin’) linked to coarse grains underneath the wire surface.

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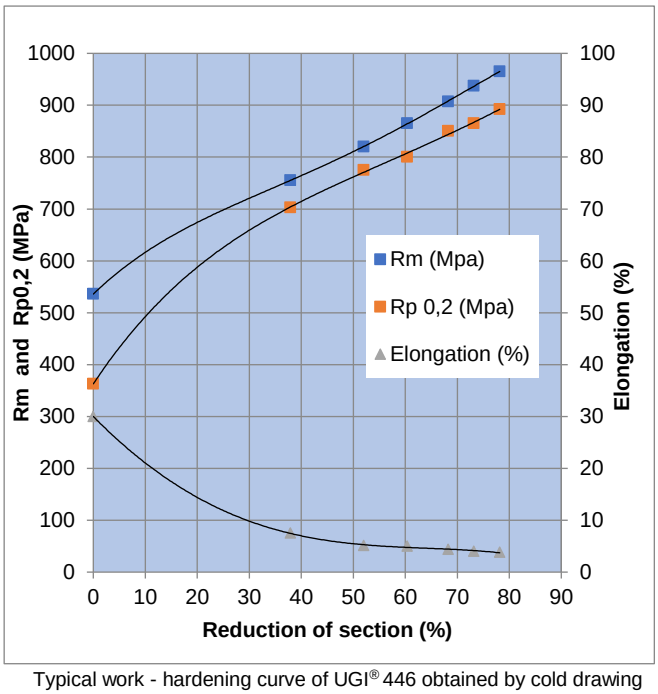
Drawing – Profiling

UGI® 446 is suitable for cold forming by conventional methods. As others ferritic grades, cold deformation increases slightly the mechanical properties (Rm and $Rp_{0.2}$) of the grade and reduces its ductility. Cold drawing can be processed in reduction of section up to 80%.



Typical work - hardening curve of UGI® 446 obtained by cold drawing

Machinability

Turning

As other ferritic grades, the machinability of UGI® 446 requires some cares. During turning, accumulation and sticking material may occur at the tip of the cutting tool. This could lead to early tool wear, rough surface of the turned parts, even up to deviation on part size. To contain these inconveniences, the use of coated cutting tools is recommended (TiN or TiAlN for example).

In order to ease chips removal, a high pressurized flow of lubricant is advisable. Lubricant with extreme pressure additives is recommended.

Metallurgical condition (Rm)	Cutting depth / feed rate		
	6 mm / 0.5 mm/r	3 mm / 0.4 mm/r	1 mm / 0.2 mm/r
Annealed (450 – 550 MPa)	160 m/min	190 m/min	260 m/min

Drilling

Even more critical than for turning operations, lubrication during drilling of UGI® 446 is critical. Lubricant flow should be regular and generous (pressure and flow rate). On large drilling diameters, the use of drills with through hole of oil (internal lubrication) is preferred. 130 – 140° included angle for carbide drills or 118° for HSS drills are recommended.

Welding

As all the ferritics grades non stabilized with titanium nor niobium, UGI® 446 is difficult to weld. Welding parameters should be finely adjusted to avoid brittle melted zone due to coarse grains, and to limit intergranular corrosion both in melted zone or affected thermal zone.

In order to maintain impact properties close to the original material, welding technique where rapid cooling of the melted zone and where low welding energies are possible are preferred (laser welding rather than TIG welding).

To avoid intergranular corrosion of welded zones, welds should be done with a stabilized welding wire like EXHAUST® F1 – 18LNb or l'EXHAUST® F1 EVO – 18LNbSi. If the thickness of

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the weld is above 2 mm, a double stabilized (Ti and Nb) like l'EXHAUST® Bi-Stab – 18LNbTi EVO is preferred.

Heat treatment

UGI® 446 has a structure 100% ferritic when annealed. Thus there is no need to do further heat treatment if the material has been only cold worked. However, after a long exposure to temperature in between 350 and 800°C which may lead to material brittleness (sigma phase or ferrite de-mixing), it is possible to restore annealed structure with a thermal treatment in between 800 and 1130°C.

A full annealing without producing coarse grains which could be detrimental for applications like bending should be done with a thermal treatment in between 840 and 900°C (2 hours minimum) followed by rapid cooling in water or pulsed air.

Available products

Product	Form	Finish	Tolerance	Dimension	
Wire rod	Round	Pickled		5,0 to 32	mm
Drawn wire	Round			0,8 to 18,0	mm
Profil				2 to 70	mm²
Bar	Round	Rolled and descaled	12 to 13	22 to 71	mm
	Round	Turned and polished	9 to 11	22 to 71	mm
	Round	Drawn	8 to 9	2,0 to 55	mm

Others contact us.

Applications

- Sealing glass metal
- Electrical conductors for lighting
- Parts assembly in contact with copper or brass
- Parts for glass moulds