URANUS® 45N

A 22Cr 3Mo Duplex stainless steel with PREN ≥ 33 or 34

URANUS® 45N (UR 45N) is a nitrogen alloyed (≥ 0.15%) austenitic-ferritic stainless steel (22.05 type) with improved structure stability and high general, localised and stress corrosion resistance properties.

UR 45N with 22% Cr and 3% Mo additions, performs much better than 316L grade in almost all corrosive media,.

The yield strength is about twice that of austenitic stainless steels. This allows the designer to save weight and makes the alloy more cost competitive when compared to 316 L grade.

Typical operation temperatures are -50°C/+ 280°C (*-58°F/+536°F*). Lower temperatures uses could to be considered require additional precautions, in particular for welded structures.

UR 45N is a multi-purposes material which can be used in various corrosive media. Typical applications are Pulp and Paper industry, Oil and Gas industry, Pollution control equipments, Chemical industry and Chemical tankers.

STANDARD

EURONORM..... 1.4462 - X2 Cr Ni Mo 22.5.3
AFNOR ..... Z3 CND 22.05 AZ
DIN..... X2 Cr Ni Mo 22-05
W. Nr 1.4462 ; VdTÜV Blatt 418
ASTM..... A240 - UNS S31803

CHEMICAL ANALYSIS

Typical values (Weight %)

C	Cr	Ni	Mo	N	Others
.020	22	5.3	3	.16	S ≤ .002
PREN = [Cr %] + 3.3 [Mo %] + 16 [N %] ≥ 33 or 34					

Mo content is optimised in the 2.7 - 3.1% range

MECHANICAL PROPERTIES

Tensile properties - Minimum values

°C	Rp 0.2 MPa	Rp 1.0 MPa	Rm MPa	°F	YS 0.2% KSI	YS 1.0% KSI	UTS KSI	A/El %
20	460	490	680	*68*	67	71	98	25
50	430	470	660	*122*	62	68	96	25
100	360	400	630	*212*	52	57	92	25
150	340	380	605	*302*	49	54	88	20
200	320	360	590	*392*	46	52	86	20
250	305	345	590	*482*	44	50	86	20
300	290	330	590	*572*	42	48	86	20

For solution annealed condition and plate thickness ≤ 50 mm (2").

UR 45N grade should not be used over 280°C (530°F) for long periods.

PHYSICAL PROPERTIES

Impact strength (KV minimum values)

Temp.	-50°C	-20°C	+20°C	-60°F	0°F	+70°F
Single	75 J	90 J	120 J	54 ft.lbs	65 ft.lbs	87 ft.lbs
Average(5)	90 J	120 J	150 J	65 ft.lbs	87 ft.lbs	109 ft.lbs

Hardness values - Typical values

Average (5)	HV_{10} 210-260	HB : 210-240	HRC : 15-20

Density : 7,800 kg/m^3

Interval Temper °C	Thermal expansion ax$10^{-6}K^{-1}$	°C	Resistivity (µΩ cm)	Thermal conductivity ($W.m^{-1}.K^{-1}$)	Specific heat ($J.kg\text{-}1.K^{-1}$)	Young modulus E (GPa)	Shear modulus G (GPa)
		20	80	17	450	200	75
20-100	13.5	100	86	18	450	190	73
20-200	14	200	92	19	500	180	70
20-300	14.5	300	100	20	550	170	67

Density : 0.282 Lb/in^3

Interval Temper °F	Thermal expansion ax10^{-6} °F	°F	Resistivity (µΩ.in)	Thermal conductivity (Btu/hr ft °F)	Specific heat (Btu/lb°F10^6)	Young modulus E (psi 10^6)	Shear modulus G (psi 10^6)
		68	31.5	11	0.11	29	10.9
70-210	7	212	33.8	11.5	0.12	28	10.5
70-400	7.5	392	36.2	12	0.12	27	10.1
70-600	8	572	39.3	12.5	0.13	26	9.7

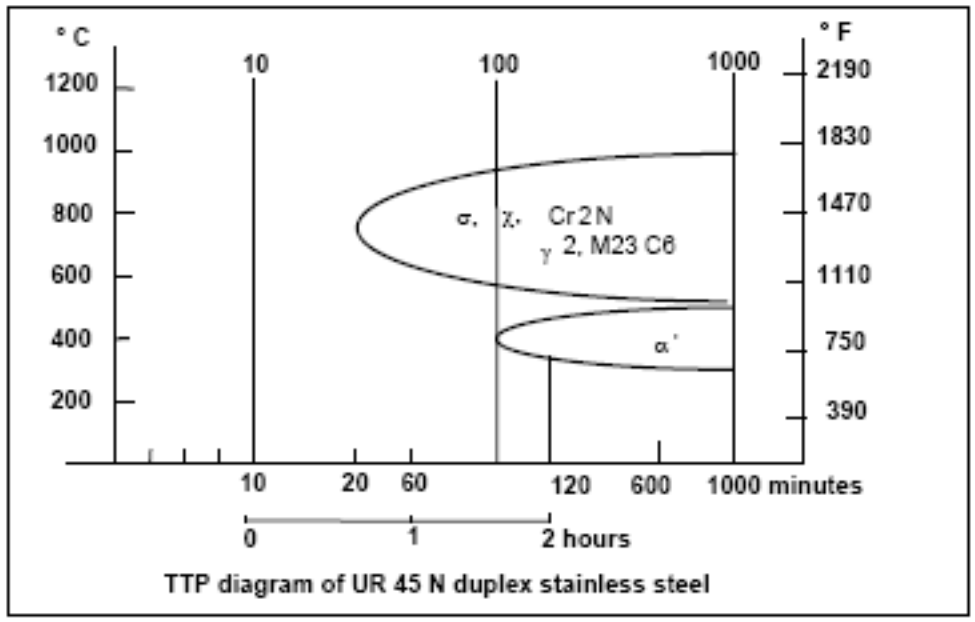
STRUCTURE

URANUS® 45N is a duplex stainless steel ; its chemical composition is optimized in order to present, after a solution annealing treatment at 1040-1080°C (1900-1975°F) followed by water quenching, a nearly 50% α /50% γ microstructure.

Heat treatments performed at 1100°C (*2010°F*) and higher may result in an increase of the ferrite content.

Typical TTP-diagram (temperature time precipitation) shows the two-phase transformation areas. At high temperature : 1000°-600° C (*1830-1110°F*), the α phase may transform in σ, χ,... intermetallic phases which makes the alloy brittle. At lower temperature (500-300°C - *930-570°F*) the α phase transforms in α' resulting in a hardening of the structure after several hours holding time.

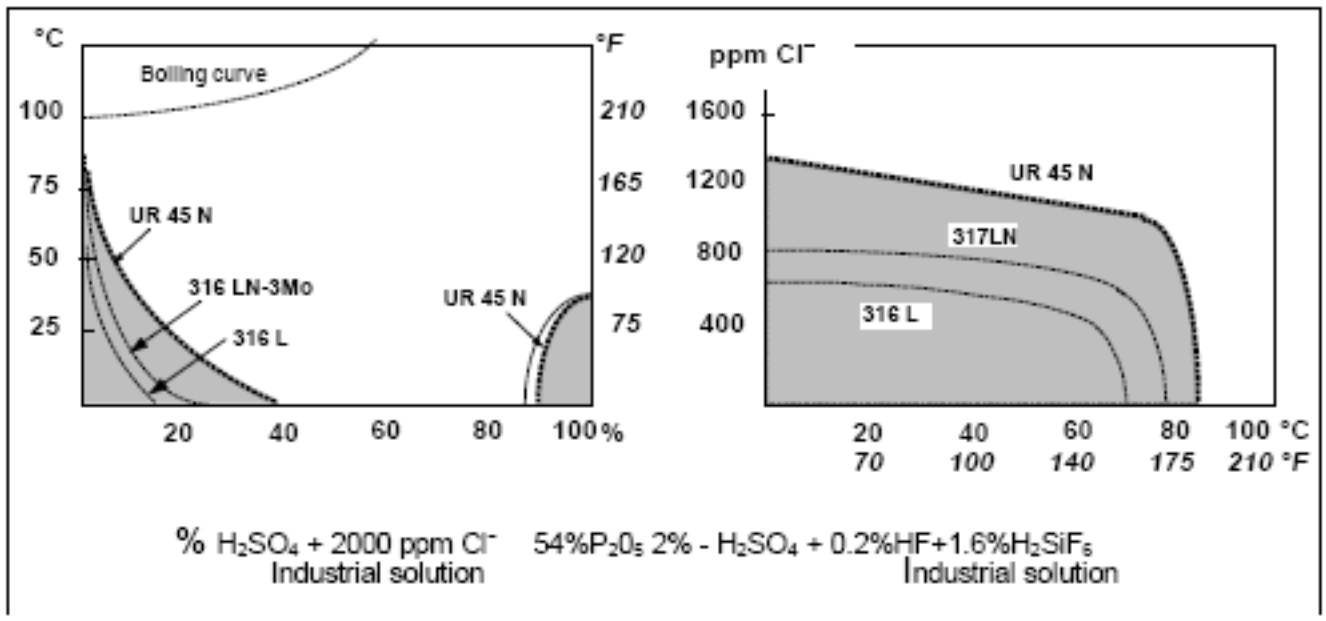
CORROSION RESISTANCE



TTP diagram of UR 45 N duplex stainless steel

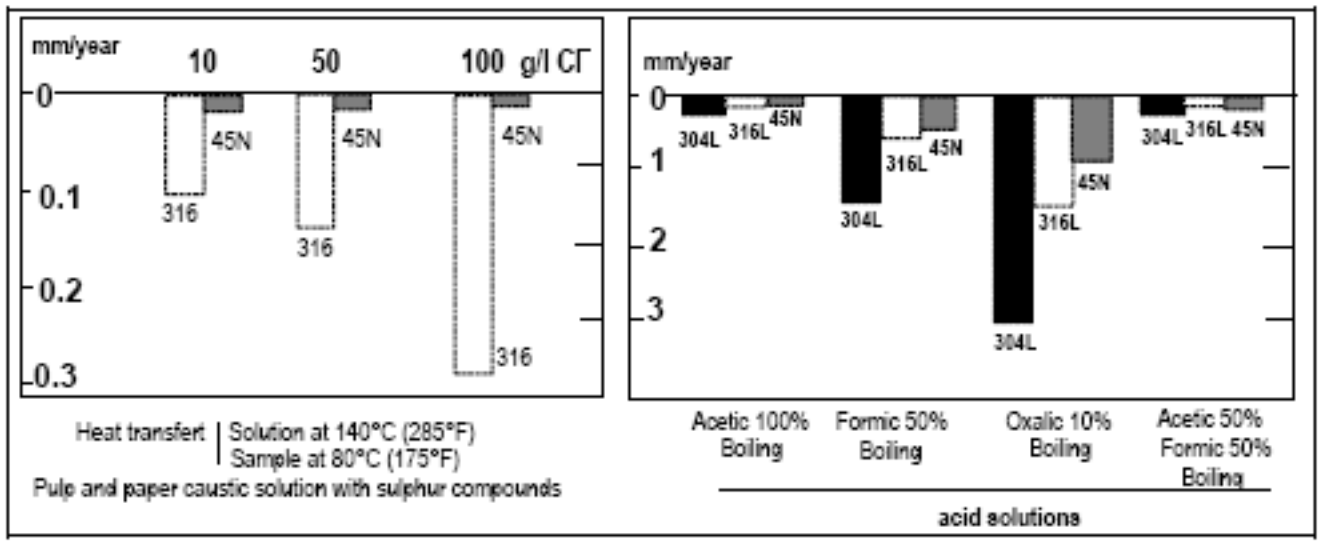
General corrosion resistance

a) Sulfuric and phosphoric acids



General corrosion resistance properties of UR 45N alloy are generally much better than austenitic 316L and 317LN alloys. UR 45N alloy is now used extensively in newly designed chemical tankers

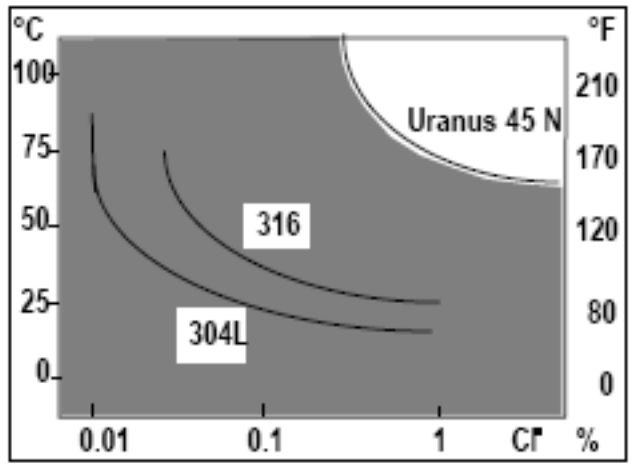
b) Caustic media (pulp and paper) and organic acids



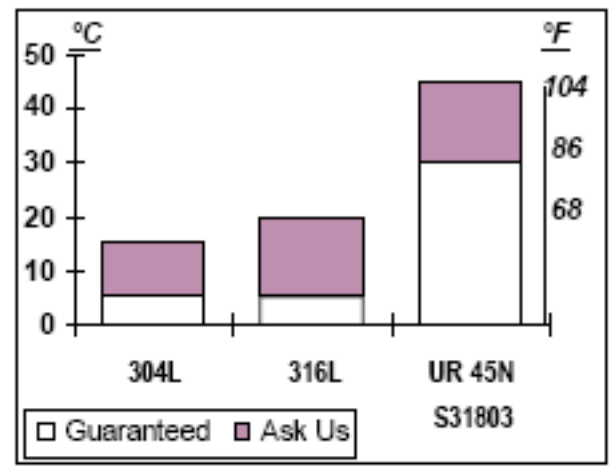
General corrosion resistance in organic solutions or caustic solutions is improved by the use of UR 45N instead of 304 or 316 L grades. UR 45N is now extensively used in chemical industries (organic and inorganic) and in the pulp and paper industry.

Localised corrosion resistance

a) Pitting corrosion



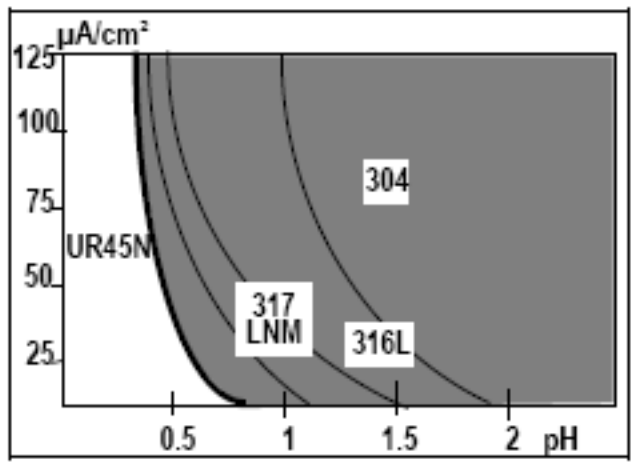
Sensivity to pitting corrosion
Effects of temperature and chloride content



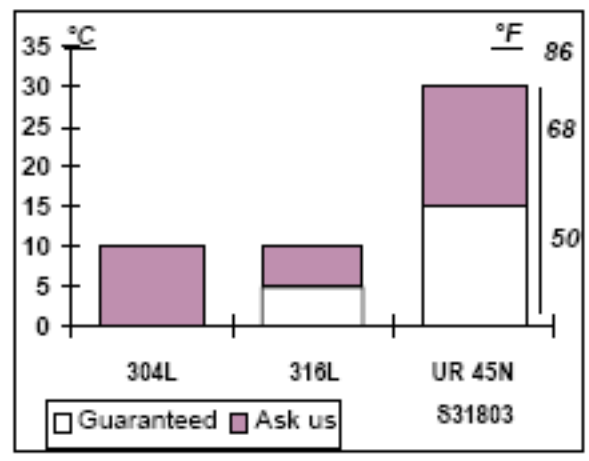
ASTM G48A Test results
10% F Cl_3 $6H_20$

The high chromium (22%) and molybdenum (3%) combined with 0.16% nitrogen additions explain why UR 45N duplex grade behaves particularly well when considering pitting corrosion resistance. UR 45N outperforms than 304 and 316L grades, even in very oxydizing and acidic solutions.

b) Crevice corrosion resistance



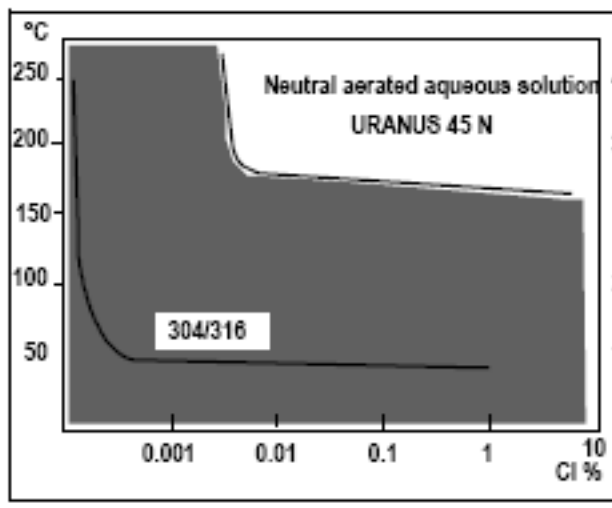
Depassivation conditions of several
stainless steels
Solution : 30 g/l NaCl 20°C

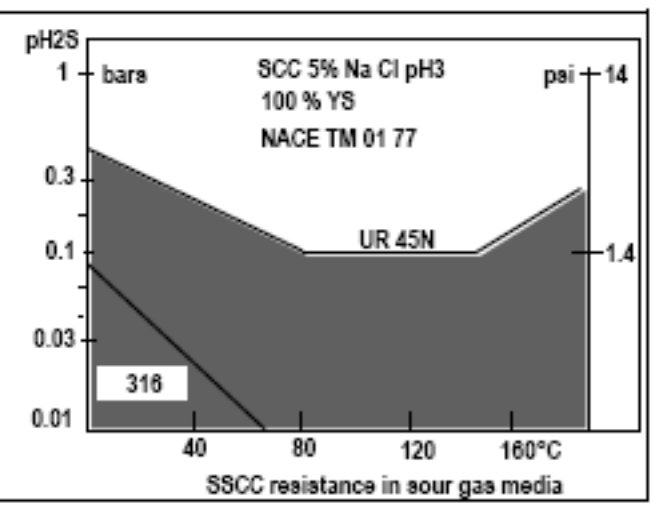


ASTM G78 - Crevice
10% $FeCl_3$ $6H_2O$ solution

The improved crevice corrosion resistance of UR 45N explains its use in chloride/fluoride processes containing deposits. Typical applications are Pulp and Paper industry, Pollution Control equipments, On/Offshore applications.

Stress corrosion cracking resistance

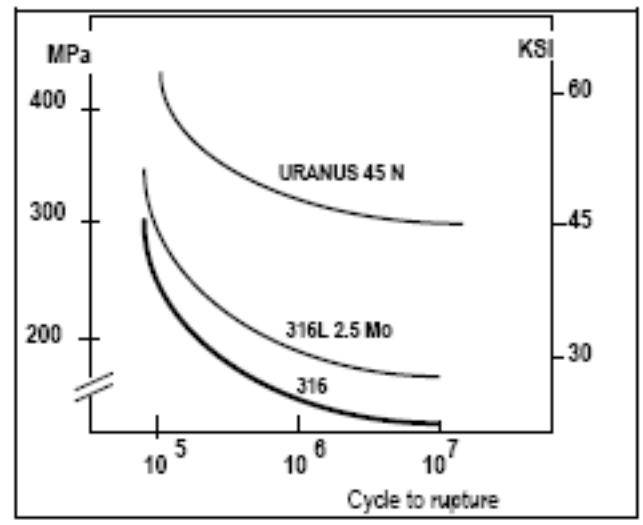




The duplex microstructure is known to improve the stress corrosion cracking resistance of stainless steels. This is the case in neutral aerated aqueous solutions containing chlorides and in sour gas conditions in the oil and gas industry. UR 45N alloy has been extensively used for welded pipes.

Corrosion fatigue resistance

Duplex stainless steels combine high mechanical and corrosion resistance properties. The fatigue corro-sion data presented are very attractive results since after 10^7 cycles, fatigue limit remains at least twice that of 316 austenitic stainless steels.



Synthetic sea water solution
(smooth samples)

PROCESSING

Hot forming

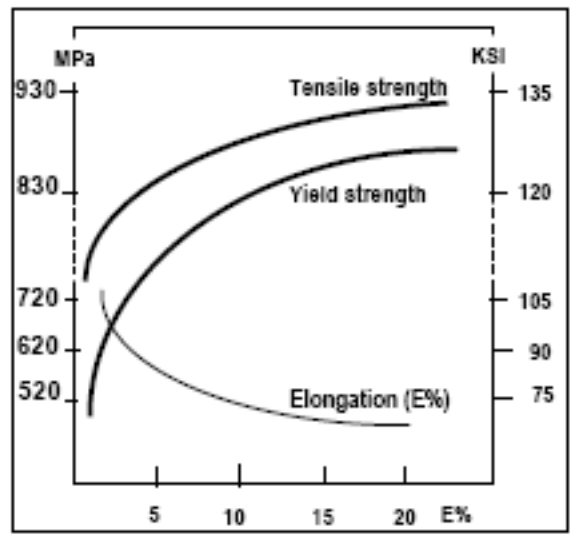
Hot forming should be carried out in a temperature range of 1150-950°C (*2100-1750°F*) after the piece has been uniformly heated. At temperatures lower than 950°C (*1750°F*), the alloy is very prone to intermetallic phase precipitatioans such as sigma phase. This affects the toughness and corrosion resistance properties of UR 45N.

A final full annealing heat treatment (1040-1080°C / *1900-1975°F*) followed by rapid quench, is required (to restore phase balance, mechanical and corrosion resistance properties).

Special precautions must be taken during heat treatment to avoid deformations.

Cold forming

UR 45N can be cold formed without any problem using equipments suited to work stainless steel. The duplex UR 45N alloy requires more power than austenitic stainless steels due to its higher mechanical properties and work hardening (which is lower than for austenitic steels). Cold working ratios exceeding 20% require an intermediate full annealing heat treatment (1040/1080°C - *1900/1975°F*). Such heat treatment is also recommended after cold forming of more than 10 % in order to restore its properties.



Cold forming

Pickling

Pickling solutions or pastes acceptable for alloy 316 L may be used. The pickling time required is at least twice that of 316L. A slight increase of the temperature of the pickling bath reduces the pickling time. Typical pickling conditions are (10 % HNO_3 - 2% HF) 60°C (*140°F*). Passivation decontamination treatments may be performed with a 10-25% nitric acid solution.

Machining

Machining is another example of a fabrication process where the techniques employed (eg. tools and lubricants) for UR 45N are very similar to those used for conventional stainless steels).

Machining characteristics of UR 45N are better than those of 316L grade.

Oper.	Tool	Lubri-cation	CONDITIONS					
			Depth of cut (mm) (*inch*)	Feed (mm)(*inch*)	SPEED (m/min) *SPEED (feet/min)*			
					18/8	18/12 Mo	Ur B6	Ur 45N
Turning	High speed steel	Cutting oil	6 *0.23*	*0.5* *0.019*	13-18 *427-59.1*	11-16 *36.1-52.5*	6-11 *19.7-36.1*	15-20 *49.2-65.6*
			3 *0.11*	0.4 *0.016*	20-25 *65.6-82*	18-23 *59.1-75.5*	9-14 *29.5-45.9*	23-28 *75.5-91.9*
			1 *0.04*	0.2 *0.008*	26-31 *85.3-101.7*	25-30 *82-98.4*	15-20 *49.2-65.6*	30-35 *98.4-114.8*
	Carbide	Dry or cutting oil	6 *0.23*	0.5 *0.019*	75-85 *246.1-278.9*	70/80 *229.7-262.5*	25-35 82-114.8	75-85 *246.1/278.9*
			3 *0.11*	0.4 *0.016*	90-100 *295.3-328.1*	85/95 *278.9-312.7*	45-55 *147.6-180.4*	90-100 *295.3-328.1*
			1 *0.04*	0.2 *0.008*	110-120 *360.9-393.7*	100/110 *328.1-360.9*	65-70 *213.3-229.7*	110-120 *360.9-393.7*
Parting off	High speed steel	Cutting oil	Blade width	Feed	SPEED (m/min) *(feet/min)*			
			1.5 *0.06*	0.03 *0.0012*	21-26 *68.9-85.3*	17-22 *55.8-72.2*	10-13 *32.8-42.7*	23-28 *75.5-91.9*
			3 *0.11*	0.04 *0.0016*	22-27 *72.2-88.6*	18-23 *59.1-75.5*	11-14 *36.1-45.9*	24-29 *78.7-95.1*
			6 *0.23*	0.05 *0.0020*	23-28 *75.5-91.9*	19-24 *62.3-78.7*	12-15 *39.4-49.2*	25-30 *82.-98.4*
Drilling	High speed steel	Cutting oil	Drill Ø	Feed	SPEED (m/min)			
			1.5 *0.06*	0.25 *0.0010*	10-14 *32.8-45.9*	10-14 *32.8-45.9*	6-10 *19.7-32.8*	10-14 *32.8-45.9*
			3 *0.11*	0.06 *0.0024*	11-15 *36.1-49.2*	11-15 *36.1-49.2*	7-11 *23.-26.1*	11-15 *36.1-49.2*
			6 *0.23*	0.08 *0.0031*	11-15 *36.1-49.2*	11-15 *36.1-49.2*	7-11 *23.-26.1*	11-15 *36.1-49.2*
			12 *0.48*	0.10 *0.0039*	11-15 *36.1-49.2*	11-15 *36.1-49.2*	7-11 *23.-26.1*	11-15 *36.1-49.2*
Milling profiling	High speed steel	Cutting oil		Feed	SPEED (m/min)			
				.05/0.10 *.002/.0039*	12-22 *39.4-72.2*	10-20 *32.8-65.6*	10-20 *32.8-65.6*	12-22 *39.4-72.2*

WELDING

- UR 45N is easily welded by the following processes :
  - TIG welding, both manual and automatic,
  - Plasma welding,
  - MIG welding,
  - SMAW,
  - SAW
  - FCAW

- Austenitic-ferritic structure of UR 45N steel (ferrite primary solidification) limits hot cracking risks in the HAZ.

- Special care must be taken in controlling the ferrite content of the weld deposit which is usually between 25 and 60 % ; a lower ferrite content will be recommended (20-40 % of α, for some welding procedures) *i.e.* for SMAW, SAW and FCAW.

- Chemical composition has to be adapted to stabilize austenite (generally, nickel or nitrogen overalloyings compared to the base metal).
  Cr and Mo overalloyed filler metals are also recommended in order to increase the corrosion resistance properties of welded structures.

- As for autenitic grades : No preheat is necessary prior to welding,

- The heat input must be controlled (about 10 to 25 KJ/cm is generally counselled) - Consult our technical staff for more accurate information if needed. Optimum heat input is related to plate thicknesses.

- Interpass temperature must be limited to 150°C (*302°F*), or better 120°C (*248°F*).

- Post weld heat treatment is not necessary, except if, in particular cases, welding without filler metal for instance, a lower ferrite content is required. Heat treatment will be realised at a sufficient temperature to avoid phase transformation.

- Usual precautions including cleaning and degreasing of weld area, protection against weld spatters must be taken to ensure corrosion resistance of the finished product.

- Careful final mechanical or/and chemical cleaning of the weld is highly recommended.

- *Plasma + TIG welding*

  Typically used for thicknesses of 5 to 12 mm
  If no filler metal is used for the plasma pass, Ar + (2-3)% N_2 will be used as shielding gas.

  Ferrite content will be between 30 and 60 %. Complementary TIG welding will also be realised with a duplex or super-duplex wire. The ferrite content will also be kept between 30 and 60 %.

  Nitrogen additions (2-3%) in the protective gas improve the corrosion behaviour and stabilize the microstructure. Technical is available for special cases. Contamination of the shielding gas by hydrogen must be avoided.

- *Manual arc welding*

  A standard duplex or super-duplex electrode will be used. The ferrite content is between 20 and 40%. Avoid hydrogen pick up (moisture, hydrogen containing gases...) which can result in cold cracking.

  For further information, please contact us (choice of the electrode depending on the application).

- *Submerged arc welding*

  This process can be used for single pass or multipass welds for high thicknesses (≥10 mm) or to complete a plasma pass. The filler metal is a duplex wire basic fluxes should be preferred.

  Ferrite content will be controlled between 20 and 40 % in order to avoid cold cracking risks ; Use only well dryed fluxes to avoid hydrogen pick up.

DESIGN

URANUS 45N is particularly cost effective when its high mechanical properties of the alloy are taken into account to design vessels.

Allowable design stress values : ASME Boiler and Pressure vessel code Section VIII - Division 1, Stress, MPa - KSI

Grade	-30/40°C *(-20/100°F)*		205°C *(400°F)*		260°C *(500°F)*	
	MPa	KSI	MPa	KSI	MPa	KSI
316L	108	15.7	74	10.8	68.9	10
904L	123	17.8	95	13.8	87	12.7
UR 45 N	**155**	**22.5**	**144**	**20.9**	**141**	**20.4**

These higher design stress values allow the fabricator to reduce the weight of the equipments which, combined with the high corrosion resistance properties, provide additional cost savings.

APPLICATIONS

- Oil and Gas industry including sour gas applications
- Pulp and Paper industry (digesters...)
- Chemical industry (reactor vessels...)
- Acetic acid distillation towers
- Phosphoric acid plants (reactors...)
- Sulphuric acid processes (hydrometallurgy...)
- Pollution control equipments
- Truck, lorries
- Chemical tankers

SIZE RANGE

	Hot rolled plates	Cold rolled plates	Clad plates
Thickness	5 to 150 mm 3/16" to 6"	2 to 14 mm 5/64" to 5/8"	6 to 150 mm 1/4" to 6"
Width	Up to 3300 mm Up to 130"	Up to 2300 mm Up to 90.5"	Up to 3300 mm Up to 130"
Length	Up to 12000 mm Up to 472"	Up to 8250 mm Up to 325"	Up to 14000 mm Up to 551"

Other sizes are available on request, including 4100mm (161,4") width plates

NOTE

This technical data and information represents our best knowledge at the time of printing. However, it may be subject to some slight variations due to our ongoing research programme on corrosion resistant grades.

We therefore suggest that information be verified at time of enquiry or order.
Furthermore, in service, real conditions are specific for each application. The data presented here is only for the purpose of description, and may only be considered as guarantees when our company has given written formal approval.