



## VIRGO™ 15.5 PH

### VIRGO™ 15.5 PH: A 15Cr 5Ni 3Cu precipitation hardening martensitic stainless steel

Alloy VIRGO™ 15.5 PH is a precipitation hardening martensitic stainless steel with 15% Cr, 5% Ni, 3.5% Cu and 0.3% Nb/Cb. The grade combines high mechanical properties and medium corrosion resistance. The VIRGO™ 15.5 PH grade is similar to the VIRGO™ 17.4 PH grade having equivalent mechanical properties. Due to the lower Chromium content and increased Nickel content the VIRGO™ 15.5 PH grade contains less ferrite which provides better through thickness properties particularly when considering thick plates. The corrosion behaviour is close to 304 grade and better than 410 grade. The main applications are similar to those of VIRGO™ 17.4 PH grade i.e. mechanical components and offshore industry.

#### PROPERTIES

#### STANDARDS

> EURONORM	-
> ASTM	A693 Grade XM12 (AMS 5862) UNS S15500

#### CHEMICAL ANALYSIS - WEIGHT %

##### Typical values

C	Cr	Ni	Cu	Nb-Cb
< .07	15	4.5	3.5	0.3

PREN (%Cr + 3.3% Mo + 16%N) ≥ 15

#### PHYSICAL PROPERTIES

Density: 7.8 kg/dm<sup>3</sup>

Following physical properties have been obtained after hardening 480°C (896°F) - 1 hour - air cooling

Interval Temperature °C (°F)	Thermal expansion ( $\alpha \times 10^{-6} \text{ K}^{-1}$ )	T (°C)	T (°F)	Thermal conductivity ( $\text{W m}^{-1} \text{ K}^{-1}$ )	Young modulus E (GPa)
0-100	10.8	20	68	14	197
0-200	11	100	212	16	193
0-300	11.3	200	392	18.5	186
0-400	11.6	300	572	20	180
0-500	12	400	752	22	175
		500	932	23	170

**Room temperature properties**

- > Resistivity 80  $\mu\Omega$  cm
- > Specific heat 460 J.kg<sup>-1</sup>.K<sup>-1</sup>
- > Tension modulus 77 Gpa

*The alloy is magnetic.*



**MECHANICAL PROPERTIES**

**Room temperature properties (longitudinal direction)**

Guaranteed values (ASTM A693 hot rolled plates) Thickness from 5 up to 75 mm (.20" to 2.95").

Heat treatment		Y.S. 0.2%		UTS		Elongation
		MPa	ksi	MPa	ksi	%
Hardening 496 °C (925 °F) 4 h, air cooling	mini	1070	155	1170	170	8
	Typical	1207	175	1310	190	14
Hardening 593 °C (1100°F) 4 h, air cooling	mini	790	115	965	140	10
	Typical	931	135	1034	150	17

*Other Hardening Heat Treatments may be applied (refer to ASTM A693). For specific request, please contact us.*

**Elevated temperature properties**

Minimum guaranteed values following EN 10088 hot rolled plates. The EN guaranteed values are valid for a thickness from 5 up to 75 mm (.20" up to 2.95")

Heat treatment Hardening 590°C (1094°F) 4h - air cooling		Yield Strength	
°C	°F	MPa	ksi
100	212	730	106
150	302	710	103
200	392	690	100
250	482	670	97
300	572	650	95

*For specific request, please consult us.*

**Impact values - Minimum guaranteed room temperature**

Minimum guaranteed values following ASTM A693 hot rolled plates - The ASTM guaranteed values are valid for a thickness from 5 up to 75 mm (.20" up to 2.95")

Heat treatment	KV transverse	
	J	ft.lb
Hardening 593°C (1100°F) 4h - air cooling	20	15

**Hardness values - Minimum guaranteed room temperature**

Minimum guaranteed values following ASTM A693 hot rolled plates - The ASTM guaranteed values are valid for a thickness from 5 up to 75 mm (.20" up to 2.95")

Heat treatment	Hardness	
	Rockwell	Brinell
Hardening 496°C (925°F) 4h - air cooling	C38	375
Hardening 593°C (1100°F) 4h - air cooling	C29	293

*For specific request, please consult us.*

## IN SERVICE CONDITION

### CORROSION RESISTANCE

Alloy VIRGO™ 17.4 PH withstands corrosive attack better than any of the standard hardenable stainless steels and is comparable to type 304 in most media. If there are potential risks of stress corrosion cracking, the higher aging temperatures then must be selected over 550°C (1022°F), preferably 590°C (1094°F). 550°C (1022°F) is the optimum tempering temperature in chloride media. 590°C (1094°F) is the optimum tempering temperature in H<sub>2</sub>S media. The alloy is subject to crevice or pitting attack if exposed to stagnant seawater for any length of time. It is corrosion resistant in some chemical, petroleum, paper, dairy and food processing industries (equivalent to 304L grade).



## DELIVERY CONDITIONS

### SIZE RANGE

	Quarto plates	Plates cut to length	Clad plates
Thickness	5 to 150 mm 3/16" to 6"	3 to 12 mm 1/8" to 1/2"	6 to 150 mm 1/4" to 6"
Width	Up to 3800 mm Up to 150"	Up to 2000 mm Up to 79"	Up to 3900 mm Up to 154"
Length	Up to 16000 mm Up to 52 ft	Up to 12000 mm Up to 39 ft	Up to 16000 mm Up to 52 ft

*Indicative dimensional programe. Width related to thickness. For specific request, please consult.*

## PLATE PROCESSING

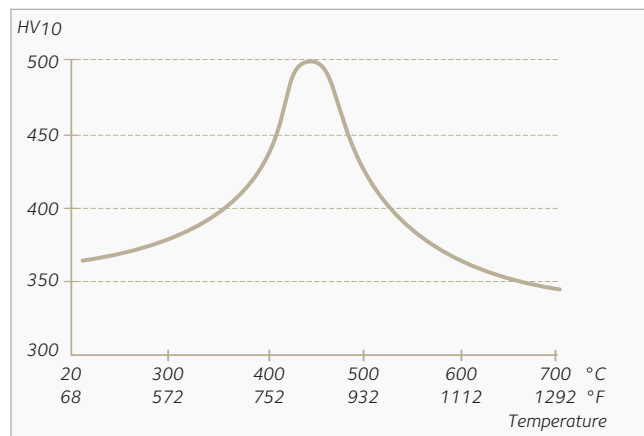
### HEAT TREATMENTS

#### Solution annealing

1038°C ±15°C (1900°F ±25°F) 30 minutes, up to 1 hour Air cooling / Oil quenching below 25°C (76°F)

#### Aging / Tempering

The highest mechanical properties are obtained with the following heat treatment: 480°C (896°F), 1 hour, air cooling. Higher ductilities are obtained when using higher aging temperatures up to 620°C (1148°F).



*Hardness / Temperature tempered for 4 hours after austenitizing at 1040°C (1904°F) for 30 min. quenched 100°C/sec. (212°F/sec.).*

## HOT FORMING

Hot forming should be carried out in a temperature range of 950-1200°C (1742-2192°F). A full heat treatment including solution annealing, cooling lower than 25°C (76°F) and aging at the required temperature must be made after hot forming (function of the requested mechanical properties).

## COLD FORMING

Cold forming can be performed only to a limited extent and only on plates in the fully softened condition. Stress corrosion resistance is improved by re-aging at the precipitation hardening temperature after cold working. Following processes may be performed: rolling, bending, hydroforming... (fully softened conditions).

## WELDING

VIRGO™ 15.5 PH can be welded by the following welding processes : SMAW, GTAW, PAW and GMAW. SAW should not be used without preliminary testing (to check freedom of cracks and toughness of the weld metal). Due to a ferrite delta primary type of solidification, the hot cracking risk of the weld metal or the HAZ is reduced. Generally no preheating must be done and interpass temperature must be limited to 120°C (248°F). The better toughness is obtained in the weld after a complete heat treatment (solution annealing + precipitation hardening). Due to the martensitic microstructure, a low oxygen content in the weld metal is preferable to increase ductility and toughness. To avoid cold cracking, the introduction of hydrogen in the weld must be limited. VIRGO™ 15.5 PH can be welded with homogeneous filler metals such as E 630 (AWS A5.4) electrodes and ER 630 (AWS A5.9) wires. Austenitic filler material can be used when the mechanical properties of VIRGO™ 15.5 PH steel are not required in the weld and in this case no post weld heat treatment must be applied.

## CUTTING

Thermal cutting (plasma, thermal sawing...). Due to the HAZ, the grade requires a suited cutting process. After cutting grinding is necessary to eliminate the oxide formed layer. Mechanical cutting (shearing, stamping, cold sawing...)

## MACHINING

Alloy VIRGO™ 15.5 PH can be machined in both solution treated and precipitation hardened conditions. Machining condition may vary according to the hardness of the material. High speed steel tools or preferably carbide tools with standard lubrication are normally used. If very stringent tolerances are required, it is necessary to take into account the dimensionnal changes during heat treatment.



## APPLICATIONS

- > Offshore (foils, helicopter deck platforms...)
- > Food industry
- > Pulp and paper industry
- > Aerospace (turbine blades...)
- > Mechanical components
- > Nuclear container casks



## YOUR CONTACTS

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*Technical data and information are to the best of our knowledge at the time of printing. However, they may be subject to some slight variations due to our ongoing research programme on steels. Therefore, we 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 are only for the purpose of description, and considered as guarantees when written formal approval has been delivered by our company. Further information may be obtained from the address opposite.*