AISI: nil	JIS: nil	EN: nil	DIN: nil	Wst Nr: 1.4427 So

History

In the late 70s the PX Group developed their famous Inox PX® in collaboration with major Swiss watch manufacturers. Today this alloy is still a reference in the watch industry, especially for complex machining. Available now in Asia, the 316LS-PXQ™ (PXQ standing for PX Quality) shares the same chemistry, properties and elaboration process with the Inox PX®.

Description

The 316LS-PXQ™ is an austenitic Chromium-Nickel-Molybdenum stainless steel, resulfurised to a tightly controlled level, to provide excellent machinability while retaining a good corrosion resistance. The fine distribution of the Manganese Sulphides in the matrix gives very consistent machining characteristics without affecting its ability to be mirror polished.

Equivalence

This alloy (Wst Nr 1.4427 So) belongs to the same group as the 316L alloys (Wst Nr 1.4435 and 1.4404). Therefore the 316LS-PXQ™ may be used in conjunction with these alloys without risk of corrosion caused by differences in electrical potential.

Chemical Composition (% weight)

Carbon	< 0.030	Nickel	12.0 - 14.0
Silicon	< 1.00	Chromium	16.5 - 18.5
Manganese	< 2.00	Molybdenum	2.00 - 2.80
Phosphorus	< 0.045	Sulphur	0.10 - 0.13

Controlled Elements

To reduce the likelihood of hard oxides which are detrimental to a good polishability, Aluminium, Nobium and Titanium contents are kept to an extremely low level. Known for its negative impact on corrosion resistance when the content is above 0.80%, Copper content is controlled and maintained at a maximum of 0.40%, way below the critical limit.

Microstructure

Unique steps are taken during the alloy elaboration and casting, to guarantee a very fine grain structure (ASTM 6 or finer), low delta ferrite, the absence of sigma phase, limited quantity of inclusions and uniform distribution of Manganese Sulphides.

The typical microcleanliness of the 316LS-PXQ™, according to ASTM Practice E 45 Method A, except using Plate III, is better than:

Sulfide **A**		Alumina **B**		Silicate **C**		Globular Oxide **D**	
Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick
Not Applicable		1.5	1.0	1.5	1.0	1.5	1.0

Physical Properties

Density, ρ [kg·m^{-3}]	7,900	Thermal conductivity, λ [W·m^{-1}·K^{-1}]	15.0
Electrical resistivity, ρ [$\mu\Omega$·m]	0.73	Thermal expansion at 100°C, α [10$^{-6.0}$C^{-1}]	16.0
Mean specific heat, C_p [J·kg^{-1}·K^{-1}]	500	Modulus of elasticity at 20°C, E [Gpa]	200

Mechanical Properties

Condition	Yield Strength [Mpa]	Tensile Strength [Mpa]	Elongation [%]	Hardness [Hv]
Annealed	300 +/-50	550 +/-50	50	180 +/-20
10% cold work	680 +/-50	850 +/-50	20	250 +/-20
20% cold work	900 +/-50	1,000 +/-50	10	280 +/-20
50% cold work	1,200 +/-50	1,250 +/-100	5	340 +/-30

Magnetic Properties

This alloy is non-magnetic in the annealed condition, but may become very slightly magnetic as a result of extreme cold work.

Corrosion Resistance

The combination of a PRE value around 25, minimum Copper content, well distributed Manganese Sulphides and controlled inclusions, give the 316LS-PXQ™ a pitting corrosion resistance much higher than other resulfurized austenitic stainless steel grades (e.g. 303, 316F, 316LSCu, etc.).

Its low Carbon content make this alloy not sensitive to Chromium Carbide precipitate ($Cr_{23}C_6$), even after repeated heat treatments, thus intergranular corrosion is unlikely.

		Pit Density [pits/cm^2]			
		$FeCl_3$, 0.5 °/$_{00}$ 50°C, 2 hours	$FeCl_3$, 0.1 °/$_{00}$ 37°C, 15 days	NaCl, 0.5 °/$_{00}$ 37°C, 26 days	NIHS sweat 37°C, 30 days
Alloy	PRE				
316LS-PXQ™	24.6				
AISI 316F	22.8				
AISI 303	17.0				
316L 1.4435	25.3				
AISI 316L	22.6				
JIS SUS 316L	22.6				
AISI 304L	18.0				

Results Under Compilation

Note: Results are for information only. Tests were conducted as per ASTM G 48, 4 samples per alloy per test. Pit density is the average results of the 4 samples. Samples section around 12 x 6 mm, taken longitudinally. PRE is the minimum value guaranteed by the chemistry specification given in the Stahlschlussel.

Biocompatibility

Thanks to its high corrosion resistance to chlorine and saline environments, the 316LS-PXQ™ releases only minute amount of Nickel upon contact with human skin. Nickel release tests were conducted in October 2000 by PX Tech (Swiss Testing, STS 230) in Switzerland, on several samples of 316LS-PXQ™.

These tests, performed as per EN 1811, gave a Nickel release between 0.026 and 0.079 $\mu g \cdot cm^{-2} \cdot wk^{-1}$, for an unadjusted result, and 0.003 to 0.008 $\mu g \cdot cm^{-2} \cdot wk^{-1}$ for the adjusted analytical result. The adjusted results show a Nickel release 60 to 160 time lower than the limit of 0.5 $\mu g \cdot cm^{-2} \cdot wk^{-1}$ fixed by EN 1811.

Note: the Nickel release of an alloy has been shown to be closely interrelated to the corrosion resistance of the said alloy. Therefore heat treatment, grain size, contaminant, surface finish, surface treatment, etc. may have a significant impact on the amount of Nickel released by an alloy.

Machining

The greatly improved machinability of the 316LS-PXQ™ is achieved through the adjunction of 0.10 to 0.13 % of Sulphur, distributed evenly in the matrix. This creates Manganese Sulphides particles which break the chips and lubricate the cutting tools.

Drilling

Tool material	Diameter [mm]	Feed [mm/min]	Speed [rpm]
Carbide	0.90	133	5,300
Carbide	1.20	100	4,000
Carbide	1.70	70	2,800

Sawing (Slitting saw)

Tool material	Diameter [mm]	Feed [mm/min]	Speed [rpm]
Carbide	96 / 100	70	800
Carbide	63	70	1,250
Carbide + coating	96 / 100	90	1,050
Carbide + coating	63	90	1,600

Heat Treatment

The annealing of the 316LS-PXQ™ is done between 1,020°C and 1,080°C with a holding time between 10 to 30 minutes, depending on the mass of the parts being treated, and followed by a fast cooling. For bright annealing, use a protective atmosphere of H_2, $H_2 + N_2$ or cracked NH_3.

This alloy cannot be hardened by heat treatment and hardens only by cold working.

Chemical Treatment

The 316LS-PXQ™ can be pickled in a hot bath of 6-25% HNO_3 + 0.5-8% HF. This operation should be done only on material in an annealed condition.

This alloy can be passivated in a hot bath, 50°C to 70°C, of 40-60% HNO_3 between 20 to 30 minutes. This must be followed by neutralisation.

Cold Working

The 316LS-PXQ™ can be drawn, rolled and stamped without difficulty. Since this alloy work hardens, severe forming operations should be followed by annealing.

Welding

This alloy may be welded with TIG or MicroPlasma. After welding, a stress relief annealing at 1,050°C, under a protective atmosphere of H_2, $H_2 + N_2$ or cracked NH_3, is advisable.

Brazing

The brazing of 316LS-PXQ™ in a temperature range of 950°C to 1,100°C is not particularly challenging. To achieve the best possible result, the use of a conveyor furnace under a protective atmosphere of H_2, $H_2 + N_2$ or cracked NH_3, is highly recommended.

The usage of the following filler alloys are recommended to achieve the strongest bond:

- Ag-Cu-Ni filler alloys, melting point around 900°C
- Palladium filler alloys
- 8 to 18 carat gold filler alloys, melting point around 850°C

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