WIRE
DATA SHEET ZAPP 2507-SW
FOR WIRELINES

ZAPP IS CERTIFIED ACCORDING TO ISO 9001

Zapp 2507-SW is a super-duplex (austenitic-ferritic) stainless steel for service in highly corrosive conditions. The grade is characterized by:

_ Excellent resistance to stress corrosion cracking (SCC) in chloride-bearing environments
_ Excellent resistance to pitting and crevice corrosion
_ High resistance to general corrosion
_ High resistance to erosion corrosion and corrosion fatigue
_ High mechanical strength and correspondingly high breaking loads in its slickline wire product form

STANDARDS
_ UNS: S32750
_ EN Number: 1.4410
_ EN Name: X2CrNiMoN 25-7-4
_ SS: 2328

CHEMICAL COMPOSITION (NOMINAL) %

C	Si	Mn	P	S	Cr	Ni	Mo	Others
≤ 0.030	≤ 0.8	≤ 1.2	≤ 0.035	≤ 0.015	25.0	7.0	4.0	N=0.3

FORMS OF SUPPLY

Zapp 2507-SW slicklines are supplied cold drawn and degreased, in continuous lengths, without welds, on metallic spools.

Diameter		Breaking load		Weight	
mm	inch	N	lbf	kg/1000m	lb/1000ft
2,083	0.082	6,134	1,397	26.6	17.8
2,337	0.092	7,721	1,736	33.5	22.4
2,743	0.108	10,637	2,391	46.1	30.9
3,175	0.125	14,251	3,204	61.8	41.4
3,556	0.140	17,877	4,019	77.5	52.1
3,810	0.150	19,382	4,357	88.9	59.8
4,064	0.160	22,052	4,957	101.2	68.0

MECHANICAL PROPERTIES

Wire in Zapp 2507-SW is tested and certified in accordance with a minimum tensile strength. Proof strength is approximately 90 % of the tensile strength. Zapp 2507-SW is able, therefore, to resist high loads without permanent set of the wire.

At 20 °C (68 °F)

Diameter		Proof strength $R_{p0.2}$ *		Tensile strength R_m	
mm	inch	MPa	ksi	MPa	ksi
2,083 – 3,556	0.082-0.140	≥ 1620	≥ 235	≥ 1800	≥ 261
3,810 – 4,064	0.150-0.160	≥ 1530	≥ 222	≥ 1700	≥ 247

* $R_{p0.2}$ corresponds to 0.2 % offset yield strength.

CORROSION RESISTANCE

GENERAL CORROSION

Zapp 2507-SW is highly resistant to corrosion by organic acids, e.g. experience less than 0.05 mm/year in 10 % formic and 50 % acetic acid where ASTM 316L has a corrosion rate higher than 0.2 mm/year. Pure formic acid, see Figure 2.

Zapp 2507-SW remains resistant even in contaminated acids. Figure 3 and Figure 4 show results from tests of Zapp 2507-SW and various stainless steels and nickel alloys in acetic acid contaminated with chlorides which in practice are frequently present in processes.

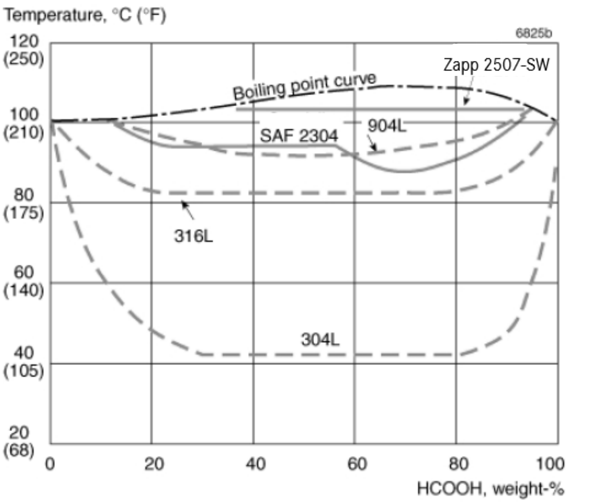
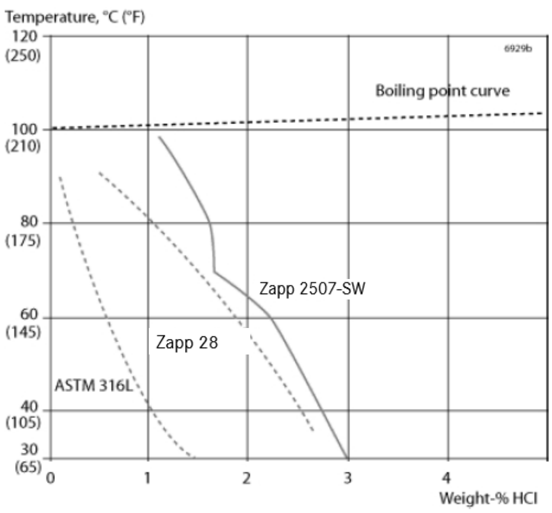


Figure 2. Iso-corrosion diagram in formic acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in stagnant test solution.



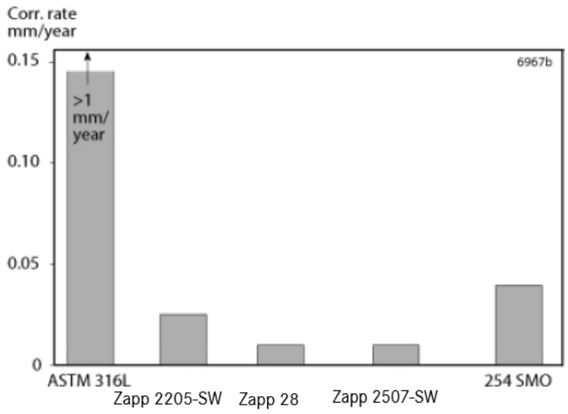


Figure 3. Corrosion rate of various alloys in 80 % acetic acid with 2,000 ppm chloride ions at 90 °C (194 °F).

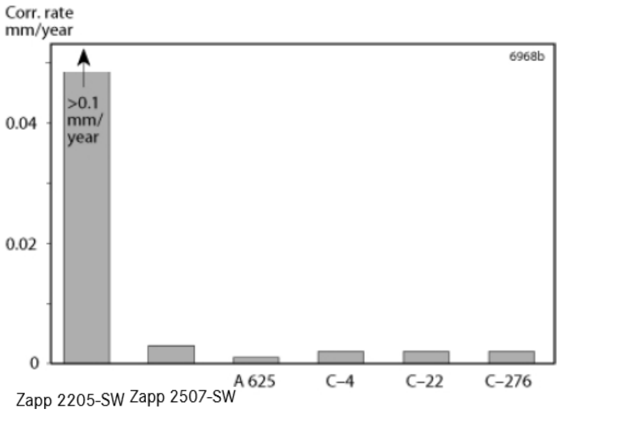


Figure 4. Corrosion rate of various alloys in concentrated acetic acid with 200 ppm chloride ions.

Practical experience with Zapp 2507-SW in organic acids, e.g. in teraphthalic acid plants, has shown that this alloy is highly resistant to this type of environment. The alloy is therefore a competitive alternative to high alloyed austenitics and nickel alloys in applications where standard austenitic stainless steels corrode at a high rate.

Resistance to inorganic acids is comparable to, or even better than that of high alloy austenitic stainless steels in certain concentration ranges. Figures 5 to 7 show isocorrosion diagrams for sulphuric acid, sulphuric acid contaminated with 2,000 ppm chlorid ions, and hydrochloric acid, respectively.

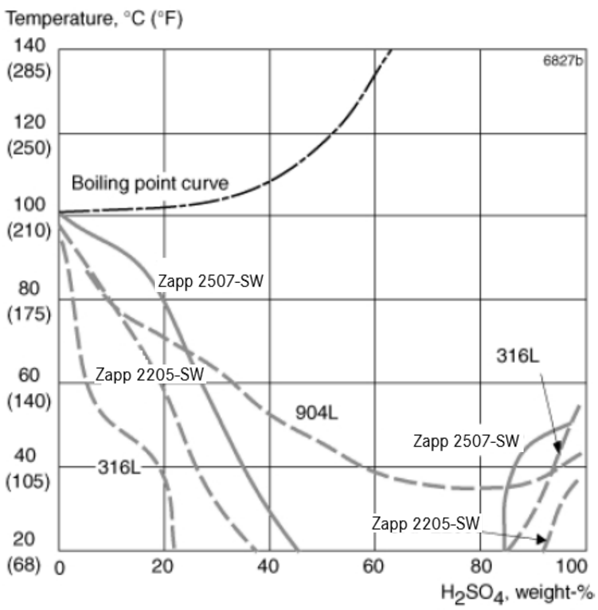


Figure 5. Isocorrosion diagram in naturally aerated sulphuric acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in a stagnant test solution.

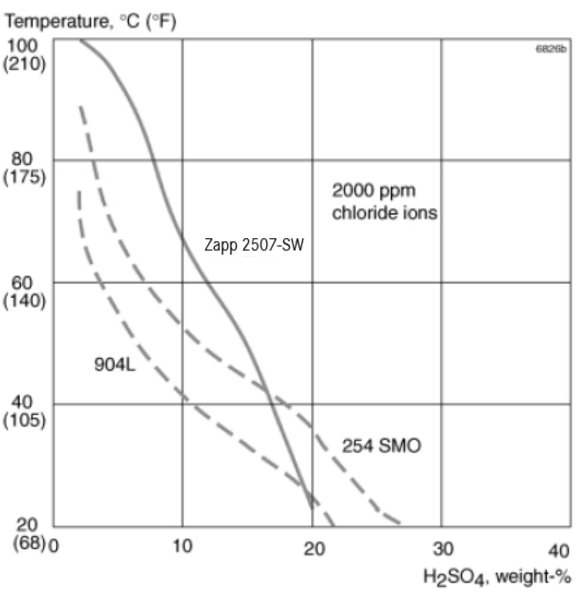


Figure 6. Isocorrosion diagram, 0.1 mm/year (4 mpy) in a naturally aerated sulphuric acid containing 2,000 ppm chloride ions.

Figure 7. Isocorrosion diagram in a hydrochloric acid. The curves represent a corrosion rate of 0.1 mm/year (4 mpy) in stagnant test solution.

PITTING AND CREVICE CORROSION

The pitting and crevice corrosion resistance of stainless steel is primarily determined by the content of chromium, molybdenum and nitrogen.
One parameter for comparing the resistance to pitting in chloride environments is the PRE number (Pitting Resistance Equivalent). The PRE is defined as,
in weight-% PRE = %Cr + 3.3 x %Mo + 16 x %N
For duplex stainless steels the pitting corrosion resistance is dependent on the PRE value in both the ferrite phase and the austenite phase, so that the phase with the lowest PRE value will be limiting for the actual pitting corrosion resistance. In Zapp 2507-SW the PRE value is equal in both phases, which has been achieved by a careful balance of the elements.
The minimum PRE value for Zapp 2507-SW wirelines is 42.5.

STRESS CORROSION CRACKING

Zapp 2507-SW has excellent resistance to chloride induced stress corrosion cracking (SCC). Figure 8 clearly demonstrates that Zapp 2507-SW has better SCC resistance in chloride solutions in comparison with several duplex and austenitic alternative grades in the annealed condition.

There were no signs of SCC in Zapp 2507-SW up to 1,000 ppm Cl /300 °C (572 °F) and 10,000 ppm Cl /250,°C (482,°F).

The super-duplex stainless steel Zapp 2507-SW has a higher resistance to SCC in in sour environments in oil and gas production than lower alloyed duplex stainless steels. The partial pressure of hydrogen sulphide should not exceed 3 psi (0.20 bar).

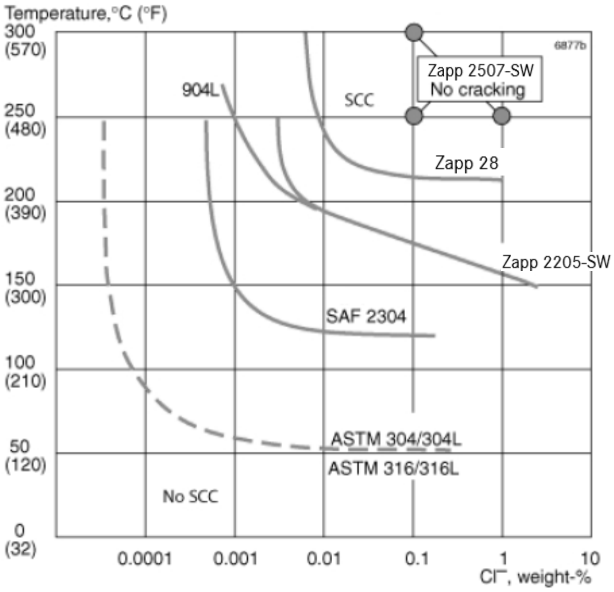


Figure 8. SCC resistance in oxygen-bearing (abt. 8 ppm) neutral chloride solutions. Testing time 1,000 hours. Applied stress equal to proof strength at testing temperature.

EROSION CORROSION

The mechanical properties combined with corrosion resistance give Zapp 2507-SW a good resistance to erosion corrosion. Testing in sand containing media has shown that Zapp 2507-SW has an erosion corrosion resistance better than corresponding austenitic stainless steels. Figure 9 below shows the relative mass loss rate of the duplex
Zapp 2507-SW, Zapp 2205-SW and an austenitic 6Mo+N type steel after exposure to synthetic seawater (ASTM D-1141) containing 0.025-0.25 % silica sand at a velocity of 8.9-29.3 m/s (average of all tests is shown).

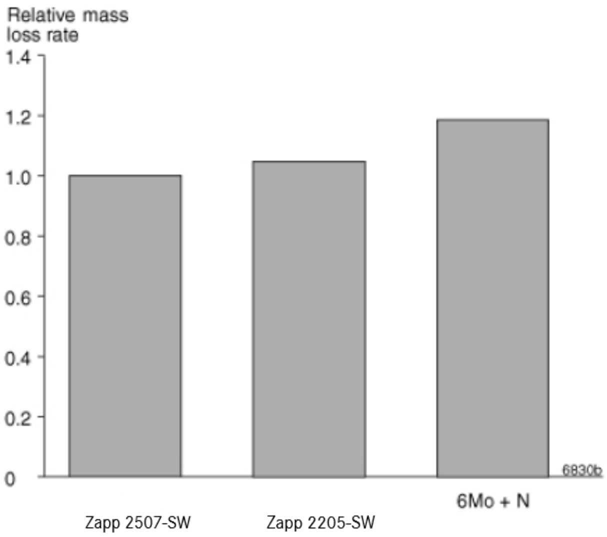


Figure 9. Relative mass loss rate after testing for resistance to erosion corrosion.

CORROSION FATIGUE

Duplex stainless steels which have a high tensile strength usually have a high fatigue limit and high resistance to both fatigue and corrosion fatigue.

The high fatigue strength of Zapp 2507-SW can be explained by its good mechanical properties, while its high resistance to corrosion fatigue has been proven by fatigue testing in corrosive media.

PHYSICAL PROPERTIES

Density: 7.8 g/cm^3 , 0.28 lb/in^3

Specific heat capacity			
Metric units		Imperial units	
Temperature °C	J/(kg °C)	Temperature °F	Btu/(lb °F)
20	490	68	0.12
100	505	200	0.12
200	520	400	0.12
300	550	600	0.13
400	585	800	0.14

THERMAL CONDUCTIVITY

Metric units, W/(m °C)

Temperature °C	20	100	200	300	400
Zapp 2507-SW	14	15	17	18	20
ASTM 316L	14	15	17	18	20

Imperial units Btu/(ft h °F)

Temperature °F	68	200	400	600	800
Zapp 2507-SW	8	9	10	11	12
ASTM 316L	8	9	10	10	12

THERMAL EXPANSION

Zapp 2507-SW has a coefficient of thermal expansion close to that of carbon steel. This gives Zapp 2507-SW definite design advantages over austenitic stainless steels in equipment comprising of both carbon steel and stainless steel. The values given below are average values in the temperature ranges.

Metric units x10^{-6}/° C

Temperature °C	30 - 100	30 - 200	30 – 300	30 - 400
Zapp 2507-SW	13.5	14.0	14.0	14.5
Carbon steel	12.5	13.0	13.5	14.0
ASTM 316L	16.5	17.0	17.5	18

Imperial units, x10^{-6}/° F

Temperature °F	86 – 200	86 – 400	86 – 600	86 – 800
Zapp 2507-SW	7.5	7.5	8.0	8.0
Carbon steel	6.8	7.0	7.5	7.8
ASTM 316L	9.0	9.5	10.0	10.0

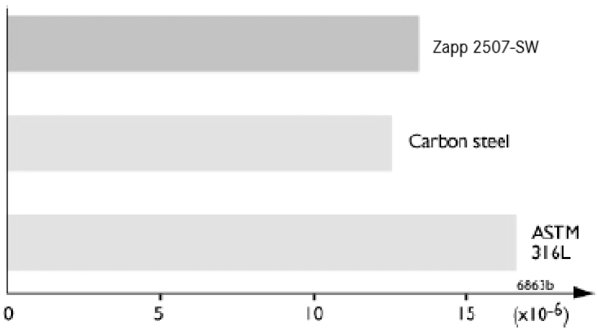


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Figure 1. Thermal expansion, per °C (30-100 °C, 86-210 °F).

Resistivity

Temperature °C	μΩm	Temperature °F	μΩin
20	0.83	68	32.5
100	0.89	200	34.9
200	0.96	400	37.9
300	1.03	600	40.7
400	1.08	800	43.2

Modulus of elasticity, (x10^3). Metric units and imperial units

Temperature, °C	MPa	Temperature, °F	ksi
20	200	68	29.0
100	194	200	28.2
200	186	400	27.0
300	180	600	26.2

Zapp Precision Metals (Sweden) AB
PRECISION WIRE
Järnverksleden 8
811 34 Sandviken
Sweden
Phone +46 26 265467
precisionmetals-sweden@zapp.com
www.zapp.com

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