# Stainless steels

Stainless steels were first manufactured in Germany between 1912 and 1914, at the Krupp workshops. They were made with 8 parts of nickel to 18 parts of chromium. At the same time, in 1913, a stainless steel was produced in the United Kingdom, using only chromium. Initially, stainless steel was used to make knives, as well as valves to be used in internal combustion engines. Stainless steels are iron, chromium- and carbon-based alloys, enriched with other elements such as nickel, molybdenum, silicon, titanium, etc. The peculiarity of these alloys is their high resistance to corrosion by atmospheric agents.

This characteristic is due to a thin layer of chromium oxides which spontaneously forms on the steel surface, protecting the metal underneath from corrosion. This layer, very stable and resistant, prevents the inner part of steel from coming into direct contact with the outside atmosphere. Unlike standard protective coating treatments (zinc coating, painting, etc.), this chromium layer re-forms if the metal happens to crack, making steel impervious to corrosion.

Stainless steel alloys must contain at least 11% of chromium for oxides to be able to form.
The resistance and the anchoring properties of the protective layer of chromium oxides depend on chromium concentration and on the presence of any other elements, such as nickel, molybdenum, titanium, etc.

**Stainless steels can be classified into:**

- martensitic
- ferritic
- austenitic
- Duplex (austenitic-ferritic)
- precipitation hardening
- uper-inoxidable

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**Notes:**

1. Sulphur content can be up to 0,030% in bars, wires, profiles and semi-finished products. Recommended (and permitted) sulphur content is S=0,015÷0,030% in products to be processed with machine tools.
2. In the case of special requirements (hot-working for the manufacturing of weldless pipe tubes; in order to minimize Delta ferrite content; in order to keep magnetic permeability low), maximum Ni value can be thus increased:

+ 0,50% per 1,4571
+ 1% per 1,4306, 1,4406, 1,4429, 1,4436, 1,4438, 1,4541, 1,4550, 1,4434
+ 1,50% per 1,4404

*All values in the following tables are merely indicative.
**All the following information and data are indicative and therefore not to be taken as a warranty for specific applications.

**Bibliography:**
"Stainless Steels", TN by G. Di Caprio, Editore Ulrico Hoepli, Milan
"Stainless Steels – Table of Correspondence", TN, published by Centro Inox (Milan 1999)

# AISI 304

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN 10088/3 | (European norms) | X 5 Cr Ni 18-10 |
| W. | (Germany) | 1,4301 |
| JIS | (Japan) | SUS 304 |
| AISI | (U.S.) | 304 |

## INDICATIVE ANALYSIS %

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,07max | 2 | 0,045 | 0,015[a] | 1 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 17÷19.5 | 8÷10,5 | - | N ≤ 0,11 |

## DESCRIPTION

This is the most common type of stainless steel. Austenitic stainless steel, non-magnetic if annealed, slightly magnetic if cold worked. Not quenchable. It can be strengthened via cold working. Good mechanical properties: not outstanding at room temperature, but excellent at very low temperatures, especially as regards resilience and endurance limit – it shows low notch sensitivity.

## USES

Food processing machinery; food preserving machinery; chemical, pharmaceutical, textile, petroleum, and furniture industry; architectural decorations; car trims.

## CORROSION RESISTANCE

At a solution heat-treated state, resistant to corrosion by plenty of substances used in the chemical, textile, petroleum, dairy, and food industry. It is recommended that slow cooling and heating be avoided between the temperatures 450÷900°C.

# AISI 304

### OXIDATION RESISTANCE
Good resistance up to 925°C in continuous service, up to 870°C in intermittent service.

### WELDABILITY
Easily weldable. AISI 308 or 347 electrodes are recommended. No need for post-welding treatments when the thickness of welded sections is less than 25mm.

### HEAT TREATMENT
Solution heat treatment 1050÷1100°C.

### PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 200.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 15 [W/mK] |
| SPECIFIC HEAT | 500 [J/KgK] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 200°C) 16,5 [$10^{-6}K^{-1}$]<br>(20°- 400°C) 17,5 [$10^{-6}K^{-1}$]<br>(20°- 600°C) 18,5 [$10^{-6}K^{-1}$] |

### ROOM-TEMPERATURE MECHANICAL PROPERTIES

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 190$ [N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 500 ÷ 700 [N/mm²] |
| ELONGATION | A 5% ≥ 45 |
| BRINELL HARDNESS | HB ≤ 215 |

# AISI 304L

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN 10088/3 | (European norms) | X 2 Cr Ni 19-11 |
| W. | (Germany) | 1,4306 |
| JIS | (Japan) | SUS 304L |
| AISI | (U.S.) | 304L |

## INDICATIVE ANALYSIS %

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,03max | 2 | 0,045 | 0,015[a] | 1 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 18÷20 | 10÷12[b] | - | N ≤ 0,11 |

## DESCRIPTION

Austenitic stainless steel, non-magnetic if annealed, slightly magnetic if cold worked. As compared to AISI 304, its carbon content is lower (<0,030%). Not quenchable. It can be strengthened via cold working. Resistant to intercrystalline corrosion. Its mechanical properties at room temperature are similar to those of standard types, but welded joints operating at very low temperatures – e.g. liquid H2 (-254°C) – have better shock resistance.
Mechanical properties at high temperatures are inferior to those of stabilized stainless steels.

## USES

Food processing machinery; food preserving machinery; textile, petroleum, chemical, pharmaceutical, and furniture industry; cryogenic field.

## CORROSION RESISTANCE

The same as Type 304, with the added advantage that it is impermeable to intercrystalline corrosion.

## OXIDATION RESISTANCE

Good resistance up to 850°C in continuous service, up to 800°C in intermittent service.

# AISI 304L

### WELDABILITY

Easily weldable – even welded structures of significant thickness – without carbide precipitations in welded areas. AISI E308 or 347 electrodes are advisable. No need for post-welding treatment.

### HEAT TREATMENT

Solution heat treatment 1050÷1100°C.

### PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 200.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 15 [W/mK] |
| SPECIFIC HEAT | 500 [J/KgK] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 200°C) 16,5 [$10^{-6}K^{-1}$]<br>(20°- 400°C) 17,5 [$10^{-6}K^{-1}$]<br>(20°- 600°C) 18,5 [$10^{-6}K^{-1}$] |

### ROOM-TEMPERATURE MECHANICAL PROPERTIES

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 175$ [N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 450 ÷ 680 [N/mm²] |
| ELONGATION | A 5% ≥ 45 |
| BRINELL HARDNESS | HB ≤ 215 |

# AISI 303

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN 10088/3 | (European norms) | X 8 Cr Ni S18-9 |
| W. | (Germany) | 1,4305 |
| JIS | (Japan) | SUS 303 |
| AISI | (U.S.) | 303 |

## INDICATIVE ANALYSIS %

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,10 | 2 | 0,045 | 0,015÷0,35 | 1 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 17÷19 | 8÷1 | - | N ≤ 0,11; Cu ≤ 1 |

## DESCRIPTION

Austenitic stainless steel, non-magnetic if annealed, slightly magnetic if cold worked. Not quenchable. It can be strengthened via cold working. Excellent malleability and excellent seizing resistance, due to the adding of sulphur.

## USES

All details to be processed with automatic chip-removal machine tools.

## CORROSION RESISTANCE

Corrosion resistance was slightly sacrificed in favour of a higher machinability as against Type 304 in mildly corrosive environments (atmosphere, food products, organic chemical products). However, its resistance to very corrosive substances – i.e. acids – is significantly lower.

## WELDABILITY

Normally, this type of steel is not used for applications requiring welding. However, it can be welded, as long as it is done extremely carefully.

# AISI 303

## HEAT TREATMENT

Solution heat treatment 1050÷1100°C.

## PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 200.000 [N/mm²] |
| CTHERMAL CONDUCTIVITY | 15 [W/mK] |
| SPECIFIC HEAT | 500 [J/KgK] |
| | (20°- 200°C) 16,5 [$10^{-6}K^{-1}$] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 400°C) 17,5 [$10^{-6}K^{-1}$] |
| | (20°- 600°C) 18,5 [$10^{-6}K^{-1}$] |

## ROOM-TEMPERATURE MECHANICAL PROPERTIES

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 190$[N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 500 ÷ 750 [N/mm²] |
| ELONGATION | A 5% $\geq$ 35 |
| BRINELL HARDNESS | HB $\leq$ 230 |

# AISI 316

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN 10088/3 | (European norms) | X 5 Cr Ni Mo17-12-2 |
| W. | (Germany) | 1,4401 |
| JIS | (Japan) | SUS 316 |
| AISI | (U.S.) | 316 |

## INDICATIVE ANALYSIS %

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,07 | 2 | 0,045 | 0,015[a] | 1 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 16,5÷18,5 | 10÷13 | 2÷2,5 | N ≤ 0,11 |

## DESCRIPTION

Austenitic stainless steel, non-magnetic if annealed, slightly magnetic if cold worked. Not quenchable. It can be strengthened via cold working. Its corrosion resistance is higher than Type 304 as regards pitting due to Cl ions and stress corrosion.

## USES

Equipment for: ships; the chemical, pharmaceutical, food, textile, and paper-making industry; photography; oven parts; heat exchangers; orthopedic field.

## CORROSION RESISTANCE

Excellent resistance to atmospheric corrosion. Excellent resistance to corrosion due to a large number of salts, organic acids and food products. Moderate resistance to weak solutions of reducing acids, to halides and to sea water.

## OXIDATION RESISTANCE

Good resistance up to 925°C in continuous service, up to 870°C in intermittent service.

# AISI 316

### WELDABILITY

Easily weldable. If electrodes are necessary, they must be made of the same type of steel. No need for post-welding treatments when the thickness of welded sections is less than 25mm.

### HEAT TREATMENT

Solution heat treatment 1050÷1100°C.

### PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 200.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 15 [W/mK] |
| SPECIFIC HEAT | 500 [J/KgK] |
| | (20°- 200°C) 16,5 [$10^{-6}K^{-1}$] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 400°C) 17,5 [$10^{-6}K^{-1}$] |
| | (20°- 600°C) 19,0 [$10^{-6}K^{-1}$] |

### ROOM-TEMPERATURE MECHANICAL PROPERTIES

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 200$[N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 500 ÷ 700 [N/mm²] |
| ELONGATION | A 5% $\geq$ 40 |
| BRINELL HARDNESS | HB $\leq$ 215 |

# AISI 316L

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN 10088/3 | (European norms) | X 2 Cr Ni Mo17-12-2 |
| W. | (Germany) | 1,4404 |
| JIS | (Japan) | SUS 316L |
| AISI | (U.S.) | 316L |

## INDICATIVE ANALYSIS %

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,03 | 2 | 0,045 | 0,015[a] | 1 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 16,5÷18,5 | 10÷13[b] | 2÷2.5 | N ≤ 0,11 |

## DESCRIPTION

Austenitic stainless steel, non-magnetic if annealed, slightly magnetic if cold worked. Not quenchable. It can be strengthened via cold working. Resistant to intercrystalline corrosion and to chloride pitting. As compared to AISI 316, its carbon content is lower.

## USES

The same as AISI 316. Thanks to its intercrystalline corrosion resistance, it is even more suitable in the case of considerable cold-working deformations or details to be welded.

## CORROSION RESISTANCE

Excellent resistance to atmospheric corrosion. Excellent resistance to corrosion in the presence of a large number of salts, organic acids and food products. Moderate resistance to weak solutions of reducing acids, to halides and to sea water. Due to its extremely low carbon content, this type of steel is virtually impermeable to intercrystalline corrosion.

## OXIDATION RESISTANCE

Good resistance up to 850°C in continuous service., up to 800°C in intermittent service.

# AISI 316L

### WELDABILITY
Easily weldable. If electrodes are necessary, they must be made of the same type of steel. No need for post-welding treatments.

### HEAT TREATMENT
Solution heat treatment 1050÷1100°C.

### PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 200.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 15 [W/mK] |
| SPECIFIC HEAT | 500 [J/KgK] |
| | (20°- 200°C) 16,5 [$10^{-6}K^{-1}$] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 400°C) 17,5 [$10^{-6}K^{-1}$] |
| | (20°- 600°C) 18,8 [$10^{-6}K^{-1}$] |

### ROOM-TEMPERATURE MECHANICAL PROPERTIES

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 200$[N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 500 ÷ 700 [N/mm²] |
| ELONGATION | A 5% $\geq$ 40 |
| BRINELL HARDNESS | HB $\leq$ 215 |

# AISI 310S

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN 10088/3 | (European norms) | X 8 Cr Ni 25-21 |
| W. | (Germany) | 1,4845 |
| JIS | (Japan) | SUS 310S |
| AISI | (U.S.) | 310S |

## INDICATIVE ANALYSIS %

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,10 | 2 | 0,045 | 0,015 | 1,50 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 24÷26 | 19÷22 | - | N ≤ 0,11 |

## DESCRIPTION

Austenitic stainless steel, non-magnetic if annealed, slightly magnetic if cold worked with large deformations. Not quenchable. Its higher nickel and chromium content gives it very good mechanical properties and high corrosion resistance, even in the case of hot corrosion.

## USES

Oven parts; heat exchangers; burners; endothermic engines; chemical and petroleum industry; plants for the treatment of sulphite lye; hydrogenation plant; drain pipes for gas turbines.

## CORROSION RESISTANCE

Good resistance, normally higher than Type 304. Type 310 withstands high temperatures quite well, while it becomes brittle at low ones (750÷900°C). Embrittlement can be overcome by solution heat treating (if possible) and subsequently cooling quickly. Not very suitable for environments rich in sulphurous gases, due to its high nickel content.

# AISI 310S

### OXIDATION RESISTANCE
Good resistance up to 1150°C in continuous service, up to 1035° in intermittent service.

### WELDABILITY
Easily weldable. If electrodes are necessary, AISI E310 electrodes are recommended. Must be treated after welding.

### HEAT TREATMENT
Solution heat treatment 1050÷1100°C.

### PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 206.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 15 [W/mK] |
| SPECIFIC HEAT | 500 [J/KgK] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 200°C) 15.5 [$10^{-6}K^{-1}$]<br>(20°- 400°C) 17,0 [$10^{-6}K^{-1}$]<br>(20°- 600°C) 17,5 [$10^{-6}K^{-1}$] |

### ROOM-TEMPERATURE MECHANICAL PROPERTIES

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 200$[N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 655 [N/mm²] |
| ELONGATION | A 5% $\geq$ 35 |
| BRINELL HARDNESS | HB $\leq$ 185 |

# AISI 321

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN 10088/3 | (European norms) | X 6 Cr Ni Ti 18-10 |
| W. | (Germany) | 1,4541 |
| JIS | (Japan) | SUS 321 |
| AISI | (U.S.) | 321 |

## % INDICATIVE ANALYSIS

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,08 | 2 | 0,045 | 0,015[a] | 1 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 17÷19 | 9÷12[b] | - | Ti=5xCmin; 0,7max |

## DESCRIPTION

Austenitic stainless steel, non-magnetic if annealed, slightly magnetic if cold worked. Not quenchable. It can be strengthened via cold working. Similar to AISI 304, but titanium is added for a stabilizing effect. Mechanical properties at room temperature are similar to those of AISI 304, while they are better at higher temperatures.

## USES

Equipment for the chemical industry, to be used at temperatures between 450° and 900°C; exhaust manifolds for endothermic engines; pressure containers; welded structures; boiler units; plants and equipment for the petroleum industry; expansion joints.

## CORROSION RESISTANCE

At a solution heat treated state, good resistance to plenty of substances found in the chemical, textile, petroleum, dairy, and food industry. If Ti is added, this steels becomes impermeable to intergranular corrosion.

# AISI 321

### OXIDATION RESISTANCE
Good resistance up to 925°C in continuous service, up to 870°C in intermittent service.

### WELDABILITY
Easily weldable. If electrodes are necessary, AISI E347 electrodes are recommended. No need for post-welding treatments.

### HEAT TREATMENT
Solution heat treatment 1000÷1080°C.

### PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 200.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 15 [W/mK] |
| SPECIFIC HEAT | 500 [J/KgK] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 200°C) 16,5 [$10^{-6}K^{-1}$]<br>(20°- 400°C) 17,5 [$10^{-6}K^{-1}$]<br>(20°- 600°C) 18,5 [$10^{-6}K^{-1}$] |

### ROOM-TEMPERATURE MECHANICAL PROPERTIES

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 190$[N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 500÷700 [N/mm²] |
| ELONGATION | A 5% ≥ 40 |
| BRINELL HARDNESS | HB ≤ 215 |

# AISI 430

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN 10088/3 | (European norms) | X 6 Cr 17 |
| W. | (Germany) | 1,4016 |
| JIS | (Japan) | SUS 430 |
| AISI | (U.S.) | 430 |

## % INDICATIVE ANALYSIS

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,08 | 1 | 0,04 | 0,015[a] | 1 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 16÷18 | - | - | - |

## DESCRIPTION

Ferritic stainless steel, ferromagnetic and not quenchable. It can be strengthened via cold working (rolling, drawing, etc.) in order to increase its mechanical resistance.

## USES

Widely used in the car manufacturing industry, as well as in the chemical one and in the manufacturing of domestic appliances. Employed in the manufacturing of fire-boxes for fan heaters; metal ware; safety cages for fans; parts of plants for the petroleum industry and the nitric acid industry; indoor and outdoor architectural decorations; bolts and screws; parts of oil-fired burners; household accessories; kitchenware; cutlery; sanitary sewer pipes; electromagnetic valves.

## CORROSION RESISTANCE

Good resistance, both at room temperature and at higher temperatures. Not resistance to the presence of dry sulphurous gases. Good resistance to average corrosion (i.e. atmospheric corrosion, especially if cleaned frequently; sweet water; organic compounds, petroleum and phenol; household cleaners; food substances; weak organic acids; various alkalis).

# AISI 430

### OXIDATION RESISTANCE
Good resistance up to 700°C in continuous service, up to 800°C in intermittent service.

### WELDABILITY
Moderate weldability. However, steel grain swells in welded areas, due to the high temperatures such areas reach. This makes steel more brittle at room temperature and less resistant to corrosion. It is therefore good practice to carry out a re-crystallization at 800°C after the welding, which decreases brittleness and improves corrosion resistance. Before welding, pre-heating at 150÷200°C is also advisable. If post-welding re-crystallization is not possible, electrodes made of AISI E308 steel are recommended, in order to increase the tenacity of the weld bead. In spite of this, though, base material areas next to the weld bead will still be rather brittle.

### HEAT TREATMENT
Recrystallization 780÷820°C.

### PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 220.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 25 [W/mK] |
| SPECIFIC HEAT | 460 [J/KgK] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 200°C) 10,0 [$10^{-6}K^{-1}$]<br>(20°- 400°C) 10,5 [$10^{-6}K^{-1}$]<br>(20°- 600°C) 12,0 [$10^{-6}K^{-1}$] |

### ROOM-TEMPERATURE MECHANICAL PROPERTIES

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 240$[N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 400 ÷ 630 [N/mm²] |
| ELONGATION | A 5% ≥ 20 |
| BRINELL HARDNESS | HB ≤ 200 |

# AISI 410

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN 10088/3 | (European norms) | X 12 Cr 13 |
| W. | (Germany) | 1,4006 |
| JIS | (Japan) | SUS 410 |
| AISI | (U.S.) | 410 |

## % INDICATIVE ANALYSIS

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,08÷0,15 | 1,5 | 0,04 | 0,015[a] | 1 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 11.5÷13.5 | 0,75max | - | - |

## DESCRIPTION

Martensitic stainless steel, ferromagnetic and quenchable. Quenching improves its mechanical properties.

## USES

Self-tapping screws; scissors; monobloc knives; gun barrels; metal measuring tapes; comparators; parts of micrometers and of measuring tools; reels for fishing lines; base plates for irons; protective grids for dams; details for petrochemical plants; cylinders for laminating copper; oven parts; burners; steam turbine vanes; parts of valves and pumps; flanges; cutlery.

## CORROSION RESISTANCE

Good resistance to average corrosive environments (atmospheric corrosion; sweet water; water vapour; crude oil; petrol; alcohol; ammonia; cold diluted organic acid solutions; food substances; organic solvents). Use in highly corrosive environments is not recommended. Corrosion resistance is at its best when this type of steel is quenched and tempered at low temperatures (150÷200°C).

# AISI 410

### OXIDATION RESISTANCE
Good resistance to scaling up to ±700°C in continuous service. In intermittent service, scaling occurs at ±800°C.

### WELDABILITY
Easily weldable, but it is advisable to pre-heat at 200°C at least. Post-welding annealing eliminates the brittleness of the weld bead.

### HEAT TREATMENT
Complete annealing 840÷870° with slow cooling. Isothermal annealing 830÷885° and slow, 6-hour cooling up to 705° followed by quick cooling in air or ventilated air. Machinability annealing at 730÷780° and quick air cooling. Quenching 930÷1010° and quick oil-air cooling. Tempering 550÷750°.

### PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 215.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 30 [W/mK] |
| SPECIFIC HEAT | 460 [J/KgK] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 200°C) 11,0 [$10^{-6}K^{-1}$]<br>(20°- 400°C) 12,0 [$10^{-6}K^{-1}$]<br>(20°- 600°C) 12,3 [$10^{-6}K^{-1}$] |

### ROOM-TEMPERATURE MECHANICAL PROPERTIES

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 276$[N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 730max [N/mm²] |
| ELONGATION | A 5% ≥ 35 |
| BRINELL HARDNESS | HB ≤ 220 |

# AISI 420

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN 10088/3 | (European norms) | X 30 Cr 13 |
| W. | (Germany) | 1,4028 |
| JIS | (Japan) | SUS 420 J2 |
| AISI | (U.S.) | 420 |

## % INDICATIVE ANALYSIS

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,26÷0,35 | 1,5 | 0,04 | 0,015[a] | 1 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 12÷14 | - | - | - |

## DESCRIPTION

Martensitic stainless steel, ferromagnetic and quenchable. With a suitable heat treatment, it can reach high hardness values and have a good tenacity at the same time.

## USES

Knife blades; surgical and odontological instruments; molds for plastic materials; shafts for pumps and valves; hand utensils (spanners for bolt nuts, screwdrivers, etc.); flanges; connectors.

## CORROSION RESISTANCE

Among martensitic stainless steels, type 420B has the best corrosion resistance when quenched and stress relieved at low temperatures, with mirror-polished surfaces. Only slightly less resistant than Type 410.

## OXIDATION RESISTANCE

Good resistance up to 620°C in continuous service, up to 735°C in intermittent service.

# AISI 420

### WELDABILITY

Must be welded with the utmost carefulness, due to its self-quenching characteristics. Must be pre-heated at 200÷250°C and annealed at 700÷750°C immediately after welding for 6-8 hours. This should be followed by air cooling.

### HEAT TREATMENT

Complete annealing ±870° with slow cooling. Isothermal annealing 830÷885° and slow, 2-hour cooling up to 705° followed by quick cooling in air or ventilated air. Machinability annealing at 750÷780°C and quick air cooling. Quenching 980÷1040° and quick oil-air cooling. Tempering at 550÷750°C.

### PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 215.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 30 [W/mK] |
| SPECIFIC HEAT | 460 [J/KgK] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 200°C) 11,0 [$10^{-6}K^{-1}$]<br>(20°- 400°C) 12,0 [$10^{-6}K^{-1}$] |

### ROOM-TEMPERATURE MECHANICAL PROPERTIES

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 345$[N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 800max [N/mm²] |
| ELONGATION | A 5% ≥ 25 |
| BRINELL HARDNESS | HB ≤ 245 |

# DUPLEX 22-05

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN | (European norms) | X 2 Cr Ni Mo N 22-5-3 |
| W. | (Germany) | 1,4462 |
| JIS | (Japan) | SUS 329 J3L |

## % INDICATIVE ANALYSIS

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,03 | 2 | 0,035 | 0,015 | 1 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 21÷23 | 4,5÷6,5 | 2,5÷3,5 | $0,10 \leq N \leq 0,22$ |

## DESCRIPTION

Duplex stainless steels are characterized by a two-phase microstructure, consisting of ferrite islands in an austenitic matrix – the two should have an equal volumetric percentage. This allows for steels with better mechanical properties as compared to standard stainless steels, as well as better resistance to pitting corrosion and stress corrosion.

## USES

Good mechanical resistance and corrosion resistance. Used for valve bodies and valve parts; pumps; centrifuges subject to severe corrosion environments; the chemical and petrochemical industry; offshore plants; the energy industry.

## OXIDATION RESISTANCE

Resistant to hot oxidation up to 1000°C. Precipitation and sigma-phase formation occur if steel is kept at the critical temperatures of 475°C and near 800°C for medium to long periods of time. In such cases, mechanical properties and corrosion resistance are decreased.

# DUPLEX 22-05

### CORROSION RESISTANCE
Better than that of Cr-Ni austenitic types, even in the presence of chlorides, and especially when corrosion is combined with mechanical tension (stress corrosion). Resistance is at its maximum when the alloy is at a solution heat treated state. Best used between -50°C and 250°C.

### WELDABILITY
Weldable with all standard tools. Use E329 as filler metal.

### HEAT TREATMENT
Solution heat treatment at 1040°C/water.

### PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 200.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 15 [W/mK] |
| SPECIFIC HEAT | 500 [J/KgK] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 200°C) 13,5 [$10^{-6}K^{-1}$]<br>(20°- 400°C) 14,0 [$10^{-6}K^{-1}$] |

### ROOM-TEMPERATURE MECHANICAL PROPERTIES AFTER RECRYSTALLIZATION

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 450$[N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 650÷880 [N/mm²] |
| ELONGATION | A 5% $\geq$ 25 |
| BRINELL HARDNESS | HB $\leq$ 270 |

# AISI 630

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN | (European norms) | X 5 Cr Ni Cu Nb 16-4 |
| W. | (Germany) | 1,4542 |
| JIS | (Japan) | SUS 630 |

## % INDICATIVE ANALYSIS

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,07 | 1,5 | 0,04 | 0,015[a] | 0,70 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 15÷17 | 3÷5 | 0,6max | 3≤Cu≤5; 5xC≤Nb≤0,45 |

## DESCRIPTION

Martensitic stainless steel enriched with Cr, Ni, Cu. Corrosion resistant. Thermal aging gives it tensility and superficial hardness.

## USES

All details subject to high strain in corrosive environments, in both the chemical and the motor industry. E.g.: valves for the petroleum industry; turbine valves; tension rods; tail shafts; turbine vanes; gears, bolts; springs; support cables to be used in sea water.

## CORROSION RESISTANCE

Similar to Type 304, if aged at temperatures higher than 550°C. Good resistance also in a sea water or sulphuretted environment. Do not use at solution heat treated state.

## WELDABILITY

Better than that of martensitic steels. No need to pre-heat. However, a post-welding heat treatment is advisable, for the fusion zone to gain properties comparable to those of the base metal.

# AISI 630

### HEAT TREATMENT

Solution heat treatment 1040°C water-air. Aging 480÷620°C (1 to 4 hours). Machinability annealing 620÷760°C (2 to 4 hours).

### PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 200.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 16 [W/mK] |
| SPECIFIC HEAT | 500 [J/KgK] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 200°C) 10,8 [$10^{-6}K^{-1}$]<br>(20°- 400°C) 11,6 [$10^{-6}K^{-1}$]<br>(20°- 600°C) 12,0 [$10^{-6}K^{-1}$] |

### ROOM-TEMPERATURE MECHANICAL PROPERTIES AFTER RECRYSTALLIZATION

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq$ 1000max (*) [N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 1270max (*) [N/mm²] |
| ELONGATION | A 5% 18max (*) |
| BRINELL HARDNESS | HB $\leq$ 360 |

(*): valori variabili in funzione del trattamento termico impiegato.

# AISI 940L

## INDICATIVE CORRESPONDENCE

| | | |
|---|---|---|
| EN | (European norms) | X 1 Ni Cr Mo Cu 25-20-5 |
| W. | (Germany) | 1,4539 |
| JIS | (Japan) | 2562 |

## % INDICATIVE ANALYSIS

| C | Mnmax | Pmax | Smax | Simax |
|---|---|---|---|---|
| 0,02 | 2 | 0,030 | 0,010 | 0,70 |

| Cr | Ni | Mo | Other elements |
|---|---|---|---|
| 19÷21 | 24÷26 | 4÷5 | N≤0,15; Cu=1,2÷2 |

## DESCRIPTION

Super inoxidable steel enriched with Ni-Cr-Mo-Cu, austenitic, resistant to pitting corrosion, stress corrosion and interstitial corrosion.

## USES

Reactors; distillation plants; pipes to be used for highly aggressive substances, such as sulphuric acid, phosphoric acid, nitro-hydrochloric acid, or acetic acid. High resistance to Cl ions.

## CORROSION RESISTANCE

Higher than that of the 316L series for all kinds of corrosion (pitting, interstitial, intergranular, stress corrosion).

## WELDABILITY

Easily weldable using materials of the same quality, or containing nickel alloys.

## HEAT TREATMENT

Solution heat treatment 1100°C in water.

# AISI 940L

## PHYSICAL PROPERTIES

| | |
|---|---|
| ELASTIC MODULUS | 195.000 [N/mm²] |
| THERMAL CONDUCTIVITY | 12 [W/mK] |
| SPECIFIC HEAT | 450 [J/KgK]<br>(20°- 200°C) 16,1 [$10^{-6}K^{-1}$] |
| COEFFICIENTS OF LINEAR EXPANSION | (20°- 400°C) 16,9 [$10^{-6}K^{-1}$]<br>(20°- 600°C) 17,5 [$10^{-6}K^{-1}$] |

## ROOM-TEMPERATURE MECHANICAL PROPERTIES AFTER SOLUTION HEAT TREATMENT

| | |
|---|---|
| YIELD POINT | $RP_{0,2} \geq 230$[N/mm²] |
| ULTIMATE TENSILE STRESS | Rm 530÷730 [N/mm²] |
| ELONGATION | A 5% $\geq$ 35 |
| BRINELL HARDNESS | HB $\leq$ 230 |