

Laboratory Technology

Materials of Construction **highpreactor**

Designation

| Trade name | DIN Mat. No. | UNS |
|------------------------------|--------------|--------|
| SS 316 TI | 1.4571 | |
| Hastelloy® C-4 (Alloy C-4) | 2.4610 | N06455 |
| Hastelloy® C-22 (Alloy C-22) | 2.4602 | N06022 |

Chemical Composition

| | Major Elements [%] | | | | | |
|-------------|--------------------|------|---|------|------|---------------|
| | Cr | Mo | W | Fe | Ni | Other |
| SS | 17.5 | 2.25 | - | 65.6 | 11.5 | Mn, C, Si |
| C-4 | 16 | 16 | - | 3 | 63.2 | Ti, Mn, C, Si |
| C-22 | 22 | 13 | 3 | 3 | 58 | V, Mn, C, Si |

Physical-chemical properties

Stainless steel (SS 316 TI)

Stainless steels are Iron-based alloys with at least 12% Chromium. Corrosion resistance is a function of composition, heat treatment, surface condition and fabrication. Chromium is the essential element in forming a passive film spontaneously with oxygen. Higher Chromium contents (maximum is approx. 30%) leads to improved passivation and corrosion resistance.

SS 316 TI is the material of choice for use with organic solvents or organic acids. This is the standard material in chemical engineering.

Only few acids and halides can attack this steel. Care is also necessary with halogen salts. Halides can cause cracking due to stress corrosion at temperatures above 100°C.

Hastelloy® C-4 and C-22

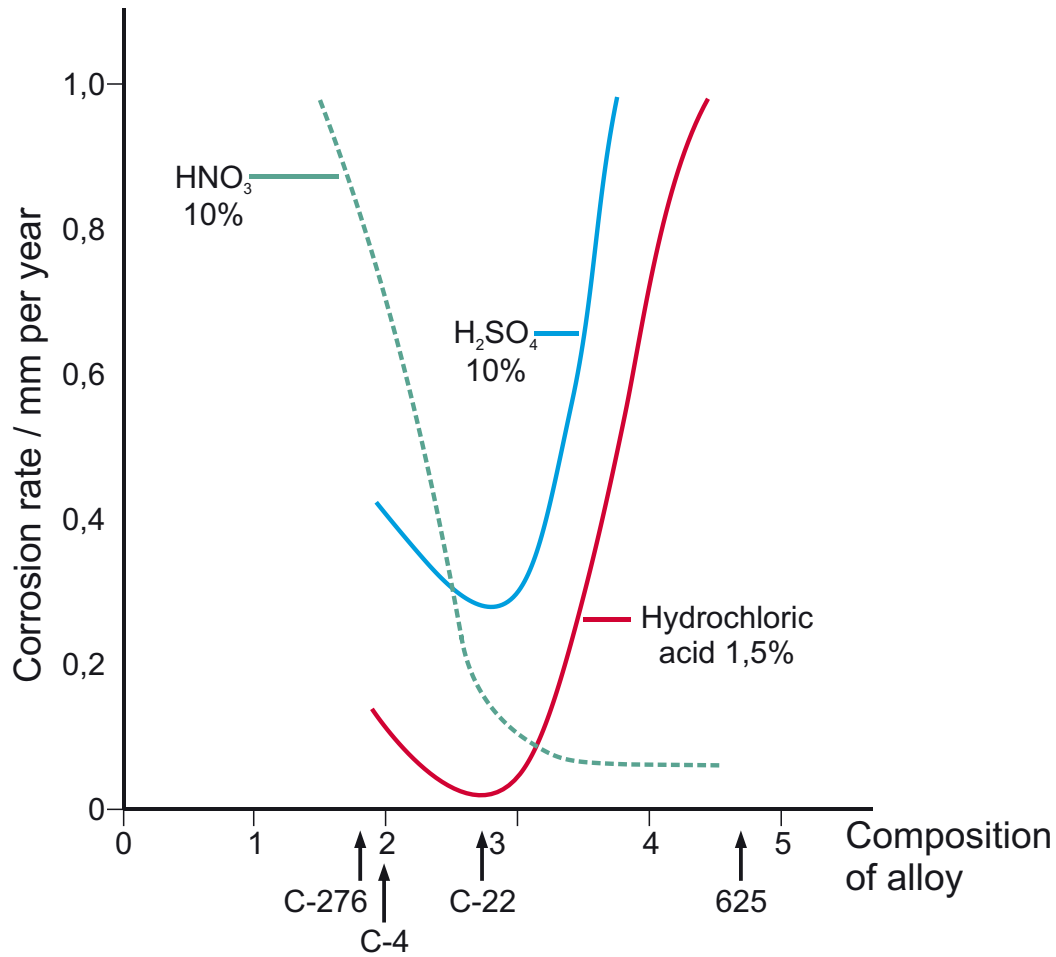
Hastelloy® C-4 and C-22 are both representatives of the highly corrosion resistant Nickel-Chromium-Molybdenum alloys with increased pitting and crevice corrosion resistance. The atomic composition of the relevant elements defines the corrosion rate (see diagramm, wherein composition of alloy = 4 Cr / (2 Mo + 1 W) with the stoichiometric ratio of the elements Cr, Mo and W).

A high resistance to oxidising acids is achieved at high and to reducing acids at low values. This shows clearly that C-22 has optimum corrosion resistance with respect to oxidising and reducing acids.

Hastelloy® C-4 and C-276 have virtually the same corrosion resistance.

Due to the broad chemical resistance, these alloys are second most important alloys, following SS 316 Ti, in chemical technology.

Materials of Construction **highpreactor**



Composition of alloy = $4 \text{ Cr} / (2 \text{ Mo} + 1 \text{ W})$ with stoichiometric ratio of the elements Cr, Mo and W.

Materials of Sealing **highpreactor**

Designation

| ISO Symbol | Trade names | Temperature Resistance |
|------------|---|--------------------------------------|
| PTFE | Lubriflon [®] , Teflon [®] , Hostaflon [®] , Fluon [®] | -200 to +260°C (short term 280°C) |
| FPM | Viton [®] (Flourel [®] , Tecnoflon [®]) | -20 to +200°C (short term 250°C) |
| FFKM | Kalrez [®] | -20 to +316°C |

Physical-chemical properties

PTFE

Polytetrafluorethylene (PTFE) is a linear, perfluorinated polymer with the following formula $-\text{CF}_2-\text{CF}_2\text{-}$. PTFE is far the most important fluoroplastic with exceptional properties:

- PTFE is temperature resistant between -200 and +260°C;
- PTFE is virtually universal resistant to chemicals. Care is only necessary with elementary fluorine, chlorine trifluoride, alkali metals (dissolved or molten) and fluorinated hydrocarbon. Hard (energetic) radiation decomposes PTFE;
- PTFE has an extremely low coefficient of friction, thus eliminating any stick/slip effect;
- PTFE is extremely anti-adhesive.

FPM (e.g. Viton[®])

FPM is a elastomeric fluor-rubber with outstanding chemical and thermal properties.

- FPM is temperature resistant between -20 and +200°C (short time +250°C);
- FPM has a good chemical resistance to chemicals. It is resistant to mineral, vegetable and animal oils, fuels, many alkaline solutions, acids and solvents.

FFKM (e.g. Kalrez[®])

FFKM is also a elastomeric fluor-rubber with extreme chemical and thermal properties.

- FFKM is temperature resistant between 20 and +316°C;
- FFKM has a superior chemical resistance to chemicals comparable with PTFE.

Chemical resistance of fluoroplastics

| | PTFE | TFM | PFA | FEP | ECTFE | PVDF | FPM FKM | FFPM FAKM |
|------------------------------|------|-----|-----|-----|-------|------|------------|--------------|
| Aldehydes | A | A | A | A | A | A | D | A |
| Alcohols | A | A | A | A | A | A | A/B | A |
| Amines | A | A | A | A | A | B | C | A |
| Bases/alkalis | A | A | A | A | A | A | B | A |
| Esters | A | A | A | A | A | B | D | A |
| Ethers | A | A | A | A | B | B | C | A |
| Glycols | A | A | A | A | A | A | A | A |
| Ketones | A | A | A | A | B | B | D | A |
| Hydrocarbons, aliphatic | A | A | A | A | A | A | A | A |
| Hydrocarbons, aromatic | A | A | A | A | A | A | A/B | A |
| Hydrocarbons, halogenated | A | A | A | A | A | A | B/C | B |
| Mineral oils | A | A | A | A | A | A | A | A |
| Oxidants, strong | A | A | A | A | B | A | A | A |
| Vegetable oils | A | A | A | A | A | A | A | A |
| Acids, inorganic | A | A | A | A | B | A | A | A |
| Acids, organic | A | A | A | A | B | A | A/B | A/B |
| Lubricants | A | A | A | A | B | A | A | A |

Chemical resistance of fluoroplastics against gases

| | PTFE | TFM | PFA | FEP | ECTFE | PVDF | FPM FKM | FFPM FAKM |
|-------------------------------|------|-----|-----|-----|-------|------|------------|--------------|
| O ₂ | A | A | A | A | A | A | A | A |
| CO/CO ₂ | | | | | | | A | A |
| H ₂ | A | A | A | A | A | A | A | A |
| CH ₄ | A | A | A | A | A | B | C | A |
| Supercritical CO ₂ | | | | | | | D | |

A = good resistance (virtually no or only slight attack)

B = limited resistance (moderate attack)

C = no resistance (strong attack)

D = partially dissolved (partially swollen or dissolved)



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