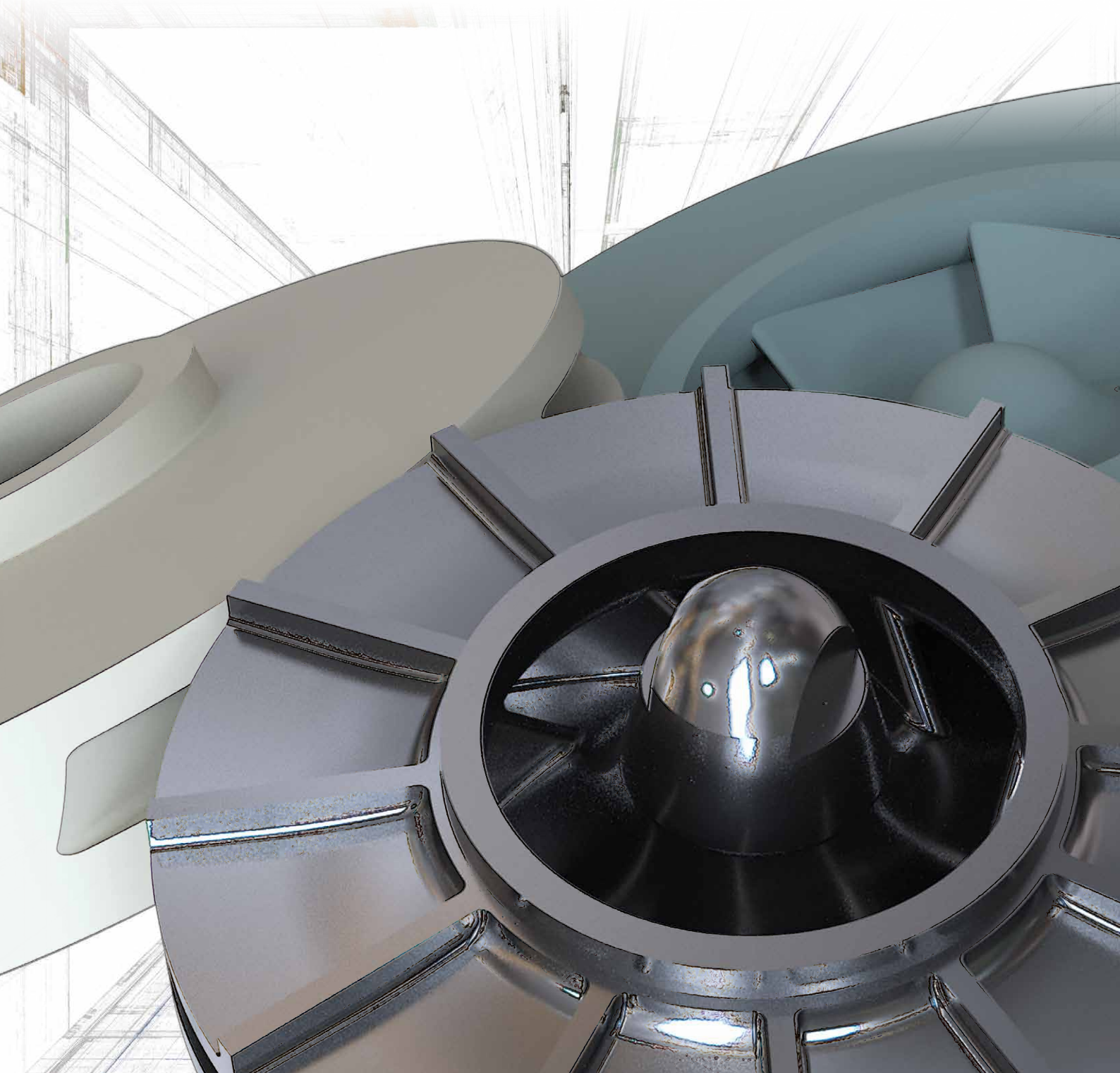


# Material Range

Metal, Plastic and Ceramic

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# Extensive Material Knowledge

Essential for a perfect, customized solution



Anyone looking for efficient, lasting and economical solutions for their demanding industrial conveyance. Applications need more than just a coherent technical concept. Our extensive materials and application knowledge, along with an open dialogue with the customer ultimately leads us to the optimal solution. These collaborative efforts, between Rheinhütte Pumpen and the customer have been the key to Rheinhütte's success for more than 160 years.

Through decades of continuous development of pump materials, Rheinhütte Pumpen provides fluid specific solutions that maximize material resistance. Rheinhütte Pumpen's expertise in materials goes beyond material selection and has led to successful, in-house material developments.

## Special materials for individual requirements

As experts in corrosion resistant materials we offer process and media-specific solutions. We will select the

right material for your conveyance requirement and will ensure minimum wear during long operational life – even when handling difficult media.

Our extensive pump program includes three groups of material: metals, plastics and ceramics.

**Metal** – Our range includes over 20 different metals. They differ from each other in terms of their alloying elements, their structure and their manufacturing process. As every alloy has its own characteristic properties, a suitable material can be used for each conveyance task.

**Plastic** – Plastics provide a good supplement to many areas of application. Our pumps are available in six different materials, each tailored to your specific application.

**Ceramic** – Ceramic materials achieve universal corrosion and abrasion resistance during long operational lives. For such applications Rheinhütte Pumpen offers you with Frikorund, a ceramic development optimised and proven for pump construction.

# Analysis and Recommendation

Our experts select the optimal materials for your application - taking into consideration all operating conditions and alternative solutions.

Expertise plays a crucial role in determining the best seal design and the appropriate pump selection.

Our materials specialists stay up to date on all things materials by communicating regularly with materials leaders at renowned institutes, universities and technical departments alike.

# Material Overview

## Metallic Materials

| Material                       | Designation<br>DIN [ASTM]                              | Properties and application                                                                                                                                                                                                                                                                                                                                                           |
|--------------------------------|--------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cast iron and cast steel       |                                                        |                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>1.0619</b>                  | GS-C 25<br>(GP 240 GH)<br>[A 216 WCA / WCB]            | High temperature ferritic cast steel, can be used up to 450 °C. For use with low or non-corrosive media, such as molten sulphur.                                                                                                                                                                                                                                                     |
| <b>1.7357</b>                  | GS-17CrMo 5 5<br>[A 216 WC 6]                          | High temperature ferritic cast steel, can be used up to 450 °C. The most frequent application is the pumping of molten salts.                                                                                                                                                                                                                                                        |
| <b>V5700</b>                   | G-X 260 CrMo 27 1<br>[A 532 Class 111 Typ<br>A 25% Cr] | Particularly wear resistant high alloy cast iron. This material is used for suspensions with an abrasive effect such as gypsum, carbonates, carbides, sand, ore or metal oxides.                                                                                                                                                                                                     |
| Silicon iron alloys            |                                                        |                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>SIGUSS</b>                  | G-X 90 SiCr 15 5<br>ASTM A518                          | Highly corrosion resistant chromium alloy silicon cast iron with a good resistance to wear and increased chemical resistance. This material is chemically resistant to H <sub>2</sub> SO <sub>4</sub> at all concentrations up to boiling point, therefore for all sulphuric acid applications including the evaporation of waste sulphuric acid, Siguss is virtually indispensable. |
| Pure metals                    |                                                        |                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Titanium</b><br>(3.7031)    | G-Ti 2<br>Titanium Grade 2                             | Titanium is especially resistant to heavily oxidising and chloride containing media. The material is preferred for use in chloralkali-electrolysis, bleaching solutions containing chlorine and in the manufacture of acetic acid.                                                                                                                                                   |
| <b>Titanium Pd</b><br>(3.7032) | 3.7032<br>TiPd Grade 7                                 | Titanium alloyed with palladium. This improves the corrosion resistance in reducing media, e.g. in solutions of iron chloride or aluminium chloride containing hydrochloric acid.                                                                                                                                                                                                    |
| <b>Nickel</b> (2.4170)         | G-Ni 95                                                | Nickel is mainly used for alkali evaporation, pumping molten alkalis and other highly refined alkalis that are not contaminated with iron ions.                                                                                                                                                                                                                                      |
| Nickel based materials         |                                                        |                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Alloy C1</b><br>(2.4686)    | G-NiMo 17 Cr                                           | Highly resistant nickel-base alloys for special applications such as liquids containing high chloride, hydrochloric acid, FGD liquids, heavily contaminated phosphoric acid, hypochlorites and solutions with oxidizing chlorides.                                                                                                                                                   |



| Material                       | Designation<br>DIN [ASTM]                                   | Properties and application                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------|-------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| High-alloy cast steel          |                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>1.4136S</b><br><b>RHRS</b>  | G-X 50 CrMo 29 2                                            | Corrosion and erosion resistant high alloy ferritic cast steel. Typical applications are highly concentrated sulphuric acid up to 225 °C, oleum, fertilizer production, crude phosphoric acid containing solids.                                                                                                                                                                                                                                   |
| <b>RHSX</b>                    |                                                             | Special high-alloyed material with excellent resistance to erosion-corrosion for pumps operating in the dryer-, intermediate- and end-absorber stage of sulphuric acid plants up to temperatures of 150 °C.                                                                                                                                                                                                                                        |
| <b>1.4306S</b>                 | 304L / A743 CF-3                                            | A specially developed material for the pumping of ammonium nitrate melt, hot nitric acid at medium concentrations and also the vaporization of waste nitric acid.                                                                                                                                                                                                                                                                                  |
| <b>1.4361</b>                  | G-X 2 CrNiSi 18 15 4<br>[ANTINIT A610]                      | Low carbon silicon alloy material for pumping strongly oxidizing media. Particularly suitable for hot highly concentrated nitric acid, e.g. 98 % HNO <sub>3</sub>                                                                                                                                                                                                                                                                                  |
| <b>1.4408</b><br><b>1.4581</b> | G-X 6 CrNiMo 18 10<br>316 (316 Nb)<br>[A 743 CF-8 M]        | Austenitic chromium nickel molybdenum steels with good general corrosion resistance. These materials are suitable for pumping almost all organic liquids, 50 % caustic soda up to 90 °C, KTL paint, pure phosphoric acid, dry chlorine, liquid sulphur, PTA and many other media.                                                                                                                                                                  |
| <b>1.4463</b>                  | G-X 6 CrNiMo 24 8 2                                         | Semi-austenitic, easily welded material with an increased strength and a good general resistance to corrosion. Due to good welding properties and wear resistance it is frequently used for jacketed pumps for handling melts containing solids, such as pitch and tar.                                                                                                                                                                            |
| <b>1.4517</b>                  | G-X 5 CrNiMoCu 25<br>6 3 3 ~ [A 743<br>CD 4 MCuN]           | Duplex (Semi-austenitic), molybdenum and copper alloyed material with a high resistance to pitting and stress corrosion. This material is one of the super duplex steels. It can be used with crude phosphoric acid, containing solids at up to 100 °C, hot sea water, many solutions containing chloride, FGD suspensions and sulphuric acid at all concentrations at low temperatures.                                                           |
| <b>R3020</b>                   | G-X 3 NiCrMoCu 30<br>25 4<br>Alloy 20 < R3020 <<br>Alloy 28 | Fully austenitic special stainless steel with a high of chrome and nickel content. High resistance to pitting, stress corrosion and intercrystalline corrosion. Suitable for 70 % caustic soda up to 200 °C, sulphuric acid at all concentrations at low and medium temperatures, sulphuric acid pickling solutions, in certain areas of the manufacture of phosphoric acid, for pumping solutions with a high chloride content and in spin baths. |
| <b>1.4529S</b>                 | G-X 3 NiCrMoCu 25<br>20 6<br>Alloy 926                      | A fully austenitic cast material highly resistant to acidic media containing solids and rich in chlorides. Used in absorber and quench fluids of the FGD, acidic and chloride containing gypsum slurries, phosphoric acid production, in vaporization and crystallization processes and for hot sea water.                                                                                                                                         |
| <b>1.4652S</b>                 | GX2 CrNiMoCuN<br>24-22-8                                    | Higher austenitic cast material with extremely high corrosion resistance, especially in corrosive phosphoric acid containing solids.                                                                                                                                                                                                                                                                                                               |

## Metallic materials according to US standards

| ASTM-/ US-Code                                 | UNS code           | Composition                   | Rheinhütte Code | Similar to Rheinhütte               |
|------------------------------------------------|--------------------|-------------------------------|-----------------|-------------------------------------|
| Ironbased materials                            |                    |                               |                 |                                     |
| <b>304L A743 CF-3</b>                          | S30 403            | GX2 CrNi 19 11                | 1.4306S         |                                     |
| <b>ANTINIT A610</b>                            | S30 600            | GX2 CrNiSi 18 15 4            | 1.4361- R4Si    |                                     |
| <b>316 A 743 CF-8M</b>                         | J92 900            | GX5 CrNiMo 19 11 2            | 1.4408          |                                     |
| <b>316 Ti</b>                                  | S31 635            | X6 CrNiMoTi 17 12 2           | 1.4571          |                                     |
| <b>904L</b>                                    | N08904             | X1 NiCrMoCu 25 20 5           | 1.4539          | R3020                               |
| <b>321</b>                                     | S32100             | X6 CrNiTi18-10                | 1.4541          |                                     |
| <b>A890 Grade 1B or A743 CD4MCuN</b>           | J93 371 / J93 372  | GX2 CrNiMoCuN 25 6 3 3        | 1.4517          | HA28.5†                             |
| <b>SAF 2205 (Typ F51)</b>                      | S39 209            | X2 CrNiMoN 22 5 3             | 1.4462          |                                     |
| <b>Alloy 926 CN-3MN</b>                        | N08926, J94651     | GX2 NiCrMoCuN 25-20-6         | 1.4529S         |                                     |
| <b>Alloy 20 A 743 CN7M</b>                     | N08020             | GX3 NiCrMoCu 30 25 4 2        | R3020           | better than Alloy 20!               |
| <b>Alloy 28</b>                                | N08028             | X1 NiCrMoCu 31-27-4           |                 |                                     |
| <b>Alloy 31</b>                                | N08031             | X1 NiCrMoCu 32-28-7           |                 |                                     |
| <b>SX</b>                                      | Comparable S30 601 | GX6 NiCrSiCu 20-18-5          | RHSX            | RHSX is a cast material             |
| <b>A 518 (ASTM)</b>                            | No UNS code        | GX90 SiCr 15 5                | Siguss          |                                     |
| <b>654 SMO</b>                                 | S32 654            | GX2 CrNiMoCuN24-22-8          | 1.4652S         |                                     |
| <b>A 217 (WC11)</b>                            | J11 872, J12 072   | G17 CrMo 5 5                  | 1.7357          |                                     |
| <b>Cast steel A216 (WCB)</b>                   | J03 002            | GP240 GH                      | 1.0619          |                                     |
| <b>Uranus B6 904L</b>                          | N08904             | X1 NiCrMoCu 25 20 5           | 1.4539          | R3020                               |
| Higher alloys                                  |                    |                               |                 |                                     |
| <b>Alloy C1</b>                                | N26455             | G-NiMo 17 Cr                  | 2.4686          |                                     |
| <b>Alloy C22</b>                               | N06022             | NiCr 21 Mo14 W                | 2.4602          |                                     |
| <b>Alloy B1</b>                                | N30007             | G - NiMo 28                   | 2.4685          |                                     |
| <b>Inconel 600</b>                             | N06040             | G - NiCr15 Fe                 | 2.4816          |                                     |
| <b>A 494 Grade CZ100</b>                       | N02100             | G-Ni 95                       | 2.4170          | Nickel or RH Ni 98                  |
| <b>Titanium Grade 2</b>                        | R52550             | G- Ti 99                      | 3.7031          | Titan casting material              |
| Special materials                              |                    |                               |                 |                                     |
| <b>A217 WC 6, A217 WC 11</b>                   | J12072, J11872     | GX 17 CrMo 5 5                | 1.7357          | For high temperature application    |
| <b>SS 316 Nb, CF-8M (ACI)</b>                  | J92900             | GX5CrNiMoNb 19-11-2           | 1.4581          | Weldable cast stainless steel       |
| <b>ASTM A532 75<sup>a</sup>, (IIIA) 25% Cr</b> | No UNS             | GX 260 Cr 27                  | V5700           |                                     |
| <b>No US code</b>                              | No UNS             | GX6 CrNiMo 24-8-2             | 1.4463          | Duplex material                     |
| <b>No US code</b>                              | No UNS             | Cast iron with nickel         | GG-N3           | Special cast iron                   |
| <b>A53 A / A234 WPA</b>                        | No UNS             | Steel type P235 G1TH / St35.8 | 1.0305          |                                     |
| <b>A576 Grade 1045</b>                         | No UNS             | Steel C45 / C45+SH            | 1.0503          | Shaft steel                         |
| <b>Screws in 304</b>                           | No UNS             | Cr Ni 18 10                   | A2-70           | Screws, nuts and bolts material     |
| <b>Screws in 316</b>                           | No UNS             | Cr Ni Mo 18 10                | A4-70           |                                     |
| <b>No US code</b>                              | No UNS             | X22CrMoV 12-1                 | 1.4923          |                                     |
| <b>AISI 660, ASTM A 638-10</b>                 | S66286             | X6NiCrTiMoVB, 25-15-2         | 1.4980          | Shaft material for high temperature |
| <b>1045 SAE,1043 AISI</b>                      | G10450, G10430     | Low alloyed steel             | 1.0503          | Shaft material                      |
| <b>ASTM A105</b>                               | K03504             | P250GH                        | 1.0460          |                                     |
| <b>AISI 420</b>                                | S42000             | X46 Cr 13                     | 1.4034          |                                     |

No guarantee for correct allocation.

## Plastics

| Material                                    | Properties and application                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Polyolefins</b>                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>PP</b><br>Polypropylene                  | In many applications PP represents an economical alternative to high grade metallic materials. This material is suitable for pumping salt solutions, almost all dilute alkalis and acids and is also frequently used in hydrochloric acid pickling solutions. It can be used for working temperatures between 0 °C and 100 °C.                                                                                                                   |
| <b>PE 1000</b><br>Polyethylene<br>UHMW-PE   | Ultra high molecular low pressure polyethylene is used exclusively. Suitable for temperature ranges between -50 °C and 80 °C. Its general resistance to corrosion sometimes exceeds that of PP. Due to its very high resistance to wear, centrifugal pumps made of PE are often used for media which have corrosive and abrasive properties, as found in waste gas scrubbing plants.                                                             |
| <b>PE 1000R</b><br>Polyethylene             | PE 1000R is a further development of the standard polyethylene PE 1000 with wear-reducing additives for up to 20 % higher resistance – for use in highly abrasive suspensions with process-critical solids content. The material can be used at temperatures from -50 °C to +80 °C.                                                                                                                                                              |
| <b>Fluoropolymers</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>PVDF</b><br>Polyvinylidene-<br>Fluoride  | PVDF is distinguished by its excellent general corrosion resistance. Its high resistance to stress cracks and its ability to resist UV. For temperature ranges between -20 °C and 130° C. This material is particularly suitable for the pumping of hydrofluoric acid at all concentrations up to boiling point, liquids containing halogens, nitric / hydrofluoric acid pickling solutions, and for the evaporation of waste hydrochloric acid. |
| <b>PFA</b><br>Perfluoralkoxi                | PFA is a perfluorinated alkyl vinyl ether ether. Centrifugal pumps lined with PFA can be used up to 180 °C. With a few exceptions this material has a universal resistance to chemicals.                                                                                                                                                                                                                                                         |
| <b>PTFE</b><br>Polytetrafluoro-<br>ethylene | PTFE shows an outstanding resistance against nearly all organic and inorganic media over a wide temperature range. Centrifugal pumps made of PTFE can be used between -50 °C and 180 °C.                                                                                                                                                                                                                                                         |

## Ceramics

| Material         | Properties and application                                                                                                                                                                                                                                                                                                                                                           |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>FRIKORUND</b> | A silicate ceramic material with very high wear resistance due to its high corundum content. It can be used up to 120 °C. With the exception of strong, concentrated or hot alkalis, hydrofluoric acid and liquids containing fluoride, FRIKORUND can be used in all aqueous media. This material proved suitable eg. in solid-containing pickling liquor with elevated temperature. |

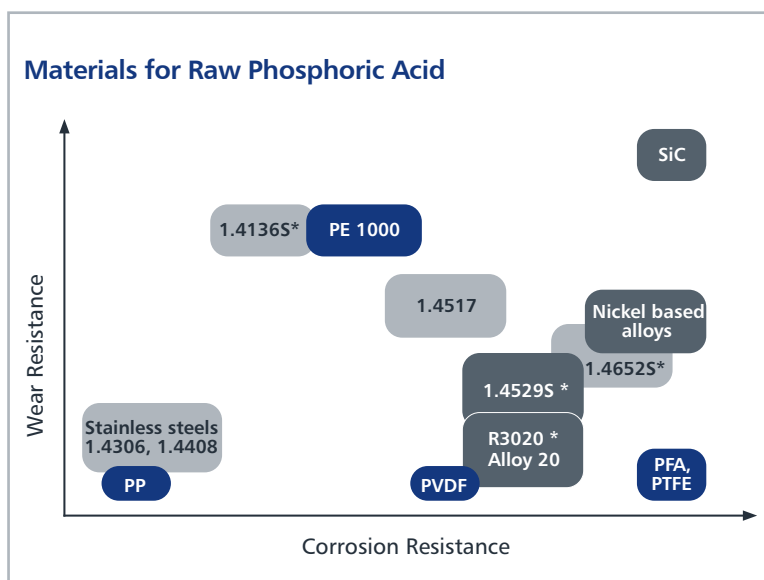
# Phosphoric Acid

The material must be extremely wear-resistant and durable



Phosphates are important parts of agricultural fertilizers. They are obtained from phosphoric acid as an intermediate product. In order to obtain phosphoric acid, phosphate containing minerals are often digested with sulphuric acid. This process produces extremely corrosive mixtures containing varied chlorides and fluorides as well as phosphoric and sulphuric acids. In addition, a large number of solids are obtained in form of gypsum and sand. Due to the chlorides and fluorides high grade steels have to be used for metallic materials. A material for this process must have superior wear and corrosion resistance.

Because there is no all-purpose material, detailed knowledge of the composition of media as well as material expertise are important to design pumps with long operational life in process.



## Material Selection

### 1.4136S

Excellent wear resistance

### 1.4517 (CD4MCuN)

High wear resistance and good corrosion resistance

### R3020 (904L)

Very high corrosion resistance

### 1.4529S (Alloy 926)

Very high corrosion resistance and wear resistance

### 1.4652S (654 SMO)

Excellent corrosion resistance and very good wear resistance

### Alloy C1 (2.4686)

Excellent corrosion resistance and wear resistance

# Sulphuric Acid

Material must be corrosion and erosion resistant

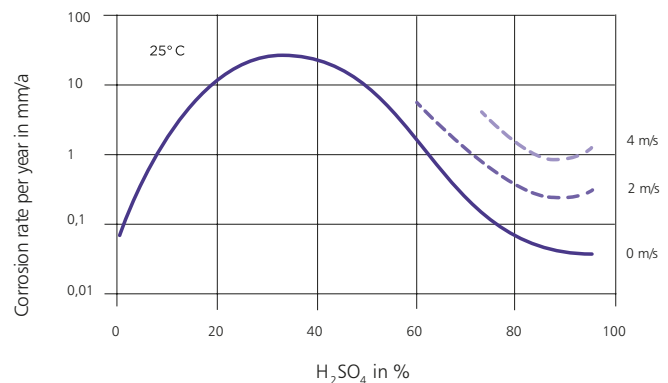


Common standard materials are not resilient enough handle the corrosive and erosive properties presented by sulphuric acid.

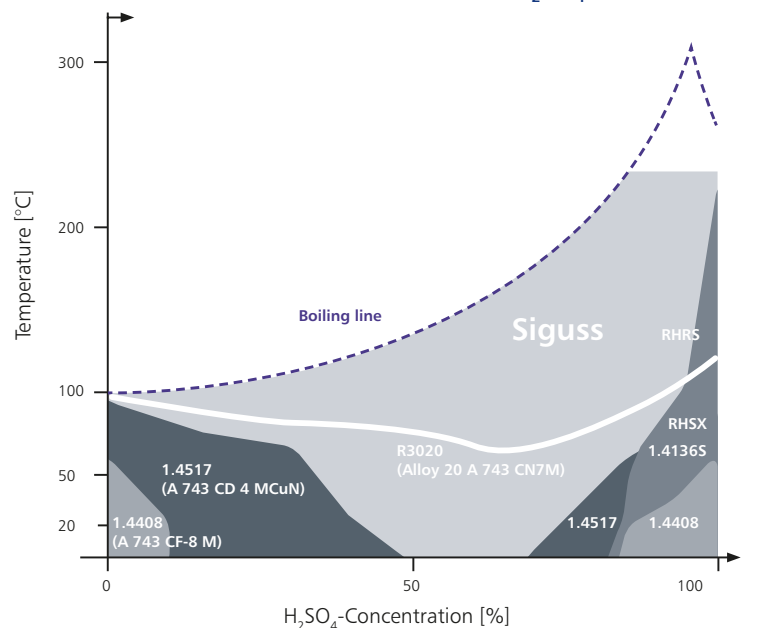
Sulphuric acid can be handled with pumps made of metal or plastic. SIGUSS, our silicon cast iron material, is suitable for nearly all concentrations and temperatures of sulphuric acid is the only metallic pump material that can be used.

For highly concentrated sulphuric acid, stainless steel alloys are especially suitable because of their oxidative properties, as they form a passive layer for corrosion protection.

**Influence of flow rate of  $H_2SO_4$  on the corrosion rate for 1.4408**

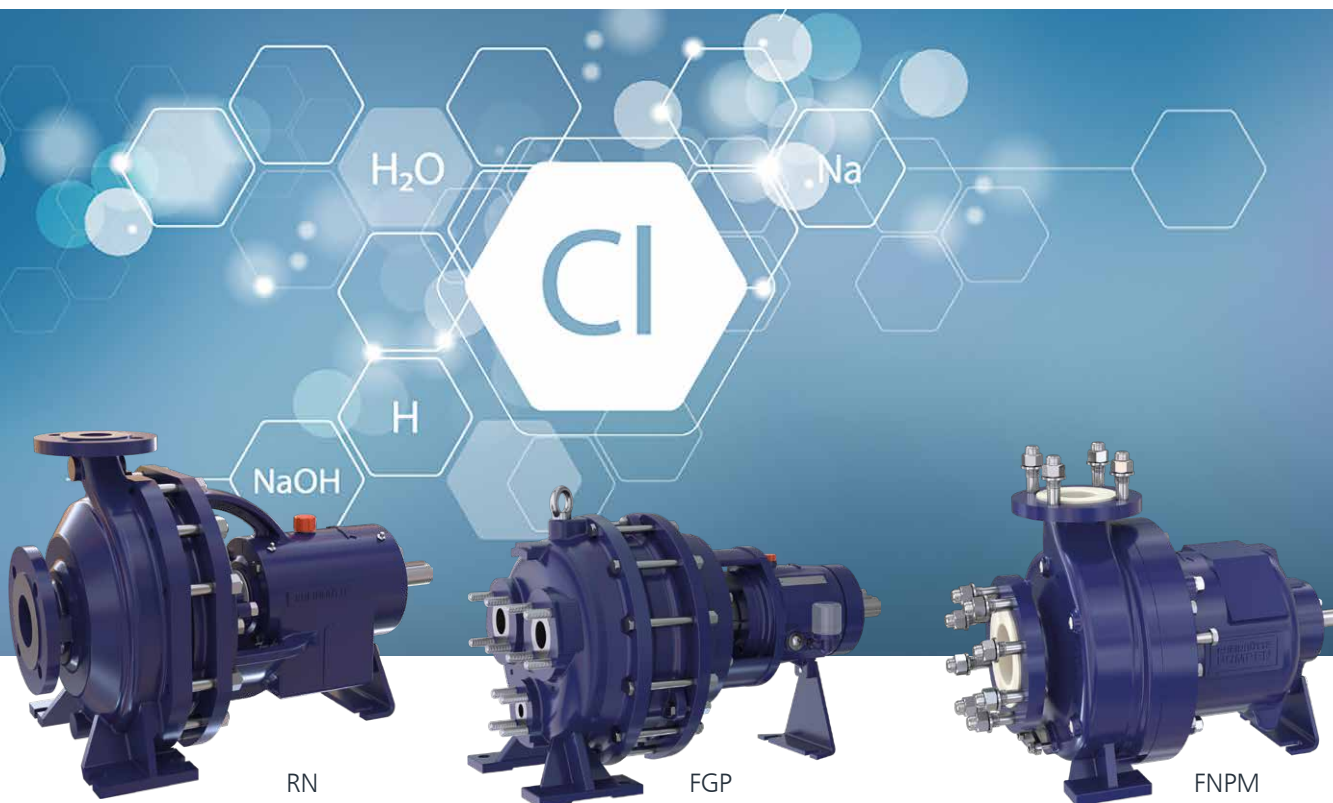


**ISO Corrosion diagram for materials in  $H_2SO_4$**



# Chloralkali Electrolysis

This aggressive application demands a corrosion resistant material



When it comes to pumping catholyte solutions (NaOH, 80°C) – to protect the electrolysis membranes from Fe-ions – only pure, iron-free pump materials can be considered for use. Rheinütte Pumpen successfully uses centrifugal pumps made of nickel, PFA or PTFE.

On the anolyte side, identical pumps made from titanium, titanium-palladium or PTFE complement our range. The pumping of wet chlorine gas presents high demands on the corrosion resistance of all of the components.

Solid ceramic liquid ring vacuum pumps have proved their worth for many decades and offer an unique alternative to special pumps made from titanium.

Sulphuric acid is used to dry the wet chlorine gas. At this point, due to the dry chlorine gas in the sulphuric acid, even titanium is not a suitable material. Rheinütte Pumpen's very own SIGUSS (silicon cast iron) material, as well as PTFE and PFA materials guarantee long centrifugal pump service life.

| Medium                                                                            | Materials                                                           |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------|
| 310 g/l NaCl – Brine – Chlorine free – Raw brine / Purified brine / Diluted brine | 1.4517, R 3020, 1.4529S, Titanium, TiPd<br>PTFE, PFA, PVDF, PE 1000 |
| Chlorine containing brine 200g/l NaCl                                             | Titan, TiPd<br>PTFE, PFA, PVDF                                      |
| Catholyte – 31% NaOH Caustic soda                                                 | Nickel (2.4170)<br>PTFE, PFA                                        |
| Hot Catholyte – 31% NaOH Caustic soda                                             | Nickel, Super austenite (R3020)<br>PTFE, PFA                        |
| Cold caustic soda NaOH                                                            | Super austenite (R3020)<br>PTFE, PFA, PE 1000, PP                   |
| Moist chlorine gas                                                                | FRIKORUND<br>SIGUSS<br>PTFE, PFA                                    |
| Chlorine containing sulphuric acid                                                |                                                                     |
| Liquefied chlorine gas                                                            | Austenite (1.4408)                                                  |

# Steel and Stainless Steel Pickling

Plastics are the perfect materials for this application



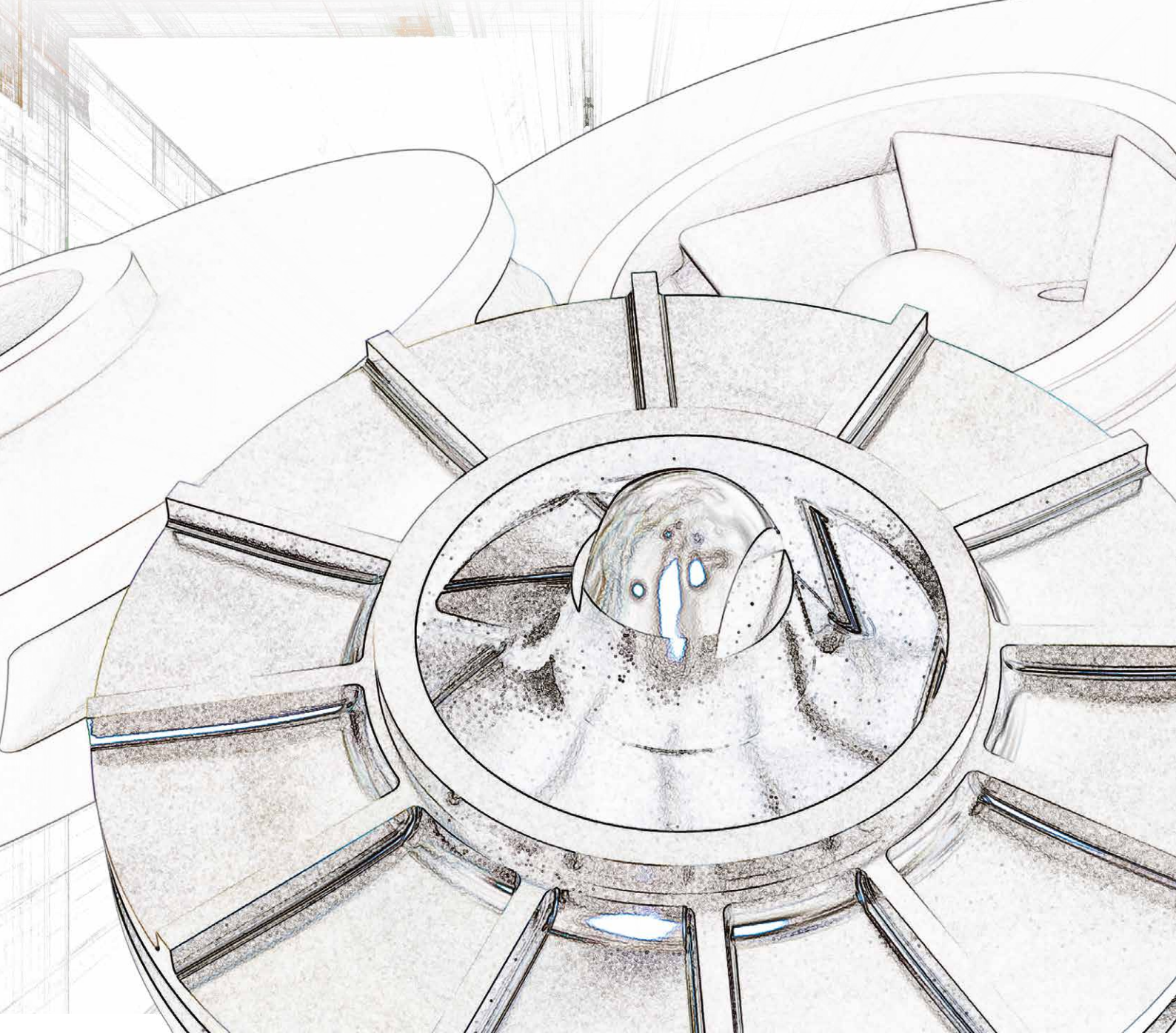
Plastics such as PP or PE 1000 have proven themselves as suitable materials, especially in steel pickling applications. In recent applications many consider these plastics the new standard for these types of applications. PE and PE 1000 show no sensitivity to pH values or chloride concentrations. Even pure hydrochloric acid can be handled with these plastics.

In solid-containing pickling PE 1000 (UHMW-PE) is the most appropriate material. In very aggressive pickling applications containing hydrofluoric acid or many fluorides, PVDF proves to be an excellent choice.

Rheinhütte plastic pumps for aggressive media can be made of solid PTFE or plastic lined with PFA. All plastics can also be used in electrical conductive quality for Rheinhütte pumps.



| Medium                                             | FRIKOR-UND  | PP                              | PE 1000                                                           | PVDF                            | PFA/PTFE             |
|----------------------------------------------------|-------------|---------------------------------|-------------------------------------------------------------------|---------------------------------|----------------------|
| HCl-Steel Pickling                                 | up to 120°C | 33% up to 100°C                 | 33% up to 80°C                                                    | up to 120°C resistant           | over 120°C resistant |
| H <sub>2</sub> SO <sub>4</sub> -Steel Pickling     | up to 120°C | 50% up to 100°C max. 75% at AT  | 80% up to 80°C max. 97% at AT                                     | 60% up to 120°C max. 97% bei RT | over 100°C resistant |
| HNO <sub>3</sub> / HF-Stainless Steel Pickling     | –           | max. 10% HNO <sub>3</sub> at AT | max. 20% HNO <sub>3</sub> or 15% HNO <sub>3</sub> + 5% HF at 60°C | max. 65% HNO <sub>3</sub> at AT | over 100°C resistant |
| Na <sub>2</sub> SO <sub>4</sub> -Electro-polishing | resistant   | resistant                       | resistant                                                         | resistant                       | resistant            |



— An ITT Brand

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