

# Alkaline solutions, anorganic acids, organic acids and water

|                           |   | immersion heaters |    |    |    |    |    |     | flat immersion heaters |     |                    |     |   | float switches |     |   |   |   |     |     |     |   |    |   |
|---------------------------|---|-------------------|----|----|----|----|----|-----|------------------------|-----|--------------------|-----|---|----------------|-----|---|---|---|-----|-----|-----|---|----|---|
|                           |   |                   |    |    |    |    |    |     | heating rods           |     | temperature probes |     |   | level probes   |     |   |   |   |     |     |     |   |    |   |
| <b>Process Solution</b>   |   | PS                | TG | QS | KB | SB | TI | FC  | KS                     | FK  | FC                 | PFA | F | L              | B   | G | M | F | L   | B   | K   | T | HC |   |
| <b>Alkaline Solutions</b> | Ammonium hydroxide (NH <sub>4</sub> OH)   | -                 | -  | -  | +  | 0  | +  | +   | +                      | +   | +                  | +   | + | -              | +   | + | + | + | -   | +   | +   | + | +  |   |
|                           | Potassium hydroxide, with water (KOH)   | -                 | -  | -  | +  | 0  | +  | +   | +                      | +   | +                  | +   | + | -              | +   | + | + | + | -   | +   | +   | 0 | +  |   |
|                           | Sodium hydroxide, with water (NaOH)   | -                 | -  | -  | +  | 0  | +  | +   | +                      | +   | +                  | +   | + | -              | +   | + | + | + | -   | +   | +   | 0 | +  |   |
| <b>Inorganic Acids</b>    | Hydrofluoric Acid (HF)  | -                 | -  | -  | -  | -  | -  | +/0 | -                      | +   | +/0                | +   | - | +              | -   | + | + | - | +   | -   | +   | - | 0  |   |
|                           | Aqua Regia (3HCl + HNO <sub>3</sub> )   | +                 | +  | +  | -  | -  | 0  | 0   | -                      | +   | 0                  | +   | - | 0              | -   | + | + | - | 0   | -   | 0   | 0 | -  |   |
|                           | Mixed Acid (HNO <sub>3</sub> /H <sub>2</sub> SO <sub>4</sub> /H <sub>2</sub> O)         | +                 | +  | +  | -  | -  | -  | +   | 0                      | +   | +                  | +   | - | 0              | -   | + | + | - | 0   | -   | +   | 0 | +  |   |
|                           | Oleum (concentrated sulphuric acid)   | +                 | +  | +  | -  | -  | -  | 0   | -                      | 0   | 0                  | 0   | - | -              | -   | - | + | - | -   | -   | -   | - | -  |   |
|                           | Phosphoric acid (H <sub>3</sub> PO <sub>4</sub> )                                       | 0                 | -  | -  | 0  | -  | -  | +   | 0                      | +   | +                  | +   | + | +              | 0   | + | + | + | +   | 0   | +   | + | -  | 0 |
|                           | Nitric acid (HNO <sub>3</sub> )   | +                 | +  | +  | 0  | -  | +  | +   | 0                      | +   | +                  | +   | - | +              | 0   | + | + | - | +   | 0   | +   | + | -  | - |
|                           | Hydrochlorid acid (HCl); <10%   | +                 | +  | +  | -  | -  | -  | +   | -                      | +   | +                  | +   | + | +              | -   | + | + | + | +   | -   | +   | - | -  |   |
|                           | Hydrochlorid acid (HCl); >10%   | +                 | +  | +  | -  | -  | -  | 0   | -                      | 0   | 0                  | 0   | - | +              | -   | 0 | 0 | - | +   | -   | 0   | - | -  |   |
|                           | Sulphuric acid (H <sub>2</sub> SO <sub>4</sub> )  | +                 | +  | +  | -  | -  | -  | +   | 0                      | +   | +                  | +   | - | +              | -   | + | + | - | +   | -   | +   | - | -  |   |
| <b>Organic Acids</b>      | Formic acid (HCOOH)   | +                 | 0  | +  | -  | -  | -  | +/0 | 0                      | +/0 | +/0                | +/0 | - | +              | -   | + | + | - | +   | -   | +/0 | - | -  |   |
|                           | Benzoic Acid (C <sub>6</sub> H <sub>5</sub> COOH)                                       | +                 | +  | +  | +  | -  | +  | +   | +                      | +   | +                  | +   | + | +              | +   | + | + | + | +   | +   | +   | + | +  |   |
|                           | Acetic acid (CH <sub>3</sub> COOH)  | +                 | +  | +  | +  | -  | +  | +   | +                      | +   | +                  | +   | + | +/0            | +/0 | + | + | + | +/0 | +/0 | +   | + | +  |   |
|                           | Lactic acid (CH <sub>3</sub> CHO · COOH)  | +                 | +  | +  | 0  | -  | +  | +   | +                      | +   | +                  | +   | + | 0              | 0   | + | + | + | 0   | 0   | +   | + | +  |   |
|                           | Oxalic acid (C <sub>2</sub> O <sub>4</sub> H <sub>2</sub> · 2H <sub>2</sub> O)          | +                 | +  | +  | -  | -  | -  | +   | -                      | +   | +                  | +   | + | 0              | -   | + | + | + | 0   | -   | +/0 | - | +  |   |
|                           | Tartaric acid (C <sub>4</sub> H <sub>6</sub> O <sub>6</sub> )                           | +                 | +  | +  | 0  | -  | +  | +   | 0                      | +   | +                  | +   | + | +              | 0   | + | + | + | +   | 0   | +   | + | 0  |   |
|                           | Citric acid (C <sub>3</sub> H <sub>4</sub> (OH) (COOH) <sub>3</sub> · H <sub>2</sub> O) | +                 | +  | +  | +  | -  | 0  | +   | +                      | +   | +                  | +   | + | +              | +   | + | + | + | +   | +   | +   | 0 | +  |   |
| <b>Water</b>              | Tap-water   | +                 | +  | +  | +  | 0  | +  | +   | +                      | +   | +                  | +   | + | +              | +   | + | + | + | +   | +   | +   | + |    |   |
|                           | Seawater  | +                 | +  | +  | -  | -  | +  | +   | 0                      | +   | +                  | +   | + | +              | -   | + | + | + | +   | -   | +   | + |    |   |
|                           | Distilled water, deionized (H <sub>2</sub> O)   | +                 | +  | +  | 0  | -  | +  | +   | +                      | +   | +                  | +   | + | +              | 0   | + | + | + | +   | Δ   | Δ   | Δ | Δ  |   |
|                           | Rinsing water, contamin. with alkaline (halogen-free)                                   | 0                 | 0  | 0  | +  | -  | +  | +   | +                      | +   | +                  | +   | + | 0              | +   | + | + | + | 0   | Δ   | Δ   | Δ | Δ  |   |
|                           | Rinsing water, contamin. with acids (fluoride-free)                                     | +                 | +  | +  | 0  | -  | 0  | +   | 0                      | +   | +                  | +   | + | +              | 0   | + | + | + | +   | Δ   | Δ   | Δ | Δ  |   |
|                           | Rinsing water, contaminated with fluoride   | 0                 | 0  | 0  | -  | -  | -  | +   | 0                      | +   | +                  | +   | + | +              | -   | + | + | + | +   | Δ   | Δ   | Δ | Δ  |   |

## Bewertungssymbole

+ ..... recommended  
 + ..... very good  
 0 ..... moderate  
 - ..... not suitable

Δ ..... general evaluation  
 not possible  
 please enquire

# Degreasing solutions, Electrolytes, Autocatalytic electrolytes

|  |   | immersion heaters |    |    |    |    |    |    | flat immersion heaters |    |                    |     |   | float switches |   |   |   |   |   |   |   |   |    |   |
|--|---|-------------------|----|----|----|----|----|----|------------------------|----|--------------------|-----|---|----------------|---|---|---|---|---|---|---|---|----|---|
|  |   |                   |    |    |    |    |    |    | heating rods           |    | temperature probes |     |   | level probes   |   |   |   |   |   |   |   |   |    |   |
|  | Process Solution  | PS                | TG | QS | KB | SB | TI | FC | KS                     | FK | FC                 | PFA | F | L              | B | G | M | F | L | B | K | T | HC |   |
| <b>Degreasing Solutions</b>                    | Acid (fluoride-free)  | +                 | +  | +  | -  | -  | -  | +  | -                      | +  | +                  | +   | + | +              | - | + | + | 0 | 0 | - | + | - | -  |   |
|  | Alkaline (halogen-free)   | -                 | -  | -  | +  | 0  | +  | +  | +                      | +  | +                  | +   | + | -              | + | + | + | 0 | - | + | + | + | +  |   |
| <b>Electrolytes</b>                            | Lead bath (fluoroborate)  | -                 | -  | -  | -  | -  | -  | +  | 0                      | +  | +                  | +   | + | +              | - | + | + | + | + | - | + | - | +  |   |
|  | Chromium bath (H <sub>2</sub> SO <sub>4</sub> ) <sup>1)</sup>       | +                 | +  | +  | -  | -  | +  | +  | 0                      | +  | +                  | +   | - | +              | - | + | + | - | + | - | + | 0 | 0  |   |
|  | Chromium bath (mixed acids, cont. fluoride)                         | 0                 | 0  | 0  | -  | -  | -  | +  | -                      | +  | +                  | +   | - | +              | - | + | + | - | + | - | + | - | 0  |   |
|  | Iron bath (FeCl <sub>2</sub> · 4 H <sub>2</sub> O) <sup>1)</sup>    | +                 | +  | +  | -  | -  | 0  | +  | +                      | +  | +                  | +   | + | +              | - | + | + | + | △ | △ | - | + | +  | + |
|  | Iron bath (FeSO <sub>4</sub> or Fe(BF <sub>4</sub> )) <sup>1)</sup> | 0                 | 0  | 0  | -  | -  | -  | +  | 0                      | +  | +                  | +   | + | +              | - | + | + | + | △ | △ | - | + | -  | 0 |
|  | Gold bath, cyanide <sup>1)</sup>                                    | 0                 | 0  | 0  | +  | -  | 0  | +  | +                      | +  | △                  | +   | + | 0              | + | + | + | + | + | + | 0 | + | +  | 0 |
|  | Gold bath, acid   | +                 | +  | +  | -  | -  | -  | △  | -                      | +  | △                  | +   | + | +              | - | + | + | + | + | + | - | + | -  | 0 |
|  | Copper bath, cyanide <sup>1)</sup>                                  | 0                 | 0  | 0  | +  | -  | 0  | +  | +                      | +  | +                  | +   | + | +              | - | + | + | + | + | △ | - | + | +  | 0 |
|  | Copper bath, acid   | +                 | +  | +  | -  | -  | -  | +  | -                      | +  | +                  | +   | + | +              | - | + | + | + | + | + | - | + | 0  | 0 |
|  | Copper bath (fluoroborate)  | -                 | -  | -  | -  | -  | -  | +  | -                      | +  | +                  | +   | + | +              | - | + | + | + | + | △ | △ | - | +  | + |
|  | Brass bath, cyanide <sup>1)</sup>                                   | 0                 | 0  | 0  | +  | -  | 0  | +  | +                      | +  | +                  | +   | + | -              | + | + | + | + | + | - | + | + | 0  | - |
|  | Nickel bath (fluoroborate) <sup>1)</sup>                            | -                 | -  | -  | -  | -  | 0  | +  | 0                      | +  | +                  | +   | + | +              | - | + | + | + | △ | △ | - | + | -  | + |
|  | Nickel bath (nickel-chloride/nickel-sulphate) <sup>1)</sup>         | +                 | +  | +  | -  | -  | 0  | +  | -                      | +  | +                  | +   | + | +              | - | + | + | + | △ | △ | - | + | 0  | - |
|  | Platinum bath / Palladium, acid                                     | +                 | +  | +  | -  | -  | -  | △  | -                      | +  | △                  | +   | + | +              | - | + | + | + | + | + | - | + | 0  | 0 |
|  | Rhodium bath (H <sub>2</sub> SO <sub>4</sub> )                      | +                 | +  | +  | -  | -  | -  | △  | -                      | +  | △                  | +   | + | +              | - | + | + | + | + | + | - | + | -  | 0 |
|  | Silver bath, cyanide <sup>1)</sup>                                  | 0                 | 0  | 0  | +  | -  | 0  | +  | +                      | +  | +                  | +   | + | +              | - | + | + | + | + | △ | △ | + | +  | - |
|  | Zinc bath, alkaline, cyanide <sup>1)</sup>                          | 0                 | 0  | 0  | +  | -  | 0  | +  | +                      | +  | +                  | +   | + | +              | - | + | + | + | + | △ | △ | + | +  | 0 |
| Zinc bath, acid                                | +   | +                 | +  | -  | -  | -  | +  | -  | +                      | +  | +                  | +   | + | -              | + | + | + | + | △ | △ | - | + | 0  |   |
| Tin bath, alkaline <sup>1)</sup>               | -   | -                 | -  | +  | -  | 0  | +  | +  | +                      | +  | +                  | +   | + | -              | + | + | + | + | △ | △ | + | + | 0  |   |
| Tin bath (fluoroborate)                        | -   | -                 | -  | -  | -  | -  | +  | -  | +                      | +  | +                  | +   | + | -              | + | + | + | + | △ | △ | - | + | +  |   |
| Tin bath (H <sub>2</sub> SO <sub>4</sub> )     | +   | +                 | +  | -  | -  | -  | +  | -  | +                      | +  | +                  | +   | + | -              | + | + | + | + | △ | △ | - | + | 0  |   |
| <b>Autocatalytic Electrolytes<sup>2)</sup></b> | Copper bath (without current), alkaline <sup>1)</sup>               | 0                 | -  | -  | +  | -  | 0  | △  | +                      | +  | △                  | +   | 0 | 0              | - | + | + | 0 | + | △ | △ | △ | △  |   |
|  | Copper bath (without current), acid                                 | +                 | +  | +  | -  | -  | -  | △  | -                      | +  | △                  | +   | 0 | +              | - | + | + | 0 | + | △ | △ | △ | △  |   |
|  | Nickel bath (without current), alkaline <sup>1)</sup>               | 0                 | -  | -  | +  | -  | 0  | △  | +                      | +  | △                  | +   | 0 | +              | - | + | + | 0 | + | △ | △ | △ | △  |   |
|  | Nickel bath (without current), acid <sup>1)</sup>                   | +                 | +  | +  | +  | -  | 0  | △  | +                      | +  | △                  | +   | 0 | +              | - | + | + | 0 | + | △ | △ | △ | △  |   |

# Additional Treatment Liquids

|                                     | Process Solution  | immersion heaters |    |    |    |    |    |          |    | flat immersion heaters |          |                    |   |   | float switches |   |   |          |          |          |          |          |          |
|-------------------------------------|---|-------------------|----|----|----|----|----|----------|----|------------------------|----------|--------------------|---|---|----------------|---|---|----------|----------|----------|----------|----------|----------|
|                                     |   |                   |    |    |    |    |    |          |    | heating rods           |          | temperature probes |   |   | level probes   |   |   |          |          |          |          |          |          |
|                                     |   | PS                | TG | QS | KB | SB | TI | FC       | KS | FK                     | FC       | PFA                | F | L | B              | G | M | F        | L        | B        | K        | T        | HC       |
| <b>Additional Treatment Liquids</b> | ABS pickle ( $\text{CrO}_3/\text{H}_2\text{SO}_4$ )   | +                 | +  | +  | -  | -  | -  | +        | 0  | +                      | +        | +                  | - | + | -              | + | + | -        | +        | -        | +        | -        | 0        |
|                                     | Aluminium pickling bath, containing fluoride  | 0                 | -  | 0  | -  | -  | -  | +        | -  | +                      | +        | +                  | + | + | -              | + | + | +        | -        | +        | -        | +        | 0        |
|                                     | Ammonium fluoride ( $\text{NH}_4\text{F}$ )   | -                 | -  | -  | -  | -  | -  | +        | -  | +                      | +        | +                  | 0 | + | -              | + | + | 0        | +        | -        | +        | -        | 0        |
|                                     | Ammonium chloride = flux bath ( $\text{NH}_4\text{Cl}$ )  | +                 | +  | +  | -  | -  | +  | +        | 0  | +                      | +        | +                  | + | + | -              | + | + | +        | +        | -        | +        | +        | +        |
|                                     | Bleaching solution = sodium hypochlorite ( $\text{NaClO}$ )                                     | +                 | +  | +  | -  | -  | 0  | $\Delta$ | -  | +                      | $\Delta$ | +                  | - | 0 | -              | + | + | -        | 0        | -        | 0        | 0        | -        |
|                                     | Borax bath ( $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ )                     | 0                 | 0  | +  | +  | 0  | -  | +        | +  | +                      | +        | +                  | + | + | +              | + | + | +        | +        | +        | +        | -        | 0        |
|                                     | Chromatizing bath ( $\text{H}_3\text{PO}_4/\text{CrO}_3/\text{H}_2\text{SO}_4$ ), fluoride-free | +                 | +  | +  | -  | -  | -  | +        | +  | +                      | +        | +                  | - | + | -              | + | + | -        | +        | -        | +        | -        | 0        |
|                                     | Pickle bath ( $\text{HCl}$ &/or $\text{H}_2\text{SO}_4$ ), fluoride-free                        | +                 | +  | +  | -  | -  | 0  | +        | -  | +                      | +        | +                  | + | + | -              | + | + | +        | +        | -        | +        | -        | -        |
|                                     | Iron III chloride solution ( $\text{FeCl}_3$ )  | +                 | +  | +  | -  | -  | +  | +        | -  | +                      | +        | +                  | + | + | -              | + | + | +        | +        | -        | +        | +        | -        |
|                                     | Photographic developer  | +                 | +  | +  | 0  | -  | +  | +        | 0  | +                      | +        | +                  | + | 0 | 0              | + | + | +        | 0        | 0        | +        | +        | 0        |
|                                     | Photographic fixer  | 0                 | 0  | 0  | -  | -  | +  | +        | 0  | +                      | +        | +                  | + | 0 | -              | + | + | +        | 0        | -        | +        | +        | 0        |
|                                     | Gloss bath, chemical ( $\text{H}_3\text{PO}_4 + \text{HNO}_3$ )                                 | 0                 | 0  | +  | 0  | -  | -  | +        | +  | +                      | +        | +                  | 0 | + | -              | + | + | 0        | +        | +        | +        | +        | +        |
|                                     | Potassium permanganate, with water ( $\text{KMnO}_4$ )  | +                 | +  | +  | +  | -  | +  | +        | +  | +                      | +        | +                  | 0 | + | +              | + | 0 | +        | +        | +        | +        | +        | +        |
|                                     | Sodium chloride solution (containing $\text{NaCl}$ )  | +                 | +  | +  | -  | -  | +  | +        | -  | +                      | +        | +                  | + | + | -              | + | + | +        | +        | -        | +        | +        | +        |
|                                     | Solder liquid, acidic (containing $\text{HCl}$ )  | +                 | +  | +  | -  | -  | -  | +        | -  | +                      | +        | +                  | + | + | -              | + | + | +        | +        | -        | +        | 0        | -        |
|                                     | Sodium sulphate ( $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ )                         | 0                 | 0  | +  | +  | -  | +  | +        | +  | +                      | +        | +                  | + | + | +              | + | + | +        | +        | +        | +        | +        | 0        |
|                                     | Phosphate bath (iron/zinc phosphate)  | -                 | -  | -  | 0  | 0  | -  | $\Delta$ | +  | $\Delta$               | $\Delta$ | $\Delta$           | + | + | 0              | + | + | $\Delta$ | $\Delta$ | 0        | +        | -        | +        |
|                                     | Black bath ( $\text{HNO}_3 + \text{FeCl}_3$ )   | +                 | +  | +  | -  | -  | +  | +        | 0  | +                      | +        | +                  | - | + | -              | + | + | -        | +        | -        | +        | +        | -        |
|                                     | Sealing bath = desalinated water  | +                 | +  | +  | +  | -  | +  | +        | +  | +                      | +        | +                  | + | + | +              | + | + | +        | +        | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |
|                                     | Hydrogen peroxide ( $\text{H}_2\text{O}_2$ )  | +                 | +  | +  | 0  | -  | 0  | +        | +  | $\Delta$               | $\Delta$ | $\Delta$           | 0 | + | 0              | + | + | 0        | +        | $\Delta$ | $\Delta$ | $\Delta$ | $\Delta$ |

## Key

- When using metallic materials (KB, SB, TI & KS), a faulty current circuit breaker with capacitor in the earth connection is recommended in order to prevent DC current escaping.
- When using metallic materials (KB, SB, TI & KS), a protective potential must be applied to the immersion tube or the metallic surface has to be passivated (i.e. with  $\text{HNO}_3$ ). Autocatalytic functioning electrolytes (without current) tend to cause metal separation on the hot surface of the immersion tube. Therefore the specific surface power density should not exceed  $2.5 \text{ W/cm}^2$ .

### Immersion heaters materials legend:

- PS** Special hard porcelain, glazed  
**TG** Technical glass (hydrolytic class1, acid class1, alkaline class2 according to DIN 12111, 12116 & 52322)  
**QS** Quartz glass (hydrolytic class1, acid class1, alkaline class1, according to DIN12111, 12116 & 52322)  
**KB** Stainless steel (material no. 316TI)  
**SB** Steel St. 34-2  
**TI** Titanium (material no. 3.7035)  
**FC** Polytetrafluorethylene (PTFE) - compound  
**KS** Special corrosion resistant alloy

### Heating rods/flat immersion heaters legend:

- FK** Polytetrafluorethylene (PTFE), pure white  
**FC** Polytetrafluorethylene (PTFE) - compound  
**PFA** Teflon®-PFA  
**Temperature probes legend:**  
**F** Polypropylene (PP)  
**L** Polyvinylidenfluoride (PVDF)  
**B** Stainless steel (material no. 1.4571)  
**G** Teflon®-PTFE  
**M** Teflon®-PFA

### Float switches/level probes legend:

- F** Polypropylene (PP)  
**L** Polyvinylidenfluoride (PVDF)  
**B** Stainless steel (material no. 1.4571)  
**K** Polytetrafluorethylene (PTFE) - compound  
**T** Titanium (material no. 3.7035)  
**HC** Hastelloy Alloy C4, PTFE

## Here are the material properties we use

|  | Alkaline resistance |                    | Breakage resistance |           | For                         | Against                   |
|--|---------------------|--------------------|---------------------|-----------|-----------------------------|---------------------------|
|  | Acid resistance     | Thermal resistance |                     |           |                             |                           |
| <b>Stainless Steel</b>                   | fairly good         | good               | high                | very high | individually processable    | /                         |
| <b>Hastelloy</b>                         | good                | good               | high                | very high | individually processable    | /                         |
| <b>Special corrosion resistant alloy</b> | fairly-good         | good               | high                | very high | individually processable    | /                         |
| <b>Porcelain</b>                         | very good           | moderate           | good                | moderate  | good heat transfer          | /                         |
| <b>PP</b>                                | good                | very good          | up to 90°C          | high      | /                           | /                         |
| <b>PTFE, pure white</b>                  | very good           | very good          | low                 | low       | clean room application      | low surface power density |
| <b>PTFE-Compound</b>                     | very good           | very good          | low                 | low       | highest chemical resistance | low surface power density |
| <b>PVDF</b>                              | very good           | moderate           | up to 140°C         | high      | /                           | /                         |
| <b>Quartz glass</b>                      | very good           | moderate           | good                | low       | thermoshock resistant       | thermal radiation         |
| <b>Steel</b>                             | poor                | moderate           | high                | very high | individually processable    | rusts                     |
| <b>Technical glass</b>                   | very good           | moderate           | good                | low       | /                           | liable to break           |
| <b>Teflon® PFA</b>                       | very good           | very good          | low                 | low       | highest chemical resistance | low surface power density |
| <b>Titan</b>                             | good                | good               | high                | very high | individually processable    | /                         |