# NOTICE:

**Prices and availability are subject to change without notice. Please contact Marlin Manufacturing before ordering for updated pricing.**

| CORRODENT | TEMP. °F. | CONC. % | RECOM. MATERIAL |
|---|---|---|---|
| Acetic Acid | 212 | ALL | Monel |
| Acetic Anhydride | 300 | | Nickel |
| Acetone | 212 | ALL | 304 SS |
| Acetylene | 400 | | 304 SS |
| Alcohols | 212 | ALL | 304 SS |
| Alum. (Potassium or Sodium) | 300 | ALL | Hast. C |
| Aluminum Chloride | 212 | ALL | Hast. B |
| Aluminum Sulfate | 212 | ALL | 316 SS |
| Ammonia, Dry | 212 | ALL | 304, 316 SS |
| Ammonium Hydroxide (Ammonia, Aqua) | 212 | ALL | 304, 316 SS |
| Ammonium Chloride | 300 | 50% | Monel |
| Ammonium Nitrate | 300 | ALL | 304 SS |
| Ammonium Sulfate | 212 | ALL | 316 SS |
| Amyl Acetate | 300 | ALL | 304 SS |
| Aniline | 75 | | Monel |
| Asphalt | 250 | | 304 SS |
| Atmosphere, (Industrial and Marine) | | | 304 SS |
| Barium Compounds | SEE CALCIUM | | |
| Beer | 70 | | 304 SS |
| Benzene (Benzol) | 212 | | Steel |
| Benzoic Acid | 212 | ALL | 316 SS |
| Bleaching Powder | 70 | 15% | Monel |
| Borax | 212 | ALL | Brass |
| Bordeaux Mixture | 200 | | 304 SS |
| Boric Acid | 400 | ALL | 316 SS |
| Bromine | 125 | DRY | Monel |
| Butane | 400 | ALL | Steel |
| Butyl Alcohol | SEE ALCOHOLS | | |
| Butyric Acid | 212 | | Hast. C |
| Calcium Bisulphite | 75 | ALL | Hast. C |
| Calcium Chloride | 212 | ALL | Hast. C |
| Calcium Hydroxide | 300 | 20% | Hast. C |
| Calcium Hypochlorite | SEE BLEACHING POWDER | | |
| Carbolic Acid | SEE PHENOL | | |
| Carbon Dioxide, Dry | 800 | ALL | Brass |
| Carbonated Water | 212 | ALL | 304 SS |
| Carbonated Beverages | 212 | | 304 SS |
| Carbon Disulfide | 200 | | 304 SS |
| Carbon Tetrachloride | 125 | ALL | Monel |
| Chlorine, Dry | 100 | | Monel |
| Chlorine, Moist | 100 | ALL | Monel |
| Chloracetic Acid | 212 | ALL | Monel |
| Chloroform, Dry | 212 | | Monel |
| Chromic Acid | 300 | ALL | Hast. C |
| Cider | 300 | ALL | 304 SS |
| Citric Acid | 212 | ALL | Hast. C |
| Copper (10) Chloride | 212 | ALL | Hast. C |
| Copper (10) Nitrate | 300 | ALL | 316 SS |
| Copper (10) Sulfate | 300 | ALL | 316 SS |

| CORRODENT | TEMP. °F. | CONC. % | RECOM. MATERIAL |
|---|---|---|---|
| Copper Plating Solution (Cyanide) | 180 | | 304 SS |
| Copper Plating Solution (Acid) | 75 | | 304 SS |
| Corn Oil | 200 | | 304 SS |
| Creosote | 200 | ALL | 304 SS |
| Crude Oil | 300 | | Monel |
| Ethyl Acetate | SEE LACQUER THINNER | | |
| Ethyl Chloride, Dry | 500 | | Steel |
| Ethanol | SEE ALCOHOLS | | |
| Ethylene Glycol (Uninhibited) | 212 | ALL | 304 SS |
| Ethylene Oxide | 75 | | Steel |
| Fatty Acids | 500 | ALL | 316 SS |
| Ferric Chloride | 75 | ALL | Hast. C |
| Ferric Sulfate | 300 | ALL | 304 SS |
| Formaldehyde | 212 | 40% | 316 SS |
| Formic Acid | 300 | ALL | 316 SS |
| Freon | 300 | | Steel |
| Fluorine, Anhydrous | 100 | | 304 SS |
| Furfural | 450 | | 316 SS |
| Gasoline | 300 | | Steel |
| Glucose | 300 | | 304 SS |
| Glue ph 6-8 | 300 | ALL | 304 SS |
| Glycerine | 212 | ALL | Brass |
| Hydrobromic Acid | 212 | ALL | Hast. C |
| Hydrochloric Acid (37-38%) | 225 | ALL | Hast. B |
| Hydrogen Chloride, Dry | 500 | | 304 SS |
| Hydrocyanic Acid | 212 | ALL | 304 SS |
| Hydrofluoric Acid | 212 | 60% | Monel |
| Hydrogen Fluoride, Dry | 175 | | Steel |
| Hydrofluogilicic Acid | 212 | 40% | Monel |
| Hydrogen Peroxide | 125 | 10-100% | 304 SS |
| Kerosene | 300 | ALL | Steel |
| Lacquers & Thinners | 300 | ALL | 304 SS |
| Lactic Acid | 300 | ALL | 316 SS |
| Lime | 212 | ALL | 316 SS |
| Linseed Oil | 75 | | Steel |
| Magnesium Chloride | 212 | 50% | Nickel |
| Magnesium Hydroxide (or Oxide) | 75 | ALL | 304 SS |
| Magnesium Sulfate | 212 | 40% | 304 SS |
| Mercuric Chloride | 75 | 10% | Hast. C |
| Mercury | 700 | 100% | Steel |
| Methylene Chloride | 212 | ALL | 304 SS |
| Methyl Chloride, Dry | 75 | | Steel |
| Milk, fresh or sour | 180 | | 304 SS |
| Molasses | SEE GLUCOSE | | |
| Natural Gas | 70 | | 304 SS |
| Nitric Acid | 75 | ALL | 304 SS |
| Nitric Acid | 300 | ALL | 316 SS |
| Oxygen | 75 | ALL | Steel |

| CORRODENT | TEMP. °F. | CONC. % | RECOM. MATERIAL |
|---|---|---|---|
| Oleic Acid | SEE FATTY ACIDS | | |
| Oxalic Acid | 212 | ALL | Monel |
| Photographic Bleaching | 100 | ALL | 304 SS |
| Palmitic Acid | SEE FATTY ACIDS | | |
| Phosphoric Acid | 212 | ALL | 316 SS |
| Phenol | 212 | ALL | 316 SS |
| Potassium Compounds | SEE SODIUM COMPOUNDS | | |
| Propane | 300 | | Steel |
| Rosin | 700 | 100% | 316 SS |
| Sea Water | 75 | | Monel |
| Soap & Detergents | 212 | ALL | 304 SS |
| Sodium Bicarbonate | 212 | 20% | 316 SS |
| Sodium Bisulphite | 212 | 20% | 304 SS |
| Sodium Bisulphate | 212 | 20% | 304 SS |
| Sodium Carbinate | 212 | 40% | 316 SS |
| Sodium Chloride | 300 | 30% | Monel |
| Sodium Chromate | 212 | ALL | 316 SS |
| Salt or Brine | SEE SODIUM CHLORIDE | | |
| Sodium Cyanide | 212 | ALL | 304 SS |
| Sodium Hydroxide | 212 | 30% | 316 SS |
| Sodium Hypochlorite | 75 | 10% | Hast. C |
| Sodium Nitrate | 212 | 40% | 304 SS |
| Sodium Nitrite | 75 | 20% | 316 SS |
| Sodium Phosphate | 212 | 10% | Steel |
| Sodium Silicate | 212 | 10% | Steel |
| Sodium Sulfate | 212 | 30% | 316 SS |
| Sodium Sulfide | 212 | 10% | 316 SS |
| Sodium Sulfite | 212 | 30% | 304 SS |
| Sodium Thiosulfate | 212 | ALL | 304 SS |
| Steam | | | 304 SS |
| Stearic Acid | SEE FATTY ACIDS | | |
| Sugar Solutions | SEE GLUCOSE | | |
| Sulfur | 500 | | 304 SS |
| Sulfur Chloride | 75 | DRY | 316 SS |
| Sulfur Dioxide | 500 | DRY | 316 SS |
| Sulfur Trioxide | 500 | DRY | 316 SS |
| Sulfuric Acid | 212 | 10% | 316 SS |
| Sulfuric Acid | 212 | 10-90% | Hast. B |
| Sulfuric Acid, Fuming | 175 | | Hast. C |
| Sulfurous Acid | 75 | 20% | 316 SS |
| Titanium Tetrachloride | 75 | ALL | 316 SS |
| Tannic Acid | 75 | 40% | Hast. B |
| Toluene | 75 | | Steel |
| Trichloracetic Acid | 75 | ALL | Hast. B |
| Trichlorethylene | 300 | DRY | Monel |
| Turpentine | 75 | | 316 SS |
| Varnish | 150 | | Steel |
| Zinc Chloride | 212 | ALL | Hast. B |
| Zinc Sulfate | 212 | ALL | 316 SS |

In recommending the above materials, consideration has been given to providing good service life without undue cost. Where two or more materials are satisfactory, the least expensive is listed. Consult the factory for information on materials or services not given. Other factors which will influence corrosion rates include: degree and frequency of temperature fluctuation, concentration, ·rations of fluids, high velocities or abrasives in the fluid stream, flashing or cavitating conditions, etc. Therefore the data presented should be interpreted as one basis for material selection and not as a complete recommendation.

Since 1952
Marlin
MANUFACTURING CORPORATION 12404 TRISKETT ROAD CLEVELAND, OHIO 44111
(216) 941-6200
FAX: (216) 941-6207

## Thermowells

Thermowells provide maximum protection for thermal sensors from corrosion, pressure and flow induced stresses. When selecting thermowells these parameters determine the type and material that should be used. In general, thermowells are machined from solid bar stock for "A" dimensions to 24" but for longer lengths a built-up design is used.

## General Application Considerations

Select sensor location for representative temperature measurement.

Provide sufficient depth of immersion so that heat transfer along the instrument does not influence temperature measurement.

Select materials that are compatible with corrosive media elements.

Select thermowell with sufficient stiffness to resist destruction from flow induced stresses.

## Thermowell Materials

Strength at operating temperature and resistance to corrosion are the primary considerations in material selection. A corrosion guide is supplied in the general Data Section.

### General Material Considerations

**Carbon Steels** can be used to 1300° F (700° C) usually in oxidizing atmospheres.

**Austenitic Stainless Steels** (300 series) can be used to 1600° F (870° C) mostly in oxidizing atmospheres although type 316 can be used in some reducing environments.

**Ferritic Stainless Steels** (400 series) can be used to the 1800° F (982° C)—2100° F (1149° C) range in both oxidizing and reducing atmospheres.

**High Nickel Alloys** can be used to 2100° F (1149° C) in oxidizing atmospheres.

| Material Code | MATERIAL | Melting Point | Recom-mended Operating Atmosphere | Maximum Operating Temp. in Atmosphere |
|---|---|---|---|---|
| | STAINLESS STEELS | | | |
| 304 | 304 | 2560 | ORNV | 1650 |
| 310 | 310 | 2560 | ORNV | 2100 |
| 316 | 316 | 2500 | ORNV | 1700 |
| 321 | 321 | 2550 | ORNV | 1600 |
| 347 | 347 | 2600 | ORNV | 1600 |
| 446 | 446 | 2700 | ORNV | 2000 |
| CS | Carbon Steel | 2500 | ON | 1300 |
| INC | Inconel™ | 2550 | ONV | 2100 |
| INX | Inconel X™ | 2620 | ONV | 1500 |
| INY | Incoloy™ | 2500 | ON | 1600 |
| HTX | Hastelloy X™ | 2300 | O | 2200 |
| HTC | Hastelloy C™ | 2310 | O | 1800 |
| HTB | Hastelloy B™ | 2375 | OR | 1400 |
| MON | Monel™ | 2460 | OR | 1000 |
| BR | Brass | 1850 | O | 650 |
| AL | Aluminum | 1220 | O | 700 |
| NCK | Nickel | 2647 | O | 1400 |
| TRN | Tantalum | 5425 | V | 5000 |
| TIT | Titanium | 3035 | VN | 2000 |

O = Oxidizing R = Reducing N = Neutral V = Vacuum

## Velocity Rating

Once the selection of material is made attention should be given to the parameter of flow induced stresses. Fluids flowing by a well form a turbulent wake called the Von Karman Trail. This wake has a definite frequency based on the diameter of the well and the fluid velocity. It is important to provide a well with sufficient stiffness so that the wake frequency will never exceed the natural frequency of the well itself. Should the natural frequency of the well coincide with the wake frequency the well would vibrate to destruction. Tapered shank wells provide greater stiffness for the same sensitivity than a straight shank well. The higher strength to weight ratio gives these wells a higher natural frequency and therefore are able to operate at higher fluid velocities. Recommended maximum velocity rating can be found for every standard well length and material catalogued. Ratings are based on operating temperatures as shown in the table below.

| Material | Velocity Rating Operating Temperature |
|---|---|
| Carbon Steel (C1018) 304 SS 316 SS | 1000° F (538° C) |
| Monel | 900° F (482° C) |
| Brass | 350° F (177° C) |

Single values that appear in the velocity tables may be considered safe for water, steam, air or gas. Double values distinguish between water (parenthesized) and steam, air and gases. These values are intended as general guides to selection. If you have operating conditions requiring special well designs our engineering staff is available to assist you.

## Pressure Rating

The limit pressure versus temperature ratings are tabulated for various materials for each thermowell series.

Here is a typical table.

**LIMIT PRESSURE vs TEMPERATURE** (lbs/in²) (° F)

| MATERIAL | CODE | TEMPERATURE – °F 70° | 200° | 400° | 600° | 800° | 1000° | 1200° |
|---|---|---|---|---|---|---|---|---|
| Brass | BR | 5000 | 4200 | 1000 | — | — | — | — |
| Carbon Steel | CS | 5200 | 5000 | 4800 | 4600 | 3500 | 1500 | — |
| A.I.S.I. 304 | 304 | 7000 | 6200 | 5600 | 5400 | 5200 | 4500 | 1650 |
| A.I.S.I. 316 | 316 | 7000 | 7000 | 6400 | 6200 | 6100 | 5100 | 2500 |
| Monel | MON | 6500 | 6000 | 5400 | 5300 | 5200 | 1500 | — |

**Selection of material and/or equipment is at the sole risk of the user of this publication. The data presented does not and should not preclude professional engineering design and consulting for your particular application. Marlin Manufacturing Corporation, its distributors, representatives, and the contributors to this publication specifically deny any warranty expressed or implied.**

Since 1952 Marlin MANUFACTURING CORPORATION 12404 TRISKETT ROAD CLEVELAND, OHIO 44111 (216) 941-6200 FAX: (216) 941-6207

**Process Connection** supports and/or seals the thermowell into the process system.

Types:

| | |
|---|---|
| Threaded | one piece well with NPT threads (may require welding or brazing for seal). |
| Flanged Welded | a primary J groove weld and a bevel groove secondary weld join the flange to the well. Flanges are made to specification. |
| Lap Joint | flanges are made to specification. |
| Socket Weld | fits A.S.A. standard socket weld couplings for field installation. |

**Bore Size** is the inside diameter of the thermowell in which the temperature sensor will be located. Standard sizes are .260" or .385" with a ± .002" tolerance.

**Instrument Connection** supports and/or seals the temperature sensor into the thermowell bore. Standard connection is a ½" NPS thread. An optional brass or stainless steel captive cap is available for keeping the well bore clean when not in use.

## Shank Constructions

| | |
|---|---|
| Straight | the outside diameter of the well is consistent over its immersion length. |
| Reduced Diameter | the outside diameter at the end of well is reduced for greater sensor sensitivity. |
| Tapered | the outside diameter of the well decreases along the immersion length for greater stiffness. (see Velocity Ratings) |

**Immersion Length** is the distance along the shank from the end of the well to the underside of the process connection. Immersion length implies that this is the portion of the well that sees the fluid or gas that is being monitored. Care must be taken so that dead lengths (required lengths to pass through walls, pipe fittings, etc.) and proper sensitivity lengths (lengths required for proper temperature measurement of the sensor) are taken into account.

**Lagging Extension Length** is the distance along the shank from the top side of the process connection to the termination connection of the well. If needed dead lengths (i.e.-that required to pass through walls, pipe fittings etc.) should be taken into account.

Note: For special thermowells please send your prints and/or specifications — Marlin will promptly quote price and delivery.