ALLOY
Engineering Company, Inc

Technical Brief

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Thermowell Materials Service Guide

A thermowell is the pressure-tight receptacle designed to protect sensitive temperature measurement instrumentation from harsh process conditions. Usually material chosen for the thermowell is governed by the corrosion conditions the well will face. Occasionally, extreme conditions require that a thermowell be manufactured for strength, then coated or protected by a sleeve of corrosion or erosion resistant material. Recommended materials for various services are based on resistance to specific corrosive environments, temperature, and the mechanical stresses of the process.

KEY CONSIDERATIONS:

- Operating Temperature
- Operating Environment
- Velocity & Pressure

"thermowell material is usually chosen based on the corrosion conditions the well will face."

Common Materials

Carbon Steel (A105, A350, CF2) – most often used in oxidizing environments with operating temperatures to 1300°F.

304 SS – Nickel based alloy with good corrosion resistance in both oxidizing and reducing environments. Operating temperatures up to 1650°F.

310 SS – Good resistance to carburizing and reducing environments, better than 304 in many high temperature applications. Subject to carbide precipitation in the 900˚ -1600˚ range. Continuous service to 2100°F.

316 SS – Operating temperatures the same as 304, but better corrosion resistance and creep strength. Used in both oxidizing and reducing environments.

416SS – Most popular of the ferritic stainless steels. Used in reducing, oxidizing, vacuum and neutral environments. Operating temperatures up to 2000°F.

Low Carbon Stainless Steels – available in 304L and 316L are generally used to reduce the effect of carbide precipitation. Operating temperatures the same as 304SS.

Alloy® 600 – has excellent corrosion resistance at elevated temperatures. Not recommended in reducing or high-sulfur environments. Operating temperatures to 2100°F.

Alloy® 800 – Same elevated temperature resistance to oxidation as Alloy 600. Good sulfur and corrosion resistance. Same operating temperatures as Alloy 600.

Hastelloy® B – Excellent resistance to pitting and stress-corrosion cracking. Can be used in inert atmospheres and oxidizing environments up to 1500°F

Hastelloy® C – Excellent corrosion resistance to ferric and cupric chlorides, contaminated mineral acids, wet chlorine gas. Oxidation resistance to 1800°F.

Monel® – Good resistance to sea water and not subject to chloride stress cracking. Not recommended for oxidizing atmospheres. Operating temperatures to 1000°F.

Nickel – Use in oxidizing atmospheres and sulfur free environments. Maximum operating temperature 1400°F.

Tantalum – Good to excellent resistance to corrosion to most chemicals and a high heat conductivity. Most commonly used as a sheath material for stainless flanged wells. Operating temperatures to 5000°F

Please see *Materials Service Guide* on page 2

Materials Application Service Guide

Heat Treating	
Annealing	
Up to 1300°F	Black steel
Over 1300°F	Inconel® 600, Type 446 SS
Carburising hardening	
Up to 1500°F	Black steel, Type 446 SS
1500 to 2000°F	Inconel® 600, Type 446 SS
Over 2000°F	Ceramic*
Nitriding salt baths	Type 446 SS
Cyanide	Nickel (CP)
Neutral	Type 446 SS
High speed	Ceramic*
Iron and steel	
Blast furnaces	
Downcomer	Inconel® 600, Type 446 SS
Stove dome	Silicon carbide, LT-1
Hot blast main	Inconel® 600
Stove trunk	Inconel® 600
Stove outlet flue	Black steel
Open hearth	
Flues and stack	Inconel® 600, Type 446 SS
Checkers	Inconel®600, LT-1
Waste heat boiler	Inconel® 600, Type 446 SS
Billet heating slab heating and butt welding	
Up to 2000°F	Inconel® 600, Type 446 SS
Over 2000°F	Silicon carbide, ceramic*
Bright annealing batch	
Top work temperature	Not required (use bare Type J thermocouple)
Bottom work temperature	Type 446 SS
Continuous furnace section	Inconel® 600, ceramic*
Forging	Silicon carbide, ceramic*
Soaking pits	
Up to 2000°F	Inconel® 600
Over 2000°F	Silicon carbide, ceramic*
Nonferrous metals	
Aluminum	
Melting	Hexoloy®, Syalon®, 1100, Cast, Iron
Heat treating	Black steel
Brass or bronze	Not required (use dip-type thermocouple)
Lead	Type 446 SS, black steel
Magnesium	Black steel, cast iron
Tin	Extra heavy carbon steel
Zinc	Extra heavy carbon steel
Pickling tanks	Chemical lead
Cement	
Exit flues	Inconel® 600, Type 446 SS
Kilns, heating zone	Inconel® 600
Ceramic	
Kiln	Ceramic, and silicon carbide
Dryers	Silicon carbide, black steel
Vitreous enameling	Inconel® 600, Type 446 SS
Paper	
Digesters	Type 316 SS, Type 446S

Glass	
Fore hearths and feeders	Platinum thimble
Lehrs	Black steel
Tanks	
Roof and wall	Ceramic
Flues and checkers	Inconel® 600, Type 446 SS
Petroleum	
De-waxing	
Towers	Types 304, 310, 316, 321, 347 SS, carbon steel
Transfer lines	
Factioning column	
Bridgewall	
Power	
Coal-air mixtures	304 SS
Flue gases	Black steel, Type 446 SS
Pre-heaters	Black steel, Type 446 SS
Steel lines	Types 347 or 316 SS
Water lines	Low carbon steels
Boiler tubes	Types 304, 309, or 31 0 SS
Gas producers	
Producer gas	Type 446 SS
Water gas	
Carburetor	Inconel® 600, Type 446 SS
Superheater	Inconel® 600, Type 446 SS
Tar stills	Low carbon steels
Incinerators	
Up to 2000°F	Inconel® 600, Type 446 SS
Over 2000°F	Ceramic (primary) Hexoloy® (secondary)*
Food	
Baking Ovens	Slack Steel
Charretort, Sugar	Slack Steel
Vegetables and fruit	Type 304 SS
Chemical	
Acetic acid	
10 to 50%, 70°F	Type 304SS, Hastelloy® C, Monel®
50%, 212°F	Type 316SS, Hastelloy® C, Monel®
99% 21 to 212°F	Type 430SS, Hastelloy® C, Monel®
Acetic Anhydride to 300°F	Nickel
Acetone to 212°F	Type 304SS
Acetylene to 400°F	Type 304SS
Alcohol, ethyl, methyl 70 to 212°F	Type 304SS
Alum (potassium or sodium) to 300°F	Hastelloy® C
Aluminum Chloride to 212°F	Hastelloy® B
Aluminum Sulfate to 212°F	Type 316 SS
Ammonia All concentration 70°F	Types 304, 316 SS
Ammonium chloride All concentration 212°F	Types 316 SS, Monel®

Chemical (cont'd)	
Ammonium nitrate All concentration70 to 212°F	Type 316 SS
Ammonium sulfate, 10% to saturated to 212°F	Type 316 SS
Amyl acetate to 300°F	Type 304SS
Aniline to 75°F	Monel®, Hastelloy® C
Asphalt to 250°F	Type 304SS
Atmosphere (industrial & marine)	Type 304SS
Barium chloride, all concentration, 70°F	Monel®, Hastelloy® C
Barium hydroxide, all concentration, 70°F	Low carbon steels
Barium sulphite	Nichrome® Hastelloy® C
Beer to 70°F	Type 304SS
Benzene to 212°F	Type 304SS
Benzoic acid to 212°F	Type 316 SS
Borax to 212°F	Brass
Boric acid to 400°F	Type 316 SS
Brines	Monel®
Bromine	Tantalum, Monel®
Butadiene	Type 304 SS
Butane	Type 304 SS
Butyl acetate	Monel®
Butyl alcohol	Type 304 SS
Butyric acid to 212°F	Hastelloy® C
Calcium bisulphite to 75°F	Hastelloy® C
Calcium chlorate, dilute 70 to 150°F	Type 304 SS
Calcium chloride to 212°F	Hastelloy® C
Calcium hydroxide	
10 to 20%, 212°F	Type 304 SS, Hastelloy® C
50%, 212°F	Type 316 SS, Hastelloy® C
Calcium hypochlorite 15% to 75°F	Monel®
Carbolic acid, all, to 212°F	Type 316 SS
Carbon dioxide, wet or dry	2017-T4 aluminum, Brass, Monel®, Nickel
Carbonated water, to 212°F	Type 304 SS
Carbonated beverages, to 212°F	Type 304 SS
Carbon disulfide, to 200°F	Type 304 SS
Carbon tetrachloride, to 125°F	Monel®
Chlorine gas	
Dry, 70°F	Type 316 SS, Monel®
Moist, 20 to 212°F	Hastelloy® C
Chloracetic acid, to 212°F	Monel®
Chromic acid, 10 to 50% 212°F	Type 316 SS, Hastelloy® C (all concentrations)

Chemical (cont'd)	
Citric acid	
15%, 70°F	Type 304 SS, Hastelloy® C (all concentrations)
15%, 212°F	Type 316 SS, Hastelloy® C (all concentrations)
Concentrated, 212°F	Type 316 SS, Hastelloy® C (all concentrations)
Copper chloride	Hastelloy® C
Copper nitrate	Types 304 SS, 316 SS
Copper sulfate	Types 304 SS, 316 SS
Cresols	Type 304 SS
Cyanogen gas	Type 304 SS
Dowtherm®	Low carbon steels
Ether	Type 304 SS
Ethyl acetate	Monel®, Type 304 SS
Ethyl chloride, 70°F	Type 304 SS, low carbon steel
Ethyl sulfate, 70°F	Monel®
Ethylene glycol to 212°F	Type 304 SS
Ethylene oxide to 75°F	Steel
Ferric chloride, 5%, 70°F to boiling	Tantalum, Hastelloy® C
Ferric sulfate, 5%, 70°F	Type 304 SS
Ferrous sulfate, dilute, 70°F	Type 304 SS
Formaldehyde	Types 304 SS, 316 SS
Formic acid, 5%, 70 to 150°F	Type 316 SS
Fluorine, anhydrous, to 100°F	Type 304 SS
Freon	Monel®
Furfural to 450°F	Type 316 SS
Gallic acid, 5%, 70 to 150°F	Monel®
Gasoline, 70°F	Type 304 SS, low carbon steel
Glucose, 70°F	Type 304 SS
Glycerine, 70°F	Type 304 SS
Glycerol	Type 304 SS
Hydrobromic acid, 98%, 212°F	Hastelloy® B
Hydrochloric acid	
1%, 5% 70°F	Hastelloy® C
1%, 5% 212°F	Hastelloy® B
25%, 70 to 212°F	Hastelloy® B
Hydrofluoric acid, 60%, 212°F	Hastelloy® C, Monel®
Hydrogen chloride, dry, to 175°F	Type 304 SS
Hydrogen peroxide, 70 to 212°F	Types 316 SS, 304 SS
Hydrogen sulfide, wet and dry	Type 316 SS
Iodine, 70°F	Tantalum
Lactic acid	
5%, 70°F	Type 304 SS, 316 SS
5%, 150°F	Type 316 SS
10%, 212°F	Tantalum
Magnesium chloride	
5%, 70°F	Nickel, Monel®,
5%, 212°F	Nickel

Chemical (cont'd)	
Magnesium sulfate, hot and cold	Monel
Muriatic acid, 70°F	Tantalum
Naptha, 70°F	Type 304 SS
Natural gas, 70°F	Types 304 SS, 316 SS, 317 SS
Nickel chloride, 70°F	Type 304 SS
Nickel sulphate, hot and cold	Type 304 SS
Nitric acid	
5%, 70°F	Types 304 SS, 316 SS
20% 70°F	Types 304 SS, 316 SS
50% 70°F	Types 304 SS, 316 SS
50% 212°F	Types 304 SS, 316 SS
65% 212°F	Type 316 SS
Concentrated, 70°F	Types 304 SS, 316 SS
Concentrated, 212°F	Tantalum
Nitrobenzene, 70°F	Type 304 SS
Oleic acid, 70°F	Type 316 SS
Oleum, 70°F	Type 316 SS
Oxalic acid	
5% hot and cold	Type 304 SS
10%, 212°F	Monel®
Oxygen 70°F	Steel
Palmitic acid	Type 316 SS
Pentane	Type 340 SS
Phenol	Types 304 SS, 316 SS
Phosphoric acid	
1%, 5%, 70°F	Type 304 SS
10%, 70°F	Type 316 SS
10%, 212°F	Hastelloy® C
30%, 70 to 212°F	Hastelloy® B
85%, 70 to 212°F	Hastelloy® B
Picric acid, 70°F	Type 304 SS
Potassium bromide, 70°F	Type 316 SS
Potassium carbonate, 1%, 70°F	Types 304 SS, 316 SS
Potassium chlorate, 70°F	Type 304 SS
Potassium hydroxide	
5% 70°F	Type 304 SS
25% 212°F	Type 304 SS
60% 212°F	Type 316 SS
Potassium nitrate	
5%, 70°F	Type 304 SS
5%, 212°F	Type 304 SS
Potassium permanganate, 5%, 70°F	Type 304 SS
Potassium sulfate, 5%, 70°F	Types 304 SS, 316 SS
Potassium sulfide, 70°F	Types 304 SS, 316 SS
Propane	Type 304 SS, low carbon steel
Pyrogallic acid	Type 304 SS
Quinine bisulfate, dry	Type 316 SS
Quinine sulfate, dry	Type 304 SS
Seawater	Monel®, Hastelloy® C
Salicylic acid	Nickel

Chemical (cont'd)	
Sodium bicarbonate	
All concentration, 70°F	Type 304 SS
5%, 150°F	Types 304 SS, 316 SS
Sodium carbonate, 5%, 70 to 150°F	Types 304 SS, 316 SS
Sodium chloride	
5%, 70 to 150°F	Type 316 SS
Saturated, 70 to 212°F	Type 316 SS, Monel®
Sodium fluoride, 5%, 70°F	Monel®
Sodium hydroxide	Types 304 S, 316 SS, Hastelloy® C
Sodium hypochlorite, 5% still	Type 316 SS, Hastelloy® C
Sodium nitrate, fused	Type 316 SS
Sodium peroxide	Type 304 SS
Sodium sulfate, 70°F	Types 304 SS, 316 SS
Sodium sulfide, 70°F	Type 316 SS
Sodium sulfite, 30%, 150°F	Type 304 SS
Sulfur dioxide	
Moist gas, 70°F	Type 316 SS
Gas, 575°F	Types 304 SS, 316 SS
Sulfur	
Dry molten	Type 304 SS
Wet	Type 316 SS
Sulfuric acid	
5%, 70 to 212°F	Hastelloy® B, 316 SS
10%, 70 to 212°F	Hastelloy® B
90%, 70°F	Hastelloy® B
Tannic acid 70°F	Type 304 SS, Hastelloy B
Tartaric acid	
70°F	Type 304 SS
300°F	Type 316 SS
Toluene	2017-T4 aluminium, low carbon steel
Turpentine	Types 304 SS 316 SS
Whiskey and wine	Type 304 SS, nickel
Xylene	Copper
Zinc chloride	Monel®
Zinc sulphate	
5% 70°F	Types 304 SS, 316 SS
Saturated 70°F	Types 304 SS, 316 SS
25% 212°F	Types 304 SS, 316 SS

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