# NOTICE:

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

Protecting tubes, as their name implies, are used to protect sensors, usually thermocouples, from contaminating atmospheres and/or mechanical damage. Closed on one end and open on the termination end they usually incorporate some means by which the tube, sensor, and terminal are assembled and mounted into the process.

**Ceramic Protecting Tubes** are dense, fine grained, nonporous compositions that remain gas tight even at temperatures near their melting point. Ceramic tubes are generally used at high temperatures with platinum type thermocouples although use with base metal thermocouples is prevalent in atmospheres harmful to metal tubes but not subjected to mechanical damage. Ceramic tubes will sag at temperatures below their maximum working temperatures so if they are installed horizontally and used above their sagging temperatures they should be fully supported. Sag temperature is temperature at which the tube will sag 1/4" in one hour. Ceramics will retain moisture at room temperature. This moisture may become trapped in the ceramic and cause the destruction of the tube when the tube is thermally shocked. It is recommended that preheating or slow heating of ceramic tubes to 400 to 800° F be done in order to drive off this moisture before high heat is introduced.

**Alumina** ($Al_2O_3$) tubes in their purest forms have very good thermal shock and strength characteristics and are virtually chemical resistant. For long term use Alumina 998 is very compatible for use with platinum type thermocouples. Its use is evaluated by examination of these features versus its relatively high cost.

**Mullite** ($3Al_2O_3 \cdot 2SiO_2$) has good thermal shock and strength characteristics and is chemically resistant. This low cost ceramic is also used with platinum type thermocouples usually for shorter term applications in which mechanical damage is more likely to be encountered rather than the long term detrimental effects of the silica in the mullite on the platinum type thermocouple.

**TYPICAL CHEMICAL ANALYSIS**

| | $Al_2O_3$ | $SiO_2$ | MgO | $Na_2O$ | CaO | $Fe_2O_3$ | $Cr_2O_3$ | $TiO_2$ | $B_2O_3$ | $K_2O$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 998 | 99.8 | .060 | .035 | .008 | .040 | .025 | <.003 | .004 | <.001 | <.001 |
| 997 | 99.7 | .1 | .05 | .06 | .04 | .05 | — | — | — | — |
| Mullite 60 | 60.0 | 38.0 | .2 | .2 | .1 | .5 | — | .5 | — | .7 |

**TYPICAL PHYSICAL PROPERTIES**

| Material | 998 | 997 | Mullite 60 |
|---|---|---|---|
| Constitution | 99.8% $Al_2O_3$ | 99.7% $Al_2O_3$ | 85% Mullite 15% $SiO_2$ |
| Bulk Specific Gravity | 3.85 | 3.65 | 2.8 |
| Impenetrability | gas tight | gas tight | gas tight |
| Max. Working Temp. | 1950°C (3542°F) | 1800°C (3270°F) | 1600°C (2912°F) |
| Sag. Temp. (Unsupported) | 1600°C (2912°F) | 1500°C (2730°F) | 1400°C (2552°F) |
| Thermal Conductivity @ 24°C (75°F) @ 800°C (1472°F) | (BTU/ft²/hr/°F/in) 230 60 | 125 30 | 40 25 |
| Dielectric Strength (V/Mil) @ 24°C (75°F) | 230 | 250 | 250 |
| Thermal Expansion (24 to 1000°C) | (per °C X $10^{-6}$) 8.5 | 7.7 | 5.0 |

**Silicon Carbide (SiC)** tubes are porous and highly refractory. They are used to temperatures of 1650°C (3000°F) as secondary protection against extreme temperature, abrasive atmospheres and direct flame impingement. Silicon Carbide tubes are moderate in cost. Primary mullite or alumina tubes are recommended with these tubes.

**Single-Phase Silicon Carbide (SA SiC)** is a pressureless, sintered form of alpha silicon carbide with a density greater than 98% theoretical. Having a very fine grain structure and being 50% harder than tungsten carbide makes it resistant to erosion. It contains no free silicone, which makes it highly chemical resistant in both oxidizing and reducing environments. For use in air to 1650°C (3000°F). SA SiC tubes are high in cost.

**Metal Ceramic** tubes are a high cost combination of chromium and alumina for use to temperatures of 1205°C (2200°F) that provides excellent oxidation resistance, thermal conductivity comparable to that of stainless steel, good resistance to wetting by most molten metals. A primary alumina tube is recommended when this tube is used in conjunction with platinum thermocouples.

**Refractory Laminated, Metal** tubes offer the mechanical protection of metal tubes and the corrosion resistance of ceramics. For molten aluminum and zinc applications, they resist erosion, will not contaminate metal melts, and may outlast iron tubes by many times depending on the application.

**Metal** tubes offer good mechanical protection for base metal thermocouples up to 1150°C (2100°F) in oxidizing atmospheres. All metals are porous after about 870°C (1600°F) so it may be necessary to provide a ceramic primary tube to protect the thermocouple from detrimental vapors.

**Mild Steel** provides good protection at lower temperatures against oxidizing and reducing atmospheres and non-corrosive liquids and vapors. Maximum working temperature 700°C (1300°F).

**304 SS** (18% Chrome/8% Nickel) is a general purpose material that has good resistance to corrosion and oxidation. Maximum working temperature 875°C (1600°F).

**316 SS** (16% Chrome/10% Nickel) is a material that has superior corrosion resistance as compared to 304 SS with improved oxidation resistance and a higher hot strength. Maximum working temperature 925°C (1700°F).

**446 SS** (28% Chrome) has excellent resistance to corrosion and oxidation. It is highly resistant to sulphur atmospheres, salt baths and molten non-ferrous metals. Maximum working temperature 1100°C (2000°F).

**Inconel 600™** (75% Nickel/15% Chrome) combines good mechanical strength at elevated temperatures with high resistance to oxidation, corrosion and scaling. Not suitable for use in sulfurous atmospheres above 875°C (1600°F). Maximum working temperature 1150°C (2100°F).

**Inconel 601™** (60% Nickel/23% Chrome) has similar properties of Inconel 600 and offers improved resistance to sulfur attack at elevated temperatures.

**Cast Iron** is a low cost material used in molten aluminum and aluminum alloy applications and also has good resistance to acid and caustic solutions. Maximum working temperatures 875°C (1600°F) reducing; 700°C (1300°F) Oxidizing.

™- International Nickel Co., Inc.

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