SHEATH MATERIALS

A great variety of metals can be utilized for SEMPAK sheathing. Almost any metal that can be made in tubular form and has reasonable cold ductility can be used. To aid in the selection of a sheath material a brief description of some of the properties of the more commonly used metals is linked below. The material selected must withstand the environmental effects imposed upon it but it must also be compatible with the ceramic and wire it contains. Semco's application engineers are qualified to help with your design problems and will consider component compatibility, expansion rates and other factors that will help achieve maximum reliability and accuracy of your system.

Based on a pre-sizing formula, sheath tubes are purchased with the proper dimensions to achieve a specific wall thickness and diameter after the reduction steps take place when making SEMPAK.

Procurement standards are used to specify tube composition, cleanliness, manufacturing processes and required tests. Certification of conformance to chemistry, mechanical requirements and other specified tubing tests are maintained on file with absolute traceability maintained to each tubing length in stock.

Sheath tubes are shipped to Semco with the ends sealed to assure retention of cleanliness. After receiving inspection, which verifies mechanical requirements and the level of cleanliness specified, these materials are stored and controlled in locked bins in a clean-room environment.

Characteristics of the 300 Series Stainless Steels

When annealed, these alloys con chromium, nickel and manganese (minimum of 23%) in iron are austenitic (non-magnetic). Containing nickel, the protective surface film is tougher and more resistant to corrosives, staining and discoloration that the ferritic (magnetic) 400 series. As compared to ordinary carbon steel, they have higher work hardening rates. They also have thermal expansion and greater corrosion resistance. They cannot be hardened by heat treatment; however, they are hardened and strengthened when cold worked. All of the austenitic stainless steels (300 series) are available in the seamless or welded and drawn tubing.

Type 304 and 304L

A commonly used austenitic stainless alloy because of its high ductility and excellent mechanical and corrosion resistant properties. This 18% Cr - 10% Ni heat resistant alloy has maximum corrosion resistance with it is fully annealed. It is resistant to scaling in continuous service to 1650°F and in intermittent service to 1450°F. The low carbon grade, Type 304L, has exceptionally good welding characteristics and is used in place of stabilized grades of stainless steel.

Type 310

This is a heat-resistant alloy containing 25% Cr – 20% Ni. Mechanical and corrosion resistant properties similar to, but better than, those of Type 304. Good for continuous service to 2100°F in oxidizing atmospheres. Satisfactory life in intermittent service to 1900°F. It has good high temperature strength and sub-zero mechanical properties. Subject to some carbide precipitation. Weldability is excellent. Extensively used for industrial furnace, jet engine afterburner and gas inlet temperature measuring applications.

Type 316 and 316L
A 17% Cr- 13% Ni – 2½ % Mo alloy that offers the best corrosion resistance of the standard austenitic grades, especially to H_2SO_3 compounds, and the highest creep strength of the 300 series. Scale resistance is 1700°F maximum for continuous service and 1500°F for intermittent use (because of the low chromium content). Type 316L is a low-carbon variant and can be welded and heated in the range 900-1600°F without damage to its corrosion resistant properties. Widely used in the chemical industry.

Type 321, 347, 348
All 18% chromium, 10-11% nickel alloys stabilized to overcome carbide precipitation and the resultant intergranular corrosion that is typical of other types when heated to the 900-1600°F range. All can be welded without further annealing. Type 321 is a titanium stabilized alloy, 347 is columbium/tantalum stabilized and 348 is columbium stabilized. For reactor applications, Type 348 has lower neutron capture cross-section and shorter radioactive half-life than 321 or 347 stabilized grades.

These three types approximate Type 304 in corrosion resistance. They resist scaling in air up to 1700°F in continuous operation and 1450°F when used intermittently. Type 321 usually develops higher weld porosity than does Type 347.

Characteristics of the 400 Series Stainless Steels

The principal alloying ingredient is chromium alone. They are ferritic (magnetic) in all conditions of heat treatment.

Type 410
The least expensive of the stainless steels containing only enough chromium (12%) to give satisfactory corrosion resistance. It is hardenable to Rockwell C36-40 by quenching or air cooling form 1750-1850°F followed by tempering. Somewhat difficult to weld because it air hardens. It is not subject to carbide precipitation.

Type 430 and 430 Ti
17% chromium in iron makes this alloy more corrosion and heat resistant than Type 410. Magnetic. It cannot be hardened significantly by heat treatment. Offered in seamless only. Type 430 Ti has .60% maximum titanium added to eliminate coarse grain welds of low ductility. 430 Ti is offered in welded and drawn tubing only.

Type 446
27% Cr. Has the highest heat resistance of all ferritic stainless steels. A nitrogen additive is used to previent embrittlement through the 1200-1800°F range and also to help control grain size. Resists scaling in continuous service to 1900-2100°F and in intermittent to 2050 or even 2100°F. Excellent corrosion resistance to nitric acid, concentrated sulfuric acid, and most alkalies; shows good resistance to sulfurous atmospheres at high temperatures.

Hot strength is low compared to austenitic types but scaling resistance is excellent. Welding is difficult because of tendency toward large-grain brittle welds. Can be mildly worked but not to the extent of the lower chromium ferritic stainlesses. It has a low coefficient of thermal expansion. Offered in seamless only. Used where subjected to heat in oil and gas furnaces, steam boilers, chemical equipment, and fire detection systems.

Hastelloy C
Excellent corrosion resistance, especially to the chlorides of iron and copper and to wet chlorine gas and hypochlorite and chlorine dioxide solutions. Has excellent high temperature strength. Resistant to oxidizing and reducing atmospheres to 2000°F. Useful where parts are subjected to repeated thermal shock at temperatures from 1600-1800°F. High work hardening characteristics. Can be TIG welded. Is available in welded and drawn tubing only. Primarily used where exceptional corrosion resistance and high temperature strength are required.

Hastelloy X
Excellent high-temperature strength with oxidation resistance to 2200°F. Unusual resistance ot oxidizing, reducing and neutral atmospheres. Easily formed and welded. Available in welded and drawn and seamless tubing.
Used in the chemcial industry because of its corrosion resistance and high strength. Develops a tightly adherent oxide scale which helps retain strength and oxidation resistance at high temperatures.
Good for furnace, heater sheath and jet engine applications.

Haynes 25 (Alloy L-605)
Offers unusually good corrosion resistance to most agents at ordinary temperatures. Resistance to oxidation is good for intermittent service to 1600°F and continuous service to 2000°F. Excellent resistance to the hot corrosive atmospheres encountered in jet engine operation. Resistance to salt spray corrosion is good. Available in welded and drawn tubing only.

Haynes 188
A cobalt-nickel-chromium-tungsten alloy that combines excellent high- temperature strength with very good resistance to oxidizing environments up to 2000°F (1095°C) for prolonged exposures, and excellent resistance to sulfate deposit hot corrosion. It is readily fabricated and formed. Other attractive features include excellent resistance to molten chloride salts, and good resistance to gaseous sulfidation.

Incoloy Alloy 800 (Incoloy)
A nickel-chromium-iron alloy with good resistance to oxidation retains its strength at elevated temperature, has good work-ability and welding properties. Superior to Inconel Alloy 600 in resistance to sulfur, green rot, and molten cyanide salts; inferior in resistance to nitriding, halogen gases, and molten caustics. Widely used as heater element sheathing.

Inconel Alloy 600 (Inconel)
A high nickel-chromium-iron alloy. One of the most commonly used thermocouple sheath materials. Extensively used for jet and rocket engine and general purpose instrumentation. Outstanding in strength, corrosion resistance, and oxidation resistance at elevated temperatures up to 2100°F. Can be joined by the usual welding and brazing processes. It is hardened and strenthened by cold working. Resistant to chloride stress-corrosion cracking and corrosion by primary nuclear coolant water. For nuclear service a low cobalt allow Inconel 600T is used.

Inconel Alloy 625
A nickel-chromium-iron alloy with columbium and molybdenum added. Has high strength, corrosion and heat resistance. Shows excellent resistance to oxidation under cyclic conditions to 2000°F. With the columbium and molybdenum additions it has excellent stress rupture properties to 1200°F and is not affected by radiation embrittlement. The higher hot strength of the alloy results from the solid solution strengthening of the nickel-chromium matrix by the addition of the columbium and molybdenum. Inconel Alloy 625 is used in the nuclear and aircraft industries for thermocouple and heater protective sheaths. Immune to chloride stress-corrosion cracking. It has a high fatigue strength.

Inconel Alloy 702 (Inconel 702)
A high aluminum, low titanium modification of Inconel Alloy X-750 nickel-chromium-iron alloy. Creep rupture strength at 1500°F for 1000 hours is 10,000 psi. Offers excellent oxidation resistance at temperatures to 2400°F. Offered in seamless tubing only. Recommended for applications in the high-temperature range where oxidation resistance is important.

Inconel Alloy X-750 (Inconel X)
High strength, corrosion resistance, and resistance to oxidation at elevated temperatures (1200-1500°F). Creep rupture strength at 1500°F for 1000 hours is 18,000 psi. Unusually strong at both ordinary and high temperatures and in the solution treated and aged condition. Offered in seamless tubing only. Used for highly stressed tubular parts in corrosive and oxidizing atmospheres, including jet engine afterburner thermocouples.

Monel Alloy 400 (Monel)
Combines high strength, ductility and excellent resistance to corrosion; is a general purpose alloy. Scale resistant in sulfur free atmospheres to 1000°F. Non hardenable. Magnetically attracted at room temperatures, but loses this characteristic at the curie point just above room temperature. Used in petrochemical, food processing and power generating industries.

Nickel 200 (‘A’ Nickel)
Combines excellent mechanical properties with corrosion resistance that is generally good and is outstanding under many conditions of exposure. Nonhardenable by heat treatment, by strength and hardness may be increased by cold working. Scale resistant in sulfur-free atmospheres to 1650°F. Magnetic in all tempers and in temperatures to about 400°F. Carbon content is .15% maximum. Extensively used in contact with reducing acids, chemical processing liquors, caustics, rayon, pharmaceuticals and plastics. Also used when absolute purity of product must be assured.

Platinum and Platinum-Rhodium Alloys
Excellent oxidation resistant properties. Melting points above 3200°F. Very expensive but has high recoverable salvage value. One of the few materials that can be used in air at 3000°F. Excellent welding properties.

Tantalum
High melting temperature (5450°F), high density, exceptional chemical and electrolytic corrosion resistance. Has a low rate of work hardening and is unusually ductile. It has a low expansion rate and low vapor pressure. Tantalum can absorb large volumes of hydrogen, as much as 740 volumes if heated to a red heat and cooled in the gas. When TIG welding, care should be taken to avoid oxygen, nitrogen or hydrogen contamination. At temperatures above approximately 900°F, tantalum should be used in vacuum or inert gas only.

Niobium (Columbium)
Has high melting temperature (4470°F). Is resistant to liquid metals, has low newtron absorption and has excellent heat transfer properties. It is easily worked and has good high temperature strength. It is weldable by TIG and EB processes. Scaling occurs if used above 1000°F in air. Should be used in vacuum or inert gas only.