Polished Stainless Steel Tubing and Piping.

Stainless steel tubing and piping are found in a wide variety of applications, ranging from the equipment and systems used by the processing industries to structural and ornamental end-uses, as well as in consumer-oriented products, e.g., the exhaust systems for automobiles and motorcycles. Both round and square stainless steel tubing, as well as stainless steel piping, are used for structural applications. For example, A&B Process Systems depend upon these materials in the fabrication of platforms and catwalks and in the modular systems (or skidded systems) used in the processing industries.
Tubing is usually designated by its' outside diameter (OD) and wall thickness, in contrast to piping, which is controlled by the inside diameter (ID). Sanitary tubing, which is frequently required in high purity systems used by the processing industries, is available with ODs ranging from 0.5 inches to 6 inches and walls of thickness nominally 0.065 to 0.120 inches. In the applications of tubing and piping, the smoothness of the surfaces of those components is often important, particularly the interior surfaces that contact the process fluids in the process systems. A&B has developed the capability to polish the interior and exterior surfaces of tubing and piping with larger diameters, a service that is not readily obtained from standard tubing vendors.

The Fabrication of Stainless Steel Tubing.

There are two categories of tubular products --- welded and seamless --- and each has advantages and disadvantages. Welded tubing may be fabricated from either a hot or cold rolled coil of steel, the latter providing closer tolerances, excellent mechanical properties and a fairly smooth surface finish. The coil is slit into precise widths and then processed into tubing through a series of forming, welding, sizing and cutting operations. Orbital tig welding, automated orbital welding or laser welding may be used to fabricate the tubular materials. It is claimed that laser welding offers advantages for high purity requirements, minimizing rouging, weld slag and weld porosity.

Seamless tubing is made from metal bar using one of three methods, i.e., either piercing, extrusion or gun-drilling. Piercing involves the controlled tearing of a hot metal bar and ironing of the sides of the hole and the method is limited to stainless steel alloys containing less than 12% chromium. Extrusion requires forcing the metal bar through a die over a mandrel and is the most widely used method of fabricating tubular materials, although there are problems with eccentricity and surface imperfections. Gun-drilling is believed to produce a higher quality product, but a more expensive method. In this method the metal bar is rotated as it is fed over a stationary, flute drill, the metal chips being flushed from the cavity to allow immediate inspection for straightness and concentricity. The tubular products often require further processing to reduce the tube hollow for dimensional or metallurgical reasons. Cold-drawing is a tensile operation in which the tube is pulled through a die to reduce its' diameter or change its' shape. Cold-pilgering requires compression of the tube to simultaneously reduces the outside diameter (OD), the inside diameter (ID) and the wall thickness.

Stainless Steel Tubing in the Process Industries.

The process equipment used by the chemical, pharmaceutical, biotechnology, dairy, food and beverage industries and by water treatment facilities is fabricated from the austenitic stainless steel alloys. These alloys provide the required corrosion resistance, thermal and chemical stability and represent a versatile and cost effective choice for materials of construction. The tubing and/or piping, an integral part of a process system, is presently fabricated to meet the following industry standards;

(i) ASTM A249 / ASME SA 249, which specifies pressure tubes made from the stainless steel alloys 304, 304L, 316, 316L, 317 and 321;

(ii) ASTM A269, which defines the nominal wall thickness for tubing in general service;

(iii) ASTM A270, which describes seamless and welded austenitic stainless steel sanitary tubing, required by the dairy, food and beverage industries, with closer tolerances than those specified in ASTM A269. This standard has been established to provide the closer alignment of tube to tube and tube to fittings necessary for automated orbital welding.

(iv) ASTM A312 / ASME SA312, which specifies the tubing and/or piping to be used in high temperature and general corrosive service.

The Demand for High Purity Process Systems..

There is a growing demand for processes to be completed under controlled, hygienic conditions and to incorporate CIP (clean-in-place) and SIP (sterilize-in-place) systems, particularly in the pharmaceutical, biotechnology, food and dairy industries. This concern for high purity is reflected in the demand for smooth, polished surfaces for all components in the process system, with particular attention being paid to the interior surfaces, i.e., the surfaces that are in contact with the fluids and products. Corrosion processes are slower at smooth surfaces and contamination of the process fluids and products that contact those surfaces is therefore minimized. Again standards have been established that define “sanitary tubing.” The requirements for any polished metal tubing used in the process equipment or process system are discussed in publications such as

(i) Sanitary Standards for Polished Metal Tubing for Dairy Products, Number 33-00, and
(ii) 3-A Accepted Practices for Permanently Installed Product and Solution Pipelines and Cleaning Systems used in Milk and Milk Product Processing Plants.

Corrosion and Surface Smoothness

The rate of corrosion of a metal or metal alloy is dependent upon several factors, an important one being the real surface area that is exposed to the fluids in the process system. Roughness increases the real surface area and therefore the rate of corrosion. Conversely, the smoother the surface, the lower is the real surface area and the lower is the rate of corrosion. A smooth, polished surface, particularly an interior surface that contacts the products, provides other advantages;

(i) it minimizes the number of sites available for microbial growth,
(ii) it reduces turbulence in the fluid flow,
(iii) it minimizes the adherence of particulate matter to that surface, and
(iv) it allows more efficient and reproducible cleaning and disinfection.

Polished Stainless Steel Tubing.

The metal or alloy surface may be polished by either chemical or mechanical treatments, or by electropolishing. Both the interior and exterior surfaces of stainless steel tubing can be polished mechanically, typically using 120, 150 or 180/220 grit. As the grit number is increased, a smoother surface is obtained. Surface scale and other discolorations, resulting from the heat treatments and other processing used to produce the stainless steel, are removed by chemical treatments. This involves immersioin of the tubing in "pickling baths," which are mixtures of aqueous solutions of nitric acid and hydrofluoric acid or a solution of citric acid. This treatment is typically carried out at temperatures ranging from 25 to 45ºC. Electropolishing is a process by which metal is removed by passage of an electric current, with the tubing immersed in an electrically conductive solution, usually an aqueous solution. Metal is removed at a rate that is proportional to the applied current. The amount of metal electrochemically dissolved is dependent upon the electrolyte, temperature, current density (which is itself dependent upon the real surface area) and time.

For high purity requirements electropolishing offers significant advantages over mechanical surface treatments and is more versatile than the chemical treatments. The surface obtained by electropolishing is very smooth and has been brightened, stress relieved, cleaned and deburred. It has been shown that the electrolytes used in this process enhance the formation of the passive film at the metal or alloy surface, a film that protects the steel substrate by inhibiting general corrosion. Mechanically polished surfaces contain scratches, strains, metal debris and embedded abrasive particles. Furthermore, the cold working that accompanies grinding and polishing operations penetrates into the bulk metal to decrease tensile strength.

How is Surface Smoothness Measured?

A detailed surface topography may be obtained using scanning electron microscopy (SEM), which is an ultra high vacuum technique. Surface roughness may be conveniently measured using a profilometer and is expressed as the arithmetic mean of the departure of the peak heights and valley depths from a center line over several sampling lengths. This average is termed the Ra value and is expressed in microns. Low Ra values are indicative of the smoother surfaces. For example, the Ra values for polished tubing range from 20-30 to 40-60, after mechanical surface treatments with the 180/220 grit and 120 grit respectively.
Upon request, A&B Process Systems will provide a "Surface Finish Cross Reference Chart" that conveniently displays the range of surface conditions that may be obtained. This chart tabulates grit numbers, Ra and Rmax values for various USA finishes, together with the corresponding ISO numbers, ASTM and Japanese standards.

Other Applications of Stainless Steel Tubing.

Stainless steel tubing is also widely used in structural and ornamental applications and here either square or round tubing may be selected. Presently, within the processing industries, there is considerable interest in modular process systems and the frames that support the process equipment are fabricated from stainless steel tubing. Another example of a structural application is the design and fabrication of the handrails on platforms, catwalks, stairways and ladders in manufacturing facilities. The exterior surfaces of the tubing are usually polished and smooth to avoid injury to the hands of operators, or other personnel using the platforms and stairways. There is also an aesthetic value to the polished (shiny) appearance of the handrails or tubular frames.

How is A&B Process Systems Involved with Polished Tubing and/or Piping?

A&B Process Systems is nationally recognized for the design, fabrication and installation of stainless steel equipment and systems for the processing industries. An integral part of a process system is the tubing and/or piping that allows distribution of the fluids to the tanks, mixers and other vessels in the system. A&B recognizes the need of the industries to operate high purity systems and to incorporate CIP and SIP systems into the primary process system. The smoothness of the surfaces of the tubing and/or piping, particularly the contact surfaces, is critically important. A&B Process Systems utilize both mechanical polishing and electropolishing to provide “polished tubing” to be incorporated into any given process system.

Tubing with outside diameters ranging from 0.5 to 4.0 inches is extensively used in high purity process systems and is available from tubing vendors. In contrast, polished stainless steel tubing or piping with larger outside diameters and thicker walls is not readily obtained. A&B Process Systems specializes in polishing this larger tubing and piping, e.g., schedule 5,10, 40 and 80 pipe. The company is also set up to polish long lengths of both round and square stainless steel tubing, as well as flat, stainless steel plate of various thicknesses. Although A&B primarily uses this capability to support the fabrication activities at its’ facilities in Stratford, Wisconsin, this specialty service can be made available to outside customers.