

## SELECTED LITERATURE

01. Schmidt, N. B. Product Application Manager, Carpenter Technology Corp., *Selecting Optimal Stainless Steel for Bio-Pharmaceutical Service*, Bioprocess Engineering Symposium, 1991, Reading, PA, ASME, January 1992, 1991, BED-Vol 21. Special qualities of Type 316L stainless steel with low levels of non-metallic inclusion have been developed for bio-pharmaceutical applications involving electropolishing. Vacuum arc remelting (VAR), electroslag remelting (ESR), and vacuum induction melting (VIM) are discussed as methods of producing stainless steels with controlled contents of non-metallics such as silica, alumina, sulfur, and oxides.
  
02. Schmidt, Norman B. *Type 316L-SQC Stainless*, Technical Bulletin, Reading, PA, Carpenter Technology Corporation, May 1991. Two Carpenter programs for choosing stainless steels for ultra clean gas applications are discussed. Lots of 2000 lbs. are available in air melt + vacuum arc remelt (AOD + VAR) and vacuum arc remelt + vacuum induction melt (VIM + VAR) qualities to meet designated specifications. The VIM + VAR material meets requirements for low inclusions of sulfides for electropolishing.
  
03. Brooks Instrument Rosemount, *Thermal Mass Flow Controller*, Technical Bulletin, Hatfield, PA, Brooks Instrument, Division of Emerson Electric Co., August 1991 T-094, Enhancement of the internal surfaces of mass flow controllers for ultra clean gas applications is discussed. Processes used to reduce retention of foreign particles by the surface include abrasive flow machining, micropolishing, and electropolishing. The choice of VAR quality stainless steel for the product line is described. Several SEM photomicrographs show the level of improvement achieved. Table 3 presents data on the relative rates of corrosion for electropolished and unelectropolished Type 316L stainless steel versus Type 316.
  
04. Bourscheid, G., Bertholdt, H. *How Production Technologies Influence Surface Quality of Ultraclean Gas-Supply Equipment: Assessment of Surface Technologies*, article in four parts, Microcontamination, February, March, April, and June 1990. The effects of various machining techniques on the surface finish of stainless steel are discussed. Surface finishes before and after electropolishing are shown for each process. Electropolishing is compared to chemical polishing and to mechanical smoothing as means of achieving ultra pure surfaces.

## SELECTED LITERATURE, CONTINUED

05. Szklarska-Smialowska, Z. Pitting Corrosion of Metals, Houston, TX, National Association of Corrosion Engineers, 1986, 0-915567-19-9, A survey of literature on the chemical and physical mechanisms governing the pit corrosion of metals is presented. The discussion includes application of the basic theory to stainless steel. The influence of surface condition or preparation on the relative rate of pit corrosion is also described.
06. Rokicki, R. *The Effect of Electropolishing on SS Welds and Heat Affected Zones*. Metal Finishing, April 1990, p. 31-32. Resistance to pitting in 6% ferric chloride was compared for passivated and electropolished samples from which weld scale had been removed by pickling. The results indicated that electropolishing produced a significant improvement in corrosion resistance over passivation. The author proposes that the electropolishing process produces a more stable oxide film than Type I passivation.
07. Villafranca, J., Zambrano, E. M. *Optimization of Cleanability*, Pharmaceutical Engineering, Nov/Dec 1985, Vol 5, No. 6. The traditional sanitary finish produced by mechanical polishing results in a surface having poor cleanability and poor corrosion resistance. Experimental work shows that an electropolished surface provides improved cleanability, better detection of weld cracks and pores, and higher corrosion resistance than the industry standard finish.
8. Irving, C. C. *Electropolishing Stainless Steel Implants*. 1981. Internal Communication. The electrochemical reactions occurring during electropolishing are discussed, as well as the physical techniques used to electropolish stainless steel. Data on corrosion resistance of electropolished stainless steel is compare to conventional passivation treatments.