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CarTech®

TECHNICAL REPORT

Type 316L-SCQ® Stainless

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The U.S. semi-conductor industry, independently and cooperatively through Sematech in Austin, Texas, is pursuing an improvement in manufacturing yields of semi-conductor products. One means to accomplish this is to enhance the surface quality of process media wetted surfaces of ultra clean gas supply equipment. This includes upgrading the cleanness of Type 316L which has been traditionally used for valves, regulators, fittings, glands, gaskets, pipe and tubing. By reducing the frequency and severity of non-metallic inclusions, it is possible to achieve a better electropolished surface, with fewer "pits" that might conceivably entrap contaminants in the gas stream.

The chemical composition of Type 316L-SCQ® stainless is tightly controlled within conventional analysis limits for this grade. Carefully selected melt stock is utilized to restrict the occurrence of typical residual elements. One important element, which influences inclusion count, machinability and weldability, and can be varied according to customer specification, is sulfur. The intermediate sulfur range is controlled to 0.005 to 0.015%. This composition is melted via air melt plus vacuum arc remelting techniques. For the ultra-pure composition, sulfur is held to 0.005% maximum, and melting is via vacuum induction plus vacuum arc remelting.

Since corrosion resistance and mechanical properties are characterized by chemical composition and not melting practice, the properties of Type 316L-SCQ stainless are similar to those listed in the standard alloy data sheets for Type 316L. A popular specification for purchasing bar product is ASTM A-276, with the following mechanical property requirements:

0.2% Yield Strength .... 25 ksi min.
Ultimate Tensile Strength .... 70 ksi min.
% Elongation (4D) .... 30% min.
% Reduction of Area .... 40% min.

Many customers prefer a small amount of cold work to enhance machinability and achieve a better chip characteristic and as-machined surface finish. The process of cold drawing increases the yield strength and tensile strength and decreases percent elongation and percent reduction of area. To accommodate cold work to improve machinability, many customer specifications allow a decrease in the percent elongation requirement to 20% minimum.

Cleanness is typically evaluated by means of a microscopic examination of a sample to establish a "J-K" rating. This is done in accordance with ASTM E-45 Method A with ratings based on Plate III. The evaluation is conducted at the billet stage by rating samples from the top and bottom of the first, middle and last ingot of the heat. The following limits are acceptable for air melt plus vacuum arc remelted Type 316L-SCQ stainless (AOD + VAR) with 0.005 - 0.015% sulfur.

A		B		C		D	
Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick
No Guarantee		1-1/2	1	1-1/2	1	1-1/2	1

A - (Sulfides), **B** - (Alumina), **C** - (Silicates), **D** - (Oxides)

Candidly, the reason we are offering only a single vacuum melt (AOD + VAR) and no guarantee on Category A inclusions (sulfides) is that when sulfur is **added** to meet the intermediate sulfur level, it is obvious that the level of sulfide inclusions will increase. We have, in fact, seen values up to a rating of 3 in Category A thin in some heats.

The cleanest version of Type 316L-SCQ stainless utilizes two vacuum melting techniques, in combination with restricting sulfur to 0.005% maximum. In all other respects, this material has the same chemical balance and mechanical property capability as the (AOD + VAR) single vacuum melted material. But, to illuminate the advantage of combining low sulfur and double vacuum melting, the following J-K limits apply for Type 316L-SCQ stainless (VIM + VAR).

A		B		C		D	
Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick
1	1	1	1/2	1	1/2	1	1

(over)

6-94/.5M

The two issues most frequently questioned are weldability and machinability. Since machinability means different things to different shops (speeds and feeds, tool life, surface finish, etc.) each shop needs to run comparative tests to establish optimum machining parameters for a particular sulfur level, and to generate cost data. Usually, the lower the sulfur level the greater the tendency to burnish the surface, which improves surface lustre. Also, the lower the inclusion content, the better the surface after electropolishing.

With respect to weldability, it is known that sulfur influences weld penetration and bead contour. Penetration ratio (ratio of depth to bead width) increases with an increase in sulfur content up to about .03%. The weld bead geometry (weld meandering) can be a problem if components with significantly different sulfur levels are joined. Good welds are possible between two compositions where each meet either the .005% max. sulfur or .005-.015% sulfur ranges.

Components made from bar stock are frequently welded to tubing, and some concern has been expressed about field welding components with 0.001 or 0.002% sulfur to tubing with 0.012% sulfur or greater. Currently, the industry is addressing this issue by proposing specifications that would restrict the sulfur level in tubing to 0.010% maximum. Considerable experience has demonstrated that the increased purchase price and machining costs associated with double vacuum melted ultra low sulfur is more than offset by the ability to consistently achieve an exceptional electropolished finish. Current industry practice has been evolving over a period of time, and Carpenter has demonstrated a commitment to meeting the needs of its customers.