



COMPARISON STUDY 316, 316L AND 316LVM STAINLESS STEEL

	<u>316</u> <u>ASTM A 313-08</u>	<u>316</u> <u>ASTM A 276-08a</u>	<u>316L</u> <u>ASTM A 276-08a</u>	<u>316LVM & 316LS</u> <u>ASTM F 138-08</u>
C (Carbon)	.07% Maximum	.08% Maximum	.030% Maximum	.030% Maximum
Cr (Chromium)	16.5%-18.0%	16.0%-18.0%	16.0%-18.0%	17.0%-19.0%
Cu (Copper)	Not Required	Not Required	Not Required	0.50% Maximum
Fe (Iron)	Balance	Balance	Balance	Balance
Mn (Manganese)	2.00% Maximum	2.00% Maximum	2.00% Maximum	2.00% Maximum
Mo (Molybdenum)	2.00%-2.50%	2.00%-3.00%	2.00%-3.00%	2.25%-3.00%
N (Nitrogen)	0.10% Maximum	Not Required	Not Required	0.10% Maximum
Ni (Nickel)	10.5%-13.5%	10.0%-14.0%	10.0%-14.0%	13.0%-15.0%
P (Phosphorous)	0.045% Maximum	0.045% Maximum	0.045% Maximum	0.025% Maximum
S (Sulfur)	0.030% Maximum	0.030% Maximum	0.030% Maximum	0.010% Maximum
Si (Silicon)	1.00% Maximum	1.00% Maximum	1.00% Maximum	0.75% Maximum

Additional Requirements in ASTM F 138:

1. % Cr + 3.3 x % Mo ≥ 26.0
2. Material shall be free of the delta ferrite, chi, or sigma phases when examined metallographically at 100X magnification.
3. Microcleanliness using Method A of Test Methods in E 45. Use the included table of maximum allowable inclusion types for Sulfides, Alumina, silicates, and Globular Oxides.
4. Intergranular corrosion susceptibility test in accordance with Practice E of A 262
5. Grain Size: ASTM #5 or finer.

The special tests are meant to ensure that a homogeneous metallurgical microstructure is present which provides superior corrosion and fatigue resistance. Delta ferrite is a magnetic phase that must be absent in order to provide a completely nonmagnetic microstructure that will not cause torque, displacement or heating in a Magnetic Resonance Imaging (MRI) environment).

What is the difference between 316LVM / 316LS per ASTM F 138 and the other grades ?

Carbon: Limited to .030% Maximum. The low carbon level provides an extra measure of assurance that the material will be free from susceptibility to intergranular corrosion).

Copper: Not called out in the other specifications but a maximum of 0.050% established for ASTM F138. The maximum Copper value is considered a practical limit based on a statistical evaluation of commercially available material.

Chromium: Range shifted up to 17.0%-19.0% from 16.0%-18.0% or 16.5%-18.0%.

Manganese: Same for all specifications (2.00% Maximum).

Molybdenum: Lower end was increased from 2.00% to 2.25%. (Top end remains the same at 3.00%). These shifts were made to comply with ISO 5832-1. Also, Molybdenum enriched chi and sigma intermetallic compounds must not be present in the microstructure because of reduced austenitic corrosion resistance and possible embrittlement effects

Nickel: Range is shifted upwards and is narrower to 13.0%-15.0% vs. 10.0%-14.0% or 10.5%-13.5%. These shifts were made to comply with ISO 5832-1. Previous increases in the Nickel range were to ensure that compositions melted to the upper end of the Molybdenum range would be free of delta ferrite.

Nitrogen: Same for all specifications (0.10% Maximum).

Phosphorous: Lowered to 0.025" Maximum vs. 0.045% allowed in the other specifications.

Sulfur: Lowered to 0.010" Maximum vs. 0.030% allowed in the other specifications.

Silicon: Set as 0.75% Maximum vs. 1.0% Maximum allowed in the other specifications.