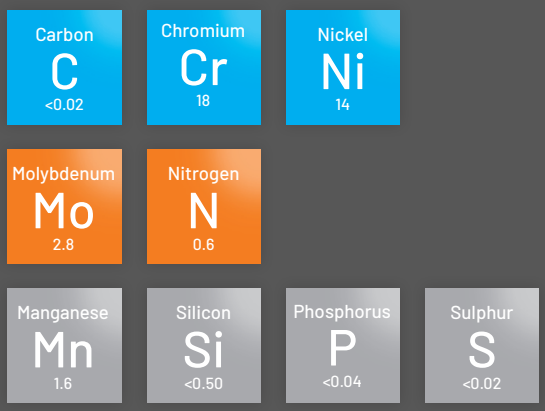
MANNESMANN STAINLESS TUBES
A Member of the Salzgitter Group

DMV 316LUG

1. Applications

DMV 316LUG is specially developed for use in urea applications, which are specified and proved by the main engineering and licensor companies, i.e. Stamicarbon, Snamprogetti or Urea Casale.

Straight and U-bent tubes can be delivered for use in carbamate condensers, scrubbers, strippers and associated piping.



Chemical composition nominal %

2. Main Features

DMV 316LUG is an austenitic stainless steel with minimum 2.3% molybdenum and max. 0.6% ferrite content.

3. Description

3.1 Reference Standards

- UNS S31603 acc. to ASTM A 213 and ASTM A 312
- 1.4435 acc. to EN 10216-5 and EN 10297-2

3.2 Chemical Composition

DMV 316LUG typical values:

	Weight %
C	< 0.02
Si	< 0.50
Mn	1.60
P	< 0.04
S	< 0.02
N	0.06
Cr	18.0
Ni	14.0
Mo	2.80
Fe	Balance

3.3 Mechanical Properties

The following values are guaranteed in the solution annealed condition:

3.3.1 Tensile Properties at 20°C (68°F)

UNS S31603 acc. to ASTM A 213 and ASTM A 312:

	MPa	ksi
0.2% Y.S. min.	170	25
U.T.S. min.	485	70
E in 2", min., %	35	

1 MPa = 1 N/mm² ; 1 ksi = 6.9 MPa

Grade 1.4435 acc. to EN 10216-5 and EN 10297-2:

	MPa	ksi
0.2% Y.S. min.	190	(27.5)
1.0% Y.S. min.	225	(32.6)
U.T.S. min.	490	(71.0)
A%	40	

( ) = calculated values

3.3.2 Tensile Properties at Elevated Temperatures

Grade 1.4435 acc. to EN 10216-5 and EN 10297-2:

Temp.		0.2% Y.S. min.	1.0% Y.S. min.
°C	(°F)	MPa (ksi)	MPa (ksi)
100	**(212)**	165 (23.9)	200 (29.0)
150	**(302)**	150 (21.7)	180 (26.1)
200	**(392)**	137 (19.9)	165 (23.9)
250	**(482)**	127 (18.4)	153 (22.2)
300	**(572)**	119 (19.2)	145 (21.0)
350	**(662)**	113 (16.4)	139 (20.1)
400	**(752)**	108 (15.7)	135 (19.6)
450	**(842)**	103 (14.9)	130 (18.8)
500	**(932)**	100 (14.5)	128 (18.6)
550	**(1022)**	98 (14.2)	127 (18.4)

( ) = calculated values

3.3.3 Impact Resistance

The notch impact energy at 20 °C (68 °F) in longitudinal direction must be min. 100 J (average value of three samples, with min. 70 J individual value).

3.4 Physical Properties

Density at 20 °C (68 °F)	
g/cm³	lbs / in³
8	0.29

Coefficient of Thermal Expansion between 20 °C (68 °F) and ...			
°C	(°F)	10^{-6} / K	10^{-6} / °F
100	**(212)**	16.0	9.2
200	**(392)**	16.5	9.5
300	**(572)**	17.0	9.7
400	**(752)**	17.5	10.0
500	**(932)**	18.0	10.2

Thermal Conductivity			
°C	(°F)	W / (m K)	Btu in / (ft h °F)
20	**(68)**	14.0	8
100	**(212)**	14.6	9
200	**(392)**	17.0	10
300	**(572)**	18.0	11
400	**(752)**	20.0	13
500	**(932)**	21.0	13

Modulus of Elasticity			
°C	(°F)	10^3 MPa	10^3 ksi
20	**(68)**	200	(29.0)
100	**(212)**	194	(28.1)
200	**(392)**	186	(27.0)
300	**(572)**	179	(25.9)
400	**(752)**	171	(24.8)
500	**(932)**	164	(23.8)

( ) = calculated values

3.5 Corrosion Properties

DMV 316LUG exhibits good resistance to oxidation and a low rate of scaling in air atmospheres.

It should also be mentioned that DMV 316LUG is barely susceptible to precipitation of chromium carbides in grain boundaries when exposed to temperatures in the range of 430 °C – 820 °C (800 °F – 1500 °F). Such "sensitized" steels are subject to intergranular corrosion when exposed to aggressive environments.

Conditions which produce Stress Corrosion Cracking (SCC) are:

- Presence of halide ions (generally chlorides)
- Residual tensile stress
- Temperature in excess of about 50 °C (120 °F)

Stresses result from cold deformation or thermal cycles during welding. Annealing or stress relieving heat treatments reduce sensitivity to halide SCC.

Nevertheless, DMV 316LUG is less susceptible to SCC in halide environments than the 18Cr-8Ni austenitic stainless steels due to its higher molybdenum content and low ferrite content (< 0.6%).

As unsensitized material, DMV 316LUG meets the requirements of HUEY test (= ASTM A 262 Practice C). Stamicarbon, for instance, specifies 5 boiling periods of 48 h each with an average corrosion rate of 0.54g/m2 h = 3.3 µm/48 h. This is equivalent to 0.6 mm/year (24 mpy). Moreover, the maximum selective attack is less than 150 µm.

4. Supply Range

4.1 Dimensional Range

Nominal Dimensional Range		
Cold Finished		
Outside Diameter	mm	inch
min	1.6	0.063
max	244.5	9.626
Wall Thickness	mm	inch
min	0.1	0.004
max	40	1.575
Hot Finished		
Outside Diameter	mm	inch
min	32	1.260
max	280	11.024
Wall Thickness	mm	inch
min	2.8	0.110
max	60	2.362

Specific dimensions by grade available upon request.

4.2 Delivery Condition

Pipes and tubes are delivered in cold or hot finished condition depending on size and specification. Normally they will be supplied in annealed condition.

4.3 U-bent

Tubes for urea applications are also available in U-bent version in lengths of up to 30 m (straight); the high deformability of the material allows cold bending down to a very small bending radius.

5. Fabrication

5.1 Heat Treatment

Tubes and pipes in DMV 316LUG are normally solution annealed in the temperature range of 1040 °C – 1100 °C (1900 °F – 2010 °F), followed by air cooling or water quenching.

As for other austenitic stainless steels, cleanliness requirements (especially contamination from greases) must be strictly observed. The furnace atmosphere must have very low sulphur content. When tubes will be subsequently used in a moist environment, oxidation must be avoided by

- use of highly reducing atmosphere (cracked ammonia, hydrogen...) or
- removal by pickling after heat treatment.

DMV 316LUG cannot be hardened by heat treatment.

5.2 Bending

DMV 316LUG is suitable for further cold or hot forming.

For hot bending the temperature may be 1000 °C – 1150 °C (1830 °F – 2102 °F) followed by rapid cooling. Cold bending of solution annealed tubes and pipes can be handled as with austenitic stainless steels. Therefore they have to be solution annealed again if the forming degree is > 20% or the R/D ratio is < or equal 2.5.

For corrosion reasons, it is sometimes recommended to perform a new solution annealing even following smaller forming degrees.

5.3 Welding

DMV 316LUG has a good weldability. Welding is possible with all usual processes for stainless steels. Preheating and heat treatment after welding is normally not necessary. To avoid hot cracks in the weld metal, the processes recommended by the filler producers have to be observed. Only approved filler materials should be used that have been tested for the expected application temperature. The calculation values for the filler materials should be followed.

In all cases the usual cleanliness precaution for welding stainless steels should be observed. Where the subsequent application might be in a moist environment, all oxidation must be avoided or eliminated.

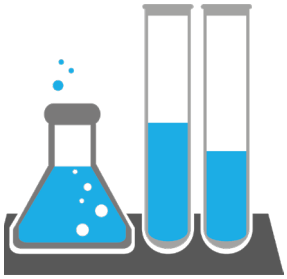
6. Standards and References

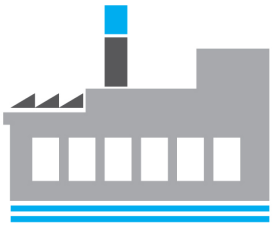
DMV 316LUG may be delivered in accordance with all commonly used European, American and other international standards. Our specialists are at your service for any guidance on drawing up your specifications.

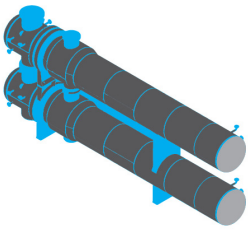
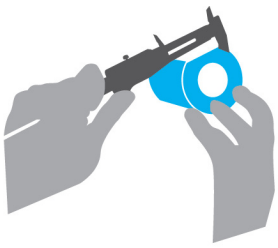
Mannesmann DMV Stainless has delivered DMV 316LUG tubes and pipes to a wide range of worldwide customers in the urea industry. References are available upon request.

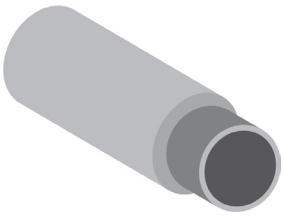
For any specific queries, please contact our sales offices.

Visit our Tech Centre for full product range details, calculators and learning.





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