## Valbruna Grade

GL3

## Steel type

Corrosion Resistant Alloys

## Description of material

GL3 is a Nickel - Chromium - Molybdenum - Niobium alloy austenitic stainless steel whose structural strengthening is obtained by the effect of the addition of Mo and Nb and it can be defined as a multi-role alloy.

## Applications

The structure and composition of GL3 offers an excellent resistance to several corrosive aggressive media in cryogenic up to high temperature environments. GL3 is suitable for the fabrication of many products such as flanges, valves, bolting, pump shafts, chains, fittings, food/beverages industry equipment, turbines, storage tanks, parts working in corrosive environments such as chemical processing, handling acid, subsea and deep-water offshore oil production systems and several marine applications. In addition, this alloy is used in several aircraft applications and nuclear components and where creep and thermal fatigue resistance are required in both in oxidizing and reducing high temperature environments.

## Corrosion resistance

GL3 is resistant to several organic chemicals and inorganic compounds, atmospheric corrosion, marine environments, and sterilizing solutions. In sea water, this grade is more resistant to uniform corrosion than NTR50 providing a very high resistance to Chloride-induced stress corrosion cracking and an outstanding pitting and intergranular corrosion resistance thanks to the stabilization effect of Niobium. These properties are warranted in applications in both organic and mineral acids and several alkali, together with good mechanical characteristics and creep resistance even in hot corrosive atmospheres. It’s important to know that two kinds of heat treatment can be performed in order to enhance these properties in different ways: a higher temperature solution annealing in the case of service at high temperature in order to increase creep resistance, or, opting for a soft annealing in the other cases such as for corrosion resistance, high fatigue strength and mechanical properties. It should be noted that GL3, as for every kind of stainless steel, surfaces should be free of contaminant and scale, heat tint for optimum resistance to corrosion.

## Cold working

GL3 can fabricated by cold working operations such as cold drawing and bending, but should not be used over a certain amount of cold heading, because its chemical balance does not allow to obtain a soft strain hardened structure after cold deformation, due to the high CWHF (Cold Working Hardening Factor). In any case, cold processes shall be carried out in the annealing condition, avoiding high levels of cold working, applying an intermediate annealing if necessary. However, after cold working, this grade should be soft or solution annealed depending on the final use. Cold working doesn’t increase its magnetic permeability as compared to type 316 and similar steels.



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## Machinability

GL3 has the typical machinability of austenitic structures strengthened by Nitrogen and some difficulties could happen in drilling, turning, threading and milling processes due to its capacity to cold work harden and its low chip-ability. Operators should know that this grade requires more rigid and powerful machines, in addition to the correct choice of tools, coating carbides and cutting fluids. GL3 has a very high hardening factor and the knowledge of this behavior must be correctly considered when a piece requires two or several cutting steps to be finished. The cold worked layer caused by the cutting tool is very hard and, if the subsequent turning or milling processes work on this hardened layer, a rapid tool wear could happen. The tool must work under this layer. Some improvement could be obtained by dissipating heat using an appropriate and large amount of cutting fluids and tools with a correct edge geometry with a suitable chip breaker. This is particularly important when using multi-spindle and automatic screw machines.

## Weldability

GL3 can be welded by using any one of welding process employed with typical austenitic grades but requires some different welding process evaluations when compared to these ones. Correct welding practices such as right heat inputs, inert shielding gas and cleanliness before/after welding must be followed to obtain best results in terms of corrosion resistance. In the case of high energy autogenous welding processes, there could be some risk of hot cracking in the fused zone as there is a not uniform distribution of Molybdenum because, during the solidification, the weld cools too rapidly. Therefore, GL3 requires special filler metals to obtain a high corrosion resistance together with high strength and toughness of the weld. No preheating or post welding heat treatment are normally necessary. The weld discoloration should be removed by acid pickling or, at least, by mechanical pickling (shot blasting or grinding) if it were impossible to perform the first one.

## Hot working

GL3 has a good hot plasticity and is suitable for processing by hot extrusion or by upsetting with electric resistance heating. This grade can be hot headed but it's important to point out that its forging temperature is lower than that of typical austenitic stainless steels. Because GL3 has hot high hardness, overheating must be always avoided. The choice of hot working temperature and process parameters must always evaluate both the strain rate and the consequent increasing of temperature that is reached after hot deformation. High strain rates and temperatures at the top of the range during the hot forming process, could generate structural loss of cohesion or internal bursts and a heavy scale formation as well. In addition, there should be no forging done at the very lower limit of the temperature forging range to avoid slivers in cold zones. Good rules impose that in Primary hot transformation processes, a high temperature homogenization of large ingots and dynamic recrystallization parameters should be rightly evaluated. In the case of open die forging of large ingots and shapes, GL3 offers a good hot plasticity if a suitable soaking and a right temperature are applied. In Secondary hot transformation processes, such as extrusion, rolling or close die forging, temperatures, strain and strain rate should be well considered. Suitable strain in terms of section reduction (for instance: 20-25%) at lower range of hot working temperature is recommended especially in the case of open – die forging. This practice is suggested in order to obtain a fine grain structure which is very important for mechanical, fatigue and corrosion resistance properties and make it easier for ultrasonic testing to detect small indications as required by several International Norms. Forgings can be cooled rapidly in air or water avoiding slow cooling.



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## Designations

| | |
|---|---|
| Commercial name | Alloy 625 |
| International Designation | NiCr22Mo9Nb |
| W.N. | 2.4856 |
| UNS | N06625 |
| BS | NA21 |

## Chemical composition

| Chemical element | C | Mn | Si | S | P | Ni | Cr | Fe | Mo | Cu | Ti | Al | Co | Ta+Nb | Ta | Nb |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum value % | - | - | - | - | - | 58% | 20% | - | 8% | - | - | - | - | 3.15% | - | 3.15% |
| Maximum value % | 0.1% | 0.5% | 0.5% | 0.015% | 0.015% | - | 23% | 5% | 10% | 0.5% | 0.4% | 0.4% | 1% | 4.15% | 0.5% | 4.15% |

## Heat treatment

| Description of condition | Condition | Minimum temperature °C | Maximum temperature °C | Cooling |
|---|---|---|---|---|
| Grade 1 - Annealed | A | 871 | 1092 | Water |
| Grade 2 - Solution Annealed | A | 1093 | - | Water |

## Physical properties

| Physical property | SI/metric units | US/BS Imperial units |
|---|---|---|
| Density | 8.45 $kg/dm^3$ | 0.305 $lb/in^3$ |
| Specific Thermal Capacity 20° C | 410 J/(kg·K) | 0.098 Btu/lb°F |
| Thermal conductivity 20° C | 9.8 W/(m·K) | 67.948 Btu in/ $ft^2$ h °F |
| Thermal expansion 20° - 100° C | 12.8 ($10^{-6}$/K) | 7.111 ($10^{-6}$/°F) |
| Electrical Resistivity 20° C | 129 $\Omega \cdot mm^2/m$ | 5078.74 μΩin |
| Modulus of Elasticity 20° C | 209 GPa | 30312.887 ksi |



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## Mechanical properties

| Condition | Subtype | Rm [N/mm²] | Rm [Ksi] | Rp0.2% [N/mm²] | Rp0.2% [Ksi] | E4d [%] | HBW |
|---|---|---|---|---|---|---|---|
| Grade 1 - Ø < 102 - Annealed | A | 830 min. | 120 min. | 414 min. | 60 min. | 30 min. | 325 max. |
| Grade 1 - 102 < Ø < 254 - Annealed | A | 760 min. | 110 min. | 345 min. | 50 min. | 25 min. | 325 max. |
| Grade 2 - Solution Annealed | A | 690 min. | 100 min. | 276 min. | 40 min. | 30 min. | 325 max. |



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