FAQ’s on AL6XN Alloy

1. Is AL-6XN stainless steel?

AL-6XN alloy is a corrosion resistant iron-base austenitic stainless alloy. It is a low carbon, high purity, nitrogen-bearing "super-austenitic" stainless steel with levels of high nickel and molybdenum to improve resistance to chloride stress corrosion cracking and chloride induced pitting.

AL6XN			316L		
Element	**Minimum** (weight %)	**Maximum** (weight %)	**Element**	**Minimum** (weight %)	**Maximum** (weight %)
Cu		0.75	Cu	None	None
N		0.25	N		0.10
Mo	6.0	7.0	Mo	2.0	3.0
Ni	23.5	25.5	Ni	10.0	14.0
Cr	20.0	22.0	Cr	16.0	18.0
Si		1.0	Si		0.75
S		0.03	S		0.03
P		0.04	P		0.045
Mn		2.0	Mn		2.00
C		0.03	C		0.03

2. Can I weld AL-6XN to 316L stainless steel?

AL-6XN alloy and 316L stainless steel can be joined easily using standard welding practices for austenitic stainless steel. However, from a corrosion resistance viewpoint, this joining is not recommended if avoidable. Whenever welding two different materials together, it is important to consider the galvanic potential between the two materials. AL-6XN contains higher levels of chromium, nickel, and molybdenum than 316L stainless steel, making it the cathodic material with a higher potential than the anodic 316L. When these two materials are joined together by welding in the presence of an electrolyte (the liquid product), an exchange of current between the anode and cathode is achieved. As the current flows between the two materials, molecular particles of the anodic material (316L) are also removed with the flow of current. The higher the potential difference between the two materials, the quicker the failure by consumption of the anode will be achieved. As the anode is consumed and therefore becomes smaller in comparison to the cathode, the larger the potential difference becomes increasing the speed by which the anode is consumed.

When welding the two materials together, as stated previously, chemical segregation of the molybdenum and chromium will occur in the heat-affected zone of the weld area. This increases the odds for crevice corrosion and pitting to occur under oxides on the surface of the weld areas. Due to the chemical composition of these materials during weld segregation, 316L actually becomes less noble when coupled by welding than if the two materials were joined together by clamping or bolting, and even these unions cannot eliminate the potential for galvanic corrosion. Dependent on the severity of the service and if indeed it is a borderline application between AL-6XN and 316L, the mixing of the two metals in the melt most likely would not be attacked. However, if the intended service is indeed very corrosive, the heat affected zone just past the weld in the 316L joining more than likely would be preferentially attacked.

3. Are there special welding procedures that have to be followed?

If the component can be heat treated, a full solution anneal at the proper temperature may be substituted for over-alloying the welds. Often annealing is not practical so in order to maintain the integrity and corrosion resistance of the weld area, over-alloying the weld by using a consumable insert ring or weld wire on all welds is imperative. The insert rings used are typically Alloy 22, a 15% Molybdenum containing alloy. The minimum alloy recommended if Alloy 22 is not available is Alloy 625 or Alloy C 276 may be substituted as well.

4. What is a weld insert ring?

Weld insert rings are used as filler metal for orbital or hand welding AL-6XN alloy. This will "over-alloy" the weld area to compensate for chemical segregation that may take place during the welding process. The filler alloy must have higher molybdenum content than the AL-6XN alloy to compensate for alloy dilution on cooling. Rings are typically available in a 9% molybdenum alloy (Alloy 625), 12% molybdenum alloy (C-22), or 15% molybdenum alloy (C-276). They are also available in three different configurations: 1. washer style, 2. OD t-shaped and 3 ID t-shaped.

5. Is one style or material of insert ring better than the other?

Our studies have shown that a better quality weld is achieved with the washer style insert ring over the t-shaped rings. Additionally there are two different t-shaped rings available. One is the OD style machined ring and the other is the ID style formed split ring. Welding studies performed have shown indications of undercuts on the t-shaped rings; specifically the ID style split ring and areas where the rings did not actually meet leaving unprotected areas in the weld. CSI has standardized on the washer style ring fabricated from C-22 material. The material choice was strictly based upon the corrosion resistant properties of C-22 in pitting applications.

6. What happens if I don't use the insert rings and don't anneal after welding?

Expect corrosion to take place in the weld and in the heat affected zone adjacent to the weld. Without following the correct welding guidelines, AL-6XN alloy will have only a little better corrosion resistance than a 317L stainless steel. In applications where AL-6XN is most commonly used, failure without following the correct installation guidelines is imminent.

7. Can I weld AL-6XN by hand?

Yes, using the same cleaning, handling, and welding procedures as used on 316L stainless steel. Reduce the amperage by approximately 10% and weld about 10% slower.

8. Do I need to passivate a system constructed of AL-6XN?

Yes, studies have been performed comparing AL-6XN and 316L stainless steel and the benefit of passivation. AL-6XN will form a passive surface on the steel just like 316L. As with any system, cleanliness is key. It is imperative that any oxides from welding, oils, cutting fluids, etc. be removed after installation in order for the passive surface to form to its full extent, therefore giving the best overall protection and corrosion resistance.

9. Aren't all 6-moly materials the same?

No. All 6% moly materials are similar in chemistry, however. Some contain lower or higher levels of chromium; some contain higher levels of copper, etc. The key to material selection is component availability and welding compatibility. AL-6XN is readily available in all forms from sheet and plate to sanitary tubing and fittings. When joining materials by welding, it is always best to match the chemistry at each joint with the same material, and if possible even from the same heat or lot of material.

10. How much longer can I expect a system fabricated from AL-6XN to last over 316L?

It is difficult to give an exact number when asked how much longer a system will last over 316L. There are many variables with formulas and processes changing over time. However, if everything remains constant and a system is well maintained, we have seen systems fabricated from 316L fail within 12 months and then last in excess of 8-9 years when replaced with AL-6XN alloy. You certainly cannot guarantee this success in every application, but remember - proper installation and maintenance is key to the life of any system.

11. Will AL-6XN help or eliminate my rouging problem?

There are three types of rouging. I have outlined each type below and the potential of AL-6XN as a material alternative.

Class I is the most prevalent type found in pharmaceutical systems; it is caused from the erosion of centrifugal pump components, impellers, volutes and venturi on the back of the pump, and cracked valves. You can see the erosion of the softer material primarily the austenite away from the heavier material which is the nickel poor ferrites. When you look at the eroded areas with a scanning electron microscope you can see the ghosts of the dendritic structures. The softer parts are blasted out by the higher velocity water (sonic velocities). What happens is the higher velocity waters erode the tips of the impellers and all other items in its path, as soon as it gets into the tube it drops velocity back to std flow velocity (approx. 5 ft per second) and drops out everything it has picked up. The metal particles are attracted to the metal walls by electrostatic actions and gather on the walls. Concentrations are always heavier in the area from the pump outlet to some distance downstream. In these areas the particles will oxidize in the WFI because this is a superior oxidizing agent and begins to develop oxide films. Class I is strictly a function of the pump and the velocities. Type I - the red oxide - is due to the formation of hematites (Fe_2O_3), yellow oxide is hydrated hematites which is water stuck on to the molecule. Any material used downstream will rouge where Class I rouging is occurring.

Class II comes from the metal itself, and it is usually caused by a corrosion mechanism eating into the passive layer. Usually this form of rouging occurs in systems that have not been chemically passivated. This is why it is so critical all WFI systems are passivated with nitric or citric acid. Class II rouging forms when little pustules developing on the surface explode, leaving brilliant silver spots under them. These are active sites of rouging, known as "in-situ rouging." Type II is primarily hematite (Fe_2O_3).

AL-6XN will help this form of rouging tremendously.

Class III is high temperature rouging and develops a heavy black film (magnetite Fe_2O_3) on the surface. If the surface has been electro polished this film will appear glossy black. If the system is non-passivated it becomes a powdery black. The glossy black is extremely stable. If you strip it off, re-passivate and pass high temp steam through it again. It will reform in a matter of months. In most cases you don't worry about this form of rouging. The powdery black surface is not stable and can release particles into the product.

Currently, not enough data has been collected to determine if AL-6XN will help this form of rouging.

In summary, AL-6XN will not help in class I rouging problems. However, class II rouging applications will see a definite benefit from the use of AL-6XN. In class III formations, there is no data available at this time to make a determination; all indications state that AL-6XN will improve class III rouging problems but will not totally eliminate the problem in all cases.

12. What type of application is best suited for AL-6XN?

Specifically, any application that is experiencing chloride induced corrosion in the forms of pitting, crevice corrosion, or stress corrosion cracking may be a candidate for replacement with the AL-6XN Alloy. The alloy has been used successfully in pharmaceutical and cosmetic process systems, food processing systems such as ketchup, soy sauces, BBQ sauces, baby foods, corn syrups, etc. AL-6XN alloy is also used successfully in beverage systems that manufacture sports drinks as well as the brewery industry.

13. How can I justify the cost of AL-6XN?

Consider the costs of continually replacing 316L stainless steel components, downtime and labor costs associated with those replacements, and the possible product contamination issues, and the question becomes "How can you not justify the cost of AL-6XN?"