TD-01-009
February 6, 2001

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Possible structural changes in the stainless steel used as spacer between the magnetic poles for VLHC 1.

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Introduction

The spacers for the magnetic poles for the VLHC 1 are foreseen in stainless steel 316 L, and they should be welded to the low carbon steel structure. Special attention should be paid to avoid the formation of magnetic phases in the welding during the assembly of the magnetic parts.

Formation of magnetic phases in the base metal.

The possible formation of magnetic phases during the welding of stainless steels is related to the ability of the material to stabilize the magnetic cubic-body-centered structure (or alpha structure) or the non-magnetic cubic-face-centered structure (or gamma structure). This ability is usually expressed in term of Chromium and Nickel equivalent of the stainless steel used

The formula to calculate the Chromium and Nickel equivalent in the weld (extended Eichelmann and Hull formulas) are the following [(1)]:

Chromium equivalent = %Cr + %Mo + 1.5 * %Si + 0.5 * %Nb + 0.5 * %Ta + 2 * %Ti + %W + %V + %Al
Nickel equivalent = %Ni + 30 * %C + 0.5 * %Mn + 0.5 * %Co

Considering the composition of the stainless steel 316L as presented in the table 1, it appears that the Chromium equivalent can vary from 18% to 22.5% and that the Nickel equivalent can vary from 10.9% to 15.9%. The values for the Nickel and Chromium equivalent for the mean composition are respectively 13.9% and 21%.

Element	Fe	C	Cr	Mn	Mo	Ni	P	S	Si
Mean composition[(2)]	65	0.03	17	2	2.5	12	0.045	0.03	1
Maximum content[(3)]			18		3	14			
Minimum content[(3)]			16		2	10			

Table 1: Chemical composition of stainless steel 316L. Composition expressed in%.

If the domain of existence of the weld is figured in the structure diagrams expressed as a function of the Chromium equivalent and Nickel equivalent (figure 1) it comes out that the weld has the biggest chance to be partly magnetic. In order to avoid this, the Nickel equivalent should be kept equal or greater as 14% and the Chromium equivalent should be less than 20% in the bare stainless steel material. A 316L stainless steel having a composition of 16% Chromium, 13% Nickel and 2% Molybdenum, the other components being equal to the mean composition, would be appropriate.

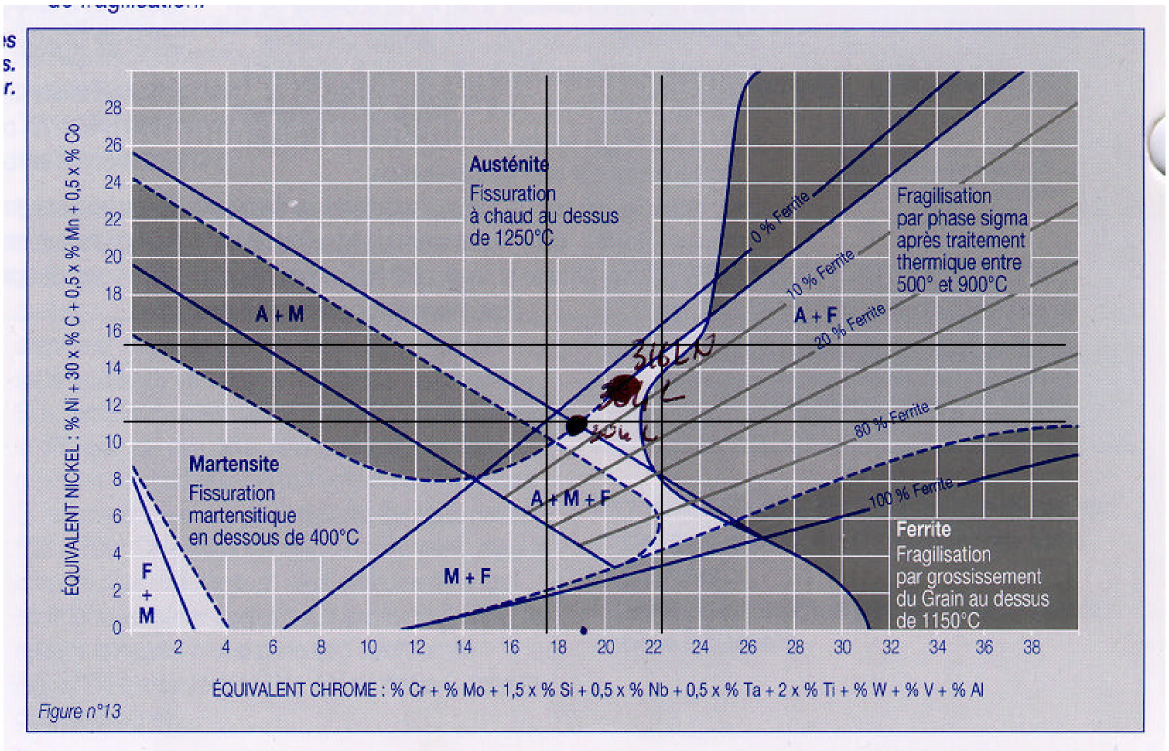

Figure 1: Schaeffler Diagram of the welded area.

Welding metal to fill the welded area.

If the stainless steel used can generate magnetic structure inside its welded areas, and in order to avoid these effects, a special welding material should be used. A high Nickel content welding material, like Hastelloy C-22 should be effective for this purpose.

Weldability and cool down

Some comments should be made on figure 1: the best weldability is obtained in the dark areas, and all the dark areas are outside the domain of composition of the 316L. Considering the location of the 316L composition area, the risk associated with the welds is a failure at high temperature (higher than 1250C) of the weld. This can appear during cool down, especially if the welded parts have different coefficient of thermal expansion, this means especially if austenitic steel is welded to ferritic steel. Therefore special attention should be paid during welding to ensure that the cool down of the weld did not damage it.

Magnetic/non magnetic interface inside the weld.

Another concern is the limit between magnetic and non-magnetic steel inside the welded area. Even if it is possible to avoid the appearance of magnetic phases in a weld between two stainless steels, it seems impossible to control the limit between magnetic and non magnetic steel with a level of precision as good as the limit of stamped parts. The uncertainty in the magnetic/non magnetic boundary should be taken with as half the size of the welded area.

References.

1 – Guide technique des aciers inoxydables, document UGINE.