Recommendations for the design of welds at elevated temperatures

EN 1993-1-4 refers to EN 1993-1-8 for the design of welds. The only specific information given is that β_w for fillet welds should be taken as 1 unless a lower value is justified by tests. A consequence of the reference to EN 1993-1-8 is that the filler metal should have a strength at least equal to that of the base material.

For the fire design of stainless steel structure EN 1993-1-4 refers to Annex C of EN1993-1-2 for properties of the base material at elevated temperatures. No information is given about the filler metal. EN 1993-1-2 gives however some design rules for welds in carbon steel. For butt welds it is stated that the same strength as the base material may be assumed up to 700 ^{o}C and for higher temperatures that the strength reduction factors for fillet welds may be applied. These factors are lower than those for the base material.

The standards leave the question of design of stainless steel welds at elevated temperatures quite open and the reason is obviously lack of information. The question has been studied in this project and the conclusions are given below. The recommendations given are applicable to annealed grades and cold worked grades are not covered.

Butt welds

Butt welds made with filler metal at least matching the base material are considered as full strength at room temperature, which means that they are at least as strong as the base material. This means that no design calculations of the weld strength are needed. It has been shown in [x] that this also is true at elevated temperatures up to 1000 ^{o}C for two austenitic stainless steel grades, 1.4318 and 1.4571 combined with filler metal G 19 9 L, X2CrNiN18-7 and G19 12 3 Nb, X6CrNiMoTi17-12-2, respectively. This is a positive sign compared to the rules in Annex D of EN1993-1-2 for carbon steel. Generalizing these results requires information that the high temperature properties of the filler metal are similar to those of the base material. The problem is here that different stainless alloys have quite different strength reductions at elevated temperatures.

Fillet welds

Fillet weld and partial penetration welds are designed according to 4.5.3 of EN 1993-1-8 with β_w=1 for stainless steel. This may be conservative in case of filler metal substantially stronger than the base material. For fire design the strength reduction factors in Annex D of EN 1993-1-2 for carbon steel may be used. This is likely to be very conservative but no better information is available.

A particular problem should be noted when fillet welds are designed for calculated forces that are smaller than the member resistance (partial strength connections). In case of restrained members the dilatation caused by heating may cause big forces, which have to be considered for the design of connections. Alternatively, full strength connections should be used for such members.

[x] Jukka Säynäjäkangas, Stainless Steel in Fire, Task 5.3 Isothermal (steady-state) tests on butt welded joints, Draft Final report, March 30, 2007.