

“SIGMA PHASE” IN DUPLEX STAINLESS STEELS? - NEVER WITH EXPANITE!

Introduction:

Duplex stainless steels contain 2 types of microstructure, austenite and ferrite. Hence the name duplex. In simple terms, the combination of these two phases is what causes duplex alloys to be highly sensitive with respect to the formation of the so-called “Sigma phase” (σ -phase), because the σ -phase primarily will form in the boundary between austenite and ferrite, growing into the ferrite.

When does σ -phase form?

Sigma phase leaves the material in a stage with unfortunate material properties and must be prevented. Sigma phase forms primarily at 800-850C, but is able to form at temperature between 600 and 1000C, and will do so at varying rates, depending on the specific alloy.

Please refer to the below TTT (Time-Temperature-Transformation) diagram for SAF2205 and the speed of which foreign phases forms. For example, then chromium nitrides, chi-phase and carbides forms if a part made from SAF2205 is held at 800C for more than 1 min. The critical σ -phase precipitation will form after approximately 16 min.

During our tests, Zeron100 SuperDuplex alloy proved worst results as it initiated formation of σ -phase after 3.5 min. at 850C.

Why is σ -phase not a concern with Expanite treatments?

Firstly, cooling rate! The worst-case alloy found here, forms σ -phase after 3.5 min. at a steady 850C. During ExpaniteHigh-T treatment, cooling from 1100C to below 500C is done in maximum 30 sec., leaving the parts in the critical 800-850C range for times well below the formation limits.

Secondly, nitrogen! In the introduction it was mentioned that σ -phase forms in the boundary between austenite and ferrite, growing into the ferritic structure. This means that it does not typically grow in austenite. The addition of nitrogen to the alloy during the ExpaniteHigh-T treatment stabilises the austenitic phase in the surface region, thereby making the alloy less susceptible to formation of σ -phase.

So due to the extremely rapid cooling, and the addition of nitrogen, σ -phase precipitation will not be an issue with Expanite treatments.

