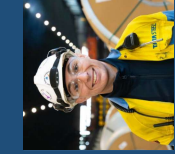


Impact of Residual Elements on Annealing Behaviour and Mechanical Properties of S250GD and S280GD Galvanised Structural Steels in the Transition from BOS to



EAf Steelmaking
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Introduction

The UK steel industry is moving from BOS to EAF steelmaking to reduce carbon emissions. EAF production uses recycled scrap, increasing residual elements such as Cu, Ni, Cr and Sn. These residuals cannot be removed during conventional refining and may increase strength while reducing ductility. This creates a risk that S250GD and S280GD galvanised structural steels could fall outside EN 10346:2015 requirements.

Key question:

Can the existing Zodiac annealing line remain compliant as residual content rises?

Methodology

Three industrial grades tested:

- Grade A: S250GD
- Grade B: S250GD
- Grade C: S280GD

Residual conditions:

Base → Low → Mid → High

Base = current BOS-type composition

Low/Mid/High = expected EAF residual levels

Key control:

C and Mn held effectively constant within each grade, so property changes could be linked mainly to residual content.

Combined Residual Index:

$Cu + Ni + Cr + 5Sn + 10Mo$

Testing:

CASIM annealing - tensile testing - SEM - EN 10346 compliance check

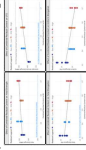
Results

All grades remained compliant with EN 10346:2015 across the full residual range and all annealing cycles. Increasing residual content generally increased yield strength and ultimate tensile strength, while reducing ductility.

Grade A and Grade B remained mostly ferritic and maintained good formability.

Grade C showed a second phase consistent with pearlite, contributing to higher strength and a higher yield-to-tensile ratio.

Across the tested range, composition had a stronger effect than annealing cycle.



Mechanical property response to combined residual content, showing the effect of increasing residuals on strength and ductility.

Industrial Context

The Zodiac line was developed around BOS-produced steel, where residual levels are low and predictable.

With EAF production, residual levels are expected to rise.

Major line reconfiguration is not commercially viable, so existing annealing windows need to remain robust.

S250GD and S280GD account for around 5.6% of Zodiac output.

This project supports the BOS to EAF transition without major process change.

Aims & Objectives

Aim:

Assess how rising residual content affects the mechanical properties and microstructure of S250GD and S280GD steels processed through Zodiac-type annealing cycles.

Objectives:

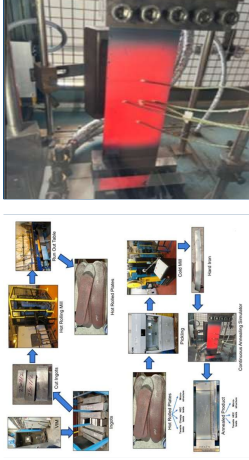
- Measure strength, ductility and formability across increasing residual levels.
- Compare the effect of residual content against annealing cycle.
- Link microstructure to mechanical property trends.
- Check compliance against EN 10346:2015.
- Identify whether composition optimisation is possible.

Experimental Route

Consistent sample route used for all grades:

VIM melting → hot rolling → cold rolling → CASIM annealing → tensile testing → SEM

The same route was used for every sample, allowing residual content and annealing cycle effects to be compared directly.



Laboratory route used to replicate Zodiac-type continuous annealing conditions.

Conclusions

- Existing Zodiac processing windows remained suitable for the tested EAF-type compositions.
- Residuals increased strength and reduced ductility, but did not cause EN 10346 failure.
 - Composition was a stronger lever than annealing cycle.
- Residual strengthening can be treated as an opportunity, not only a risk.
 - Reduced Mn in Grade C remained compliant.

Value / Further Work

£1.3M / year

Estimated saving from reduced manganese addition in S280GD.

The adjusted Grade C composition remained compliant with EN 10346:2015.

Residual-element strengthening helped offset the reduced manganese addition.

Further work should include EBSD phase confirmation, quantitative grain size measurement and wider industrial validation across full production conditions.