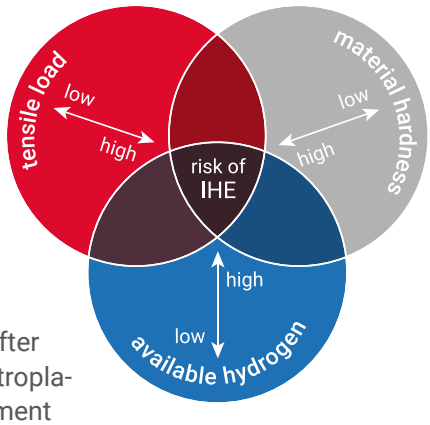
Hydrogen embrittlement

Research project: SCREW_HISCC

INTERNAL HYDROGEN EMBRITTLEMENT (IHE)

IHE is created during the manufacturing process. This means during forming, hardening and electroplating. Many parameters may influence the risk of IHE, like raw material, activators and inhibitors.

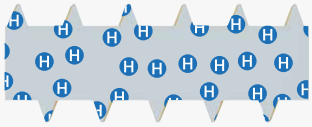


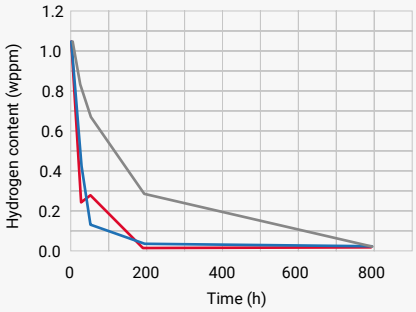
PROCESS VERIFICATION

In the frame of the FFG Bridge Project „SCREW_HISCC“ the screw production process from Schmid Schrauben Hainfeld GmbH was verified in regard to IHE. The project was carried out at Graz University of Technology by the Institutes of Timber Engineering and Wood Technology and Material Science, Joining and Forming (IMAT) and supported by the industrial partners Schmid Schrauben Hainfeld GmbH and Stiefler GmbH. As part of this, our screws were removed from the ongoing manufacturing process (after selected production steps such as quenching or galvanizing) and the hydrogen content was measured by means of a thermal conductivity detector (TCD). Here you can exemplarily see the measured results after hardening and electroplating. This measurement took place immediately after removal and was then repeated. In the meantime, the screws were stored in a dry atmosphere, as this is the common procedure during manfucature. The diagrams clearly show that the hydrogen diffuses out almost completely during the resting phase. The results of the project are therefore consistent with our many years of experience.

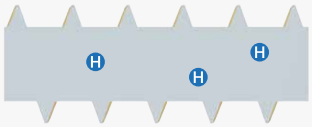
AFTER HARDENING

The hydrogen (H) content of the screw directly after hardening process:



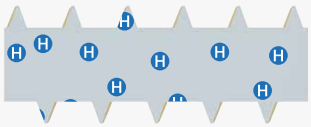


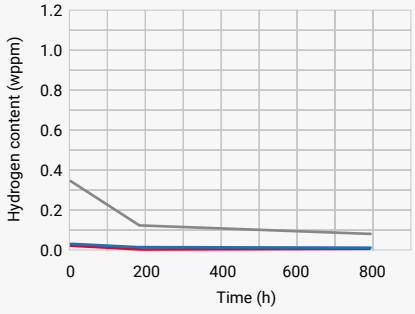
If the screw has enough time to rest, the hydrogen (H) diffuses out on its own.



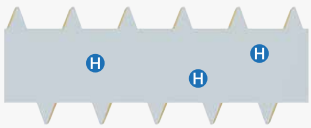
AFTER GALVANIZING

The hydrogen (H) content of the screw directly after galvanizing process:





After a relatively short time in a normal atmosphere, the hydrogen (H) diffuses out by itself. Baking would have the same effect



CONCLUSION

Internal hydrogen embrittlement (IHE) can be excluded in the finished screw if it is stored correctly.

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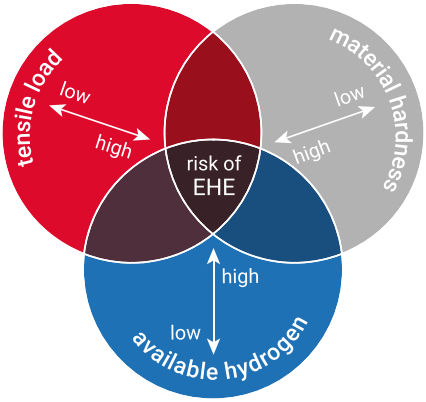
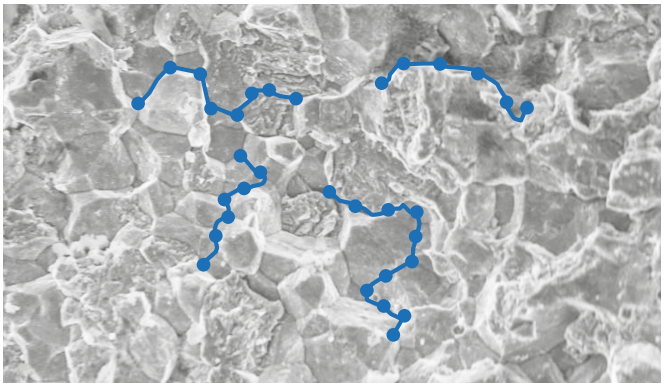
ENVIRONMENTAL HYDROGEN EMBRITTLEMENT (EHE)

EHE occurs when hydrogen penetrates the material during the use of the screw and causes damage. The risk of a failure due to HE is particularly high if the screw is exposed to high tensile loads



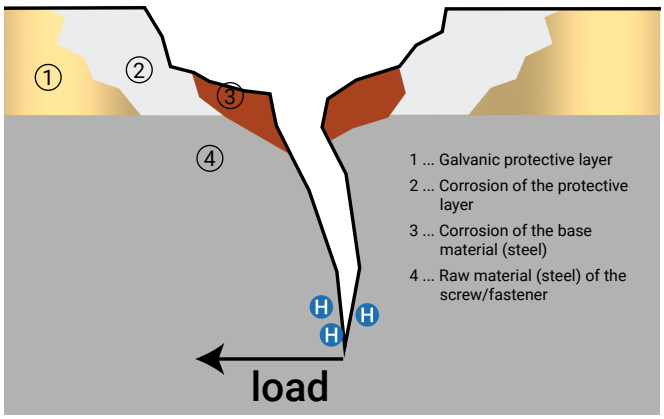


H IN THE STEEL MICROSTRUCTURE

The left image shows the sectional view of a fracture due to hydrogen embrittlement. The hydrogen is deposited at the grain boundaries and thus weakens the microstructure.

WHAT HAPPENS IN CASE OF CORROSION?

Moist surroundings and/or acidic woods cause the screw to corrode. First the galvanic protective layer corrodes, then the raw material and red rust forms. This releases hydrogen (H) and microcracks allow it to enter the base material of the screw. In this way, H diffuses into the screw and moves to the point of greatest stress. The crack increases in size until the cross-section of the screw is too small for the existing load and it breaks. This may already happen by loading with approx. 30 % of the characteristic tensile capacity of the screw $f_{tens,k}$.



FIELD TEST

The SCREW_HISCC project also shed light on the following questions: How does RAPID® screw behave in wood in a humid atmosphere? When does it crack due to corrosion and the resulting hydrogen embrittlement? For this purpose, the screws were screwed into different wooden blocks (Beech, Larch, Douglas Fir, Oak, Birch), that were sealed in a service class 2 environment according to EN 1995-1-1 and exposed to constant axial stress. Even after almost two years in this bracing, none of our screws have broken.

SUMMARY

Use the fasteners only in a dry environment and avoid corrosion. Then the risk of EHE is very limited.

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