

Hydrogen Embrittlement

Technical Data Sheet

All components made from steel which are subject to chemical or electro-chemical treatments during a coating process may absorb hydrogen if it has evolved during the activity. This absorbed hydrogen could cause premature failure if components are made from high tensile steel. Customers and end users need to be aware of the risk of embrittlement occurring in high tensile steel and to appreciate that baking treatments cannot be guaranteed to remove the risk of subsequential embrittlement occurring. Parts are usually considered to be at risk if they have a tensile strength equal to or greater than 1000 MPa, 1000 N/mm².

Baking parts after coating will substantially reduce the risk of failure, but this technique can never be assumed to be totally effective.

Embrittled parts usually fail when in use under stresses well below their design capability and most hydrogen induced embrittlement failures occur within a relatively short time after assembly, either almost immediately or several days later.

Although many studies have taken place into hydrogen embrittled failures, the exact reasons for the phenomenon have not been demonstrated.

The higher the tensile strength, the more susceptible to embrittlement a component becomes, but also the presence of phosphate (often used as a lubricant, but not removed prior to heat treatment) and inclusion of elements can alter this susceptibility considerably.

If hydrogen embrittlement is identified as a risk, the use of a non-embrittling coating, for example, zinc flake or mechanical plating should be considered.

Specifications

Most electroplating specifications include procedures to minimise the risk of embrittlement of high tensile parts. See the table below:

Requirements to reduce the likelihood of hydrogen embrittlement causing failure for parts heat treated or cold worked to a hardness of 320 – 390 Hv; property class 9.8 – 10.9 tonnes tensile	
Clean parts to remove lubricating phosphate coating prior to heat treatment to harden steel	Advised
Use wet cleaning methods avoiding cathodic electro cleaning	Advised
Use abrasive cleaning to remove rust and scale in preference to acid	Advised
Electroplating	Advised*
Use non-electroplated coating	Advised
Baking times at 180° – 210°C, if plated	4–12 hours

*Note that many automotive manufacturers prohibit the use of electroplated coatings on safety critical components.

Warning

The following matters should be considered when specifying electroplated finishes on higher tensile parts:

1. Susceptible parts subject to an embrittling process can never be guaranteed to be completely free from embrittlement, even after extensive baking treatments (ref. EN ISO 4042)
2. The removal of phosphate from higher tensile parts before hardening heat treatment does reduce the risk of embrittlement (mandatory requirement for 12.9 grade fasteners and above).
3. The risk of embrittlement increases with increasing tensile strength.
4. The risk of failure due to embrittlement increases when components are under stress, either during storage or in use.
5. Changing the coating already applied to fasteners, i.e. stripping and replating, can be a high-risk activity that would only be undertaken under certain circumstances. Discussion with the customer and end user is essential.
6. The use of non-embrittling processes, for example, mechanical plating, zinc flake or organic coating, should be considered for susceptible work.
7. Due to these risks and the availability of non-embrittling processes, the Anochrome Group will not undertake the electroplating of 12.9 (or greater) grade fasteners
8. It should be noted that hydrogen embrittlement relief by the baking process becomes less efficient when high thicknesses of zinc are applied due to the porosity of the deposit becoming significantly less with higher thicknesses. Some specifications acknowledge this and expect thick coatings (say >12µm) to be applied in two stages with a baking process after the application of 5–8 µm.
9. When components require heat treatment after processing, they will be placed in a baking oven within one hour of the process being completed and will achieve 200°C metal temperature within two hours of the process being completed.
10. Although there is data which supports the concept that inducing of hydrogen embrittlement does not arise when phosphating to the same degree as it does with electroplating it is the Anochrome Group's policy to carry out the same hydrogen embrittlement relief procedures for phosphated components as for electroplated workpieces.

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