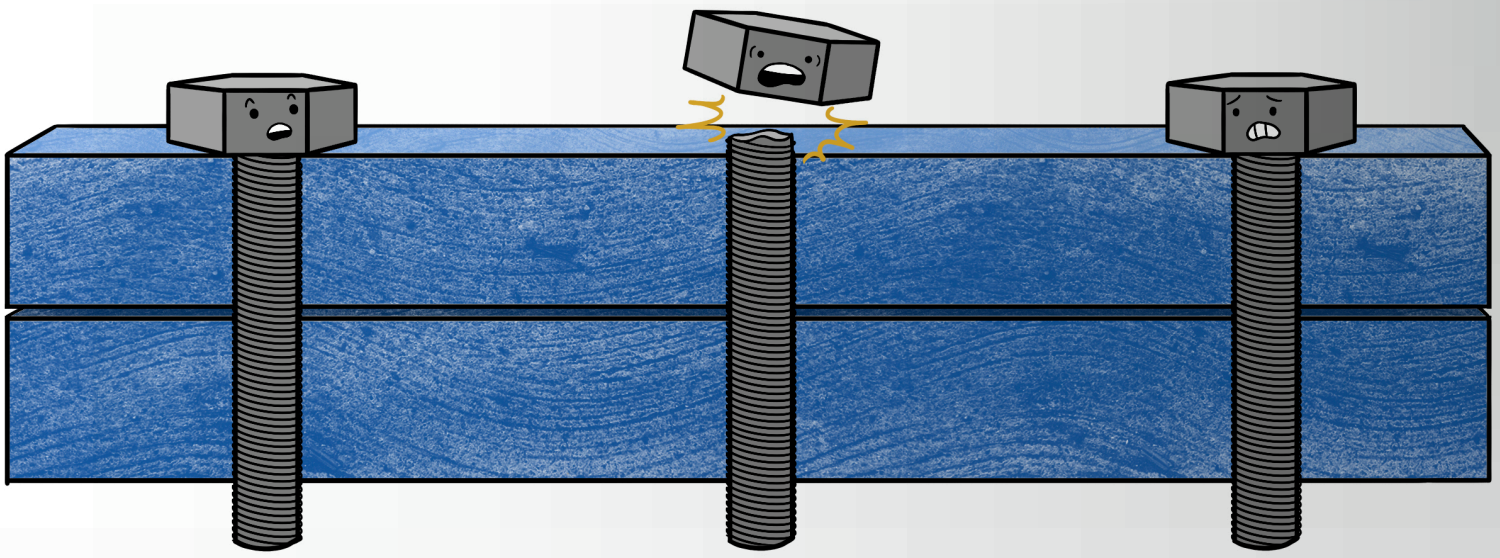
Earnest

How to Keep Your Head On:

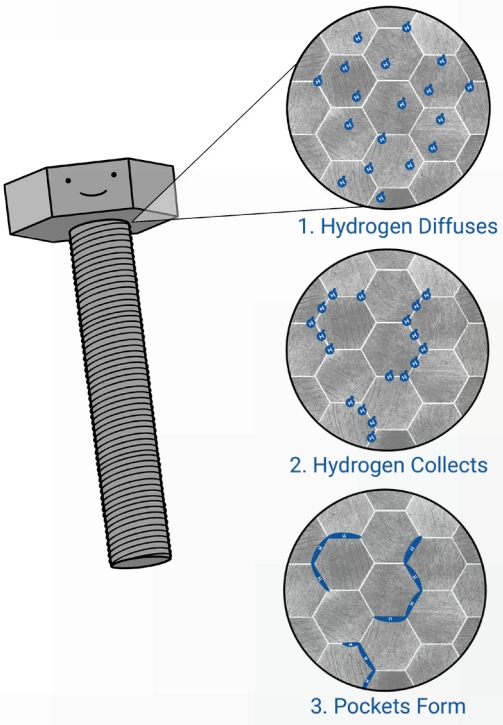
Avoiding Hydrogen Embrittlement for Zinc Plated Fasteners



What is Hydrogen Embrittlement?

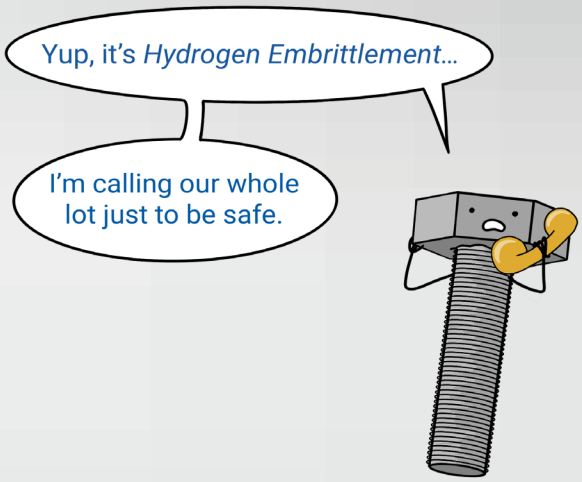
The term Hydrogen Embrittlement describes a high-strength fastener that has absorbed an excessive amount of atomic hydrogen during the electroplating process. Once absorbed, the excess hydrogen gets trapped within imperceptible pockets in the fasteners' metal structure. These trapped hydrogen atoms can cause metal to become brittle, which can result in the fastener breaking after it has been installed in its application.

Steel Microstructure Absorbing Hydrogen:



When pressure is applied to an embrittled fastener in assembly, the hydrogen atoms migrate to high-stress areas of the part, creating brittle chemical compounds and weakening those areas. Hydrogen Embrittlement fractures most commonly appear directly underneath the head and at the point where the shoulder meets the threads.

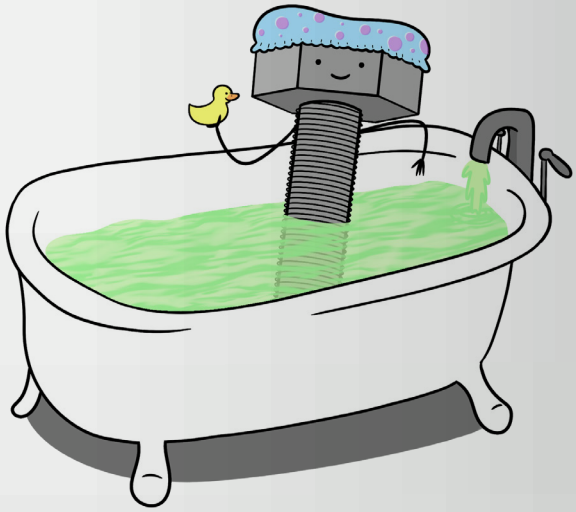
Hydrogen Embrittlement only becomes apparent after the fastener is assembled, when its load is at or near capacity. Unfortunately, embrittlement doesn't show up in a standard tensile test, so we can only identify it after installation– That's why maintaining lot traceability is important. Though one brittle fastener in the lot does not guarantee the failure of the entire lot, any suspect lot should be isolated to prevent any potential failures.

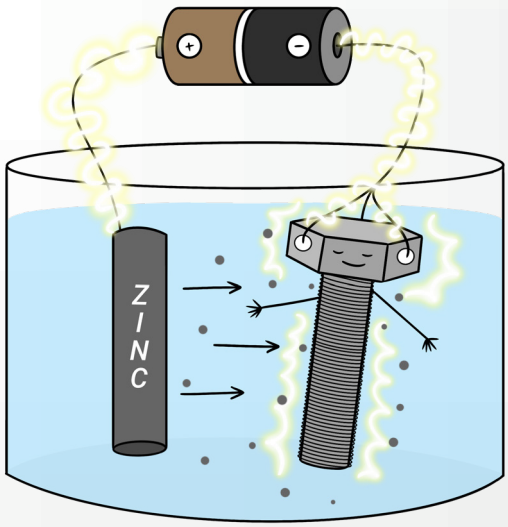


How Does It Happen?

Hydrogen Embrittlement can happen in a variety of ways but is most associated with zinc electroplated products. This finish typically involves cleaning and descaling fasteners, plating them with zinc, and finally dipping them in a chromate solution. The amount of hydrogen introduced to the fastener depends on how platers choose to clean and electroplate – certain processes have more hydrogen than others and should be avoided whenever possible.

Acid pickling, where a fastener is cleaned and descaled in an acid mixture, is one of the worst offenders of Hydrogen Embrittlement. During acid pickling, there's an increased chance of a chemical reaction yielding hydrogen, which diffuses throughout the microstructure causing it to weaken under pressure.

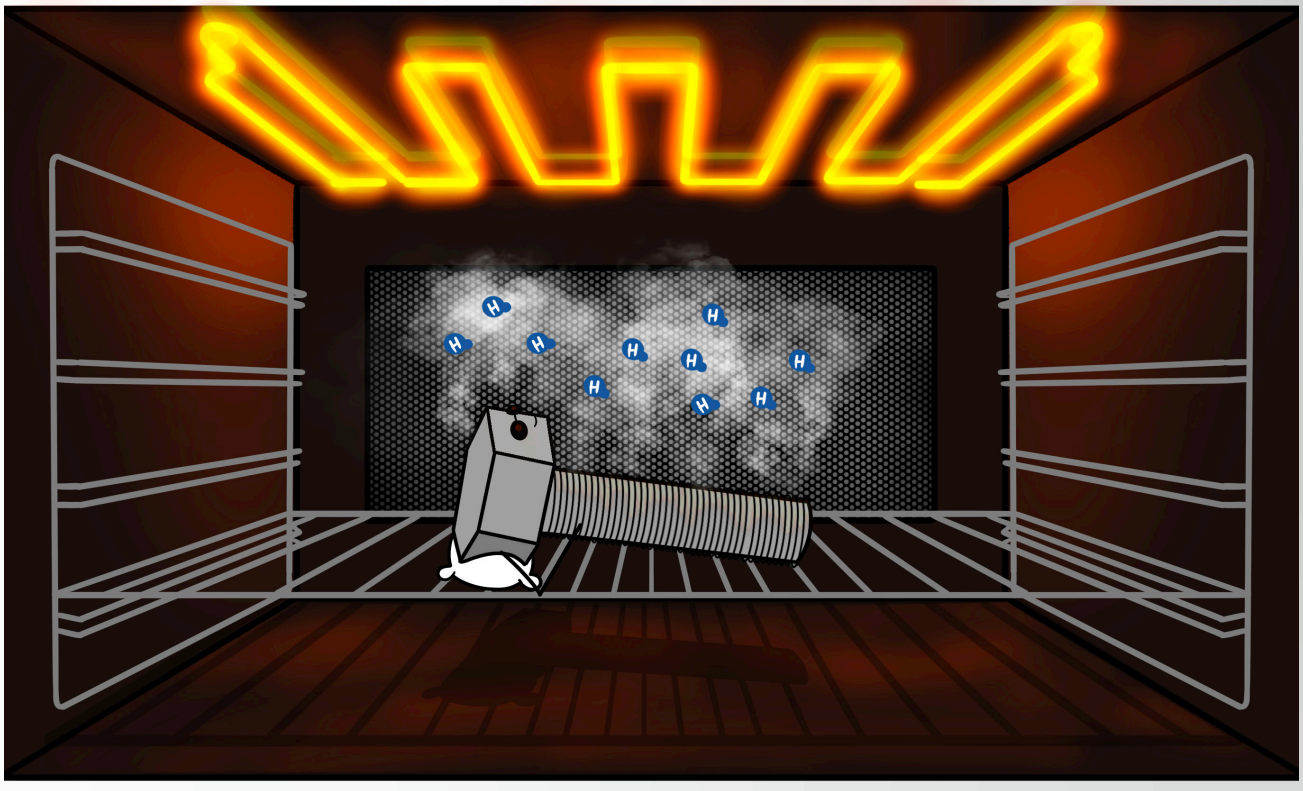




During the electroplating process, a fastener is hooked up to an electric current, which attracts the zinc ions in the plating solution to deposit in a thin layer over the fastener's surface. If this part was first subjected to acid pickling, the electric current and zinc coating seal the surface of the part, trapping the absorbed hydrogen inside.

How Can We Reduce Hydrogen Embrittlement?

The first line of defense against embrittlement is a knowledgeable plating house with good quality controls throughout their processing facility. An experienced plater can greatly reduce the parts' exposure to hydrogen by using non-acidic cleaners and plating chemistries. Adjusting the electro current's density based on the batch size also helps reduce the chance of embrittlement.



Baking is the other key to reducing embrittlement. Also known as "Low Hydrogen Annealing," it's commonly referred to as "baking" because the process involves heating fasteners in an oven for a prescribed amount of time. Heating newly plated fasteners and holding them at a certain heat for the correct amount of time allows the excess hydrogen atoms to escape the fastener's steel structure.

What Are the Industry Standards for Prevention?

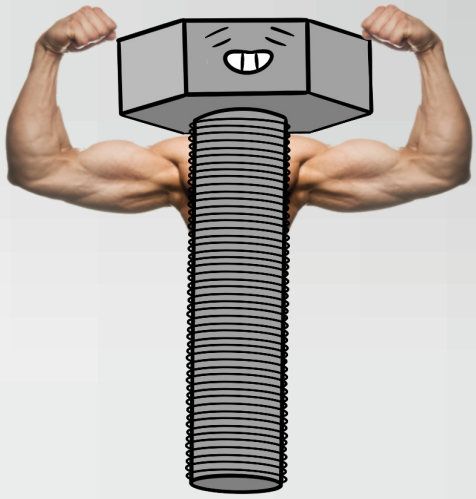
The generally accepted Industry Standard for Hydrogen Embrittlement relief is described in ASTM F1941/F1941M-16 (2016) Section 6.4. This is the standard now in place in the fastener industry and has replaced ASTM B633.

Baking fasteners at the right temperature and for the correct amount of time are also key details when preventing hydrogen embrittlement. If the temperature is too high, it could cause the zinc to degrade and may affect the structural integrity of the fastener, but if it's too cool it won't allow the hydrogen to escape.

To minimize potential embrittlement, multiple industry-standard specs recommend specific baking times and temperature, which vary depending on the strength of the fastener. Common specifications call for a fastener to bake at 400ºF for at least four hours within one hour of being plated, but some can call for anywhere from 8 to 24 hours. Generally, the harder the fastener, the longer the baking time.

Conclusion

Hydrogen Embrittlement is a serious safety concern because contaminated fasteners won't appear to have an issue until they've been installed in an application and put under immense pressure. While every fastener exposed to excess hydrogen won't become embrittled, it is important to keep track of your fasteners' source to isolate any problematic lots.



To reduce the risks of Hydrogen Embrittlement, make sure you're familiar with safe zinc electroplating practices: Avoid acid-pickling and follow ATSM baking standards to ensure zinc electroplated fasteners are safe and hardy.