Hydrogen Embrittlement

Hydrogen embrittlement is a major cause of fastener failure. Prevailing thought is that steels with Rockwell hardness above C30 are vulnerable. The phenomenon is well-known although the precise mechanism has eluded extensive research. A number of proposed mechanisms have been proposed, and most have at least some merit. Current thinking is that the susceptibility to hydrogen embrittlement is related directly to the trap population. Generally, hydrogen embrittlement can be described as the adsorption of hydrogen promoting enhanced de-cohesion of the steel, primarily as an intergranular phenomenon.

This photomicrograph of a cross-section of a mechanical plated coating shows the porous coating which allows hydrogen to escape, eliminating the risk of hydrogen embrittlement.

Electroplating is a major cause of hydrogen embrittlement. Some hydrogen is generated during the cleaning and pickling cycles, but by far the most significant source is cathodic inefficiency, which is followed by sealing the hydrogen in the parts. Baking is often performed on high strength parts to reduce this risk, and the ASTM issued a specification for baking cycles, B850 (as shown below). For the production plater, having to remove the parts from the production line to bake - followed by a separate chromating or passivating process - is a laborious undertaking.

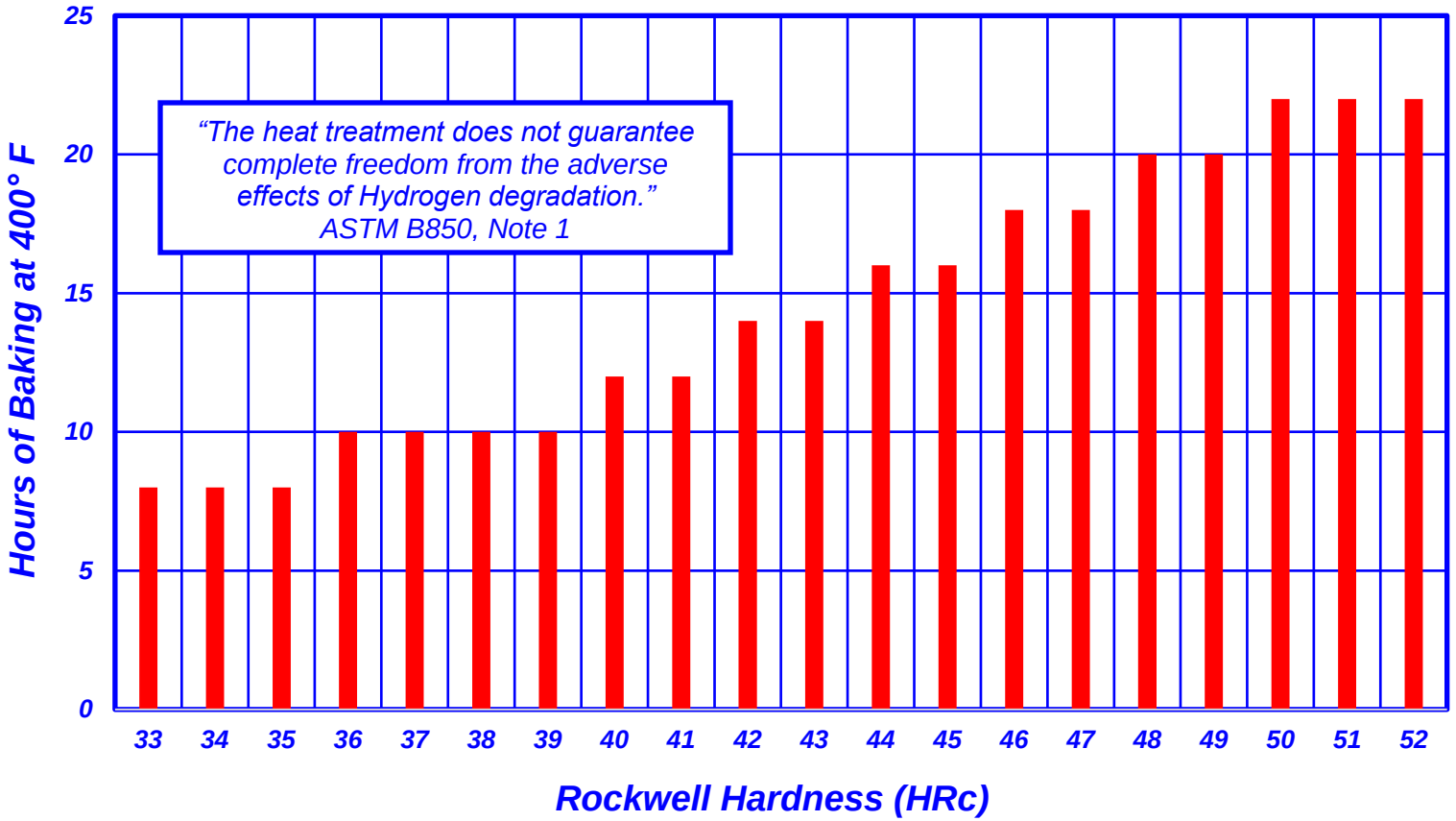
How much Baking Do Electroplated Parts need? (ASTM B 850)

Tensile Strength	*Tensile Strength (000 psi)*	*Rockwell Hardness HR_c*	*Post-Plate Bake (@190° - 220° C. or 374° - 428° F)*
1700 - 1800	*247 -261*	*49 – 51*	*22+*
1600 - 1700	*232 -247*	*47 – 49*	*20+*
1500 – 1600	*218 – 232*	*45 – 47*	*18+*
1400 – 1500	*203 – 218*	*43 – 45*	*16+*
1300 – 1400	*189 – 203*	*39 – 43*	*14+*
1200 - 1300	*174 – 189*	*36 – 39*	*12+*
1100 – 1200	*160 – 174*	*33 – 36*	*10+*
1000 – 1100	*145 – 160*	*31 – 33*	*8+*

Source: ASTM B850, according to Section 6.2 - "For Steels of actual tensile strength below 1000 MPa, Heat treatment after plating is not essential."

For nearly seventy-five years mechanical plating has been accepted as a means of eliminating hydrogen embrittlement. While it is true that mechanical plating uses inhibited acids which generate less hydrogen, PS&T believes that mechanical plating as a process is inherently free from hydrogen embrittlement because the deposit is porous (as are phosphate coatings), allowing hydrogen to escape through the coating; in electroplating, by way of contrast, hydrogen is sealed in the part.

Post-Electroplate Baking Cycles per ASTM B850



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