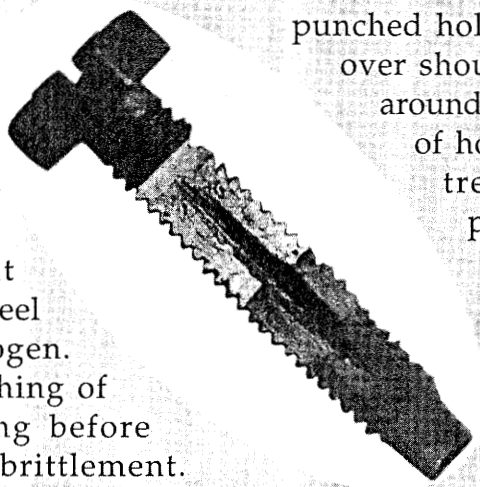
ASK DR. GALV

Q. Dear Dr. Galv: What do I say to my customer when he tells me that I have caused his part to suffer hydrogen embrittlement?

A. It is often necessary to educate your customer about various types of embrittlement that can occur when galvanizing steel. For steel to be in an embrittled condition after galvanizing is rare. The occurrence and type of embrittlement depends on a combination of factors.

Strain-age embrittlement is caused by cold working certain steels, followed by aging at temperatures under 600°C, or by warm working steels below 600°C. All structural steels may become embrittled to some extent. The extent of embrittlement depends on the amount of strain, the time at aging temperature, and the steel composition, especially nitrogen. Cold working, such as punching of holes, shearing and bending before galvanizing may lead to embrittlement. Steels less than 1/8" are rarely affected.



Steel absorbs elemental hydrogen during the pickling and fluxing steps of the galvanizing process. Hydrogen dissolved in steel can cause a significant decrease in ductility and permit brittle cracks to grow at fairly low stress levels. Past studies have shown that hydrogen embrittlement is generally not a concern in galvanizing, except for steels with very high strength levels or high levels of cold working. The temperature used in hot dipping acts to reverse the buildup of dissolved hydrogen. Cold working can produce locally intense levels of dissolved hydrogen. Another area that often shows the signs of locally induced embrittlement is the heat-affected zone near a weld joint. The weld itself may become embrittled but more likely the steel surrounding the weld area often becomes a site for embrittlement and cracking.

The ASTM Specification A143 covers procedures that can be followed to safeguard against the possible embrittlement of steel hot-dip galvanized after fabrication, and outlines test procedures for detecting embrittlement. For intermediate and heavy shapes, plates, and hardware, cold bend radii should not be less than three times the section thickness. For punched holes, heavier shapes 3/4" and over should be reamed at least 1/16" around the edge of the hole. Drilling of holes in these parts or thermal treatment of the parts after punching is preferred. For heavy cold deformation, the parts should be thermally treated at 650° to 705°C. For less severe cold deformation, the thermal treatment should be limited to a maximum temperature of 600°C to avoid excessive grain growth. The time at temperature should be 1 hour/inch of section thickness.

There are a couple of steps a galvanizer can take to reduce the chances for embrittlement. During the cleaning process, the part can be mechanically cleaned as opposed to acid cleaned. If acid cleaning is performed, a heat treatment after cleaning can reduce the dissolved hydrogen. The best step is to communicate the potential problems to the customer and together work out the optimal solution.