Section Taken From ISO 4042:1999(E) (From Pages 3&4 and Annex A)

6 Hydrogen embrittlement relief

In cases of parts
- with high tensile strength or hardness or which have been surface hardened,
- which have absorbed hydrogen and
- are under tensile stress

there is the risk of failure due to hydrogen embrittlement.

When the core or surface hardness is above 320 HV, process investigation shall be conducted using a test to detect hydrogen embrittlement, for example the "Parallel bearing surface method" in accordance with ISO 15330, to be sure that the process with regard to embrittlement is under control. If embrittlement is discovered, modification of the manufacturing process will be necessary, such as the inclusion of a baking process (see informative annex A for more information).

For fasteners of hardness in excess of 365 HV, a written agreement should exist between the customer and manufacturer to define how to manage the risk. If written agreement does not exist, the manufacturer shall process the parts in accordance with his recommended practices to reduce the risk of hydrogen embrittlement. Complete elimination of hydrogen embrittlement cannot be assured. If a reduced probability of encountering hydrogen embrittlement is desired, alternative procedures should be evaluated. NOTE Investigations are proceeding to develop methods for the reduction of hydrogen embrittlement.

Annex A (informative) Hydrogen embrittlement relief

A.1 Introduction

NOTE 1 The following two paragraphs are essentially the text of the introduction of ISO 9588:—3) (see[2]). When atomic hydrogen enters steels and certain other metals, for example aluminium and titanium alloys, it can cause loss of ductility or load carrying ability, cracking (usually as sub microscopic cracks) or catastrophic brittle failures at applied stresses well below the yield strength or even the normal design strength for the alloys. This phenomenon often occurs in alloys that show no significant loss in ductility when measured by conventional tensile tests, and is frequently referred to as hydrogen induced delayed brittle failure, hydrogen stress cracking or hydrogen embrittlement. The hydrogen can be introduced during heat treatment, gas carburizing, cleaning, pickling, phosphating, electroplating, autocatalytic processes and in the service environment as a result of cathodic protection reactions or corrosion reactions. Hydrogen can also be introduced during fabrication, for example during roll forming, machining and drilling due to the break-down of unsuitable lubricants as well as during welding or brazing operations. Parts that have been machined, ground, cold-formed or cold-straightened subsequent to hardening heat treatment are especially susceptible
to hydrogen embrittlement damage.

The results of research work indicate that the susceptibility of any material to hydrogen embrittlement in a given test is directly related to its hydrogen entrapment population (type and effectiveness of traps). Therefore the time–temperature relationship of the baking process is dependent on composition and structure of steels as well as plating metals and plating procedures. Additionally, for most high strength steels, the effectiveness of the baking process falls off rapidly with reduction of time and temperature.

NOTE 2 "Traps" refer to certain metallurgical sites within the steel structure, such as inclusions, foreign atoms, dislocations, etc., to which atomic hydrogen may bond. Hydrogen thus bonded is no longer free to migrate to areas of high stress and contribute to the initiation of embrittlement fracture. Traps may be of the reversible or non-reversible type. For further information see Professor Troiano's paper [3] .

There are many reasons why a fastener may become embrittled. The total manufacturing process has to be controlled in such a way that the probability of embrittlement will be reduced to a minimum. This annex gives examples of procedures by which the probability of hydrogen embrittlement can be reduced during the manufacturing process for electroplating of fasteners.

A.2 Stress relief

Fasteners which have been cold worked hardened to 320 HV or above and are to be electroplated may benefit from a stress relieving process. This process should be carried out before application of the cleaning process defined in A.3. The temperature and duration applicable to the process will vary according to the design, manufacturing and heat treatment conditions of the parts concerned, and shall be notified to the coater, if the process is required in accordance
with clause 12. Parts with a hardness above 320 HV that have been machined, ground, cold-formed or cold straightened subsequent to heat treatment should be treated according to ISO 9587.

Stress relief may not be desirable in cases where residual stresses are intentionally introduced, for example, screws
which are thread rolled after heat treatment.