

ENGINEERING MATERIAL SPECIFICATION

Material Name

Specification Number

EMBRITTLMENT AVOIDANCE

WSS-M99A3-A

1. SCOPE

This specification outlines the conditions that enhance the risk of embrittlement of steel components and identifies requirements that need to be satisfied in order to minimize that risk.

2. APPLICATION

The requirements established by this specification apply to both heat-treated and cold worked steel components.

The risk of embrittlement exists for parts:

- with high tensile strength or hardness, or which have been surface hardened,
- which have, or may, absorb hydrogen, and
- are under tensile stress.

Embrittlement of steels, which can cause brittle fracture under stress, most often occurs as a result of the absorption of hydrogen either during the manufacturing process or from exposure to an active corrosive environment. Hydrogen Embrittlement commonly results from the absorption of hydrogen, phosphorus or carbon during the cleaning, electroplating, phosphate coating, and/or heat treatment process. Stress corrosion cracking is the result of the combined action of tensile stresses (applied and/or residual) and an active corrosive environment.

The susceptibility to embrittlement increases with increasing stress and increasing material strength. Therefore, the specification of cleaning, finishing, and heat treatment requirements, as well as the review of the application environment for hardened and cold worked steel parts, is crucial in reducing the risk of embrittlement.

Hardness readings in this specification are in Vickers scale. All other readings are for reference only. The specified hardness refers to the hardness on the part drawing or product standard and not the actual part hardness. Where optional hardness values are specified, the specified hardness level that that permits compliance with this specification shall be used.

3. REQUIREMENTS

3.0 STANDARD REQUIREMENTS FOR PRODUCTION MATERIALS

Material suppliers and part producers must conform to the Company's Standard Requirements For Production Materials (WSS-M99P1111-A).

Date	Action	Revisions
2003 05 12	Revised	Para 3.0 inserted; para 3.1, 3.10 & 4 deleted Completely revised and renumbered acockman/ddrobn1
2001 04 12	Revised	Editorial – no technical change acockman/ddrobn1
1987 09 18	SM/ER 1209TC	Released J.P.C. Lines EAO

3.2 CONTROL PLAN

Parts produced to this specification shall have a Control Plan that meets the requirements of clause 3.1 and includes a verification test(s) to demonstrate the effectiveness of the de-embrittlement procedures, cleaning and freedom from inadvertent carburization.

3.3 BRITTLENESS

All parts supplied shall be free from the detrimental effects of hydrogen embrittlement or other factors that result in part brittleness.

3.4 PART USAGE

Due to the high tensile stresses involved in fastened joints, all fasteners or threaded components with a maximum specified core or surface hardness greater than 390 HV (39 HRC) shall not be used in critical applications where there is potential for corrosion. Fasteners used in non-critical applications and all other components where the maximum specified core or surface hardness is greater than 390 HV (39 HRC) shall not be used where exposed to the potential for corrosion without an appropriate Failure Mode and Effects Analysis (FMEA). The FMEA shall include consideration of cracking mechanisms such as hydrogen embrittlement and stress corrosion as possible causes of fracture, as well as the need for protective finishes in shielding.

3.5 CLEANING PRIOR TO HEAT TREATMENT
(FLTM AQ 150-01)

All components with a maximum specified core or surface hardness greater than 353 HV must be cleaned prior to heat treatment to remove phosphate associated lubricant residues and any other detrimental contaminants from the surface. The formation of a delta ferrite layer caused by the penetration of phosphorus during the hardening process is not permissible.

3.6 HEAT TREATMENT

All heat treatment operations, including tempering after quenching or stress relief after cold forming, shall be completed prior to plating or phosphate coating.

3.7 CARBURIZATION

Carburization of through hardened parts is not permitted unless specified on the Engineering Drawing. The surface hardness shall not be more than 30 Vickers points above the measured core hardness when readings of both surface and core are carried out at HV 0.3. For property class 10.9 fasteners, any increase in hardness at the surface that indicates that the surface hardness exceeds 390 HV (39 HRC) is not acceptable.

3.8 CLEANING AFTER HEAT TREATMENT OR COLD WORKING

Acid cleaning of parts which have been heat treated to a specified core or surface hardness greater than 353 HV (35 HRC) or have been highly stressed due to cold working enhances the susceptibility to hydrogen embrittlement, and shall be minimized. If high hardness parts are to be acid cleaned, an inhibited acid shall be used and a procedure shall be established that limits part exposure to the acid bath to a maximum of 10 minutes. Parts, which are acid cleaned and subsequently phosphate coated, mechanically plated, or electroplated, shall follow the requirements of clauses 3.10.1 and 3.10.2, as applicable. All other parts, which are acid cleaned, shall not be used for 48 hours, or alternately these parts shall be baked for 1-hour minimum at 115 +/- 10 °C following cleaning.

Note: Inhibited acid is an acid to which a suitable inhibitor has been added to reduce the corrosive attack on the steel and absorption of hydrogen.

3.9 PLATING/COATING METHOD

All components with a maximum specified core or surface hardness greater than 390 HV (39 HRC) shall not be electroplated.

3.10 DE-EMBRITTLMENT

The de-embrittlement procedures specified in 3.10.1 and 3.10.2 apply to all parts either hardened or cold worked to a specific core hardness greater than 320 HV (32 HRC) or surface hardness greater than 353 HV (35 HRC).

All references to temperature relate to part core temperature and not indicated oven air temperature. Statistical data of variations in temperature at the center of the oven and oven temperature shall be established to develop the oven profile. The temperature of parts in a batch type oven shall be monitored with a thermocouple placed in the middle of the load. For continuous bake ovens a temperature trace through the oven must be run with a calibrated thermocouple in the lowest temperature position, at least once a year.

Longer times at heat than those given may be necessary if verification testing detailed in the Control Plan (see para 3.2) indicates a failure risk.

3.10.1 Electroplated Components

Within one hour after the electroplating process and before any supplementary chemical treatment, parts shall be placed in an oven and heating commenced. The parts shall be heated to a part temperature of 215 +/- 15 °C and held at this temperature for a minimum of four hours. This temperature range shall be reached within one hour after commencement of heating.

Hardened parts that have been tempered at less than 230 °C must be heated within one hour after electroplating to a temperature of 150 +/- 10 °C and held at this temperature for a minimum eight hours.

3.10.2 Mechanically Plated and Phosphate Coated Components

Within four hours after mechanical plating or phosphate coating, parts shall be heated to 115 +/- 10 °C and held at this temperature for a minimum of one hour or alternatively these parts shall not be used for 48 hours after coating.

3.11 EXCEPTIONS

Exceptions to the above requirements that arise due to appearance or functional considerations may be made provided that the effects of fracture are investigated, deemed tolerable and the parts have extraordinary inspection safeguards specified. Exceptions shall be authorized by the responsible Functional Chief Engineer and communicated to the appropriate Materials/Fastener Engineering Activity. For fasteners, exception approval shall be documented on a FAF-1217, Fastener Request form.

Exceptions agreed to for some Standard Fasteners are shown in the General Requirements section of Ford Worldwide Fastener Standard WX-100.