INTERNATIONAL STANDARD

ISO 9587

Second edition
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Metallic and other inorganic coatings — Pretreatment of iron or steel to reduce the risk of hydrogen embrittlement

Revêtements métalliques et autres revêtements inorganiques — Prétraitements du fer ou de l'acier visant à réduire le risque de fragilisation par l'hydrogène

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 9587 was prepared by Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, Subcommittee SC 3, *Electrodeposited coatings and related finishes*.

This second edition cancels and replaces the first edition (ISO 9587:1999), of which it constitutes a minor revision. Table 1 has been replaced with Tables 1 and 2.

Introduction

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 or 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 cleaning, pickling, phosphating, electroplating and autocatalytic processes, as well as in service as a result of cathodic protection or corrosion reactions. Hydrogen can also be introduced during fabrication prior to cleaning, pickling and application of coatings, for example, during roll forming, machining and drilling, due to the breakdown of unsuitable lubricants, as well as during welding or brazing operations. Parts that have been machined, ground, cold-formed or cold-straightened subsequent to a hardening heat treatment are especially susceptible to hydrogen embrittlement damage.

The susceptibility to hydrogen embrittlement resulting from the absorption of atomic hydrogen and/or the tensile stresses induced during fabrication can be reduced by heat treatment. The time-temperature relationship of the heat treatment is dependent on the composition and structure of steels, as well as on the specific coatings being applied and the nature of the coating procedures. For most high strength steels, the effectiveness of the heat treatment falls off rapidly with reduction of time and temperature.

This International Standard is intended for use by purchasers in specifying requirements to the electroplater, supplier or processor, and is to be indicated on the part drawing or purchase order.

Metallic and other inorganic coatings — Pretreatment of iron or steel to reduce the risk of hydrogen embrittlement

1 Scope

This International Standard establishes stress-relief requirements for high strength steels, in order to reduce their susceptibility or degree of susceptibility to hydrogen embrittlement in subsequent pretreatment, electroplating, autocatalytic plating, chemical conversion and phosphating processes. This International Standard is applicable to steels of which the properties are not adversely affected by heat treatment at 190 °C to 230 °C or higher (see 6.2).

The heat treatment procedures established in this International Standard have been shown to be effective in reducing the susceptibility of steel having tensile strengths equal to or greater than 1 000 MPa and that have been machined, ground, cold-formed or cold-straightened subsequent to heat treatment. This heat treatment procedure is used prior to any operation capable of hydrogen charging the parts, such as the cleaning procedures prior to electroplating, autocatalytic plating and other chemical coating operations.

This International Standard does not apply to fasteners.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2080, *Metallic and other inorganic coatings — Surface treatment, metallic and other inorganic coatings — Vocabulary*

ISO 12686, *Metallic and other inorganic coatings — Automated controlled shot-peening of metallic articles prior to nickel, autocatalytic nickel or chromium plating, or as a final finish*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2080 and the following apply.

3.1
stress-relief heat treatment
thermal process carried out over a temperature range and for a duration of time such that no alteration of metallurgical structures, such as recrystallization, of the basis metal occurs, but at which stress relief of the parts to be plated is achieved

4 Requirements

Heat treatment shall be performed on basis metals in order to reduce the risk of hydrogen embrittlement in accordance with Tables 1 and 2. In all cases, the heat treatment shall be deemed to commence at the time at which the whole of each part attains the specified temperature.

Parts made from steel with actual tensile strengths greater than or equal to 1 000 MPa (with corresponding hardness values of 300 HV 10, 303 HB or 31 HRC) and surface-hardened parts shall require heat treatment unless class SR-0 is specified. Preparation involving cathodic treatments in alkaline or acid solutions shall be avoided.

Tables 1 and 2 list stress-relief heat-treatment classes that can be specified by the purchaser to the electroplater, supplier or processor on the part drawing or purchase order. When no stress-relief treatment class is specified by the purchaser, then class SR-1 shall be applied.

NOTE 1 The treatment class selected is based upon experience with the part or similar parts, and the specific alloy used, or with empirical test data. Some parts, because of factors such as alloy composition and structure, size, mass or design parameters, can perform satisfactorily with no stress-relief treatment. Therefore, Class SR-0 treatment is provided for parts that the purchaser wishes to exempt from treatment.

NOTE 2 The use of inhibitors in acid pickling baths does not necessarily guarantee that hydrogen embrittlement is minimized.

NOTE 3 Class SR-1, the longest treatment, is the default when the purchaser does not specify a class. The electroplater, supplier or processor is not normally in possession of the necessary information, such as design considerations, induced stresses from manufacturing operations, etc., that have to be considered in selecting the correct stress-relief treatment. It is in the purchaser’s interest that their part designer, manufacturing engineer or other technically qualified individual specify the treatment class on the part drawing or purchase order, in order to avoid the extra cost of the default treatment.

5 Categorization of steels

With the exception of surface-hardened parts the heat treatment conditions shall be selected on the basis of the actual tensile strength. When only the minimum tensile strength is specified or if the tensile strength is not known, the heat treatment condition shall be selected by relating known or measured hardness values to equivalent actual tensile strengths. The tensile strength, or equivalent derived from known or measured hardness values, shall be supplied by the purchaser.

Steels that have been wholly or partly surface hardened shall be considered as being in the category appropriate to the hardness of the surface-hardened layer.

6 Stress relief

6.1 For high strength steels, the following conditions apply. For steels of actual tensile strength less than 1 000 MPa, stress-relief treatment is not essential. For steels of actual tensile strength greater than or equal to 1 000 MPa, the conditions given in Tables 1 and 2 shall apply. The heat treatment shall be carried out before commencement of any preparation of cleaning treatment using aqueous solutions, or before any treatment liable to cause embrittlement.

6.2 Combinations of shorter time at appropriate higher temperatures may be used if they have been shown not to be detrimental. For tempered steels, articles shall not be heated above a temperature that shall be at least 50 °C below the tempering temperature.

6.3 If stress relief is given after shot-peening in accordance with ISO 12686 or other cold working process to introduce beneficial compressive stresses, the temperature shall not exceed 230 °C.

6.4 For articles made of steel with an actual tensile strength below 1 400 MPa, articles having surface-hardened areas that would suffer an unacceptable reduction in hardness by treatment in accordance with Tables 1 and 2 shall be heat treated at a lower temperature, but at not less than 130 °C, for a minimum period of 8 h. Lower-temperature heat treatment can adversely affect the fatigue strength of the article.

Table 1 — Classes of stress-relief requirements for high strength steels
(see Clauses 4, 5 and 6 for details)

Class	Tensile strength of steel, R_m MPa	Temperature °C	Minimum time h
SR-0	Not applicable		
SR-1	$R_m > 1\,800$	200 to 230	24
SR-3	$1\,401 \leqslant R_m \leqslant 1\,800$	200 to 230	18
SR-6	$1\,000 \leqslant R_m \leqslant 1400$	200 to 230	3
SR-8	Surface-hardened parts $< 1\,400$	130 to 160	8

Table 2 — Classes of stress-relief requirements for high strength steels for "traditional treatments" in some national standards
(see Clauses 4, 5 and 6 for details)

Class	Tensile strength of steel, R_m MPa	Temperature °C	Minimum time h
SR-0	Not applicable		
SR-2[a]	$R_m > 1\,800$	190 to 220	24
SR-4[a]	$1\,450 \leqslant R_m \leqslant 1\,800$	190 to 220	18
SR-5[a]	$R_m \geqslant 1\,034$	177 to 205	3
SR-7[a]	$1\,050 \leqslant R_m \leqslant 1\,450$	190 to 220	1

[a] Traditional treatments.

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