

# Guide to methods for assessing the acceptability of flaws in metallic structures

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## Foreword

This British Standard has been prepared by Technical Committee WEE/37. It supersedes BS 7910:1999, which is withdrawn.

As the number of application standards specifying requirements for weld flaw acceptance levels based on fitness for purpose increases, so it is necessary to update and extend the guidance to be used in co-ordinating and rationalizing those requirements. This revision incorporates recent developments in fracture mechanics assessment methods, details of which are given in the appropriate clauses of this guide. While arbitrary acceptance levels will continue to be used for quality control purposes, the complementary use of the methods described in this guide permits the acceptability of known or postulated flaws in particular situations to be evaluated in a rational manner. Applications standards that formerly referred to PD 6493 or BS 7910:1999 should, in future, refer to this guide.

This guide has been revised to cover all failure modes that could be influenced by the presence of flaws. However, it should be noted that, whilst fracture, fatigue and creep are treated thoroughly, the treatment of other failure modes is less detailed.

Improvements in the methods outlined are continuing and users of this document should obtain an appreciation of the status of the various methods before applying them. For the purpose of this document, the treatment of the methods has necessarily been simplified, but appropriate references have been included to assist those willing to obtain further guidance. However, the information will seldom be found in the reference in identical form to that used in this document.

It has been assumed in drafting BS 7910 that the execution of its provisions is entrusted to appropriately qualified and experienced people, having appropriate knowledge of inspection technology, NDT, materials behaviour and fracture mechanics.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

**Compliance with a British Standard does not of itself confer immunity from legal obligations.**

### Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 298, an inside back cover and a back cover.

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## Introduction

In circumstances where it is necessary to examine critically the integrity of new or existing constructions by the use of non-destructive testing methods, it is also necessary to establish acceptance levels for the flaws revealed. The derivation of acceptance levels for flaws is based on the concept of fitness for purpose. By this principle, a particular fabrication is considered to be adequate for its purpose, provided the conditions to cause failure are not reached. A distinction has to be made between acceptance based on quality control and acceptance based on fitness for purpose.

Quality control levels are usually both arbitrary and conservative but are of considerable value in the monitoring and maintenance of quality during production. Flaws that are less severe than such quality control levels as given, for example, in current application standards, are acceptable without further consideration. If flaws more severe than the quality control levels are revealed, rejection is not necessarily automatic. Decisions on whether rejection and/or repairs are justified may be based on fitness for purpose, either in the light of previously documented experience with similar material, stress and environmental combinations or on the basis of an “engineering critical assessment” (ECA). It is with the latter that this document is concerned. It is emphasized, however, that a proliferation of flaws, even if shown to be acceptable by an ECA, is regarded as indicating that quality is in need of improvement. The use of an ECA can in no circumstances be viewed as an alternative to good workmanship. The response to flaws not conforming to workmanship criteria needs to be the correction of the fault in the process causing the non-conformance. The philosophy that the methods covered by this standard are complementary to, and not a replacement for, good quality workmanship is inherently assumed in this standard.

A procedure for an ECA is described whereby the significance of flaws under a particular set of circumstances may be determined. All parties need to agree to its use.

It is impossible to provide a single list of flaws that are known not to cause premature failure, since a large number of variables are involved, as enumerated in this document. It is possible, where relevant experience and data already exist, to dispense with the full ECA procedure and to use authenticated previous assessments as a basis for the establishment of acceptability limits. An ECA may also be used as a basis for deferring necessary repairs to a time mutually agreeable to the contracting parties. It needs to be appreciated that the unsatisfactory repair of innocuous flaws could result in the substitution of more harmful and/or less readily detectable flaws.

The implication of flaw assessment on a fitness for purpose basis is the need for thorough examination by non-destructive testing using techniques capable of locating and sizing flaws in critical areas. This document may be used to identify such areas and to assist in optimizing the NDT procedures by identifying those aspects of flaw characterization, size and position which need to be determined. Such non-destructive testing needs to be carried out after any post-weld heat treatment (PWHT) and/or proof test. However, since a major objective of this document is to reduce costs by eliminating unnecessary repair, careful consideration needs to be given to the level of inspection required to implement this document.

The limitations of non-destructive testing methods have to be taken into account. The following are the stages in the assessment of flaws revealed by such tests.

- a) If the flaws do not exceed the quality control levels in the appropriate application standard, no further action is required.
- b) If acceptance limits have already been established on the basis of an ECA for the appropriate combination of materials, fabrication procedure, welding consumables, stress and environmental factors, flaws need to be assessed on that basis.
- c) If no relevant documented experience exists, then an ECA based on the guidance given in this document needs to be carried out.

ECA will help to identify the limiting conditions for failure or the limiting design conditions. It is emphasized that some aspects of ECA are based on new concepts that could be subject to review. The application of these principles will mean that “safe” results will be obtained. The option of using appropriate safety factors has been incorporated or is inherent in each of the relevant clauses. If the accuracy of the input information employed (e.g. stress levels, material properties at the appropriate temperature, flaw size determination) is in question, appropriate additional safety factors need to be agreed. Equally, a flaw will not necessarily be unacceptable when it is found initially to exceed the acceptance levels that are derived from this document. A further assessment can be made following the principles given in this document, but incorporating more precise input data or analysis methods, or by testing structurally relevant components.

This document also gives guidance on the use of safety factors, reliability factors, and probabilistic methods. These factors and methods do not constitute a full risk analysis of the component undergoing assessment, as they do not quantify the consequences of a failure. Where failure of the structure under assessment may pose an unjustifiable or intolerable risk to the surrounding environment or population, then a full risk analysis may be needed, with due recognition of both individual and societal risk [1].

## **1 Scope**

This guide outlines methods for assessing the acceptability of flaws in all types of structures and components. Although emphasis is placed on welded fabrications in ferritic and austenitic steels and aluminium alloys, the procedures developed can be used for analysing flaws in structures made from other metallic materials and in non-welded components or structures. The methods described can be applied at the design, fabrication and operational phases of a structure's life.

## **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.

BS 5400 (all parts), *Steel, concrete and composite bridges*.

PD 5500:2003, *Specification for unfired fusion welded pressure vessels*.

BS 5950-1:1990, *Structural use of steelwork in building — Part 1: Code of practice for design in simple and continuous construction: hot rolled sections*.

BS 7448 (all parts), *Fracture mechanics toughness tests*.

BS 7608, *Code of practice for fatigue design and assessment of steel structures*.

BS 8118 (all parts), *Structural use of aluminium*.

BS EN 571-1, *Non-destructive testing — Penetrant testing — Part 1: General principles*.

BS EN 1289, *Non-destructive examination of welds — Penetrant testing of welds — Acceptance levels*.

BS EN 1290, *Non-destructive examination of welds — Magnetic particle examination of welds*.

BS EN 1291, *Non-destructive examination of welds — Magnetic particle testing of welds — Acceptance levels*.

BS EN 1435, *Non-destructive examination of welds — Radiographic examination of welded joints*.

BS EN 1712, *Non-destructive examination of welds — Ultrasonic examination of welded joints — Acceptance levels*.

BS EN 1714, *Non destructive examination of welded joints — Ultrasonic examination of welded joints*.

BS EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature*.

BS EN 10002-5, *Metallic materials — Tensile testing — Part 5: Method of test at elevated temperatures*.

BS EN 12517, *Non-destructive examination of welds. Radiographic examination of welded joints — Acceptance levels*.

BS EN ISO 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1: Fusion welding*.

BS EN ISO 7539 (all parts), *Corrosion of metals and alloys*.

BS ISO 12108, *Metallic materials — Fatigue testing — Fatigue crack growth method*.

BS EN ISO 12737, *Metallic materials — Determination of plane-strain fracture toughness*.