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

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to x, pages 0/1 to V/14, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 December 2019. It was prepared by Technical Committee WEE/37, *Acceptance levels for flaws in welds*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 7910:2013+A1:2015, which is withdrawn.

Information about this document

This is a full revision of the standard. It introduces the following principal changes, which reflect both advances in structural integrity technology and feedback from users.

- Annex A to Annex U are now all designated as "informative" (in earlier editions they were classified as either "informative" or "normative". This minor change reflects the nature of the document, i.e. it provides guidance rather than prescribing a particular set of rules.
- A new Annex V has been added, addressing strain-based assessment and design.
- The document has been broken down into self-contained clauses and annexes, each with its own bibliography, tables, equations, figures and symbols. This has inevitably introduced an element of repetition, e.g. of key reference documents, but is intended to improve the flexibility and agility of the document in years to come.
- New bibliographic references have been added, in particular to a series of papers published in a special BS 7910-focussed issue of the *International Journal of Pressure Vessels and Piping*. These cover the major damage/failure mechanisms covered by BS 7910 (fracture, fatigue, creep, corrosion), plus specific topics related to the annexes (residual stress, constraint, reliability, NDT, strain-based assessment) and the application of BS 7910 to pipelines. Whilst the background papers are based mainly on BS 7910:2013, the information is equally applicable to BS 7910:2019 in most cases.
- New rules for flaw interaction criteria and some new materials property clauses have been introduced in Clause **7**.
- Annex F (Procedure for leak-before-break (LbB) assessment) has been simplified; the detectable leakage procedure has been retained and the full LbB removed.
- In Annex J (Use of Charpy V-notch impact tests), a new subclause addresses interpretation of incomplete transition curves and gives more guidance on use of the Master Curve approach.
- Annex K (Probabilistic assessment) has been updated; the tables of generic partial safety factors (PSFs) for use with fracture assessment have been removed.
- Annex M (Stress intensity factor solutions) contains solutions for finite and extended surface-breaking flaws in plates subjected to non-linear stress fields. These were previously included in Annex Q (Residual stress distributions in as-welded joints) but have been moved to Annex M in the interests of consistency and to underline their potential use with primary, as well as secondary, stresses.

- Annex N (Allowance for constraint effects) has been simplified by removing the look-up tables based on the Q parameter.
- Annex P (Compendium of reference stress and limit load solutions) includes additional information on the source of the solutions, in particular on the distinction between global and local solutions. Limit load solutions for offshore tubular joints and clad plates containing a repair weld have been removed. As a result of this change, Equation (P.31) has been removed; however, in order to maintain continuity with the 2013 edition, subsequent equations have not been renumbered.
- Annex R (Determination of plasticity interaction effects) has been simplified. In the interests of continuity with earlier revisions, both plasticity interaction factors (ρ and V) have been retained; the simplified approach has been kept and the alternative approaches described in the 2013 edition have been removed. Moreover, the simplified approach to the calculation of V has been revised to reflect the most recent amendments to the R6 procedure.

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at bsigroup.com/standards, or by contacting the Customer Services team.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

As a guide this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

Contractual and legal considerations

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 cannot confer immunity from legal obligations.

0 Introduction

The background to the development of BS 7910 is given in reference [0.1].

Where it is necessary to examine critically the integrity of new or existing structures by the use of non-destructive testing (NDT) methods, acceptance levels are required for any flaws that might be revealed. These often already exist as quality control levels (for example in a construction code); however, in this British Standard the derivation of acceptance levels for flaws is based upon the principle of fitness-for-service.

By this principle a structure 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-service.

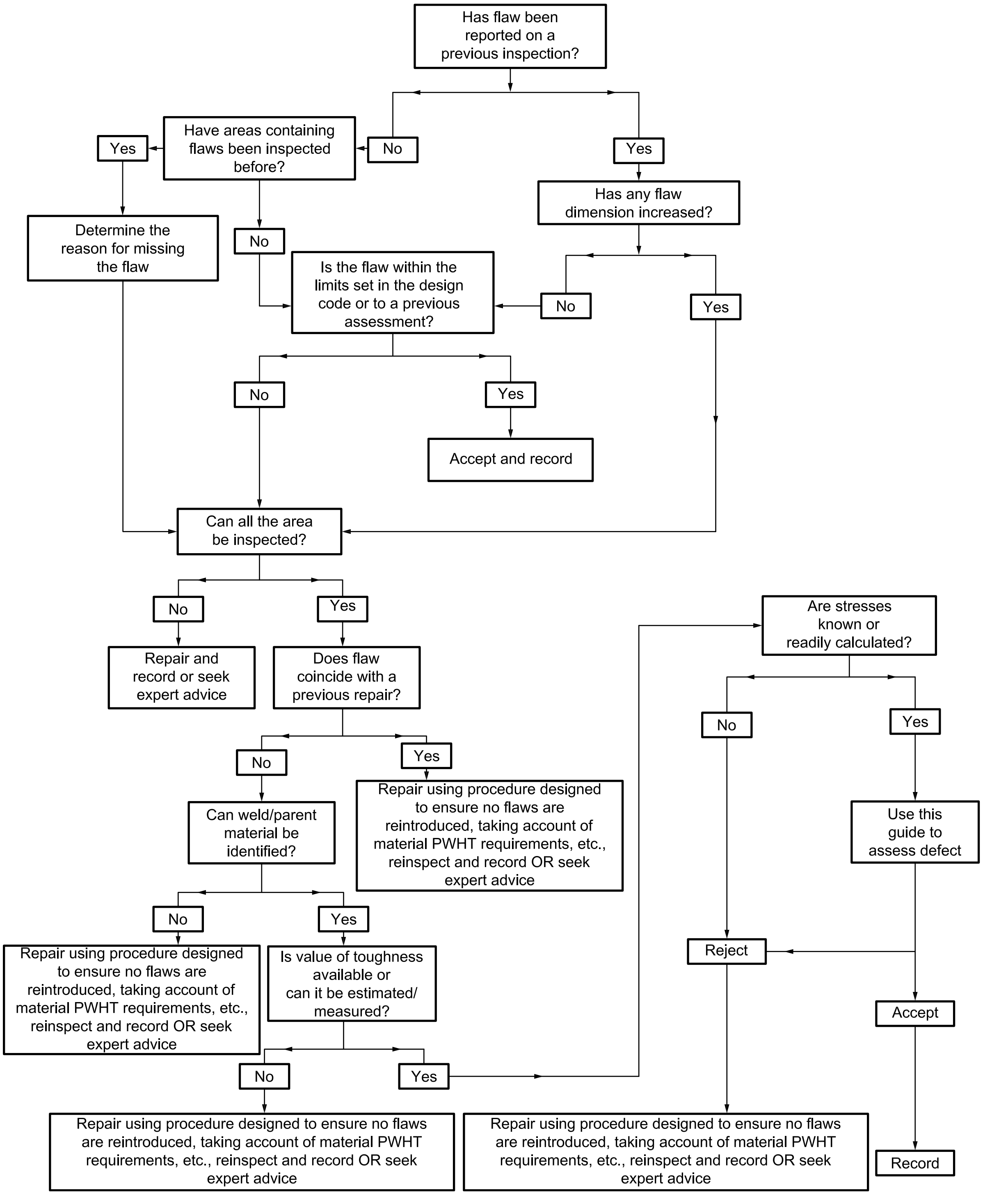
Quality control levels are usually both arbitrary and conservative, but are of considerable value in the monitoring and maintenance of quality during production. Flaws that are less severe than such quality control levels as given, for example, in current construction codes, are acceptable without further consideration. If flaws are more severe than the quality control levels, rejection is not necessarily automatic. Decisions on whether rejection, down rating and/or repairs are required may be based on fitness-for-service, 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) (see Figure 0.1). 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 is not intended to 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-conformity. The methods covered by this British Standard are complementary to, and not a replacement for, good quality workmanship.

A procedure for an ECA is described throughout whereby the significance of flaws under a particular set of circumstances can 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, as a large number of variables are involved as enumerated in this British Standard. Where relevant experience and data already exist it is possible 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. Unsatisfactory repair of innocuous flaws can result in the substitution of more harmful and/or less readily detectable flaws.

Flaw assessment on a fitness-for-service basis requires thorough examination by non-destructive testing (NDT) using techniques capable of locating and sizing flaws in critical areas. This British Standard 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 that need to be determined. Such NDT is normally carried out after any post-weld heat treatment (PWHT) and/or proof test. However, since a major objective of this British Standard is to reduce costs by eliminating unnecessary repair, careful consideration needs to be given to the level of inspection required to implement this British Standard, and to the limitations of NDT methods.

Figure 0.1 **Example of integrity management procedure for flaws**



NOTE If a component is rejected on the basis of a fitness-for-service analysis, downrating or retirement of the component may be considered as well as repair. Alternatively, the more advanced methods of this British Standard may be used, e.g. analyses based on leak-before-break (see Annex F) or recharacterization of flaws (see Annex E).

Where NDT has revealed the presence of flaws, the following options apply.

- If the flaws do not exceed the quality control levels in the appropriate application standard, no further action is required.
- 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.

- If no relevant documented experience exists, then an ECA based on the guidance given in this document may be carried out.

An ECA helps to identify the limiting conditions for failure or the limiting design conditions. It is emphasized that some aspects of an ECA are based on new concepts that could be subject to review.

The application of ECA principles means that "safe" results are obtained. The option of using appropriate safety factors has been incorporated or is inherent throughout the standard. If the accuracy of the input information employed (e.g. stress levels, materials properties at the appropriate temperature, flaw size determination) is in question, appropriate additional safety factors need to be agreed. Equally a flaw is not necessarily unacceptable when it is found initially to exceed the acceptance levels that are derived from this standard. A further assessment may be made following the principles given in this standard incorporating more precise input data or analysis methods or by testing structurally relevant components.

This British Standard also gives guidance on the use of 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 could pose an unjustifiable or intolerable risk to the surrounding environment or population, a full risk analysis might be needed, with due recognition of both individual and societal risk [0.2].

The assessment methods given in this British Standard provide a quantitative measure of the acceptability of a flaw in a structure. They are not to be used in isolation but are to be used as part of an overall process for the management of flaws. The management of flaws is part of a wider integrity management plan for the structure or system. The management processes for flaws address factors such as:

- the cause of the flaw and remedial action to prevent further occurrences or growth;
- whether a previous inspection failed to detect this flaw. If so, the reasons for not detecting the flaw need to be determined. The inspection technique or assumptions about sub-critical crack growth rates might need to be reviewed;
- the previous history of the structure and whether it is consistent with the nature, location and size of the flaw;
- whether an inspection suggests that the flaw has grown and the observed growth is consistent with assumptions about loading and sub-critical crack growth rates after allowing for uncertainty in the inspection results;
- the implications for other structures of the same or similar design and whether modifications to the structure or a change in the service conditions might be required;
- whether there is a pattern of this flaw being detected in other structures of the same design.

An example algorithm for managing the assessment of flaws is shown in Figure 0.1. Alternative approaches may be developed.

Bibliography for Introduction

Standards publications

There are no standards publications in the Introduction.

Other documents

[0.1] HADLEY, I. BS 7910:2013 in brief. *In: International Journal of Pressure Vessels and Piping*, August 2018, 165, 263–269. <https://doi.org/10.1016/j.ijpvp.2018.07.010>

[0.2] ROYAL SOCIETY. *Risk analysis, perception, management*. London: The Royal Society, 1992.

1 Scope

This British Standard gives guidance and recommendations 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 can be used for analysing flaws in structures made from other metallic materials and in non-welded components or structures. The methods described are applicable at the design, fabrication and operational phases of the life of a structure.

Specific applications include:

- assessing a known flaw in order to determine the fitness-for-service of a flawed structure;
- calculating the defect-tolerance of a structure in order to inform materials selection, load capacity or inspection requirements;
- justifying waiver of post-weld heat-treatment in thick-walled steel structures.

2 Normative references

There are no normative references in this document.

NOTE Informative references are listed in individual clauses and annexes.

3 Symbols and definitions

For the purposes of this British Standard, the symbols, definitions and units given in individual clauses and annexes apply.