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Welding - Methods for assessing imperfections in metallic structures

Soudage - Méthodes d'évaluation des défauts dans les constructions métalliques

Schweißen - Verfahren zur Beurteilung von Unregelmäßigkeiten bei metallischen Bauteilen

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Foreword

This CEN Technical Report (CEN/TR 15235:2005) has been prepared by Technical Committee CEN/TC 121 “Welding”, the secretariat of which is held by DIN.

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Introduction

European provisions for assessing imperfections in metallic structures are needed to meet the requirements of industry. The technology is being applied by many industries for materials selection, design and fabrication and in-service assessment using existing methods. Engineering Critical Assessment (ECA) methods for the assessment of imperfections have received further support by the EC directive 97/23/EC concerning pressure equipment (PED) which permits such methods as an alternative to conventional methods.

The present Technical Report gives guidance to the application of BS 7910 and the European SINTAP Report. Some further documents are also mentioned.

Experience from the application should, in a few years, provide enhanced technology in the subject and eventually permit standardisation at the European level.

Conventional design procedures involve application of mathematical models such as the theory of elasticity. Actions are described by characteristics such as stress and strain. Resistance described by characteristics such as yield stress and ultimate limit stress. The designer has to assure that the resistance of the structure is adequate, using adequate safety factors, partial coefficients, etc. The mathematical models presuppose a homogenous material.

Many failure modes involve cracks. Failure may originate from a crack and/or failure may propagate (slow or fast) as a crack. Application of the conventional theory of elasticity to a structure with a crack leads to a singularity at the crack tip because the stresses approach infinity. To this should be added that a closer study of the fracture processes shows that in-homogeneities such as grain structure and even the atomic structure may influence the mode of fracture. Conventional design procedures can, for these reasons, not be applied in situations where an analysis of the significance of a crack-like imperfection is necessary and they cannot be applied for an analysis of the propagation of fatigue cracks, creep cracks, stress corrosion cracks, etc.

Alternative methods termed fracture mechanics have been developed in order to model the behaviour of structures containing cracks. Fracture mechanics interpret crack driving force and materials resistance by an alternative set of parameters such as stress intensity factor, crack tip opening displacement, etc.

Engineering critical assessments use a combination of conventional design procedures and fracture mechanics calculations, depending on the nature of the imperfection and the likely type of failure. General corrosion results for example in a reduction in cross section and may be analysed by conventional design procedures whereas propagation of fatigue cracks has to be analysed by fracture mechanics methods.

1 Scope

This Technical Report provides guidance on the selection and application of methods for assessing the significance of imperfections in all types of structures and components. The guidance is primarily tailored to welded structures and components in steel or aluminium alloys. Some of the methods may also be applied for other types of metals and for non-welded structures and components.

2 Terms and definitions

For the purposes of this Technical Report, the following definitions apply:

ECA – Engineering Critical Assessment
methods for the assessment of the significance of imperfections for the strength and usability of structures (see also clause 4)

FAD – Failure Assessment Diagram
combines the analysis of the safety against plastic instability and final fracture in a single diagram

3 Symbols and abbreviations

CDF
Crack Driving Force plot

ETM
Engineering Treatment Model

FITNET
European Fitness-for-service Network

HIDA
High Temperature Defect Assessment

SINTAP
Structural Integrity assessment procedures for European industry

The following symbols are used to characterise the local stress-strain field around the crack front. They are (usually with subscripts) used for crack driving force as well as resistance.

K
stress intensity factor

J
a line or surface integral that encloses the crack front from one crack surface to the other

CTOD
Crack Tip Opening Displacement

See the publications listed in the clause "Bibliography" (in particular references [1] and [2]) for further detail.