IACS Common Structural Rules for Double Hull Oil Tankers, January 2006

Background Document

SECTION 9/3 – DESIGN VERIFICATION FATIGUE STRENGTH

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3 FATIGUE STRENGTH

3.1 Fatigue Evaluation

3.1.1 General

3.1.1.a Fatigue strength shall be verified according to the procedure outlined below and described in detail in *Appendix C*.

3.2 Fatigue Criteria

3.2.1 Corrosion model

3.2.1.a See *Section 6/3 of the Rules*.

3.2.2 Loads

3.2.2.a See *Section 7/3*.

3.2.2.b The main contribution to the cumulative fatigue damage is from the smaller waves; therefore, the dynamic load for fatigue is based on a 10^{-4} probability level.

3.2.3 Acceptance criteria

3.2.3.a The design basis described in *Section 2 in the Rules* specifies the requirement for 25 years design life. The fatigue damage, D, of 1.0, represents a probability of survival of 97.7% based on selection of design S-N curves, which is 2 standard deviations below the mean S-N curves, and the assumption that all the other parameters in D calculations are deterministic. All details covered by the scope of these Rules are assigned the same safety margin with respect to the probability of occurrence of fatigue cracks.

3.3 Locations to Apply

3.3.1 General

3.3.1.a For conventional type of double hull oil tankers, the scope described in *Section 9/3.3.1 and 9/3.3.2 of the Rules* is considered sufficient as a minimum requirement to cover the intention of these Rules.

3.3.2 Longitudinal structure

3.3.2.a This is the same scope as in current Classification Society requirements.

3.3.3 Transverse structure

3.3.3.a This is the same scope as in current Classification Society requirements.

3.4 Fatigue Assessment Methods

3.4.1 Nominal stress approach

3.4.1.a Traditional fatigue calculations are based on the nominal stresses and the use of geometry dependent S-N curves. S-N curves may also be developed based on the concept of hot spot stresses saying that the effect of the notch stress due to the local weld detail is imbedded in the curve, or alternatively, based on the notch stress

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where the influence of the weld is included. All concepts have their advantages and disadvantages:

(a) Advantages: the S-N curves for classified details inherently account for both the notch stress and the stress field over the crack growth area.

(b) Disadvantages: It can be difficult in practical design of ship structural details to define the nominal stress level to be applied together with the geometry specific S-N curves. Further, the use of a limited number of established S-N curves in fatigue design may complicate the utilisation of improved local detail design and workmanship in the fatigue life assessment.

3.4.2 Hot spot stress approach

3.4.2.a Geometric (hot spot) stresses include nominal stresses and stresses due to structural discontinuities and presence of attachments, but excluding stresses due to presence of welds. Stresses derived from fine mesh FEM models are geometric stresses. However, effects caused by fabrication imperfections such as misalignment of structural parts are not normally required to be explicitly considered in the FEM analyses and must be separately accounted for if this tolerance exceeds allowable limits. The peak value of the geometric stress extrapolated to the weld toe immediately outside the region affected by the geometry of the weld is commonly denoted as hot spot stress:

(a) Advantages: Using the hot spot stress method the local notch effect is embedded in the S-N curve, and one may say that the large variation in local notch geometry is accounted for in the scatter of the S-N data. Only one SN curve is used for welded connections.

(b) Disadvantages: The hot spot stress has to be determined by extrapolation of stresses outside the notch region. The finite element mesh has to be fine enough to represent the geometric stress in this region. Strict consistency in FE modelling is required. Extrapolation should be performed from points at least $0.3t$ outside the notch. Practice for extrapolation has varied as its basis is founded on experience from test measurements and numerical analysis of stress distributions at the hot spot region.

3.4.3 Alternative direct calculation approach

3.4.3.a Direct calculation approach such as spectral fatigue assessment is not part of the scope of these Rules. Where such an alternative approach is applied, they may be based on individual Classification Society procedures. However where an alternative direct calculation approach is applied to details covered by these Rules, for approval purposes, the fatigue lives are to be determined based on these Rules.

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