

Ultimate strength performance of tankers associated with industry corrosion addition practices

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ABSTRACT: In the ship and offshore structure design, age-related problems such as corrosion damage, local denting, and fatigue damage are important factors to be considered in building a reliable structure as they have a significant influence on the residual structural capacity. In shipping, corrosion addition methods are widely adopted in structural design to prevent structural capacity degradation. The present study focuses on the historical trend of corrosion addition rules for ship structural design and investigates their effects on the ultimate strength performance such as hull girder and stiffened panel of double hull oil tankers. Three types of rules based on corrosion addition models, namely historic corrosion rules (pre-CSR), Common Structural Rules (CSR), and harmonised Common Structural Rules (CSR-H) are considered and compared with two other corrosion models namely UGS model, suggested by the Union of Greek Shipowners (UGS), and Time-Dependent Corrosion Wastage Model (TDCWM). To identify the general trend in the effects of corrosion damage on the ultimate longitudinal strength performance, the corrosion addition rules are applied to four representative sizes of double hull oil tankers namely Panamax, Aframax, Suezmax, and VLCC. The results are helpful in understanding the trend of corrosion additions for tanker structures.

KEY WORDS: Corrosion addition; Double hull oil tankers; Age-related degradation; Corrosion maintenance; Pre-CSR; Common structural rules (CSR); Harmonised common structural rules (CSR-H); Time-dependent corrosion wastage model (TDCWM); Union of greek shipowners (UGS).

ABBREVIATIONS & NOMENCLATURES

CSR	Common structural rule	D_s	Ship depth
CSR-H	Harmonised common structural rule	h_w	Web height of stiffener
Pre-CSR	Structural rule applied before CSR	I	Moment of inertia

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TDCWM	Time-dependent corrosion wastage model proposed by Paik et al. (2003a)	L_s	Ship length
UGS	Union of greek shipowners	M_u	Ultimate hull girder bending moment
M_{u_net}	Ultimate hull girder bending moment at net scantling	a	Length of stiffened panel
B_s	Ship breadth	B	Breadth of stiffened panel
b	Breadth between longitudinal stiffeners	t	Plate thickness
b_f	Breadth of flange	t_f	Flange thickness
C_b	Block coefficient	t_w	Web thickness
		σ_Y	Yield strength

INTRODUCTION

Corrosion is an important age-related degradation problem that has a great impact on the service life of marine structures. Since the 1950s, the construction time of ships and offshore structures has been significantly reduced by the development of welding and maintenance technology. With maintenance technology advancing at a fast growing rate, the structural failure due to in-service damage is decreasing. These advances, along with other technical developments, have extended the lifespan of ships and offshore structures by two or three times.

Historically, various technologies for preventing corrosion have been suggested, such as corrosion addition, coating, cathodic protection, ballast water deoxygenation, and chemical inhibition (Paik and Melchers, 2008). Of these technologies, coating and corrosion addition are the two most widely adopted technologies by ship designers and builders to protect structural members from corrosion degradation because of their cost effectiveness, simple practicability, and relevance.

Before the introduction of CSR, corrosion addition rules were developed and maintained by individual classification bodies, a period known as pre-CSR. To achieve robust and safer ships, the IACS adopted CSR for oil tankers and bulk carriers on 1st April 2006, at which the corrosion additions for oil tankers and bulk carriers were specified (IACS, 2006a; 2006b). However, the CSR for oil tankers and bulk carriers were developed independently by different teams using different technical approaches. During the review of the CSR, industry stakeholders urged the IACS to harmonise the key technologies used to derive the rules. The IACS agreed and was committed to develop a harmonised version of the rules (IMO, 2012). The new structural rules are known as CSR-H (IMO, 2012), as shown in Fig. 1. The outcome of the verification will be effective soon.

The CSR-H is made up of common “general hull requirements” for both ship types, and separate parts for “ship-type specific” requirements applicable to oil tankers and bulk carriers, respectively (Kim and Cheng, 2012). The rules on the corrosion additions for each ship type are expected to be located in the “ship type specific” parts, and corrosion additions can be defined for a range of cargo hold circumstances for each ship type.

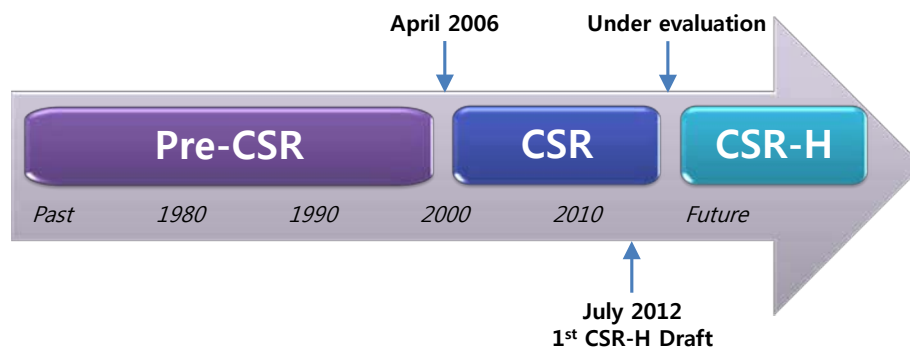


Fig. 1 Overview of corrosion addition rules (DNV, 2005; IACS, 2006a; 2006b; IMO, 2012).

This study investigates the historical trend of corrosion additions for double hull oil tankers and their effect on the ultimate strength performance of hull girders. For comparison, two other corrosion models namely UGS model, a new corrosion model

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