JFE TECHNICAL REPORT
No. 26 (Mar. 2021)

JFE-SIP™ Series Corrosion-Resistant Steel for Ships

1. Introduction

Corrosion occurs in many parts of ship, including the outer surface, which is exposed to the effects of seawater, and also inner surfaces that are affected by the cargo or other factors, and increased operation and maintenance (O&M) costs and securing safety and security have become issues. In order to improve the corrosion resistance of the steel members used in ships, JFE Steel successively developed corrosion-resistant steels for shipbuilding which demonstrate corrosion resistance corresponding to these various corrosion environments as a product series called "JFE-SIP™ (JFE-Steel for Ship Inside Protection)."

This article introduces the features of the JFE-SIP Series.

2. Overview of JFE-SIP™ Series

At present, JFE Steel has commercialized corrosion-resistant steels corresponding to the four types of corrosion environments in ships shown in Table 1 as the JFE-SIP Series. Among these products, in response to the use of heavy-duty anticorrosion coatings in ballast tanks, which is mandatory under the Performance Standard for Protective Coatings (PSPC) [1] of the International Maritime Organization (IMO), JFE Steel developed JFE-SIP-BT for ballast tanks, which has the effect of suppressing deterioration of coating films after painting, and thus is contributing to reduction of O&M costs and longer ship life. JFE-SIP-CC for the cargo holds of coal carriers is used in the side walls of cargo holds, and is also contributing to reduced O&M costs and longer ship life by reducing plate thickness loss due to corrosion, responding to requirements for a corrosion addition (additional plate thickness for predicted thickness loss due to corrosion) and side wall painting under Common Structural Rules (CSR) [2]. Unpainted use of JFE-SIP-OT1 in the inner bottom plates of cargo oil tanks in oil tankers and JFE-SIP-OT2 for the upper deck of oil tankers was recognized as an exception to the painting requirement under PSPC [3]. These products not only reduce O&M costs, but also substantially reduce the burden of painting work in shipyards during ship construction.

3. Features of JFE-SIP™ Series

3.1 Features of JFE-SIP™-BT

Corrosion of ballast tanks, which are an indispensable part of ships, is mainly caused by the seawater used to fill the tanks. In particular, the underside of the upper deck plates is exposed to a severe corrosion environment characterized by repeated wetting and drying, and electrolytic corrosion protection is ineffective because this part is not immersed in seawater. Underfilm corrosion (corrosion under the protective paint film) is a typical corrosion mode, and interaction of rust and swelling/peeling of the paint film accelerate its spread. JFE-SIP-BT, which was developed by JFE Steel as the first steel of its type in the world, can be expected to extend the conventional paint life of

Table 1 JFE-SIP™ series and features

Series	Applicable area	Grade	Thickness (mm)	Features
JFE-SIP-BT	Ballast tank	DH36 DH40 EH40	6-42	Improves coating corrosion resistance in seawater
JFE-SIP-CC	Coal carrier	AH32 AH36 AH40 DH32 DH36 DH40	6-35	Reduces plate thickness loss due to corrosion by sulfuric acid generated in coal and dew water
JFE-SIP-OT1	Inner bottom for oil tank	AH32-RCB AH36-RCB DH32-RCB DH36-RCB	6-50	Suppresses pitting corrosion of salt water (oil coat defect part). This steel can be used without painting
JFE-SIP-OT2	Upper deck for oil tank	AH32-RCU AH36-RCU AH40-RCU DH32-RCU DH36-RCU DH40-RCU EH32-RCU EH36-RCU EH40-RCU	6-40	Suppresses general corrosion of H_2S, SOx in dew water. This steel can be used without painting

† Originally published in *JFE GIHO* No. 46 (Aug. 2020), p. 76−77

15 years to 25 years or more [4], and the burden of repair painting can also be dramatically reduced by using this steel. At present, JFE-SIP-BT has a record of more than 10 years in maritime service since it was first introduced, and evaluation while ships are in dock is continuing.

Among approvals by ship classification societies, DH36, DH40 and EH40 grades have been approved, and JFE-SIP-BT has also received special approval from Nippon Kaiji Kyokai (ClassNK) for plate thicknesses up to a maximum of 42 mm.

3.2 Features of JFE-SIP™-CC

Because the steel used in the cargo holds of coal carriers is subject to severe corrosion by dilute sulfuric acid, which is formed by the reaction between sulfur in the coal and dew condensation water, use of a protective coating (painting) or a corrosion addition (additional plate thickness) is mandatory. However, physical delamination of paint coatings used in cargo frequently occurs by contact with the cargo or cargo handling equipment. As a result, a long-term corrosion protection effect cannot be expected, and repainting and local replacement of the steel due to corrosion damage are necessary.

JFE-SIP-CC, also developed by JFE Steel as the first steel of its kind in the world, suppresses corrosion caused by cargo coal [5]. A large reduction in the corrosion rate of the steel has been verified in a wet and dry corrosion test in contact with coal, and a broad decrease in the O&M costs of coal carriers can be expected. Because this steel also has weldability and workability comparable to conventional steel, special construction management is not necessary during ship construction. This steel has been applied in 9 ships (including ships currently under construction) since its development in 2014.

Approvals for AH32, AH36, AH40, DH32, DH36 and DH40 grades have been received from ship classification societies, and special approval for plate thicknesses up to a maximum of 35 mm has also been received from ClassNK.

3.3 Features of JFE-SIP™-OT1

Regulations requiring either painting or use of corrosion-resistant steel in the bottom plates and upper deck of cargo oil tanks are applied to crude oil tankers contracted for construction after January 1, 2013 [3]. In crude oil tankers, a layer consisting of an oil coat and seawater forms on the surface of the bottom plates, and if the plates are unpainted, pitting will occur due to defects in the oil coat, necessitating repair with resin or by welding when the ship is in dock, depending on the pit depth.

JFE-SIP-OT1 [6] has performance which reduces corrosion inside pits corresponding to the corrosion environment of tanker bottom plates. Unpainted use is possible, as the corrosion rate of this steel is about 1/20 that of the conventional steel in the corrosion tests in the IMO regulations, and also satisfies the corrosion rate criterion (≤ 1.0 mm/y) in the IMO performance standards. More than 15 000 tons of this steel have by used in 9 ships in Japan and other countries since it was developed in 2006.

Approvals for AH32-RCB, AH36-RCB, DH32-RCB and DH36-RCB grades, and for plate thicknesses up to a maximum of 50 mm and Z35 lamellar tearability have been received from ship classification societies.

3.4 Features of JFE-SIP™-OT2

The space between the surface of the crude oil and the upper deck plates of oil tankers contains inert gas used to fill the space for explosion prevention, and corrosive gases such as sulfur oxides (SOx) and hydrogen sulfide (H_2S) due to vaporized components of the crude oil itself. These corrosion gases also coexist with water vapor, and condensation due to difference in the daytime and nighttime temperatures of this environment causes severe general corrosion of the underside of the deck plate. Moreover, because there are a large number of longitudinal members on the underside of the deck plate, the burden of overhead painting during construction is large, and work in high places is necessary for repair painting. Therefore, reducing painting work in these cargo oil tanks of tankers is considered to be an important issue for the future.

As a steel which reduces general corrosion, JFE-SIP-OT2 [6] was developed to address these problems of the underside of tanker upper deck plates. The corrosion rate of JFE-SIP-OT2 amply satisfies the criterion (≤ 2.0 mm/25 y) in the IMO performance standard.

Approvals for AH32-RCU, AH36-RCU, AH40-RCU, DH32-RCU DH36-RCU, DH40-RCU, EH32-RCU, EH36-RCU and EH40-RUC grades, and for plate thicknesses up to a maximum of 40 mm and Z35 lamellar tearability have been received from ship classification societies.

3.5 Welding Consumables for JFE-SIP™-OT1 and -OT2

For painting-free application using JFE-SIP-OT1 and OT2, welded joints must pass the applicable corrosion resistance test and receive approval. Before ship construction, JFE Steel confirms the combination of the welding method and welding consumable to be used by each shipyard, and conducts corrosion tests and evaluations when appropriate. At present, joints extending to several tens of cases have been approved

for application. Moreover, because GMAW with the conventional welding consumables did not satisfy corrosion resistance requirements, approval has been obtained using the newly-developed DW-50JST and DW-50JSTB (both manufactured by Kobe Steel, Ltd.).

4. Conclusion

The features of the JFE Steel JFE-SIP™ Series of corrosion-resistant steels for shipbuilding were introduced. In the future, JFE Steel will continue to develop new products for various applications and use environments and improve product quality in order to supply global environment-friendly corrosion-resistant steels for shipbuilding which ensure customer satisfaction in ship construction and service.

Reference

1) ClassNK: Guidelines for Performance Standard for Protective Coatings Contained in IMO Resolution MSC, 215 (82), (2007).
2) IACS: Common Structural Rules for Bulk Carriers, (2006).
3) SOLAS Chapter II-I, Part A-1, Reg. 3–11, as amended by resolution MSC. 291 (87), APPENDIX, Test Procedures for Qualification of Corrosion Resistant Steel for Cargo Tanks in Crude Oil Tankers.
4) Shiotani, K.; Tachibana, S. Coating Deterioration Behavior of Ship Using Corrosion Resistant Steel for Ballast Tank. Journal of the Japan Society of Naval Architects and Ocean Engineers. 2016, vol. 24, p. 211–218.
5) Ikeda, H.; Shiotani, K.; Igi, S.; Yamamura, N.; Hase, K. Development of Corrosion Resistant Steel for Coal Carrier. Materia Japan. 2018, vol. 57, no. 3, p. 117–119.
6) Ikeda, H.; Samusawa, I.; Mishima, E. Development of Corrosion Resistant Steels for Cargo Oil Tank of Crude Oil Tankers "JFE-SIPTM-OT1, OT2". JFE Technical Report. 2021, vol. 26, p. 95–102.

For Further Information, Please Contact(Oct.2021-):

Plate Business Planning Dept., JFE Steel
Phone: (81)3–3597–3183 FAX: (81)3–3597–4567
http://www.jfe-steel.co.jp/en/products/plate/index.html
Email:t-atsuitasec@jfe-steel.co.jp