

# NSGP™-1&2

Highly Corrosion-resistant Steel Plates for Crude Oil Tankers

**Steel for Protecting Crude  
Oil Tankers from Corrosion**



**NIPPON STEEL**

[www.nipponsteel.com](http://www.nipponsteel.com)

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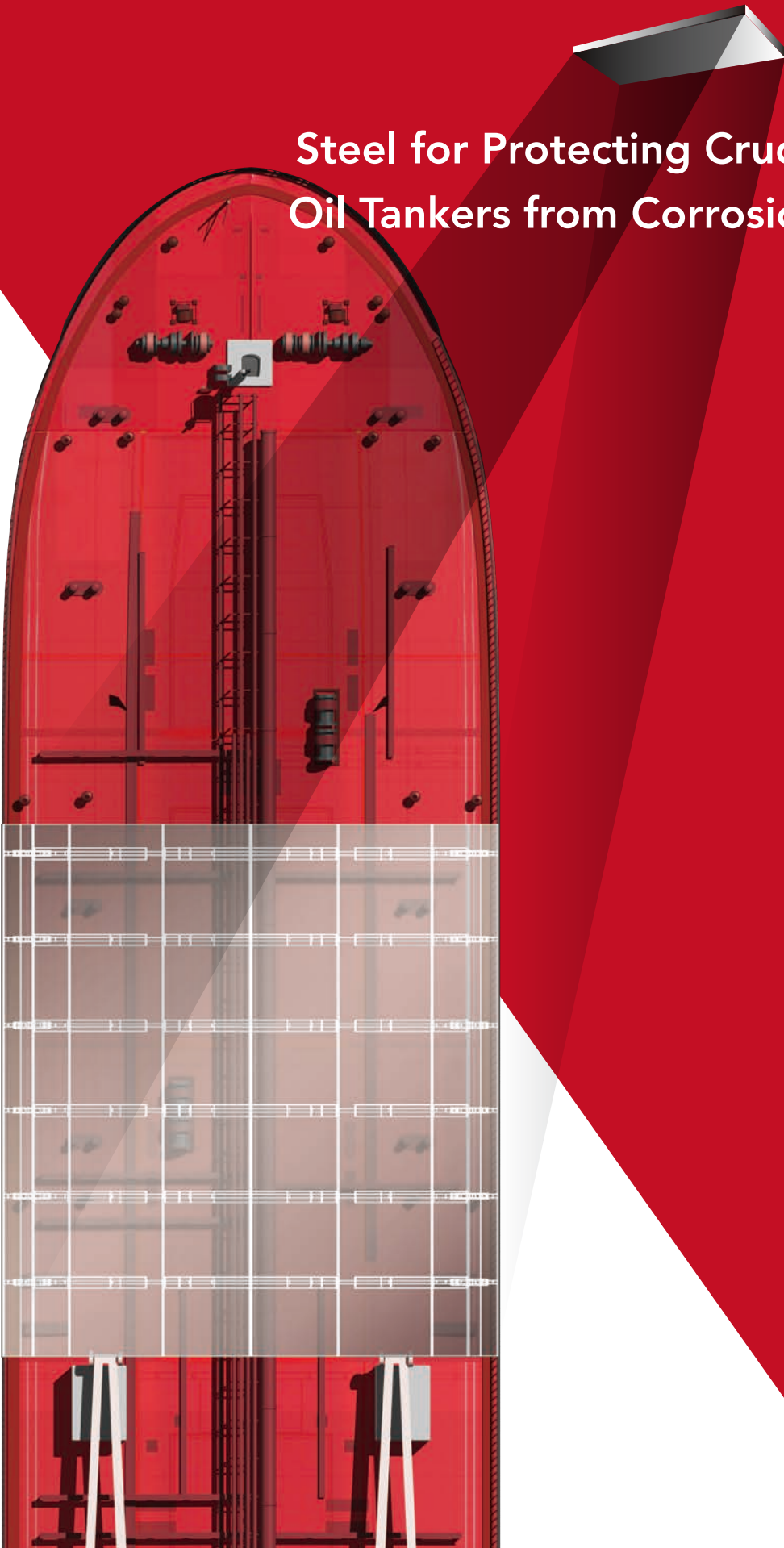
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# NSGP-1&2 Debut as the World’s First Paint-free Highly Corrosion-resistant Steel Plates

Currently, worldwide energy demand is increasing. The role of crude oil tankers as a means of maritime crude oil transport to every corner of the world is also becoming more important.

It cannot be overstated that a key factor in the evolution of tankers over the past century has been the pursuit of two compatible performances: improved safety and higher durability. One approach in this effort is to impart corrosion protection, for which one indispensable means applied throughout the world is heavy-duty painting.

In its search for new approaches to corrosion resistance, NIPPON STEEL promoted R&D efforts backed by know-how obtained through fifty years of developing low-alloy corrosion-resistant steel. This led to the successful development of NSGP-1 and NSGP-2, which are paint-free highly corrosion-resistant steel plates designed for crude oil tanker construction. NSGP-1 was developed with Nippon Yusen Kaisha and first adopted in 2004 for the bottom plate sections of tanks and thereafter received high assessments. Further in 2014, NIPPON STEEL developed NSGP-2 as steel plate for use in upper decks (ceiling parts). Both NSGP-1 and NSGP-2 are the first products in the world to have cleared the new regulations issued by the IMO (International Maritime Organization, a specialized agency of the UN).

NSGP-1&2 are the most advanced steel plates and not only allow greater cost cutting in both shipbuilding and maintenance while in service but also contribute to environmental protection.

NIPPON STEEL is confident that NSGP-1&2 will be indispensable in the building of crude oil tankers in the future.

## The advantages in ship-owner expected

Tankers are important assets for ship owners. The application of NSGP-1&2 offers to ship-owners reliable security with regard to cost reduction not only in shipbuilding but also in long-term maintenance and in the prevention of related troubles.

- ①Mitigation of uneasiness in terms of safety and cost thanks to extremely high corrosion resistance
- ②Relaxation of uneasiness concerning deviations in painting quality thanks to the paint-free finish of these steel products
- ③Favorable weldability similar to that of conventional steel
- ④Reductions of post-completion maintenance work and term and of resultant ship navigation costs
- ⑤Benefit of environmental protection associated with paint-free steel—Contribution as a link of corporate social responsibilities

## Application Records of NSGP (Examples)



Ship name: TAMBA  
Completion: Jan. 2009

Length: 333 m  
Breadth: : 60 m  
Dead weight: 300,000 DWT



Ship name: TANGO  
Completion: Oct. 2009

Length: 333 m  
Breadth: : 60 m  
Dead weight: 300,000 DWT



Ship name: TSURUGA  
Completion: Oct. 2009

Length: 333 m  
Breadth: : 60 m  
Dead weight: 300,000 DWT

## NSGP-1&2: Suppressing the Development of Corrosion in Two Different Corrosive Environments—Tank Bottom Plate Sections and Tank Rear Sections

Highly corrosion-resistant NSGP-1&2 features both paint-free application and high performance as a steel plate for crude oil tankers. It is available in two grades: NSGP-1 for bottom plate sections of tanks and NSGP-2 for rear sections of tanks, both of which demonstrate the highest level of corrosion resistance due to the addition of trace amounts of alloying elements.

NSGP-1&2 have already been applied in the record number of tankers in the world, and have proven world-class reliability through year-long application tests in working tankers over twelve years. Their paint-free performance enables reductions in both maintenance costs and shipbuilding costs. Also, the welding and fabrication of NSGP-1&2 steel plates can be conducted in the same manner as conventional steel plates, and thus no special process control is required.

Furthermore, NSGP-1&2 help to prevent environmental contamination caused by painting and offer diverse benefits in shipbuilding and maintenance while in service.

\*NSGP: NIPPON STEEL Green Protect

## Development in Japan and World’s First Paint-free Steel Plates to Have Cleared IMO Regulations

The regulations prescribed by the IMO (International Maritime Organization) are aimed mainly at enhancing marine navigation safety and at improving maritime technologies. After corrosion protection was mandated for tankers in 2013, NSGP-1&2 steel plates are the first shipbuilding products in the world to acquire approval from the major ship classification societies as being paint-free. In this way, the paint-free specification developed in Japan has been incorporated into the international rules. NSGP shipbuilding plate is an innovative steel product that has proven the reliability of made-in-Japan materials.



# Enhancing Application Effectiveness by the Combined Use of NSGP-1 and NSGP-2

Tank durability can be improved only by the adoption of new types of steel plates in crude oil tank construction.

NSGP-1&2 highly corrosion-resistant steel plates for crude oil tankers have been developed precisely pursuing that purpose.

Application effectiveness is further enhanced by combining the use of NSGP-1, which has a well proven application record, the newly-developed NSGP-2 and welding materials designed exclusively for use with these two steel plates. Further, the paint-free specification reduces the number of processing steps during shipbuilding and the overall post-completion cost as well. On top of this, paint-free applications contribute to the mitigation of air pollution caused by painting.

Steel products for shipbuilding offered by NIPPON STEEL has been further reinforced by the development of NSGP-1&2. Capitalizing on a comprehensive lineup of steel products, NIPPON STEEL is ready to meet the diversifying needs of maritime transportation.

**NSafe™-Hull**

Highly ductile steel plate with ductile properties derived from original composition design. This plate reduces the occurrence of cracks and ruptures and prevents the propagation of related damage.

Application: Ship hull

**HIAREST™**

Steel plate with greatly improved performance to arrest brittle cracking (arrestability). The application of this plate enhances ship safety by suppressing the development of brittle cracks occurring in collisions with other ships.

**TMCP Steels**

With TMCP (thermomechanical control process) technology, steel with a lower carbon equivalent and higher strength can be produced compared to conventional steels. TMCP steels offer high strength, toughness and high weldability. They can be fabricated with large heat-input welding. They can therefore contribute to improved shipbuilding efficiency.

Applications: Steel plates for entire ship hull structures

**High arrest teel (YP47 km steel)**

YP47 km steel is a steel material compatible with arrestability (toughness) and strength, in response to the enlargement of container ships. Even when brittle cracks occur in the hull, it is possible to stop the cracks and to realize the safety of the ship at a higher level.

**FCA™ Steels**

FCA (fatigue crack arrester) steels has improved fatigue strength in weld joints. If by any chance a fatigue crack occurs, the steel can reduce the propagation rate.

Applications: Longitudinal sections (frames for double-wall bottom), hutch corner sections

**S-TEN™**

Sulfuric Acid and Hydrochloric Acid Dew-point Corrosion-resistant Steel

S-TEN exhibits the best resistance to sulfuric acid and hydrochloric acid dew-point corrosion found in the flue-gas treatment equipment used with coal-fired boilers, waste incineration plants, etc.

**Marilloy™**

Oil Sludge Wear-resistant and Seawater Corrosion-resistant Steel Pipe

Marilloy steel pipe exhibits high corrosion resistance in offshore applications, and is used for the cargo oil pipe through which oil runs into the inboard tanks of a tanker and for the water ballast pipe through which seawater runs.

NSGP-2

NSGP-1

Highly Corrosion-resistant Steel Plate for Tank Rear Sections of Crude Oil Tankers

NSGP-2

Every surface of upper decks (ceiling parts) is subject to corrosion. NSGP-2 can suppress such corrosion thanks to corrosion-protection performance derived from original research. This plate formally came to market in 2014 after diverse application tests conducted on working tankers. Particularly the shape of the ceiling (deck) sections of most tanks is complex, and thus the time required for repairs can be significantly reduced due to the paint-free properties peculiar to NSGP-2.

Highly Corrosion-resistant Steel Plate for Bottom Plate Sections of Crude Oil Tankers

NSGP-1

The pitting (pitting corrosion) that occurs in the bottom plate sections of crude oil tankers has conventionally been a critical problem. NSGP-1 can suppress the occurrence of this corrosion. Nippon Yusen Kaisha and NIPPON STEEL have developped NSGP-1 and in 2004, this product was experimentally adopted in a tanker and, in a periodic inspection 2.5 years later, demonstrated that it remained free of pitting corrosion, even under paint-free conditions. NSGP-1 has since been applied in many tankers.



Welding Materials for Exclusive Use with NSGP

A seamless flux-cored welding wire for exclusive use with NSGP was developed and has acquired the approval from the ship classification societies: NK, ABS ,LR and DNV-GL. This wire is marketed by NIPPON STEEL WELDING & ENGINEERING CO.,LTD.

**Longitudinal Profiled Plate**

Steel plate in which the plate thickness can be altered in the longitudinal direction.

Application of this plate can reduce not only the structural weight of a ship but also the number of welds required.

**Safety Bow**

This plate has a large deformation capacity upon collision and can reduce damage to a struck ship through high collision safety.

Application: Bulbous bows

**NSGP™-3**

Highly corrosion resistant thick steel plate which greatly reduces corrosion of cargo holds carrying coal



# Two Types of NSGP, 1 and 2, Have Been Developed by Means of Original Approaches



Why are two types of NSGP necessary even in oil tanks with a seemingly identical application? The reason is that the corrosion mechanism that occurs in the bottom plate section of a tank is different from that of the rear section.

The concentration of salt in the water that accumulates in the bottom plate section of a tank is higher than that of the seawater contained in crude oil, thereby causing localized pitting (pitting corrosion). Conversely, in the rear section of a tank, corrosion develops nearly uniformly over the entire surface of the steel plate. The major causes for this are the waste gas that is forced into the tank to prevent an explosion and the H<sub>2</sub>S that escapes from the crude oil.

In order to control these two different corrosion mechanisms, NIPPON STEEL has fully utilized the results of the research promoted on low-alloy steel over a 50-year span and successfully built high safety and high corrosion resistance into NSGP-1&2 simply by adding trace amounts of alloying elements to the respective steel materials used for the plates.

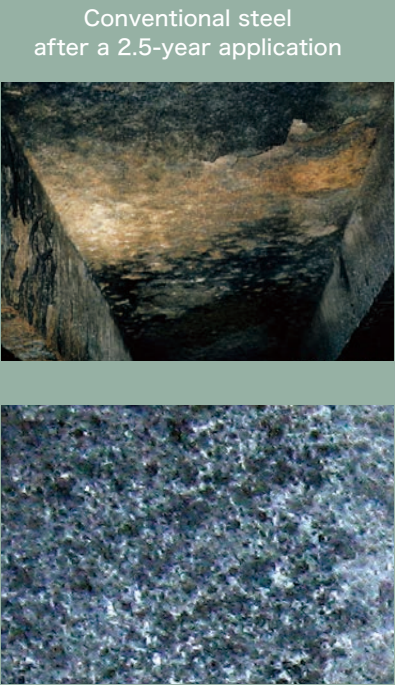
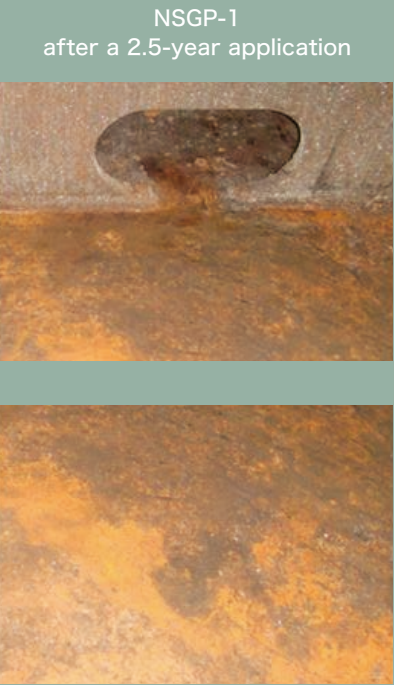
Further, corrosion-resistant welding materials for exclusive use with NSGP have been prepared for CO<sub>2</sub> gas shielded arc welding.



## Reducing Corrosion in Tank Bottom Plate Sections to 1/15 NSGP-1

There are cases in which the depth of pitting (pitting corrosion) that occurs in the bottom plate sections of tanks reaches 4 mm or more in a year. If left untended for five years, there is a danger of such pitting corrosion to penetrate entirely through the plate thickness.

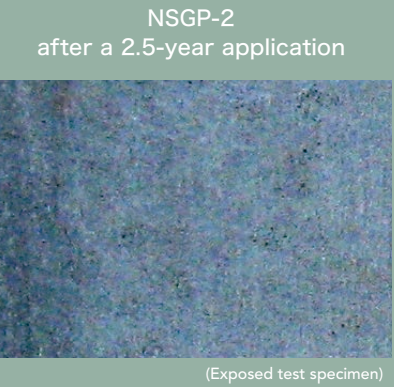
Even in a comparison of the number of occurrences of pitting corrosion of 4 mm or more in depth (per tank) after five years of service, tanks using conventional steel registered about 200 instances, while tanks using NSGP-1 registered about 13 instances—reduction to less than 1/15. This proves that NSGP-1 possesses high corrosion resistance.



## Reducing Corrosion in Tank Rear Sections by About 60% NSGP-2

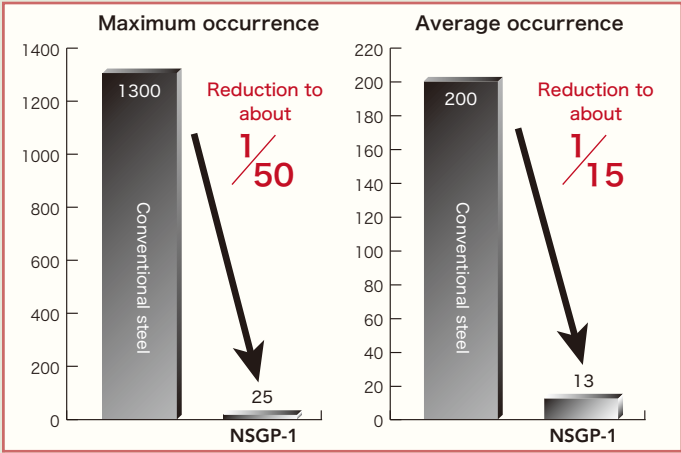
The ceiling (or deck) plate section of a tank presents two factors attributable to the progress of corrosion. One of these is the corrosive environment caused by the waste gas and the effect of H<sub>2</sub>S that escapes from crude oil as mentioned above. Another factor is the adverse conditions caused by repeated drying and condensation due to daytime and nighttime temperature differences resulting from the fact that the ceiling plate sections of the tanks also collectively serve as the deck of a tanker. It is reported that the average corrosion rate of these ceiling sections using conventional steel reaches nearly 0.1 mm/year, but there is the possibility of this level being exceeded depending on the change of the application environment.

It has been proven from the results of 10-year application of NSGP-2 in working tankers that the estimated loss of plate thickness of NSGP-2 after 25 years can be suppressed to about 60% that of conventional steel.



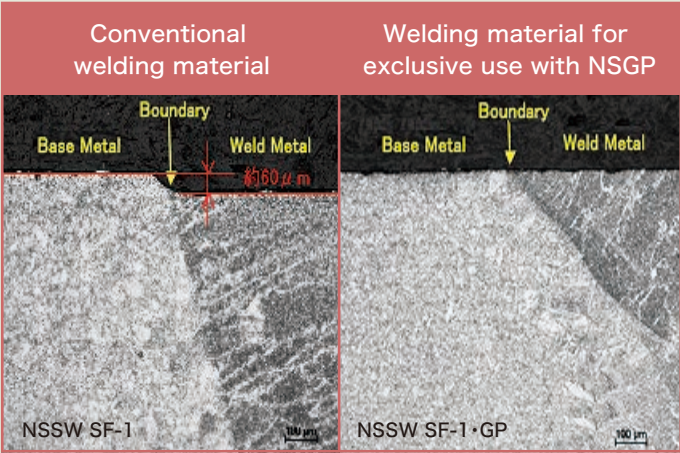
(Exposed test specimen)

Comparison of Number of Occurrence of Pitting Corrosion (4 mm or more in depth) after Five-year Application

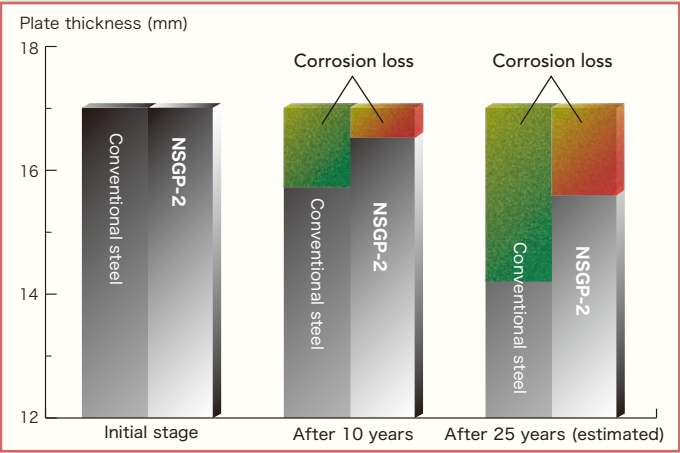


While pitting corrosion to a depth of 4 mm or more occurs at as many as 1,300 locations in tankers using conventional steel over a five-year service period, the adoption of NSGP-1 can suppress the maximum occurrence of such corrosion to about 1/50 that of conventional steel, or 1/15 in average.

Comparison of Corrosion Test Results for Welding Material



Comparison of Change in Corrosion Loss



When corrosion loss over a 25-year span is estimated from 10-year application of conventional steel and NSGP-2 in working tankers, it is predicted that, while corrosion loss in conventional steel will surpass the target value of 2 mm, the corrosion loss in NSGP-2 will be held to about 60% that of conventional steel.

Approval of Ship Classification Societies by Satisfying IMO Rule

Target application	Grade of NSGP	Suffix to material symbol	Approval-acquired ship class	Specifications obtained	Plate thickness
Bottom plate	NSGP-1	-RCB	NK,ABS, DNV-GL, (LRS)	AH32, DH32 AH36, DH36	≤50mm
Ceiling plate	NSGP-2	-RCU	NK,ABS, DNV-GL, LRS	AH32, DH32 AH36, DH36 EH32,EH36	≤40mm

NSGP-2 is the first plate in the world to acquire approval from classification societies as a steel product that satisfies the IMO rules. Recognition by other classification societies is anticipated.