Corrosion-resistant
Steel Plates

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Corrosion (rusting)
We are surrounded every day by many steel objects in diverse shapes that are used for various purposes. A massive amount of steel is used in large structures (bridges, ships, vehicles, and buildings), oil well casings, pipelines, and automobiles and electric appliances. However, steel is intrinsically corrosive (rusty) if corrosion prevention measures are not employed.

**NIPPON STEEL**  
**Corrosion-resistant Steel Plate series**

The Corrosion-resistant Steel Plates of NIPPON STEEL have been developed as a “shield” that protects the sustainability of steel structures from corrosion in both acid and neutral regions, atmospheric corrosion, dew-point corrosion, and seawater corrosion produced by various factors in diverse environments.

By selecting the Corrosion-resistant Steel Plate most suitable to the need that may vary according to the circumstances, the construction period and cost for maintenance can be reduced, effecting a significant life-cycle cost reduction.

### Corrosion protection methods
There are roughly four corrosion protection methods:
Coating, the use of special steel stock (with corrosion-resistant materials), the use of electricity, and environmental improvement. Each of them has its own characteristics such as the anti-corrosion effect, cost, workability, maintainability, etc., and is used on a case-by-case basis.

### Corrosion Factors (environments) and NIPPON STEEL Corrosion-resistant Steel Plates

**Acid region corrosion environments**

- Sulfuric acid/hydrochloric acid dew-point corrosion
  - Exhaust gas treatment equipment at waste incineration facilities: **S-TEN™ 1 & 2**
  - Boiler air preheaters at thermal power generation facilities: **S-TEN™ 1 & 2**

**Neutral region corrosion environments**

- Atmospheric/salt corrosion (coastal areas)
  - Uncoated bridges and structures: **NAW-TEN™ 12,15**
  - Coated bridges and cranes: **CORSPACE™**

- Seawater corrosion
  - Crude oil tankers, cargo oil pipes, ballast pipes, floodgates: **MARILLOY™**

**Acidic**

- Acid corrosion
  - Bottom plates and upper decks of crude oil tankers: **NSGP™ 1 & 2**

**Neutral**

- Atmospheric/salt corrosion
  - Building exteriors, bridges, towers in inland areas: **COR-TEN™**
  - Floors/walls designing: **VINCOR™, CORQ™**
  - Indoor environments/indoor vacuum containers/precision machines: **ARU-TEN™**

**Alkaline**

- You can rely on us!

**Corrosion-resistant Steel Plates**

Corrosion-resistant Steel Plates are used as special steel stock for corrosion protection. They are steel materials with corrosion resistance improved by adding anti-corrosion elements (Cr, Cu, Ni, etc.) in an amount that most suits the environment in which the steel is used. Weather-proof steel, seawater-resistant steel, sulfate-resistant steel, etc., are available in accordance with the environment from which the object in need of an anti-corrosion measure is protected.

**Corrosion protection methods**

- Corrosion protection using electricity
- Corrosion protection through environmental improvement
- Corrosion protection using special steel stock

**Corrosion-resistant Steel Plates**

- Corrosion-resistant Steel Plates
- Corrosion-resistant Steel Plates
- Corrosion-resistant Steel Plates
Sulfuric-acid/Hydrochloric-acid Dew-point Resistant Steel

**S-TEN™**

**Issues**
- Sulfuric acid dew-point corrosion due to fossil fuel-derived sulfur oxides.
- Hydrochloric acid dew-point corrosion derived from dioxins.

**Mechanism of sulfuric acid**
- Hydrochloric acid dew-point corrosion inhibits the formation of SO3 in the condenser system of a waste incineration facility.
- S-TEN is NIPPON STEEL’s original sulfuric/hydrochloric-acid dew-point resistant steel that has a long-term and excellent track record.
- More economical than stainless steel.
- It offers a wide variety of types including hot-rolled and cold-rolled steel plates, steel pipes, and weld materials.
- High accessibility is secured by steel product wholesalers that constantly have the product in stock.
- Comparable strength, workability, and weldability with those of conventional steel.

- Major prizes awarded
  - Ishimura Prize in Industry for Excellent Achievement (FY2006)

**Features**
- S-TEN™ is NIPPON STEEL’s original sulfuric/hydrochloric-acid dew-point resistant steel that has a long-term and excellent track record.
- Superior corrosion resistance in a strong acid environment at low pH levels.

**Real machine test results**
- The life extension effect of approx. five times that of conventional steel is confirmed in an air preheater of the steel pipe type for heavy oil-fired boilers.

**Test conditions**
- Temperature: 124 ~ 130°C
- Gas temperature: 95°C
- Test period: 4,808 hours

**Corrosion amount (mm)**
- SS 400: 0.46
- S-TEN 1: 0.22
- SM490A: 0.04

**Superior corrosion resistance is confirmed through a sulfuric acid immersion test.**

**Acid corrosion**

**Applicable standard**
- NIPPON STEEL
- S-TEN 1: SS400A
- S-TEN 2: SS490A

**Sulfuric acid immersion test results in a vapor-liquid equilibrium state of sulfuric acid and the water system**
- Under the conditions of 70°C and H2SO4 at 50%, S-TEN shows corrosion resistance of approx. five times that of conventional steel and approx. 10 times that of stainless steel.

**Acid corrosion**

**Applicable standard**
- Approved by classification societies as a corrosion-resistant steel product for cargo tankers.

High Corrosion-resistant Steel for Crude Oil Tankers

**NSGP™-1 & 2**

**Issues**
- Deep pits are formed in tank bottom plates.
- All surfaces of tanks under the upper deck corrode.
- Taking corrosion prevention measures for tanks was made obligatory in 2015.

**Effect of application**
- The frequency of pit forming in the bottom plate decreases to 1/15 of conventional steel.
- The corrosion amount under the upper deck decreases to approx. 60% of conventional steel.
- By eliminating the coating process, a reduction in construction cost and life-cycle cost can be achieved.

**Features**
- S-TEN significantly delays the progress of pitting deep into bottom plates (pitting corrosion) attributable to salt water contained in crude oil.
- NSGP-2 significantly delays the corrosion expansion over all surfaces of tanks attributable to H2S contained in crude oil, exhaust gas charged into tanks to prevent explosion, and dew condensation caused by the temperature gap between day and night.
- The corrosion resistance that is produced by the alloy components does not vary contrary to products with corrosion resistance provided by coating.
- Welding materials for exclusive use with enhanced corrosion resistance are also offered.
- Major prizes awarded
  - Ishimura Prize in Industry for Distinguished Achievement (FY2010)
  - Special Prize of Monozukuri Nippon Grand Award (FY2011)
  - Award for excellence of Nihonka Excellent Products & Services Award (FY2007)

**Positions to which NSGP-1 and 2 were applied**

**Comparison of pitting corrosion (4 mm deep or more) occurrence frequency after a lapse of five years (NSGP-1 & 2)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Conventional steel</th>
<th>NSGP-1</th>
<th>NSGP-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1,300</td>
<td>25</td>
<td>13</td>
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<tr>
<td>5</td>
<td>200</td>
<td>400</td>
<td>600</td>
</tr>
</tbody>
</table>

**Transition of the corrosion amount and comparison (NSGP-2)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Conventional steel</th>
<th>NSGP-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial stage</td>
<td>100 (estimated)</td>
<td>60%</td>
</tr>
<tr>
<td>After 25 years</td>
<td>10 (estimated)</td>
<td>20%</td>
</tr>
</tbody>
</table>

When the corrosion amount after 25 years is estimated from the results of the use of conventional steel and NSGP-2 in actual ships for eight years, it can be predicted that the corrosion amount of NSGP-2 can be reduced to approx. 40% of the corrosion amount of a ship with conventional steel in which the depth of a pit exceeded 2 mm.

**The high performance of NSGP-1 and 2 has been confirmed in actual ships to which they have been applied.**
**Nickel-based High Weather-resistant Steel**

**NAW-TEN™**

**Issues**
- Although the use of weather-resistant steel compliant with JIS G 3105 and G 3141 is recommended, the specifics for highway bridges, the Design Standard of Railway Structures, etc. have been referred to as the "regulations" do not apply to the installation environment.

**Effect of application**
- Provides point addition factors in assessment
- The use with no coating is possible leading to LCC and VOC reductions.

**Features**
- Exhibits superior weather resistance without coating even in an environment not applicable to the regulations regarding weather-resistant steel compliant with JIS. (Applicable environment assessment is necessary)
- Two types of steel that can be selected in accordance with the application environment and required performance are offered. (They comply with JIS with the components excluded.)
- There are abundant application cases for about 20 years.
- Prediction of the corrosion loss amount is possible using the YOSOKU™ software.
- Major prizes awarded:
  - Ishimura Prize in Industry for Distinguished Achievement (FY1999)
  - Excellence Prize of Monozukuri Nippon Grand Award (FY2009)
  - Tanaka Award in Excellence in Research Paper of the Japan Society of Civil Engineers Award (FY2009)

**Actual application to bridges using nickel-based high weather-resistant steel**
- As of the end of December 2016, accumulating total tonnage of 11,000 tons has been applied.

**Coating Cycle Extension Steel**

**CORSSPACE™**

**Issues**
- Rusting from coating pinholes, deteriorated parts, etc.
- Rusting from the sharply angled part of a member.

**Concept of CORSPACE application to a bridge of Japan**

**Advantages on order receipt, designing and manufacturing**
- We can assist with the use of the NETIS registered technology (KK-150056-A, registered in February 2016) and in making technical proposals and construction performance rating.
- Complies with all JIS regarding steel products that are mainly used for bridges. The steel plate manufacturers' range is also equivalent to that of conventional steel.
- Workability in cutting, bending, welding, etc., is comparable with those of conventional steel.
- Welding materials and bolts for exclusive use are offered.

**Exhibits effect in coastal areas with severe salt injury.**

**Corrosion resistance properties**
(assessment through an acceleration test [SAE J2334 test])

**Life-cycle cost can be reduced.**
Repainting frequency is reduced to once per 100 years.
Low-alloy Corrosion-resistant Steel Close to Stainless Steel

**ARU-TEN™**

**Effect of application**

- Exhibits red rust resistance close to that of stainless steel in a mild indoor environment.

**Features**

- Suppresses red rust without coating in an indoor environment. (The use in outdoor environments is enabled by applying a zinc-rich primer)
- The total amount of alloy addition (Ni, Cr, etc.) is approx. 1/4 that of SUS304.
- Comparable yield strength with that of SM490.
- Machining properties close to that of SS400.
- Comparable yield strength with that of SUS304.
- Comparable weldability with that of conventional steel.

**Positions to which ARU-TEN was applied**

- Conventional steel
- ARU-TEN

**Appearances of test pieces after a dry-wet-cycle test**

- Excellent corrosion resistance has been confirmed through a dry-wet-cycle test assuming a general indoor environment.
- Has corrosion resistance close to that of stainless steel and workability close to that of conventional steel.

**Effects**

- A promising new corrosion-resistant steel that balances corrosion resistance and economic efficiency without coating in a mild indoor environment.

**Features**

- Suppresses red rust without coating in an indoor environment. (The use in outdoor environments is enabled by applying a zinc-rich primer)
- The total amount of alloy addition (Ni, Cr, etc.) is approx. 1/4 that of SUS304.
- Comparable yield strength with that of SM490.
- Machining properties close to that of SS400.
- Comparable weldability with that of conventional steel.

**Positions to which ARU-TEN was applied**

- Conventional steel
- ARU-TEN

**Seawater Corrosion Resistant (Undersea) Steel**

**MARILOY™**

**Effect of application**

- Exhibits superior corrosion resistance in a seawater immersion environment.

**Features**

- The corrosion rate in seawater is approx. one half that of conventional steel.
- The mechanical properties are comparable with those of 400–490 MPa carbon steels.
- The weldability is comparable with that of 400–490 MPa carbon steels.

**Positions to which MARILOY was applied**

- Conventional steel
- MARILOY

**Seawater immersion test result**

- Has corrosion resistance close to that of stainless steel in a mild indoor environment.

**Features**

- Exhibits superior corrosion resistance in a seawater immersion environment.

**Seawater temperature**

- SS400
- MARILOY

**Seawater Corrosion Resistant (Undersea) Steel**

**MARILOY™**

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**Positions to which MARILOY was applied**

- Conventional steel
- MARILOY

**Seawater immersion test result**

- Has corrosion resistance close to that of stainless steel in a mild indoor environment.

**Features**

- Exhibits superior corrosion resistance in a seawater immersion environment.

**Seawater temperature**

- SS400
- MARILOY

### Corrosion amount measurement result for a seawater-gas cooler piping

- The results of application to the gas cooler tube of a heat exchanger have shown a corrosion rate of approx. one half that of conventional steel.
- The weldability is comparable with that of 400–490 MPa carbon steels.

**Seawater Corrosion Resistant (Undersea) Steel**

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**Positions to which MARILOY was applied**

- Conventional steel
- MARILOY

**Seawater immersion test result**

- Has corrosion resistance close to that of stainless steel in a mild indoor environment.

**Features**

- Exhibits superior corrosion resistance in a seawater immersion environment.

**Seawater temperature**

- SS400
- MARILOY

### Corrosion amount measurement result for a seawater-gas cooler piping

- The results of application to the gas cooler tube of a heat exchanger have shown a corrosion rate of approx. one half that of conventional steel.
- The weldability is comparable with that of 400–490 MPa carbon steels.
**Atmospheric corrosion**

**Example of corrosion loss amount and surface color change across the ages**

- **Features**
  - The use without coating is allowed, which reduces repainting and other maintenance and management costs.
  - The aesthetic effect can be expected from the soft color of rust (“Beauty of Rust”).

**Issues**

- Conventional steel requires coating to prevent corrosion, leading to the heavy burden of repainting and other maintenance and management costs.
- The use of steel in harmony with nature is desired.

**Effect of application**

- **COR-TEN** is used without coating (including that of rust stabilization auxiliary treatment) to exhibit excellent weather resistance.
- The change of surface colors across the ages can be enjoyed.
- Coating is also possible in the same way as conventional steel.
- Joining materials (welding materials and bolts) for exclusive use are also offered.
- Major prizes awarded
  - Otani Art Museum Prize (FY2011)

**Shimane Museum of Ancient Izumo**

**Applicable standard**

- COR-TEN™ is equivalent to SMA400W to 570W for JIS G 3114, and SPA-H for JIS G 3125.

**Conventional steel**

**Vinylidene corrosion**

**Example of a general floor material**

- (granite / flagstones)

**Parts made of CORQ**

- Expansion possibilities as a floor material used for styling purposes.

** stably colored by using the index numbers that have a high correlation with colors, the color tone is quantified and reproduced.**

<table>
<thead>
<tr>
<th>Lapse of time (years)</th>
<th>Conventional steel</th>
<th>COR-TEN</th>
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<tbody>
<tr>
<td>0.1</td>
<td>0.10</td>
<td>0.01</td>
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**High Weather-resistant Steel**

**COR-TEN™**

**Issues**

- Conventional steel requires coating to prevent corrosion, leading to the heavy burden of repainting and other maintenance and management costs.
- The use of steel in harmony with nature is desired.

**Effect of application**

- The use without coating is allowed, which reduces repainting and other maintenance and management costs.
- The aesthetic effect can be expected from the soft color of rust (“Beauty of Rust”).

**Features**

- COR-TEN is used without coating (including that of rust stabilization auxiliary treatment) to exhibit excellent weather resistance.
- The change of surface colors across the ages can be enjoyed.
- Coating is also possible in the same way as conventional steel.
- Joining materials (welding materials and bolts) for exclusive use are also offered.
- Major prizes awarded
  - Otani Art Museum Prize (FY2011)

**1969: At the time of completion**

**1973: After a lapse of four years**

**2010: After a lapse of 41 years**

**Styling with uncoated COR-TEN**

- The soft color of the protective rust and the change across the ages provide the appearance with an excellent effect.

**The corrosion amount can be reduced more than that of conventional steel.**

**There are many socially important structures and buildings to which COR-TEN has been effectively applied.**

**Needs considering the scenery and for other aesthetic purposes can be satisfied.**

**Expands the possibilities as a floor material used for styling purposes.**

**Example of corrosion loss amount and surface color change across the ages**

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**Conventional steel**

**COR-TEN™**

**Issues**

- The use of COR-TEN is desired indoors.
- There is a concern about initial rust in the shape of a flow or stream.
- The use of COR-TEN for floor material, etc. is desired for styling purposes.

**Effect of application**

- **COR-TEN** is a registered trademark owned by Kyoji Takubo and NIPPON STEEL.
- **CORQ** is a registered trademark owned by Chikumakozai Co., Ltd.

**Features**

- VINCOR is prepared by rendering COR-TEN aged before shipping to give it a special initial color.
- CORQ is a casting with the features of COR-TEN.
- Mainly used as a floor material.
- CORQ is manufactured and sold by Okayama Casting Center Cooperative Association (TEL: 81-86-277-5588).

**Styling with uncoated CORQ**

- The soft color of the protective rust and the change across the ages provide the appearance with an excellent effect.

**Concept of VINCOR**

- By using the index numbers that have a high correlation with colors, the color tone is quantified and reproduced.

**Position to which CORQ is applied**

- By using the index numbers that have a high correlation with colors, the color tone is quantified and reproduced.

**Expands the possibilities as a floor material used for styling purposes.**

**Catalog QR code**

- The corrosion amount can be reduced more than that of conventional steel.
- There are many socially important structures and buildings to which COR-TEN has been effectively applied.

**Stabilized Rust**

- Used without coating/treatment
- Used with rust stabilization auxiliary treatment
- Used with coating

**Example of a general floor material**

- (granite / flagstones)

**Parts made of CORQ**

- Expansion possibilities as a floor material used for styling purposes.

**Atmospheric corrosion**

**VINCOR™ / CORQ™**

**Issues**

- The use of COR-TEN is desired indoors.
- There is a concern about initial rust in the shape of a flow or stream.
- The use of COR-TEN for floor material, etc. is desired for styling purposes.

**Effect of application**

- **COR-TEN** is a registered trademark owned by United States Steel Corp.
- **CORQ** is a registered trademark owned by Kyoji Takubo and NIPPON STEEL.

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