EXPAL™

Steel Plates for Extended Painted Life

NETIS Registration No. CB-180015-A

JFE Steel Corporation

JFE Steel's EXPAL™

Introduction

Because painted steel structures must be repainted in order to secure durability performance, reduction of the lifecycle cost by extending the repainting cycle is strongly demanded. In particular, frequent repainting is necessary when conventional steels for general structures (JIS SS, SM and SBHS) are constructed in severe corrosive environments with high concentrations of airborne salt, such as offshore marine environments, coastal areas and areas where road deicing agents are used in winter.

In Japan, which is surrounded by oceans, the development of a structural steel with high resistance in severe corrosive environment had been strongly desired.

Responding to these needs, JFE Steel developed and commercialized EXPAL™ (Extended Painted Life) steel plate, which can be used for an extended period without frequent repainting, even in high salinity environments.

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* NETIS on the front cover means "New Technology Information System".

Features of EXPAL™

1 Demonstrates long-term durability of paint in severe, high salinity corrosive environments, including, coastal areas and areas where road deicing agents are used in winter.

2 Satisfies JIS standard (G 3101, G 3106, G 3140 etc.).

3 Contributes to excellent weldability with low carbon equivalent (Ceq) and low weld crack sensitivity composition (P_{CM}).

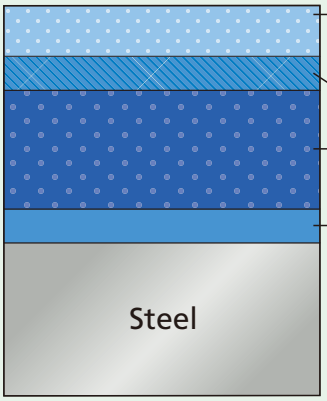


Fig. 1 C-5 paint system for bridge use*

*) Specified in Handbook for anti-corrosion of highway bridges

Table 1 Expected life until repainting of C-5 paint system (years)

Environment		Expected life until repainting (years)	Main deterioration factors
General environments	Mountainous areas, rural areas, etc.	50	① Weathering resistance** ② Corrosion
Severe environments	Coastal areas, offshore marine environments, etc.	30	① Corrosion ② Weathering resistance

**) Wear rate of high weathering resistance fluorine resin paint: (25 μm) / (0.5 μm/y) ≒ 50 years (approx.)

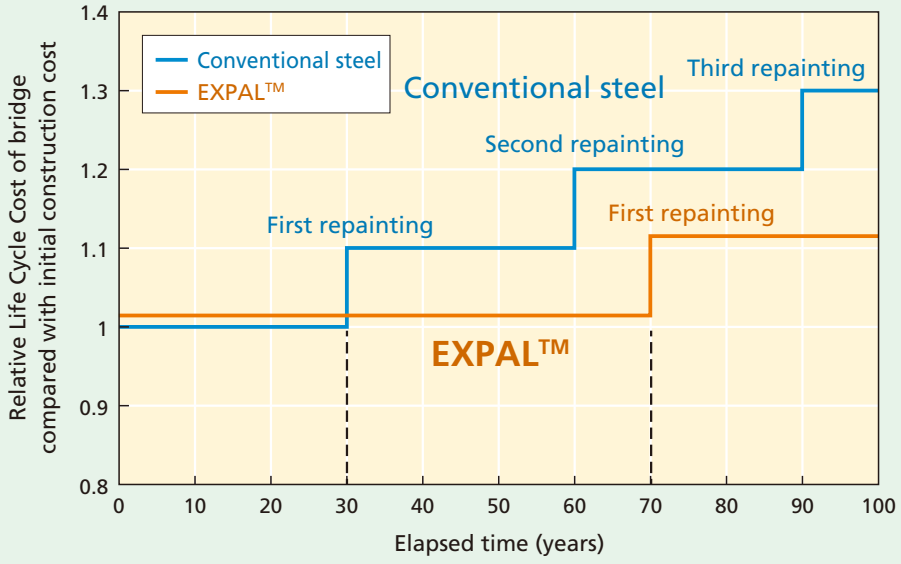


Fig. 2 Example of trial evaluation of Life Cycle Cost of EXPAL™ (C-5 paint system) in severe corrosive environment (example of 3-span continuous non-composite steel girder bridge)

Simulation results of Fig. 2 may be changed due to size and type of bridge, and total repainting cost including variable expenses such as scaffolds, labors and others.

Mechanism of Corrosion Control

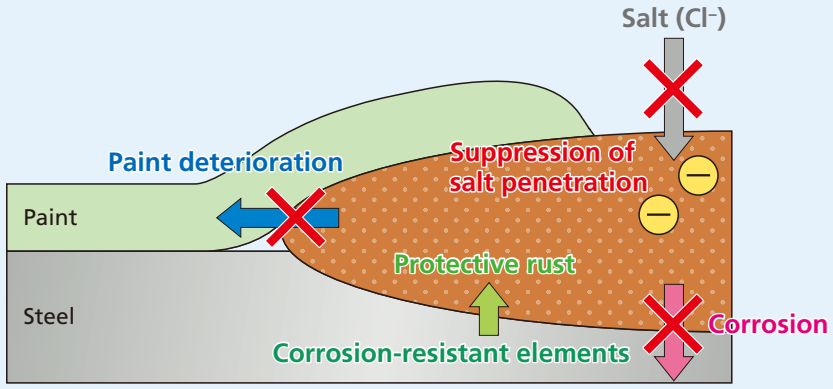
Mechanism of Paint Deterioration Suppression by EXPAL™

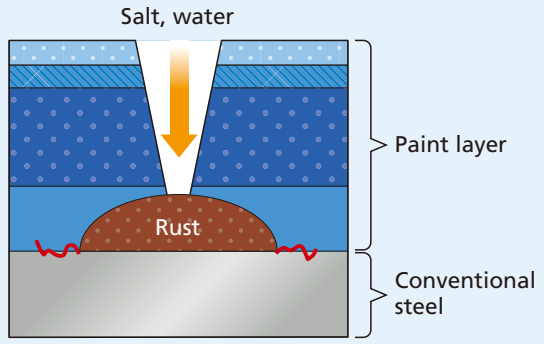
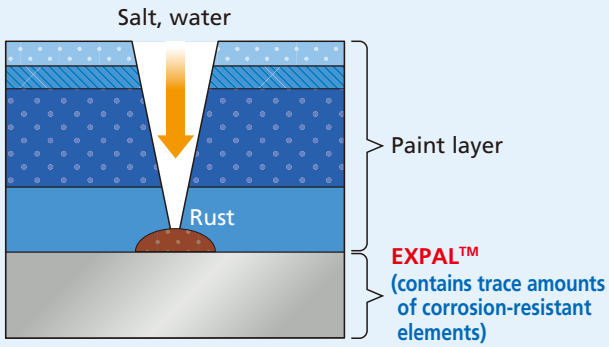
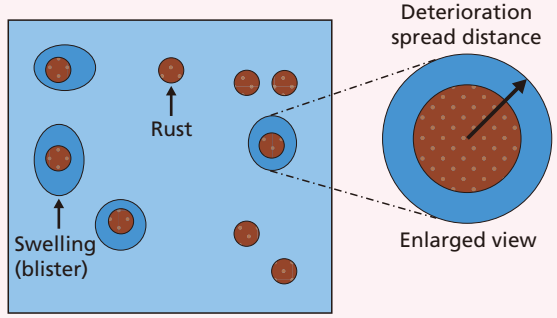
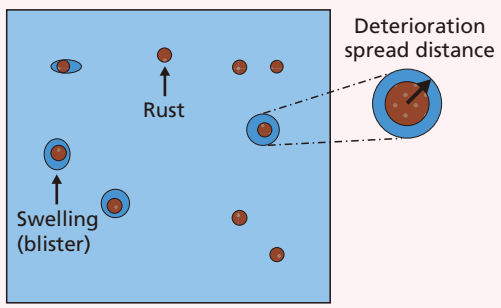
In Extended Painted Life Steel EXPAL™, multiple corrosion-resistant elements are added to the steel. The following effects are expected,

· Form dense protective rust

· Prevent salt penetration

These effects suppress corrosion and paint deterioration.



	Conventional Steel	EXPAL™
Cross section		
Surface		

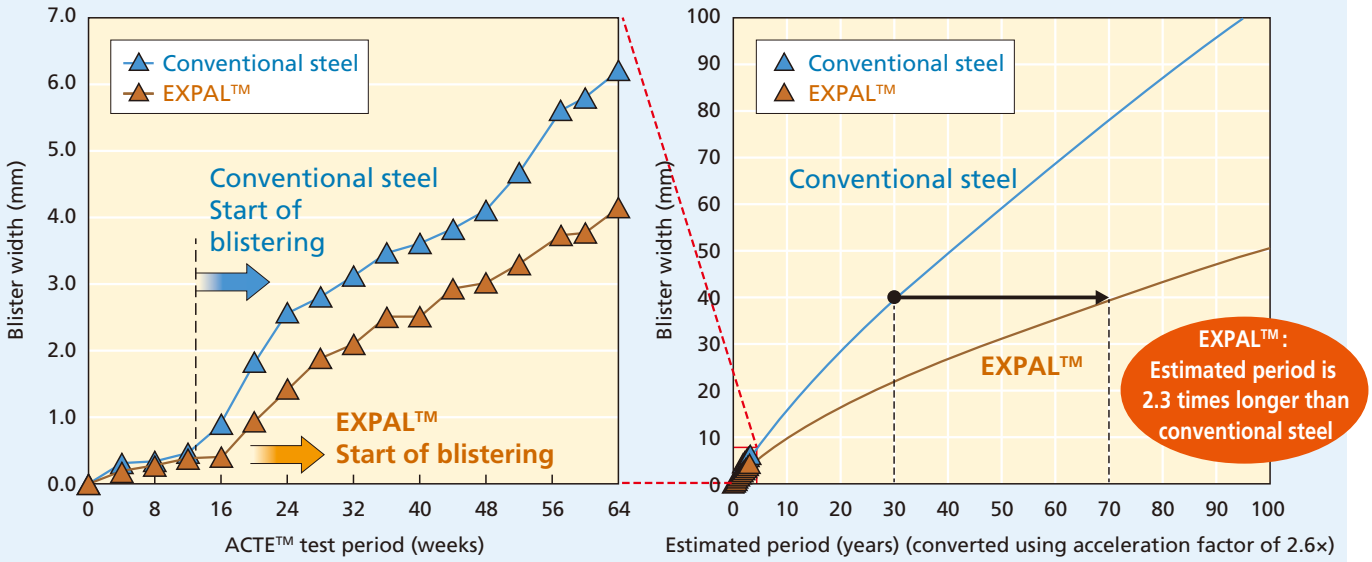
Guideline for repainting: Rust area ratio = 0.5 to 8 % (corresponds to about 30 years for conventional steel in severe corrosive environments)

Performance to Suppress Corrosion Rate EXPAL

Results of Cyclic Corrosion Test

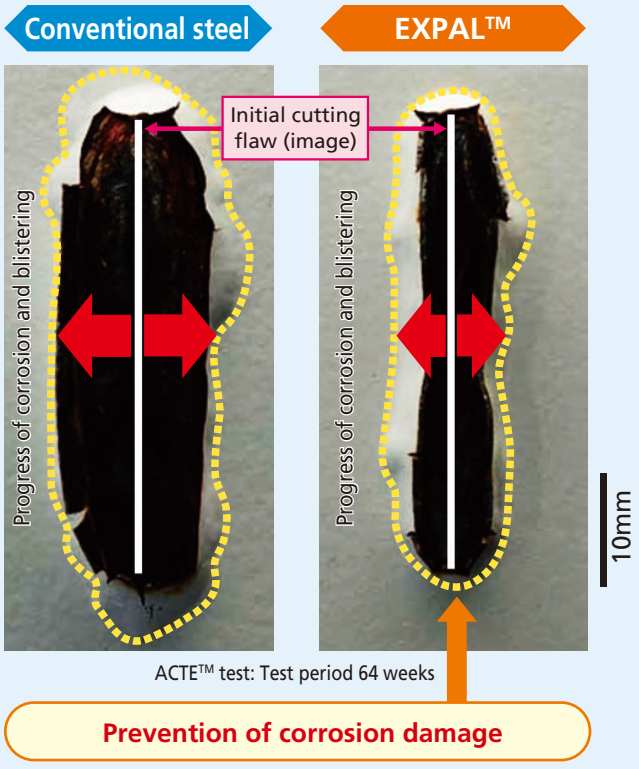
◆Test conditions Corrosion test is performed after making an artificial cutting flaw (40 mm in length).

- Test method: ACTE™ (ISO 16539 Method B) modified.
- Applied salt concentration: 6 g/m²
- Acceleration factor: 2.6× (vs. exposure tests in Okinawa)
- Test period: 64 weeks
- Evaluation: Mean value of one-side blister width from cutting flaw



Regression calculation of life extension performed by nonlinear least squares method using solver function of Excel.

Comparison when using C-5 paint system



	Conventional steel	EXPAL™
Blister width (mm)	39.4mm	39.4mm
Estimated period (years)	30	**70.3***

*Period until blister width of EXPAL™ becomes same as that of conventional steel after 30 years

JFE Standards of EXPAL™

Chemical composition

Brand	Thickness mm	Chemical composition (mass %)							Ceq*2	PCM*3
		C	Si	Mn	P	S	N	Alloy elements*1		
SS400 EP	—	—	—	—	≤0.050	≤0.050	—	Trace addition of corrosion-resistance elements	—	—
SM400A EP	t≤50	≤0.23	—	≥2.5×C	≤0.035	≤0.035	—		—	—
	50<t≤100	≤0.25							—	—
SM400B EP	t≤50	≤0.20	≤0.35	0.60～1.50	≤0.035	≤0.035	—		—	—
	50<t≤100	≤0.22							—	—
SM400C EP	t≤100	≤0.18	≤0.35	0.60～1.50	≤0.035	≤0.035	—		—	—
SM490A EP	t≤50	≤0.20	≤0.55	≤1.65	≤0.035	≤0.035	—		≤0.38*4	≤0.24*4
	50<t≤100	≤0.22							≤0.40*4	≤0.26*4
SM490B EP	t≤50	≤0.18	≤0.55	≤1.65	≤0.035	≤0.035	—		≤0.38*4	≤0.24*4
	50<t≤100	≤0.20							≤0.40*4	≤0.26*4
SM490C EP	t≤50	≤0.18	≤0.55	≤1.65	≤0.035	≤0.035	—		≤0.38*4	≤0.24*4
	50<t≤100								≤0.40*4	≤0.26*4
SM490YA EP	t≤50	≤0.20	≤0.55	≤1.65	≤0.035	≤0.035	—		≤0.38*4	≤0.24*4
	50<t≤100								≤0.40*4	≤0.26*4
SM490YB EP	t≤50								≤0.38*4	≤0.24*4
	50<t≤100								≤0.40*4	≤0.26*4
SM520B EP	t≤50	≤0.20	≤0.55	≤1.65	≤0.035	≤0.035	—		≤0.40*4	≤0.26*4
	50<t≤100								≤0.42*4	≤0.27*4
SM520C EP	t≤50								≤0.40*4	≤0.26*4
	50<t≤100								≤0.42*4	≤0.27*4
SM570 EP	t≤50	≤0.18	≤0.55	≤1.70	≤0.035	≤0.035	—		≤0.44	≤0.28
	50<t≤100								≤0.47	≤0.30
SBHS500 EP	t≤100	≤0.11	≤0.55	≤2.00	≤0.020	≤0.006	≤0.006		—	≤0.20

*1 When necessary, alloy elements not shown in this table can be added.
*2 Ceq = C + Si/24 + Mn/6 + Ni/40 + Cr/5 + Mo/4 + V/14
*3 PCM = C + Si/30 + Mn/20 + Cu/20 + Ni/60 + Cr/20 + Mo/15 + V/10 + 5B
*4 Ceq and PCM of SM490 and SM520 are specified values in case thermo-mechanical control process (TMCP) is used.

Mechanical properties

Brand	Tensile test								Impact test	
	Yield point or proof stress N/mm²				Tensile strength N/mm²	Elongation			Test temperature °C	Charpy absorbed energy J
	Thickness of steel material mm					Thickness mm	Test piece in JIS Z 2241	Elongation %		
	6≤t≤16	16<t≤40	40<t≤75	75<t≤100						
SS400 EP	≥245	≥235	≥215	≥215	400～510	6≤t≤16 16<t≤50 40<t	No. 1A No. 1A No. 4	≥17 ≥21 ≥23	—	—
SM400A EP	≥245	≥235	≥215	≥215	400～510	6≤t≤16 16<t≤50 40<t	No. 1A No. 1A No. 4	≥18 ≥22 ≥24	—	—
SM400B EP									0	≥27
SM400C EP									0	≥47
SM490A EP	≥325	≥315	≥295	≥295	490～610	6≤t≤16 16<t≤50 40<t	No. 1A No. 1A No. 4	≥17 ≥21 ≥23	—	—
SM490B EP									0	≥27
SM490C EP									0	≥47
SM490YA EP	≥365	≥355	≥335	≥325	490～610	6≤t≤16 16<t≤50 40<t	No. 1A No. 1A No. 4	≥15 ≥19 ≥21	—	—
SM490YB EP									0	≥27
SM520B EP	≥365	≥355	≥335	≥325	520～640	6≤t≤16 16<t≤50 40<t	No. 1A No. 1A No. 4	≥15 ≥19 ≥21	0	≥27
SM520C EP										≥47
SM570 EP	≥460	≥450	≥430	≥420	570～720	6≤t≤16 16<t 20<t	No. 5 No. 5 No. 4	≥19 ≥26 ≥20	–5	≥47
SBHS500 EP	≥500	≥500	≥500	≥500	570～720	6≤t≤16 16<t 20<t	No. 5 No. 5 No. 4	≥19 ≥26 ≥20	–5	≥100

Constant yield point steel (-H) can be designated for lamellar tear-resistant steels (-Z15S, -Z25S, -Z35S)*, reduced preheating temperature steel (-EX) and plates with thickness exceeding 40 mm.
* Reduction of area (RA) value and specified S content are guaranteed by a tensile test performed in the plate thickness direction in accordance with JIS G 3199.

Examples of EXPAL™ Properties

Chemical composition

Brand	Chemical composition (mass %)						Ceq*1	PCM*2
	C	Si	Mn	P	S	Alloy elements		
SM490YB EP	0.12	0.34	1.31	0.008	0.001	Trace addition of corrosion-resistance elements	0.36	0.20
SM570 EP	0.09	0.34	1.54	0.007	0.002		0.40	0.19

*1 Ceq = C + Si/24 + Mn/6 + Ni/40 + Cr/5 + Mo/4 + V/14
*2 PCM = C + Si/30 + Mn/20 + Cu/20 + Ni/60 + Cr/20 + Mo/15 + V/10 + 5B

Mechanical properties

Brand	Thickness mm	Tensile test*3				Impact test*4		
		Test piece	Yield point or proof stress N/mm²	Tensile strength N/mm²	Elongation %	Sampling position	Test temperature °C	Charpy absorbed energy J
SM490YB EP	25	JIS 1A	427	542	25.7	1/4t	0	347
	50	JIS 1A	458	558	34.7	1/4t	0	315
SM570 EP	25	JIS 5	523	651	39.4	1/4t	–5	258
	50	JIS 5	607	698	39.2	1/4t	–5	280

*3 Direction perpendicular to rolling direction.
*4 Rolling direction.

Brand	Thickness mm	Tensile test (thickness direction)*5	
		RA (%)	
		Individual values	Mean value
SM490YB-Z35 EP	25	83, 82, 83	83
	50	72, 76, 77	75
SM570-Z35 EP	25	80, 80, 79	80
	50	76, 76, 73	75

*5 Property required in cruciform joints, etc. in Specifications for Highway Bridges; in accordance with JIS G 3199, Z35

Weld joint performance

Brand	Thickness mm	Welding method*6	Welding consumable*7	Heat input kJ/mm	Tensile test	Impact test		
					Tensile strength N/mm²	Test temperature °C	Notch position	Charpy absorbed energy J
SM490YB EP	25	FCAW	DW-50WCL	2.0	553	0	HAZ of weld metal*8	116 166
SM570 EP	50	SAW	USW-62CL ×MF-38	4.1	604	–5	HAZ of weld metal*8	86 202

*6 FCAW: Flux Cored Arc Welding, SAW: Submerged Arc Welding
*7 DW-50WCL (1.2 mmϕ), USW-62CL (4.0 mmϕ) × MF-38: manufactured by Kobe Steel, Ltd.
*8 Position 1 mm from weld line

- Regarding welding consumables and high strength bolts, corrosion resistance equal or superior to that of the base material can be expected if nickel-based dedicated materials for high weathering resistance steel are used.
- The data in this catalog are presented strictly as typical examples. Please consult with JFE Steel for details concerning quality performance.

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