Eco-friendly low-friction A/F paint

BN GreenGuard FS

BN CHEMICAL

Authorized Agency

penascop

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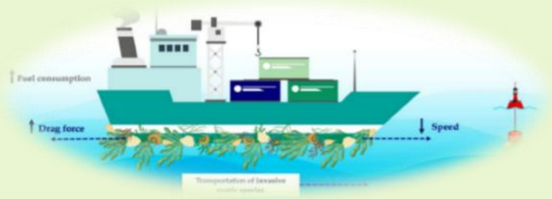
- Reduce fuel consumption (carbon generation)
- Prevention of ship speed degradation
- CII Rating Management

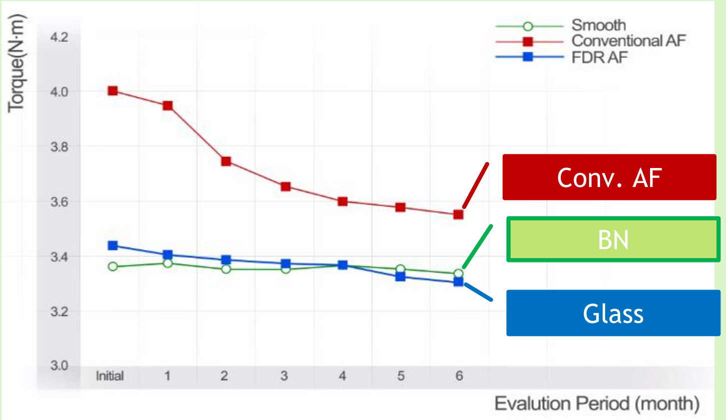


Self polishing Resin Synthesis Method

Reduced hull friction resistance

- Reduce fuel consumption (carbon generation)
- improvement of ship speed
- Best return on investment
- CII Rating Management

Compared to existing A/F paint : 15% reduction



Vessel life extension

- Extending the life of the ship's environment
- Improve your business environment

Conversion of ship life

Durability lifetime → Economic lifetime → Environmental Lifetime

Marine Pollution Protection

- Cu-free : does not use heavy metal Cu2O
- Application of Magnetic Wear Resin Synthesis Technology
- the improvement of the marine ecological environment

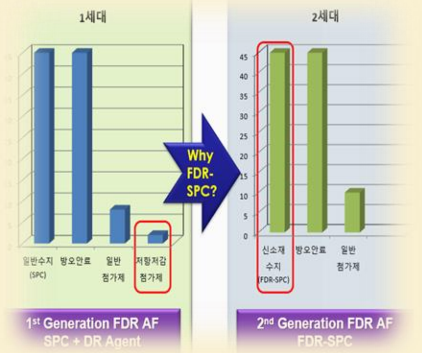
Cu-free pint (BN GreenGuard)

2000’ Cu2O Fouling paint application

’70 THT+Cu2o Fouling paint application

‘50 Apply hull paint

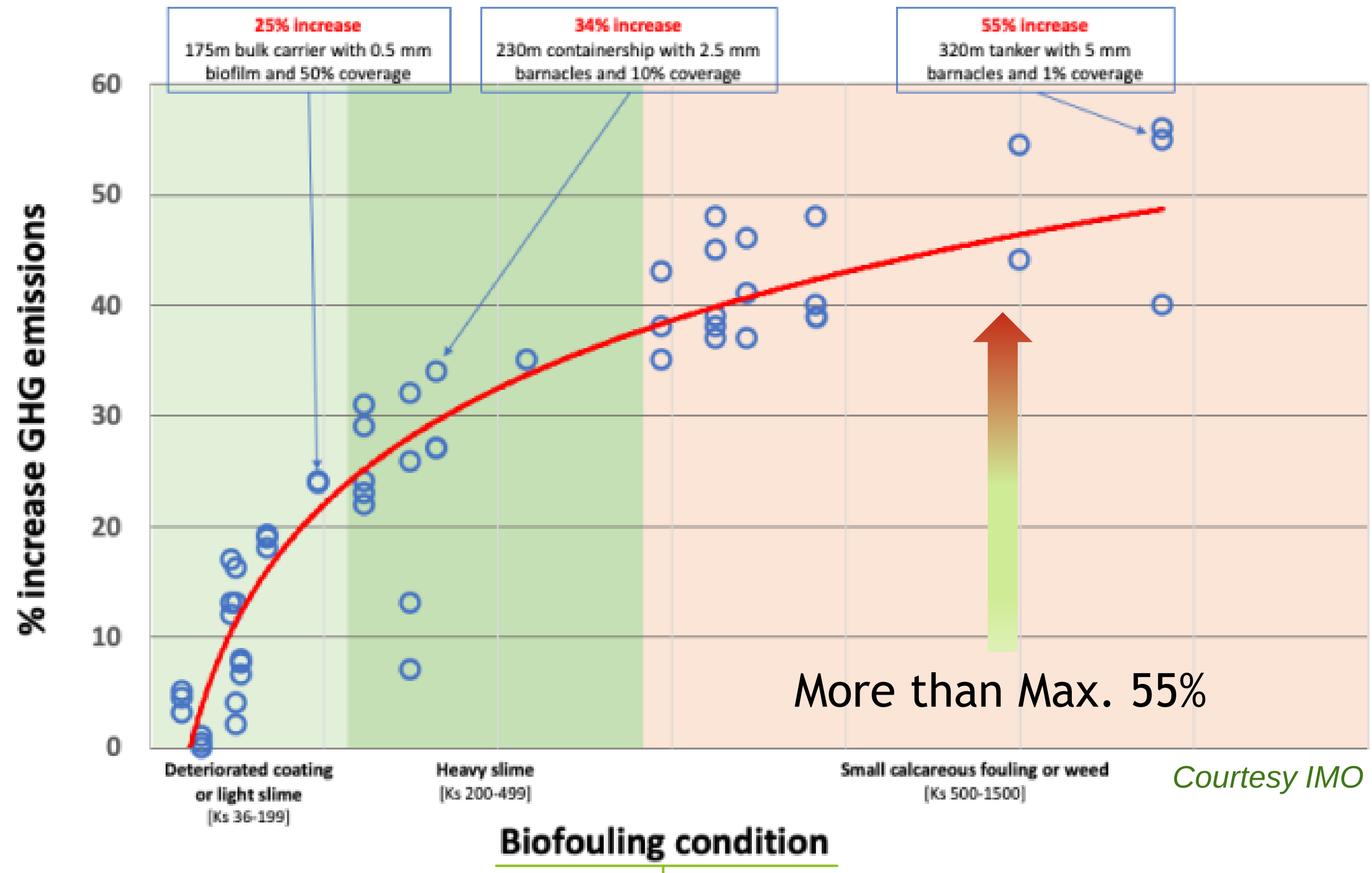
Tar



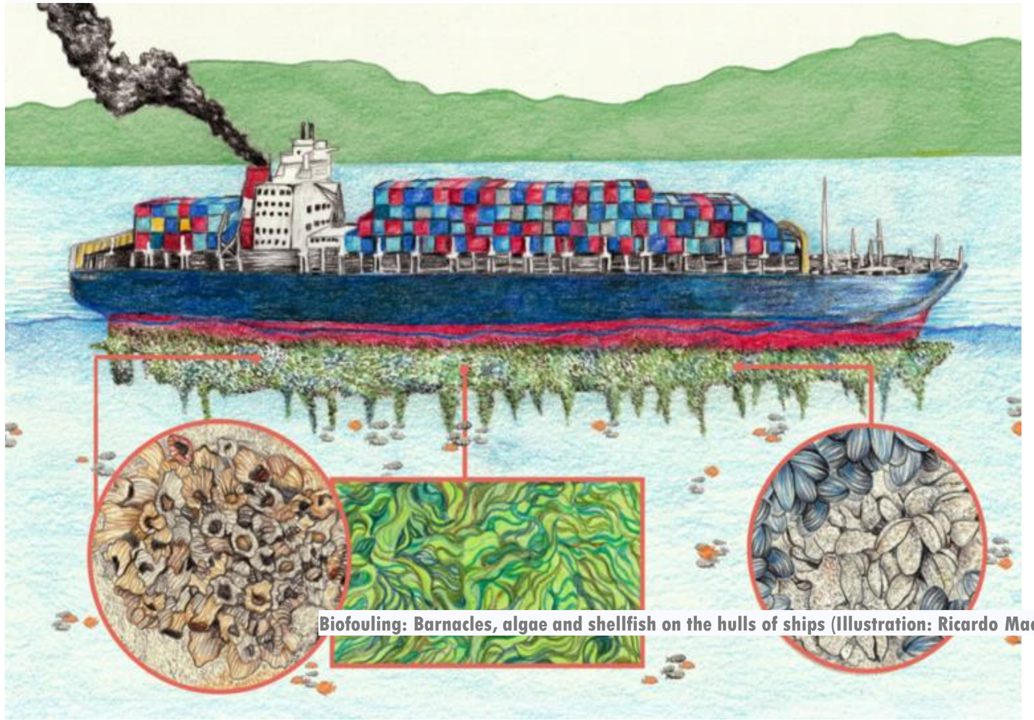
Bio Fouling

CHART: IMPACT OF SHIP HULL BIOFOULING ON GHG EMISSIONS

Compendium of results from published research studies



Courtesy IMO



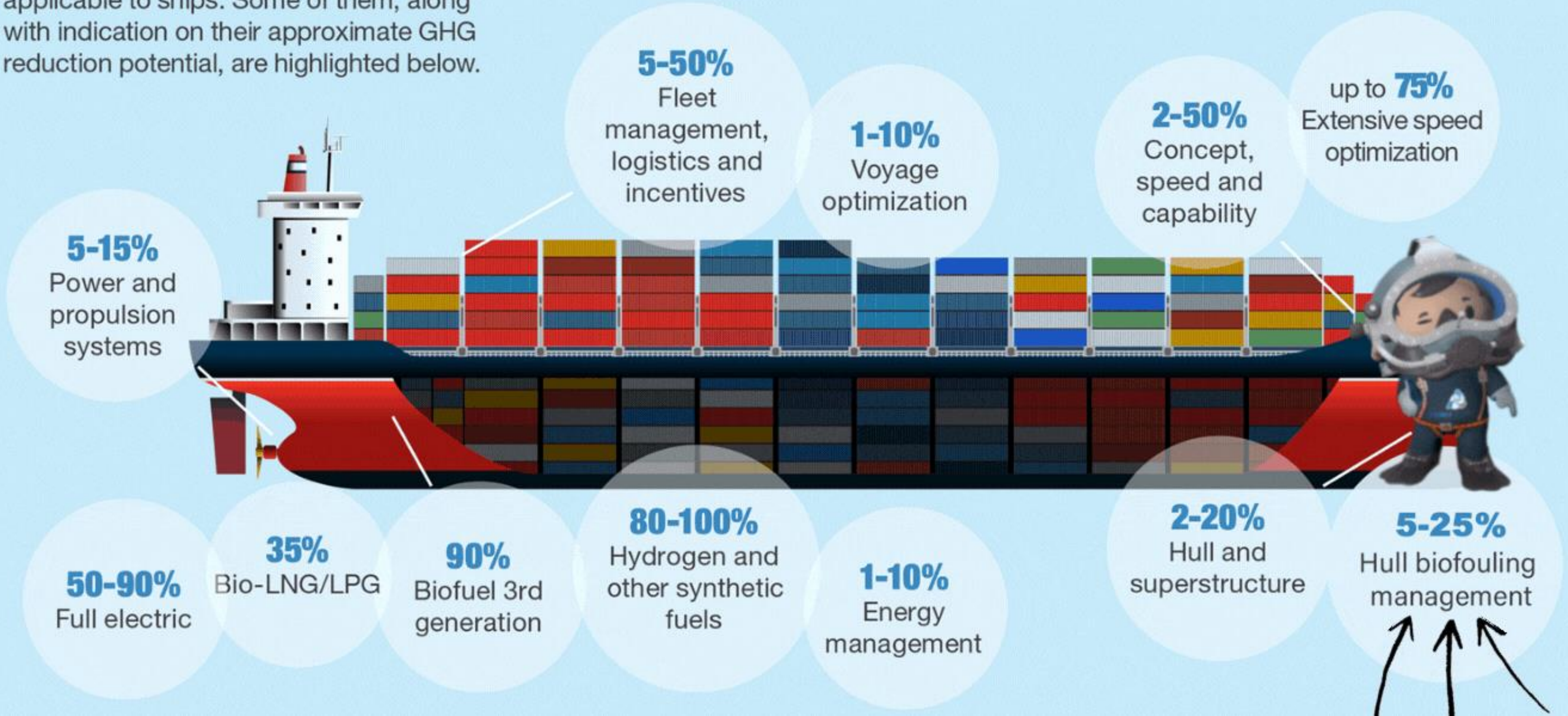
Biofouling: Barnacles, algae and shellfish on the hulls of ships (Illustration: Ricardo Macía)

Increase hull roughness

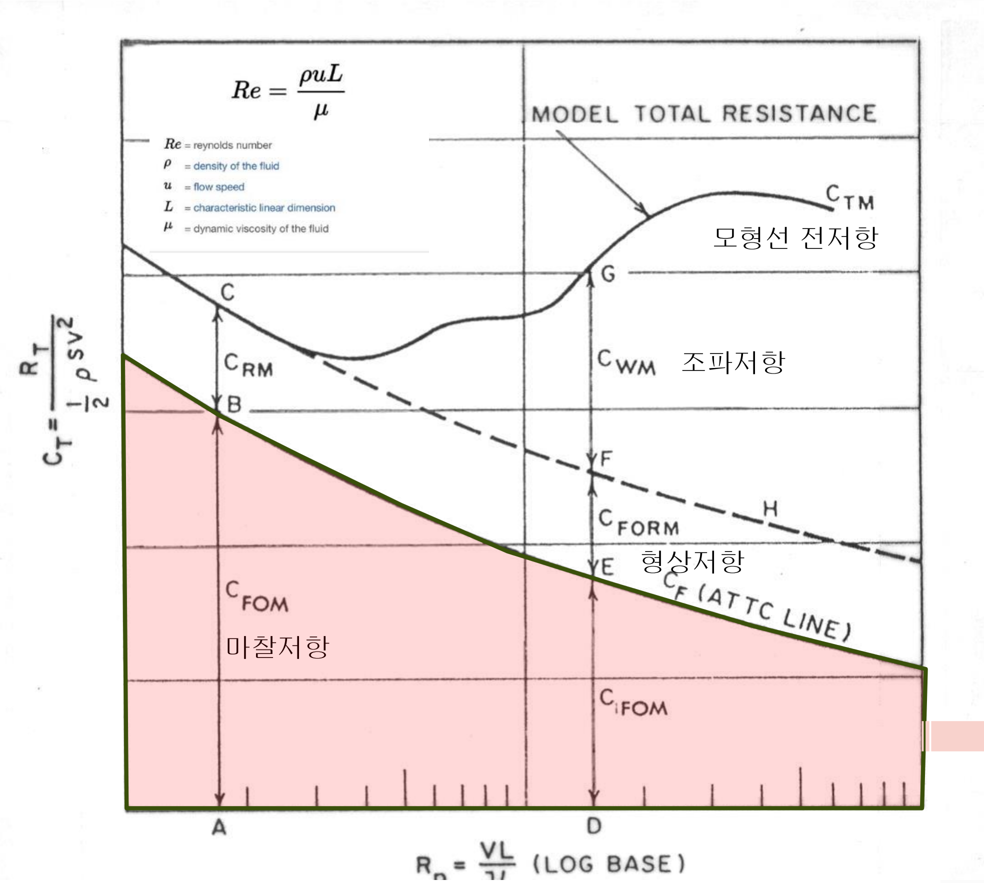
B^n CHEMICAL

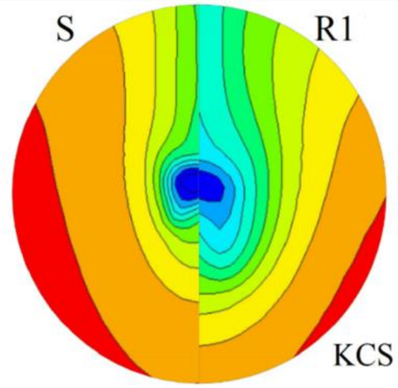
A wide variety of design, operational and economic solutions

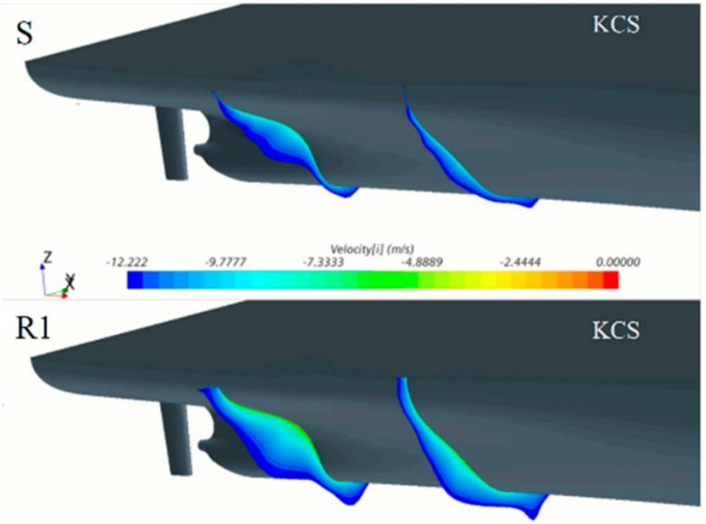
Achieving the goals of the Initial IMO GHG Strategy will require a mix of technical, operational and innovative solutions applicable to ships. Some of them, along with indication on their approximate GHG reduction potential, are highlighted below.



Low Friction







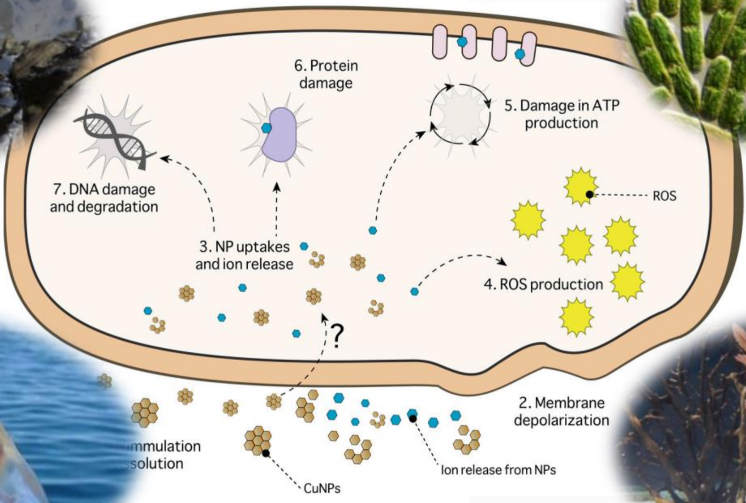
Source : MDPI Impact of Hard Fouling on the Ship Performance of Different Ship Forms (2020)

Reducing frictional resistance has a significant impact on improving energy efficiency.

Friction resistance
- High speed vessel : 40~ 50%
- Low speed vessel : 70~ 80%

Marine Pollution Prevention

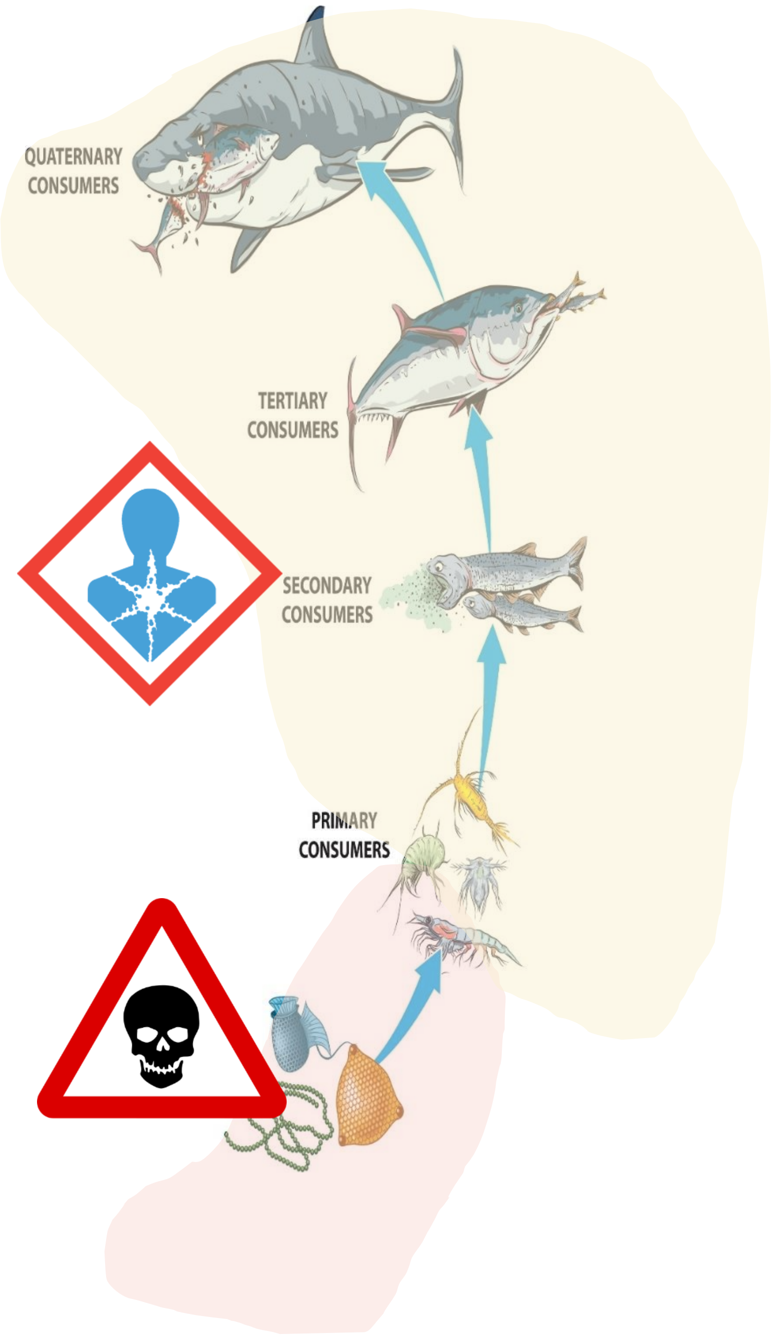
Death



Reduction

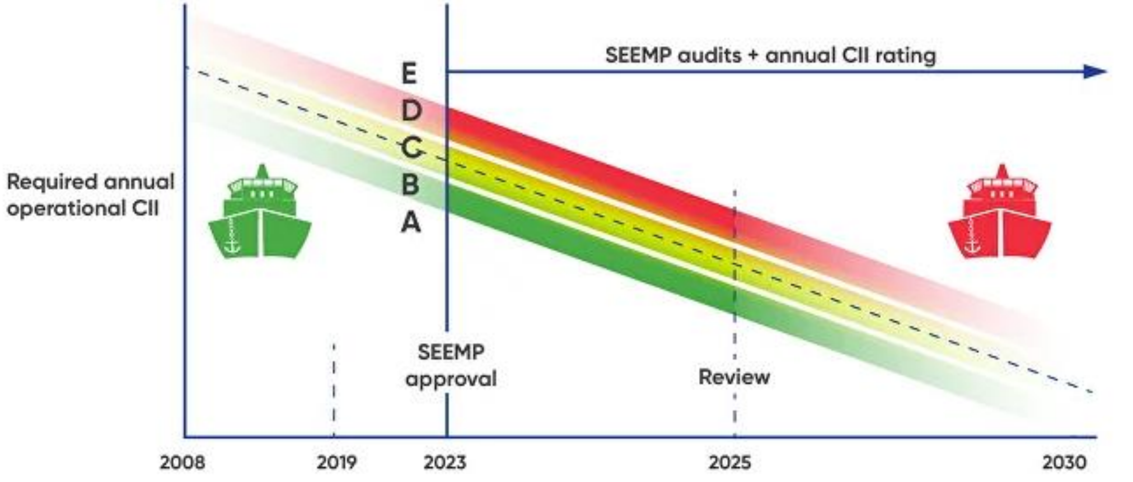
Deformity

Extinction

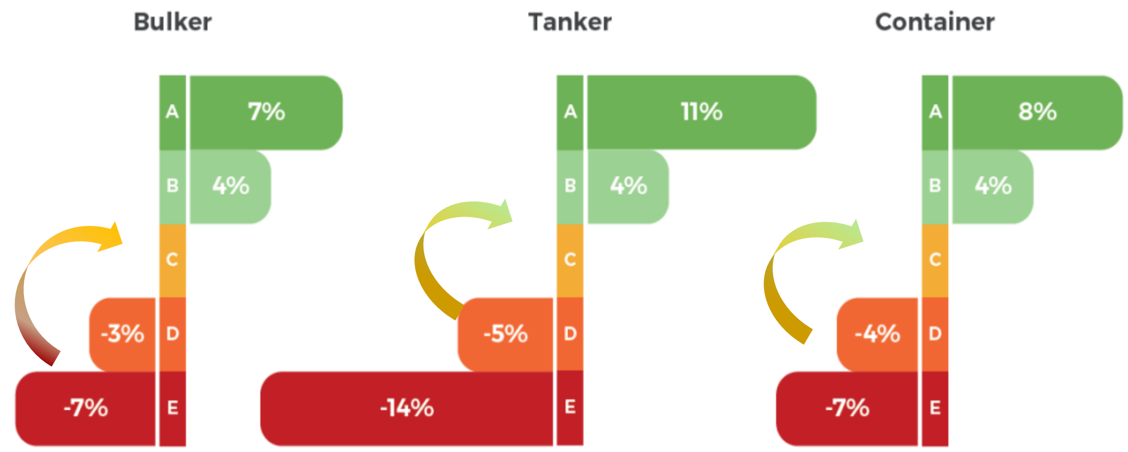


CII Management

CII rating will become stricter over time

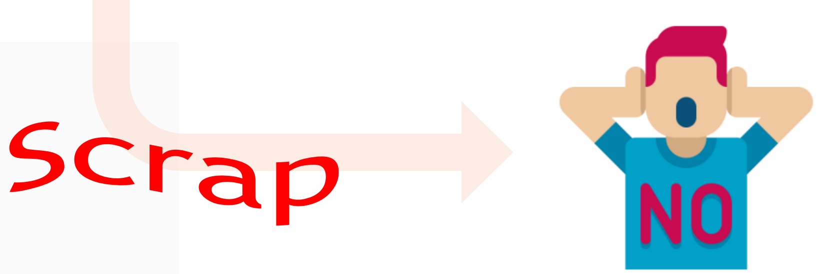


Status of CII ratings by ship's type



Grade CII, which is lowered every year

Year	Reduction factor	Required CII	Attained CII	CII rating	Grade
2023	5%	4.808	4.471	0.93	B
2024	7%	4.707	4.471	0.95	C
2025	9%	4.605	4.471	0.971	C
2026	11%	4.504	4.471	0.992	C
-	-	-	-	-	-
Sometime in the future	17%	4.2	4.471	1.064	D



Awareness

이인원/박현 교수팀은 FDR-SPC를 기반으로 한 저마찰 방오도료를 개발해 해상 및 선박 침적 시험으로 방오성능을 시험했으며, 조선소 현장 평가를 통한 선박 도장 공정 호환성 시험 등 실선 적용성을 검증했다. 아산화동(Cu_2O) 방오제를 함유하지 않는 이 방오도료를 2015년 11월 재화중량 17만6천 톤급 벌크선(길이 292m)의 수선 하부 전체 면적에 도장한 시점 이전 1년과 이후 4년, 총 5년간 실 해역 운항 데이터를 수집, 선박의 속도 성능을 분석한 결과가 이번 논문에 게재된 것이다.

이번 논문의 특징은 다음 두 가지로 요약된다. 첫째, 선박의 운항에 큰 영향을 미치는 조류와 바람, 파도 등의 기상 조건의 영향을 제거하고 선박의 성능을 정량적으로 분석하기 위해 제정된 국제 표준인 ISO19030을 기반으로 저마찰 방오도료가 적용된 선박의 실해역 성능을 검증했다는 점이다. 둘째, 3년의 간격을 두고 첫 번째 운항 기간에는 저마찰 방오도료, 두 번째 운항 기간에는 일반 방오도료를 적용함으로써 입거수리(정기검사) 직후의 동일한 선박 상태에서 방오도료만 교체된 객관적인 비교평가 조건을 재현했다. 논문에는 2014년 12월부터 약 5년간 570만 회에 걸쳐 계측된 선박 운항 빅데이터를 분석한 결과도 기술돼 있다.

저마찰 방오도료와 일반 방오도료가 도장된 직후 각각 1년간의 데이터만을 상호 비교한 결과, 저마찰 방오도료를 도장했을 때 선속이 평균 3.72% 증가하는 것으로 나타난다. 이를 동일 선속으로 환산하면 소요 동력과 연료 소모량이 11.7% 감소하며, 온실가스 배출량도 동일하게 감소함을 의미한다.

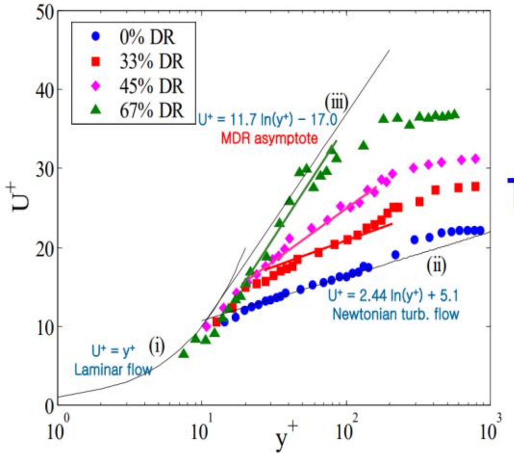
Mechanism

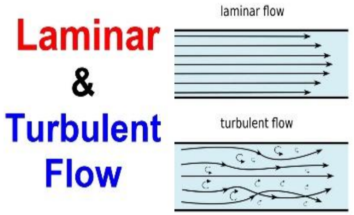
- Background technology
- Technical principles
- Application of ship’s paint
- Patent

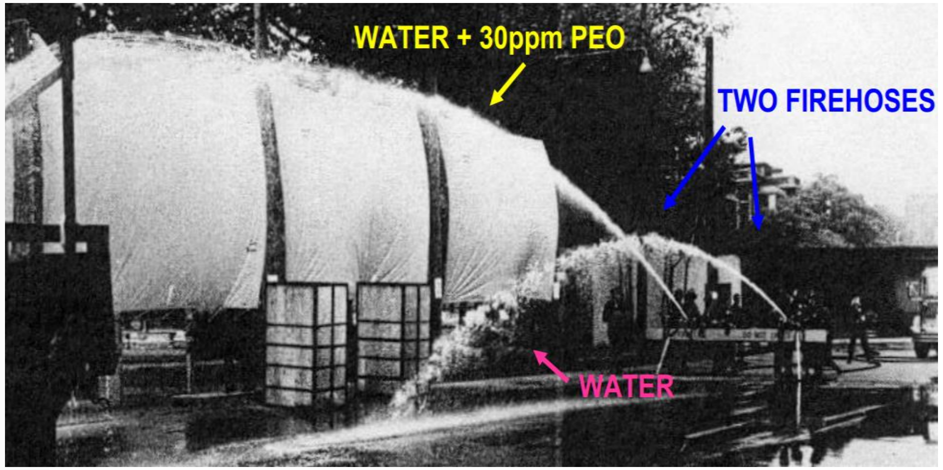
Background technology

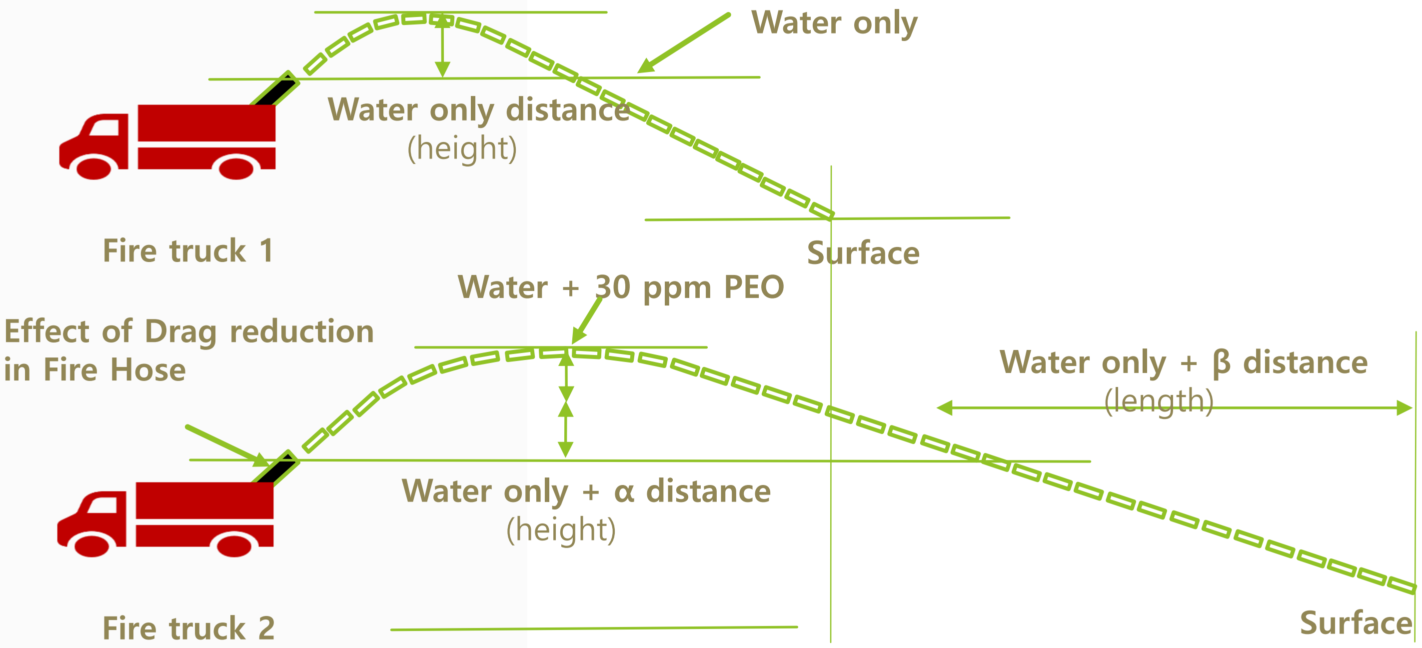
Toms effect

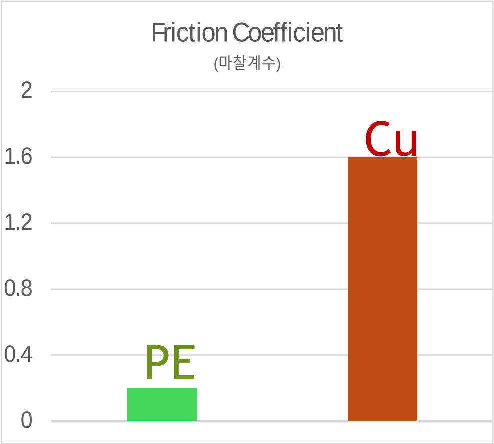
- Tom (1949): Dissolve polymer material very thin
- 80% reduction in frictional resistance
- Pipeline application from the 1970s
- Ship's paint application











Background technology

Toms effect & Polymer FDR Agent
- Ship application ? Injection holes ? Reliability ?
- SPC (Self-Polishing Copolymer) + Polymer DR agent
- Friction-reduction paint

(Quote from Role of Bio-Based Polymers on Improving Turbulent Flow Characteristics)

3. Flow Geometry for Turbulence

To study the drag reduction properties, most studies adopted turbulent pipe flow that produces pressure-driven flow within a closed conduit as an internal flow. As shown in Figure 1, there are three flow layers in turbulent pipe flow, including a laminar sublayer (next to the wall), a transitional zone, and a fully turbulent layer (in the center of pipe). With the addition of polymer additives to a pipeline flow system, minute amounts of polymer suppress the formation of turbulent bursts in the buffer region and the propagation of turbulent eddies [40].

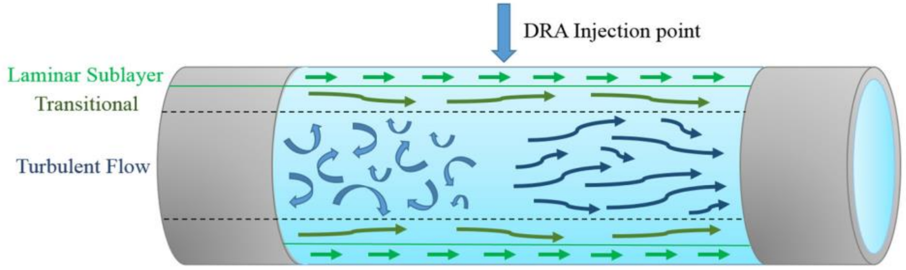
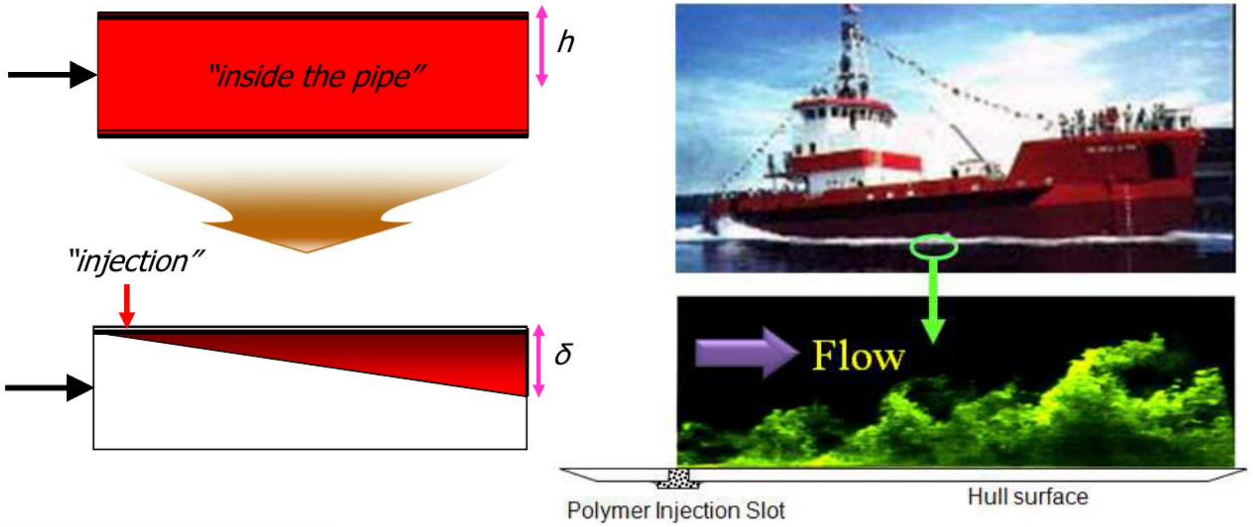


Figure 1. Schematic diagram for the methods of added polymer to a solution with pipeline turbulent flow.

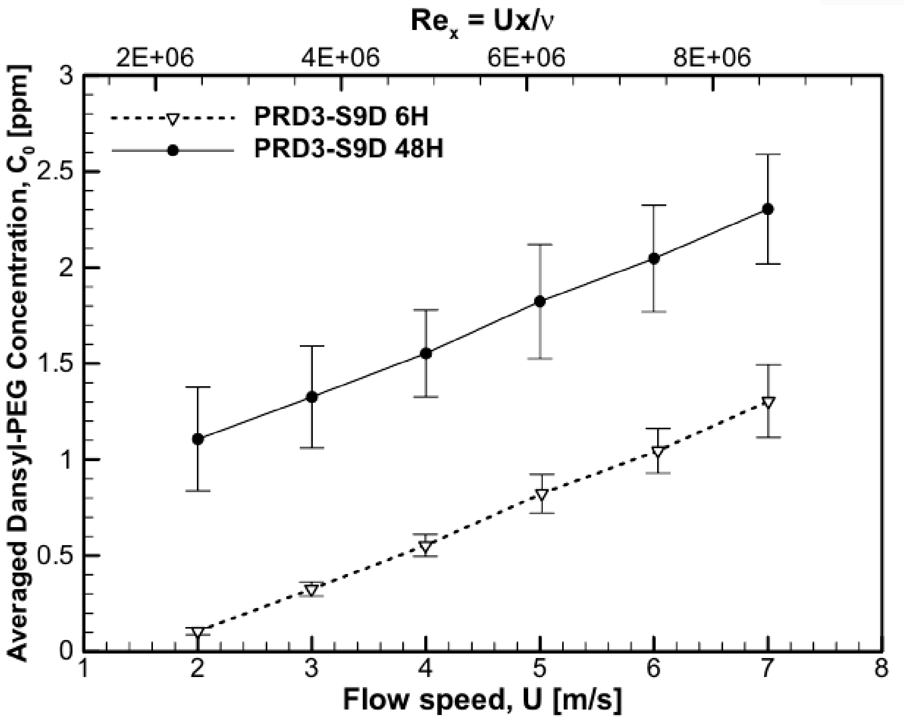
A preliminary study to reduce the hull resistance of the U.S. Navy



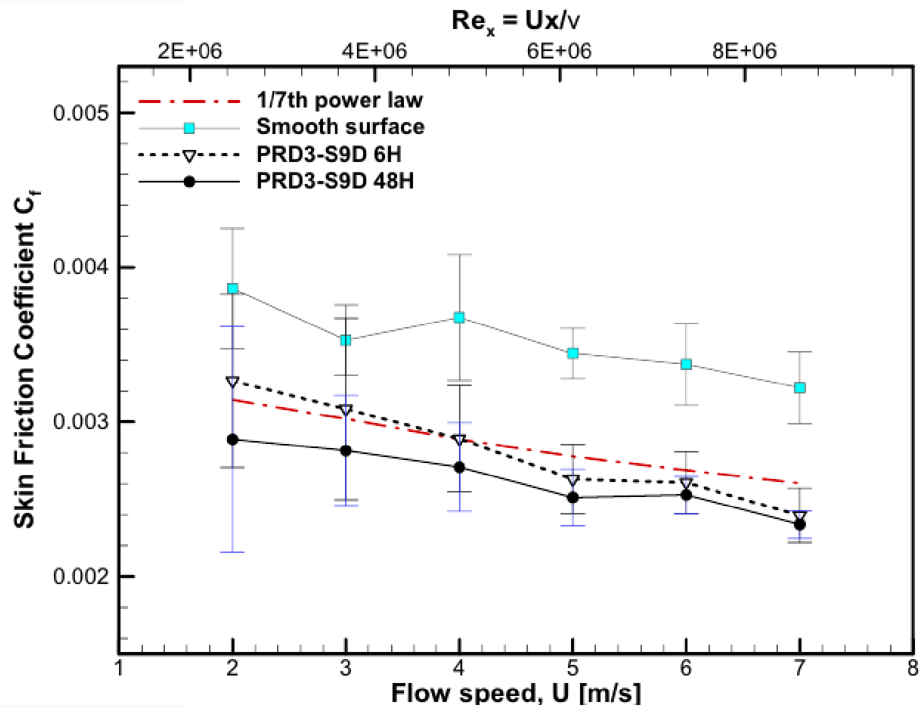
Technical principles

A novel frictional drag reducing self-polishing copolymer (FDR-SPC) was first developed by the authors. The FDR-SPC is a special derivative of an SPC that was designed to achieve skin frictional drag reduction in turbulent water flow by releasing polyethylene glycol (PEG) into water through a hydrolysis reaction.

FDR-SPC elution control for speed

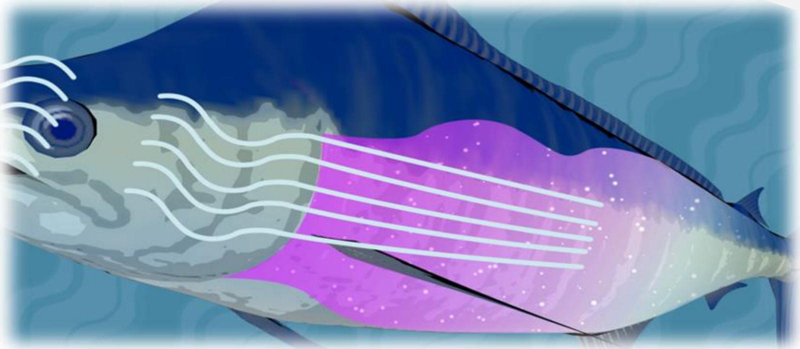


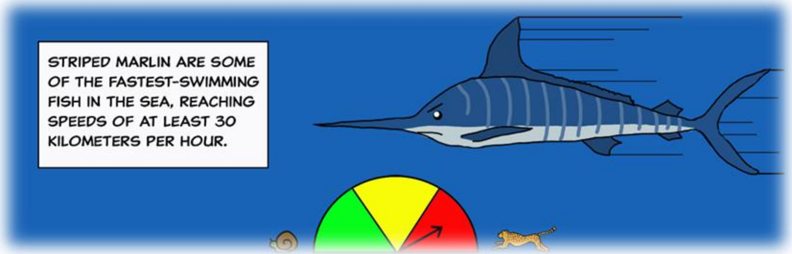
Verifying the coefficient of friction for velocity

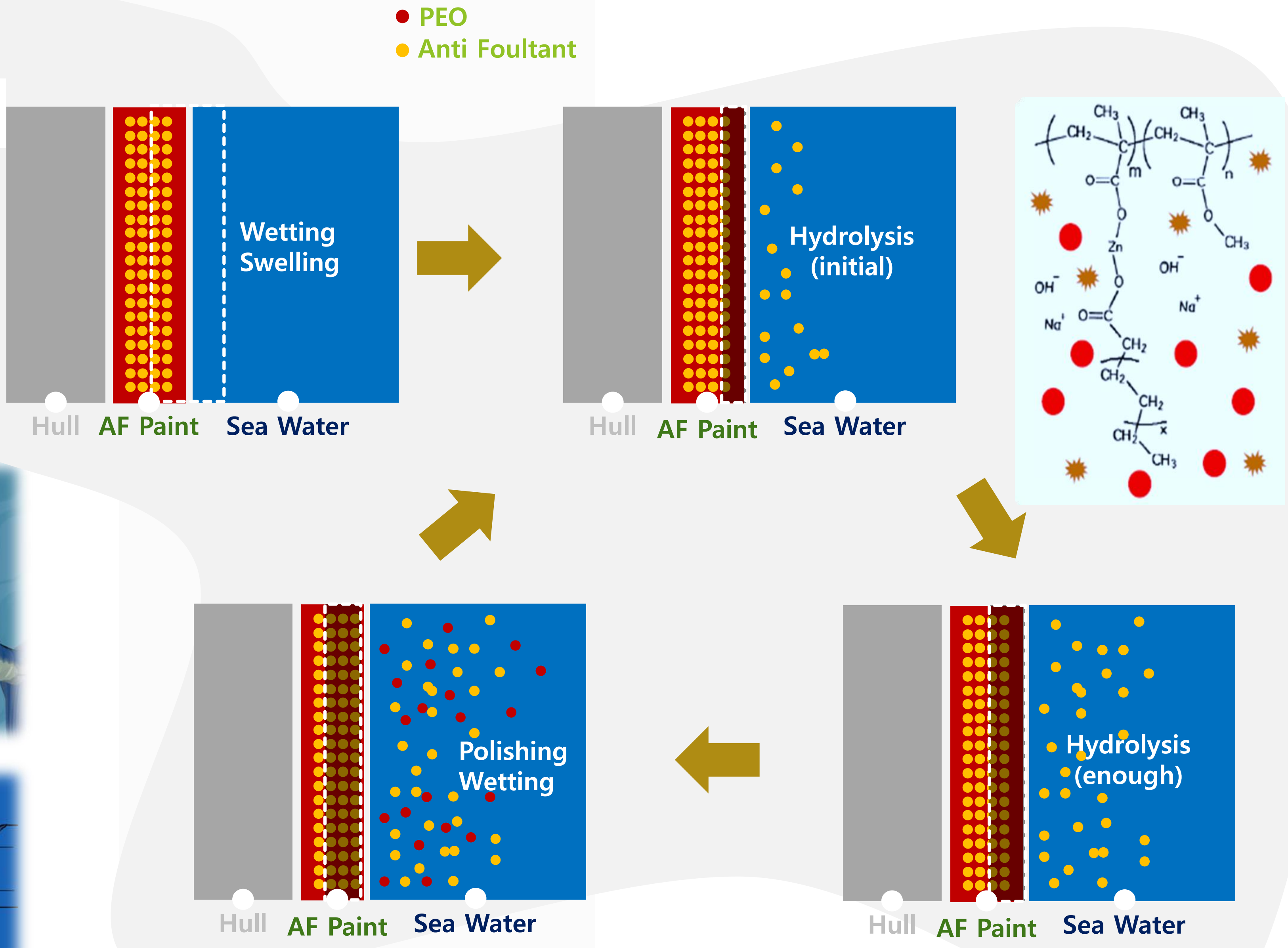


Application of ship's paint

The surface of the fastest fish, the marlin, was applied.





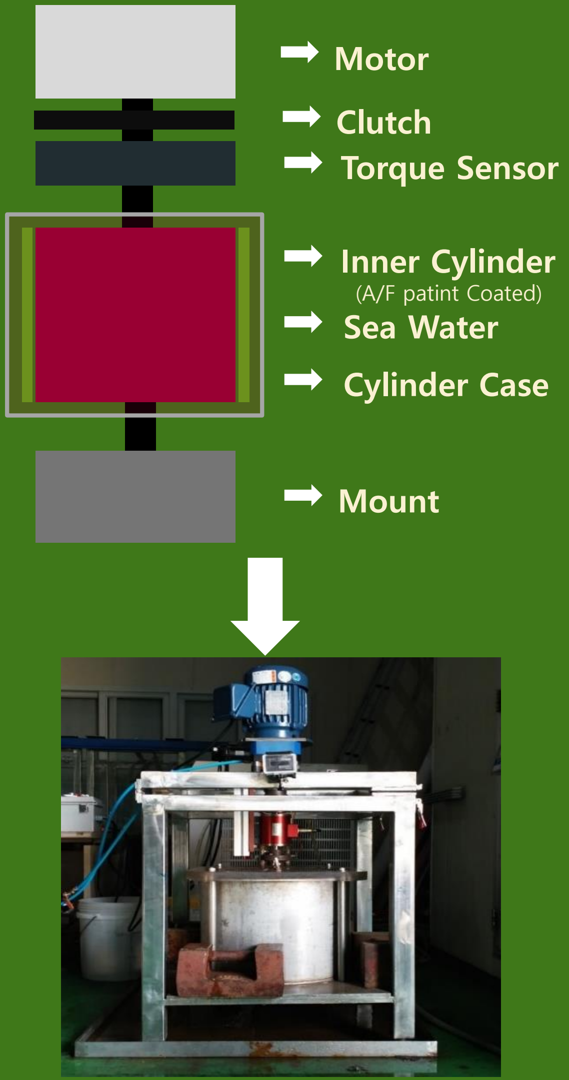


Verification

1. **Rotor Test** (Skin Friction Reduction Test)
2. **High-Speed Water Tunnel Test**
   (Skin Friction Reduction Test)
3. **Static Immersion Test by HHI**
   (Antifouling Performance Test)
4. **Static Immersion Test (During 2 years)**
5. **Patch Test**
   (Antifouling Performance Test) / 181K Bulk Carrier
6. **Existing Vessel Verification by ISO 19030**

Rotor Test (Skin Friction Reduction Test)

1 -1



▶ Rotor Test I step

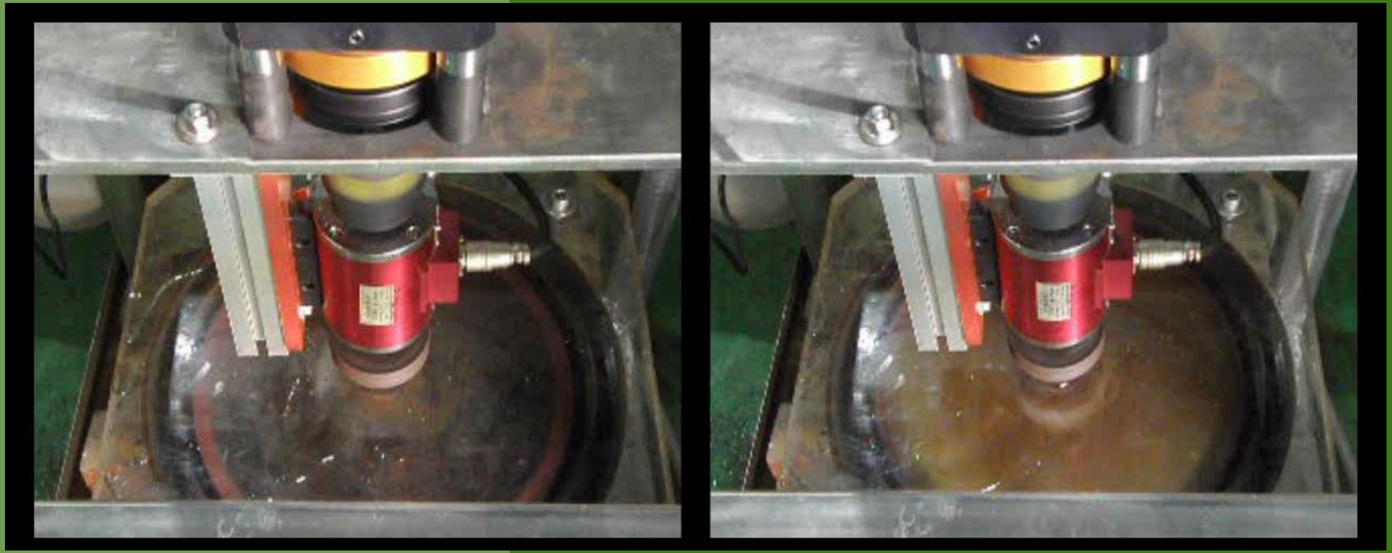
- Rotating A/F Paint Coated Inner Cylinder until 500 RPM(equal to 16.3 kts)
- Cut off the Power by Clutching at the 500 RPM
- Time check from power off to inner cylinder stop

▶ Rotor Test II step (After 6 month inundated state)

- Rotating A/F Paint Coated Inner Cylinder for 6 month
- Check Troque variations each of A/F Paint Coated Inner Cylinders

Conventional A/F Paint
(18.2 sec.)

BN GreenGurad FS
(32.3 sec.)



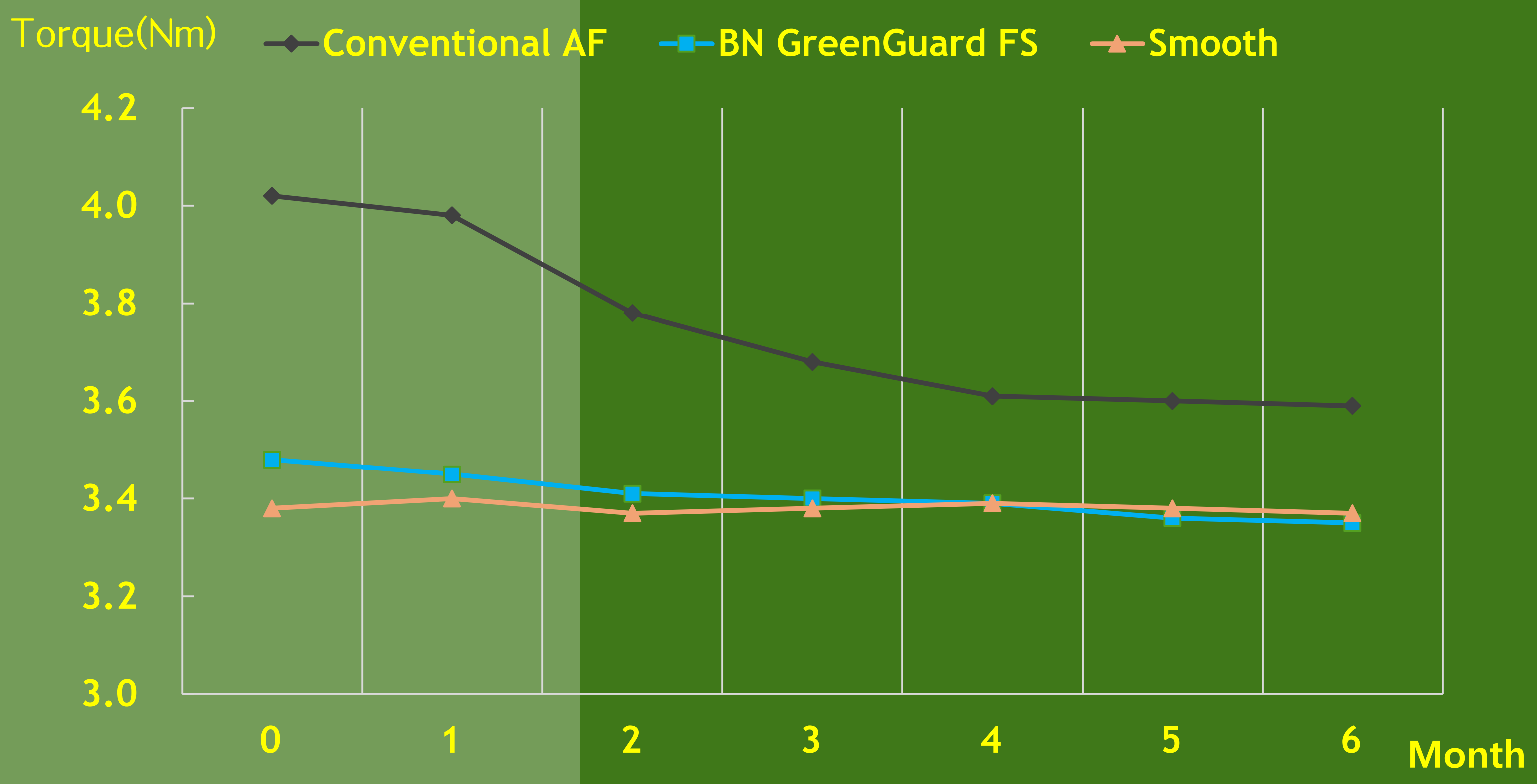
Rotor Test Result (Skin Friction Reduction Test)

1 -2

- Performance was checked monthly for 6 months.
- BN GreenGuard FS Shows avg. 7.6 % Skin Friciton Reduction Effect compared with Conventional
- AF in a Chart

Torque

Average 7.6% reduction



High-Speed Water Tunnel Test (Skin Friction Reduction Test)

1-3

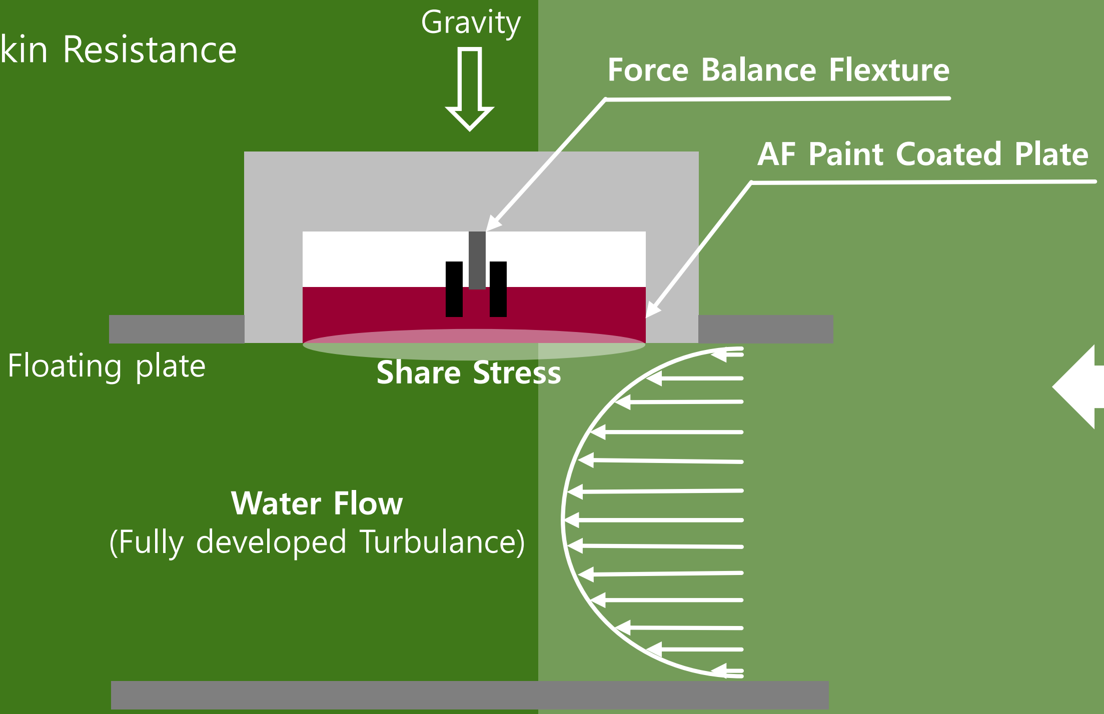
- Rotor Torque Measurement
  - ✓ Verification of long-term FDR performance : around 6 months

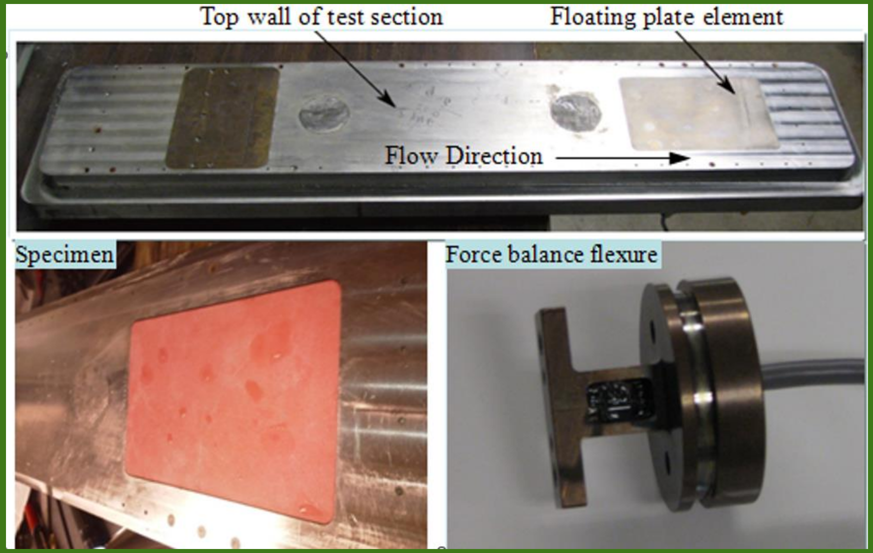
For reference: Various tests are conducted for product development

High-Speed Water Tunnel Test (Skin Friction Reduction Test)

2-1

- Measure Skin Resistance of Smooth Plate
- Measure Skin Resistance of Reference AF Paint Coated Plates and BN GreenGuard FS Coated Plate.
- Compare Measured Skin Resistance





- ✓ 1/14 scale model of LCC
- ✓ Test section : 0.22m × 0.22m
- ✓ Local skin friction measurement : floating plate balance
- ✓ Performed ONR project : "Skin Friction Testing of Various Coatings"
- ✓ Force balance flexure : shear force measurement on flush-mounted specimen
- ✓ Flow speed : 1.24~10.4 m/s (Re_x = 1.04 ~ 8.70×10^6)

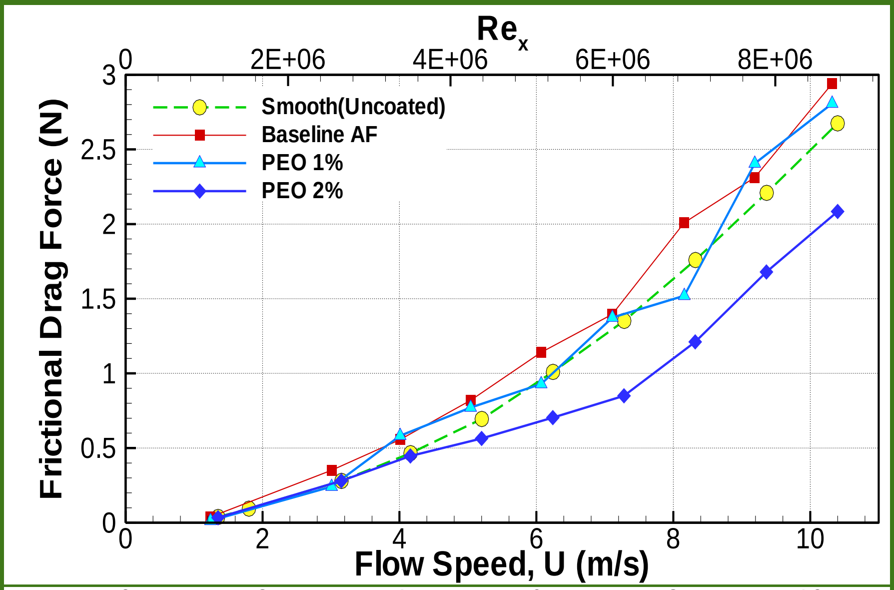
High-Speed Water Tunnel Test Result (Skin Friction Reduction Test)

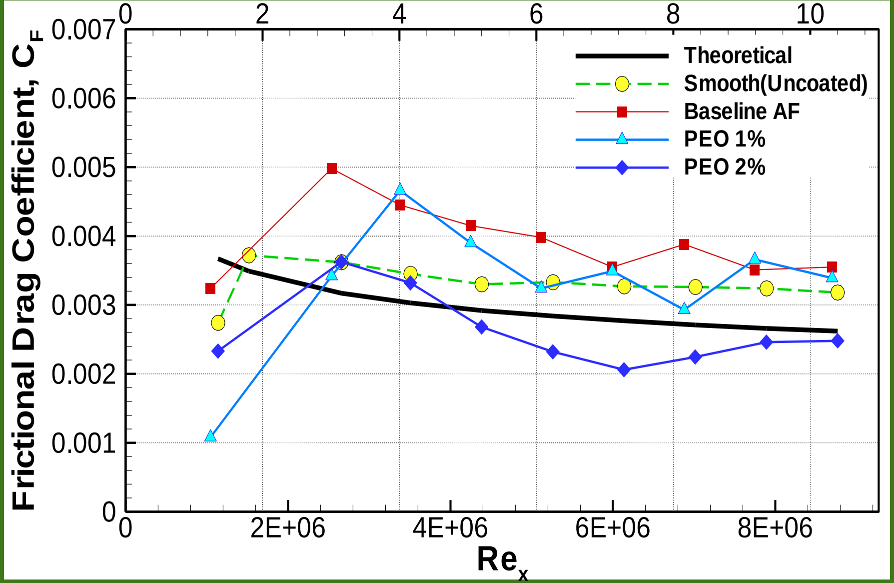
2-2 *Evaluation based on Resistance Reduction Agent Content*

C_F results : Average DR effect

- ✓ PEO 1%
  - 16.0% (rel. to baseline AF)
  - 0.5% (rel. to uncoated)
- ✓ PEO 2%
  - 33.1% (rel. to baseline AF)
  - 21.7% (rel. to uncoated)

U(m/s)	Re_x ($\times 10^{-6}$)	Uncoated (Smooth)	Baseline AF	PEO 1%		PEO 2%	
		C_F ($\times 10^{-3}$)	C_F ($\times 10^{-3}$)	C_F ($\times 10^{-3}$)	DR(%)	C_F ($\times 10^{-3}$)	DR(%)
1.24	1.041	2.74	3.24	1.08	66.67	2.33	26.91
3.01	2.537	3.62	4.98	3.42	31.33	3.63	26.52
4.01	3.379	3.45	4.45	4.66	-4.72	3.32	24.90
5.04	4.249	3.30	4.15	3.90	6.02	2.68	34.98
6.07	5.118	3.33	3.98	3.24	18.59	2.32	41.50
7.11	5.996	3.27	3.55	3.49	1.69	2.06	41.76
8.16	6.879	3.26	3.88	2.93	24.48	2.25	41.93
9.19	7.751	3.24	3.51	3.66	-4.27	2.46	29.65
10.32	8.697	3.18	3.55	3.39	4.51	2.48	29.87





High-Speed Water Tunnel Test **Result** (Skin Friction Reduction Test)

2-3 Evaluation of Developed Products

❖ Compared to <u>Smooth</u>

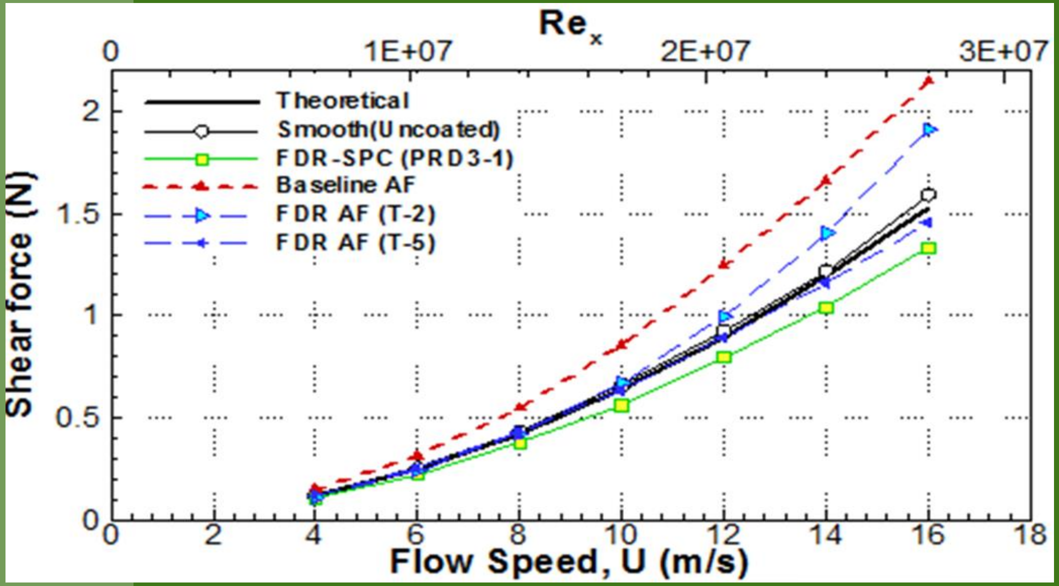
-. PRD3-1 : Avg. 13.53 % reduction

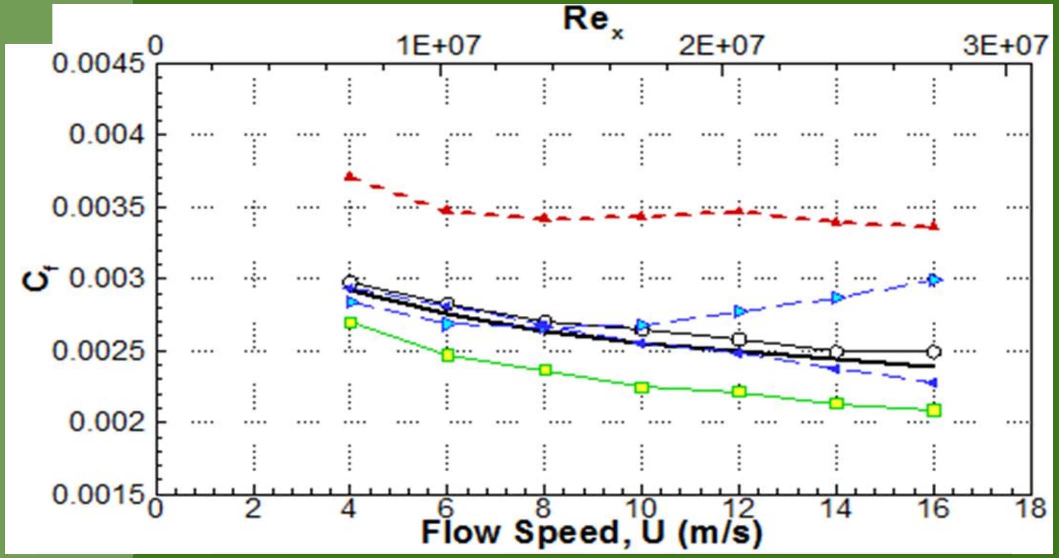
❖ Compared to Baseline AF

-. Development paint T-2 : Avg. 19.54% reduction

-. Development paint T-5 : Avg. 25.38 % reduction

U(m/s)	Re_x ($\times10^{-6}$)	Uncoated (Smooth)	FDR-SPC (PRD3-1)		Baseline AF	FDR-AF (T-2)		FDR-AF (T-5)	
		C_F ($\times10^{-3}$)	C_F ($\times10^{-3}$)	DR(%)	C_F ($\times10^{-3}$)	C_F ($\times10^{-3}$)	DR(%)	C_F ($\times10^{-3}$)	DR(%)
4	6.85	2.977	2.700	9.30	3.708	2.838	23.46	2.935	20.85
6	10.28	2.829	2.471	12.65	3.472	2.684	22.70	2.813	18.98
8	13.71	2.708	2.363	12.74	3.415	2.665	21.96	2.677	21.61
10	17.14	2.646	2.246	15.12	3.431	2.674	22.06	2.551	25.65
12	20.56	2.580	2.212	14.26	3.467	2.771	20.07	2.485	28.32
14	23.99	2.491	2.132	14.41	3.392	2.869	15.42	2.374	30.01
16	27.42	2.490	2.087	16.18	3.362	2.989	11.09	2.279	32.21



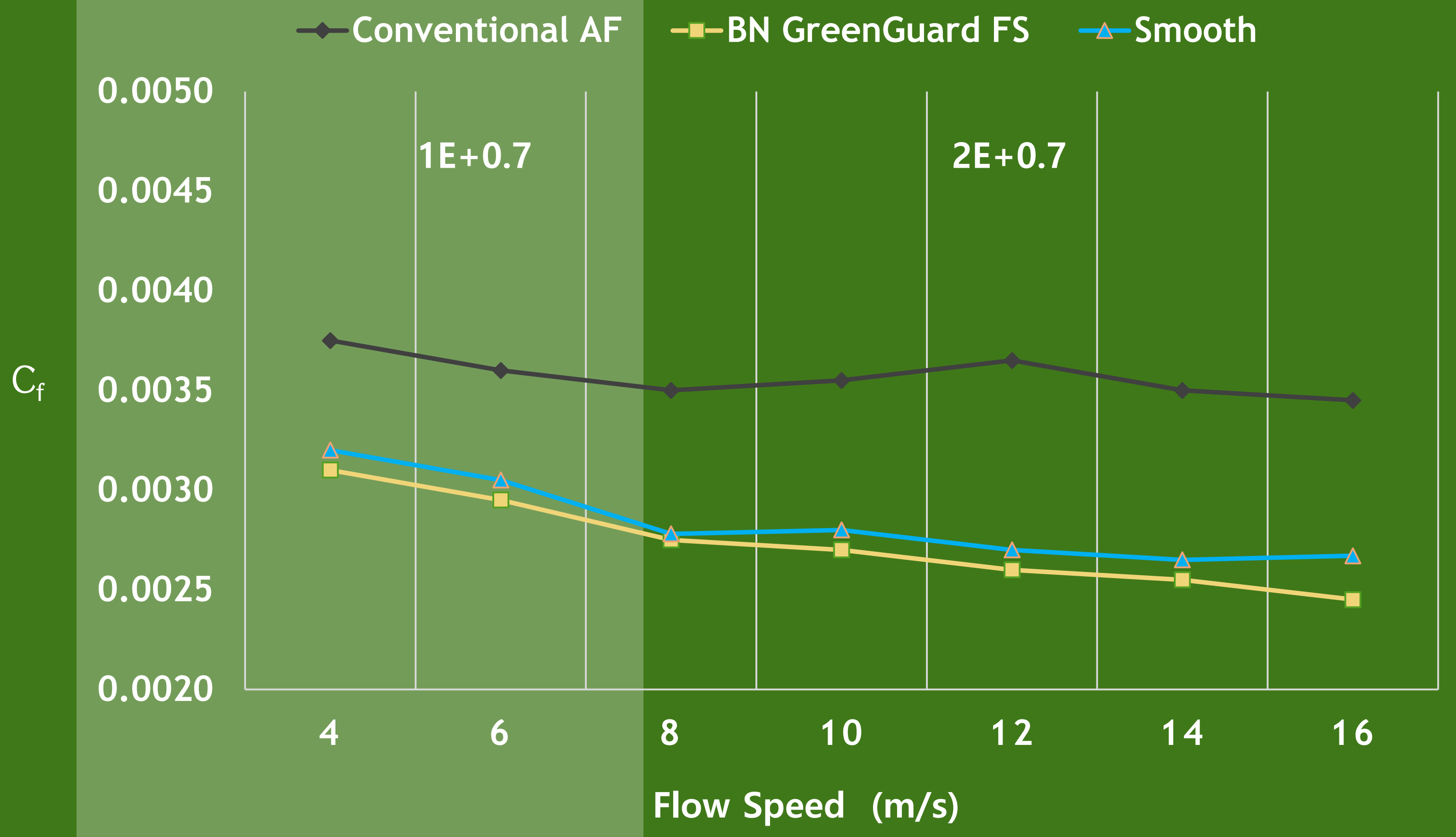


High-Speed Water Tunnel Test **Result** (Skin Friction Reduction Test)

2-4

Friction

Average 25.4% reduction



· BN GreenGuard FS Shows avg. 25.4% Skin Friction Reduction Effect compared with Conventional AF

Static Immersion Test by HHI (Antifouling Performance Test)

3-1

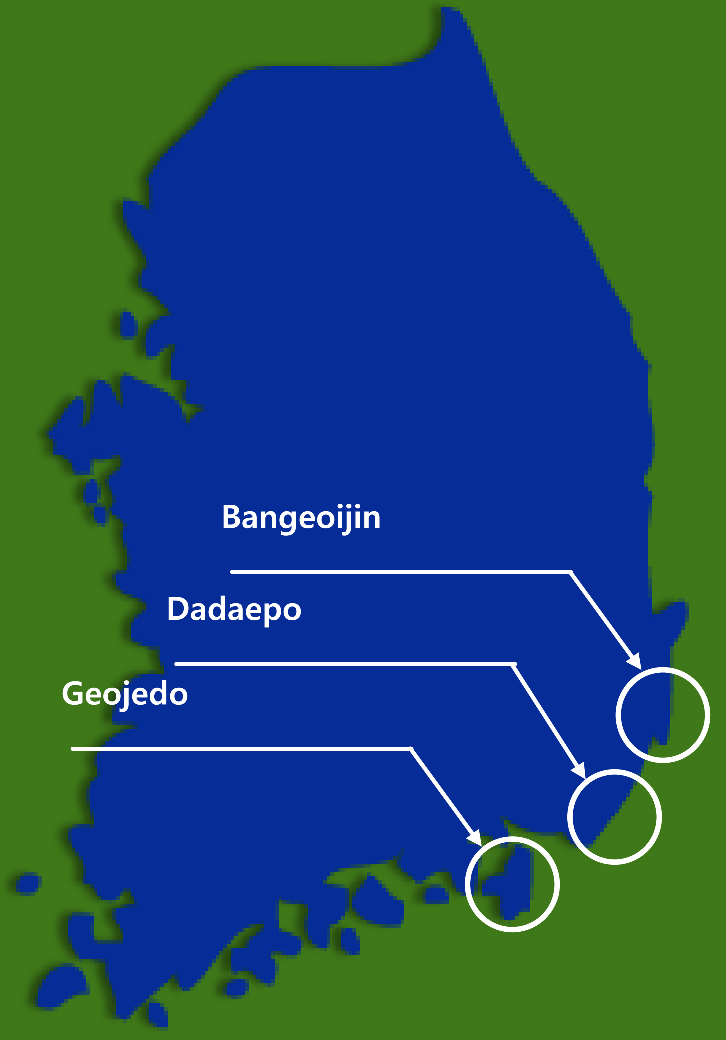
▶ Test&Verification Company
- Hyundai Heavy Industry Co., Ltd.

▶ Test Place (Korea)
- Ulsan(Bangeojin), Gyeongsangnam-do(Geojedo), Busan(Dadaepo)

▶ Test Period
- 6 Month('14. April ~ '14. October)

▶ Test Method
- Collected AF Paint on sale from Manufacturer
- AF Paint Coated to the Test Plate by HHI
- Performed Immersion Test at the 3 Places for 6 Month
- Checked Immersion Test Execution Result

▶ Verification Method
- Visual Inspection after 6 month by HHI



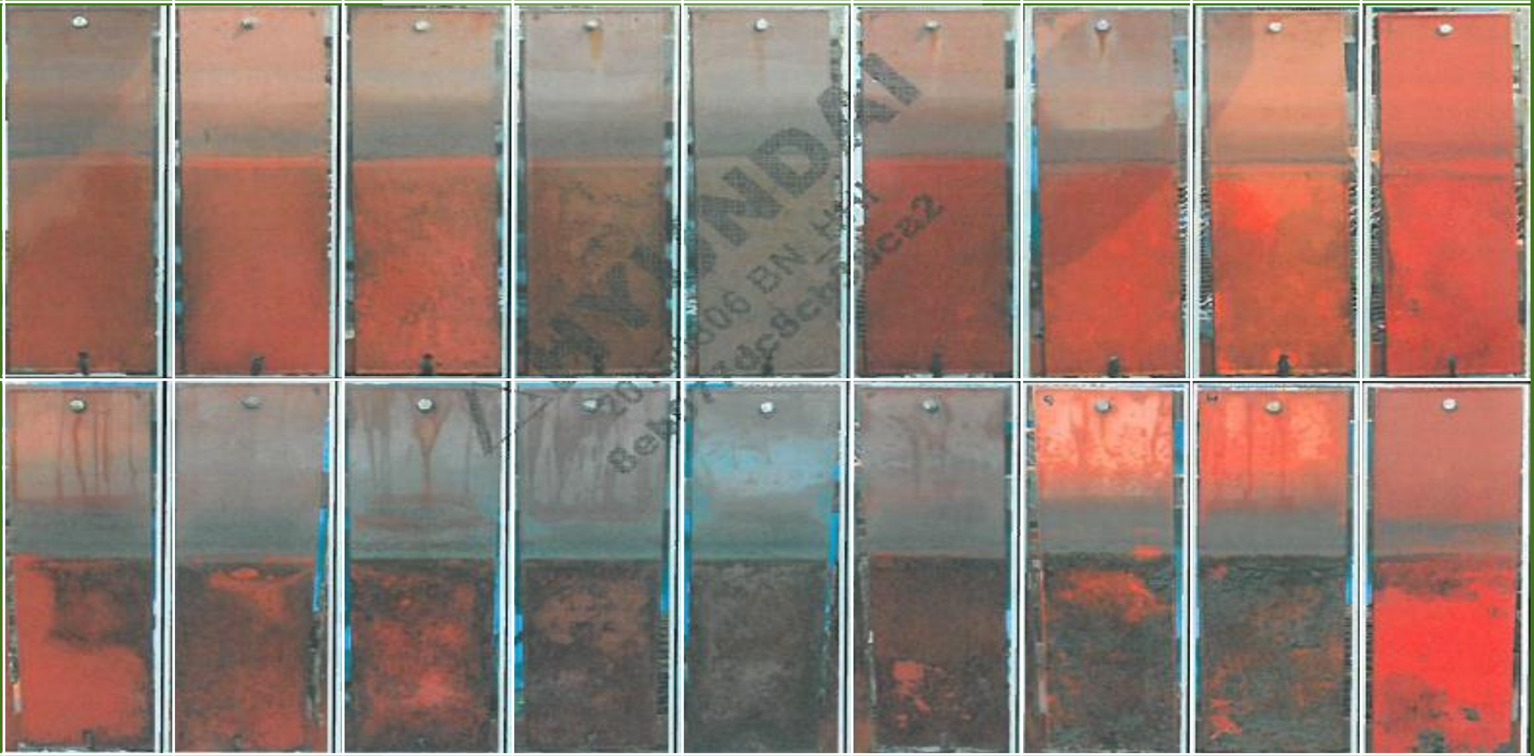
Static Immersion Test by HHI (Antifouling Performance Test) / Ulsan

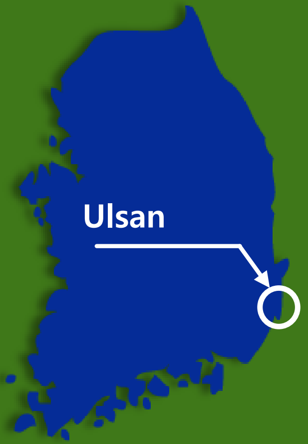
3-2

	A	B	C	D	E	F	G	H	I
Manu-facturer	K	K	N	C	J	I	BN Chemical	**BN Chemical**	Silicone Paint
Product Type							BN GreenGuard CF	**BN GreenGuard FS**	

After 1 Month (Jun)

After 5 Month (October)

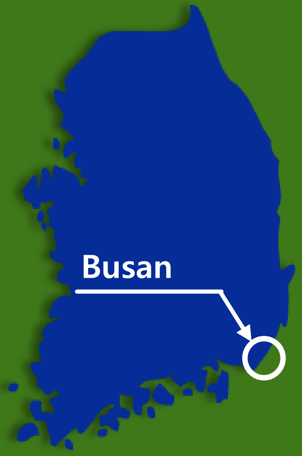




Static Immersion Test by HHI (Antifouling Performance Test) / Busan

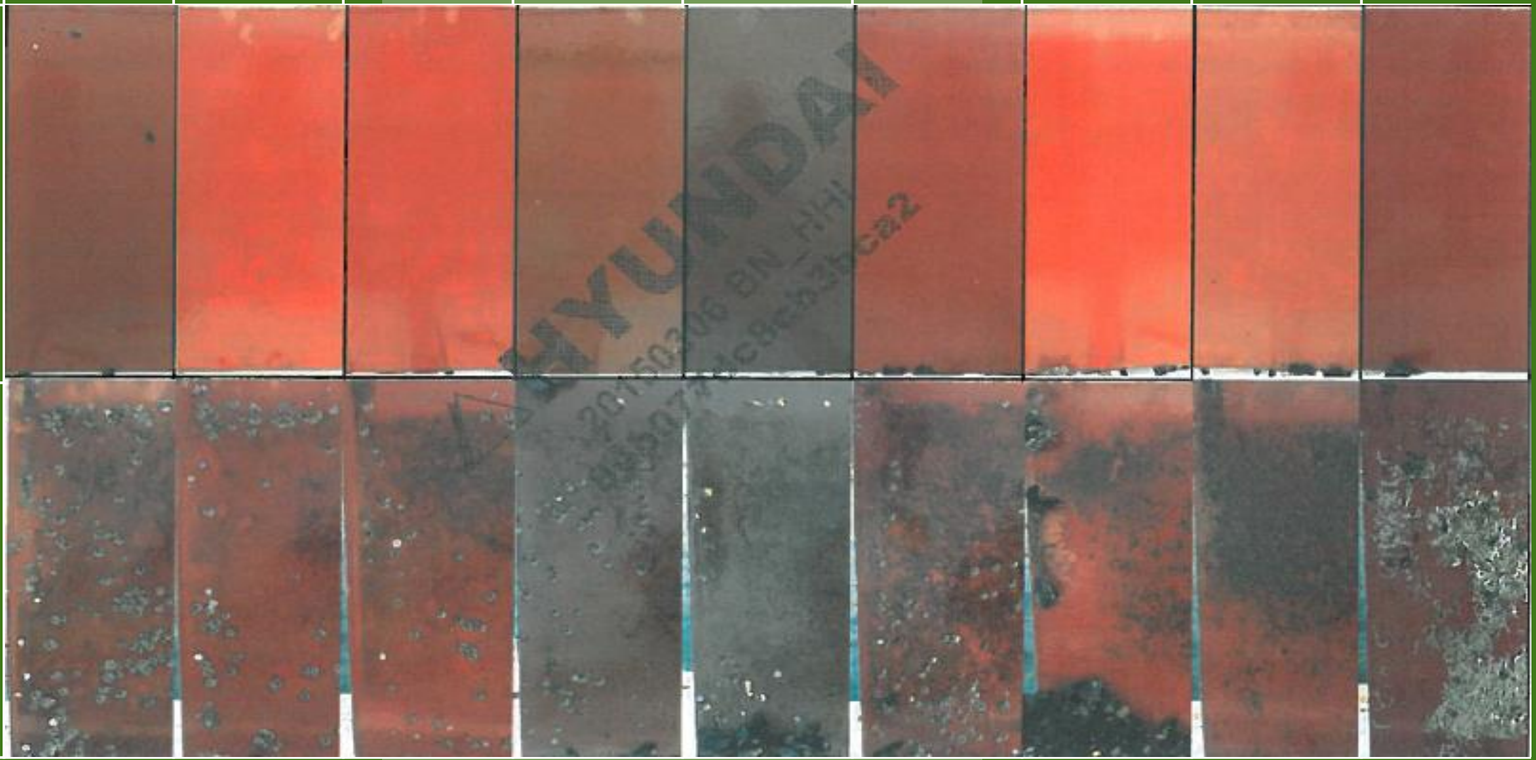
3-3

	A	B	C	D	E	F	G	H	I
Manu-facturer	K	K	N	C	J	I	BN Chemical	BN Chemical	Silicone Paint
Product Type							BN GreenGuard CF	BN GreenGuard FS	
After 1 Month									
After 6 Month									



Static Immersion Test (Antifouling Performance Test) / Geojedo

3-4

	A	B	C	D	E	F	G	H	I
Manu-facturer	K	K	N	C	J	I	BN Chemical	**BN Chemical**	Silicone Paint
Product Type							BN GreenGuard CF	**BN GreenGuard FS**	
After 1 Month									
After 6 Month									

Static Immersion Test Report (Company(HHI) Internal)

외부 기관 검증 : 현대 중공업 (내부 보고 자료 인용)-2

3-5

1. 균열 저항 성능

1) 도장 후 장기간 옥외 폭로에 대한 균열 저항 성능 평가
2) 도료의 수지, Rosin 함량, 배합 등에 따라 균열이 발생할 수 있음.
3) 균열저항성능이 낮을 경우 장기 운항 후 균열이 발생할 수 있음.
4) 10개월 폭로 결과, 평가 도료 모두 우수한 균열 저항 성능을 가짐.

2. 도막 변형률

1) 반목부 도막 손상 예방을 위하여 건조시간에 따른 도막 경도를 측정함.
2) 수지의 낮은 경도, 높은 도막두께로 인한 미건조로 도막 밀림이 발생함.
3) 도막 손상 및 오염 부위는 방오성능 저하와 돌출로 저항을 상승 시킴.
- 반목개수: 10,000 TEU 컨테이너선 기준 약 550개
- 반목크기: 1,200mm x 350mm

4) B 및 C 방오도료는 경도 개선이 필요함(3일 건조 98 이하).

3. 변색 저항 성능

1) 도막 변색으로 인하여 보수 도장이 빈번하게 발생함.
2) 변색은 도막이 완전 건조 되기 전에 해수 침적, 표면의 수분 응축, 폭로 노화 등으로 변색이 발생함.
3) 청수 및 해수에 따른 변색 저항 성능 평가 결과, D, E, H 社는 청수에서 변색이 발생하여 개선이 요구됨.

예인수조 마찰저항 성능 평가

① 114K 모형 PC선(1/36.4 scale ratio, 약 7m)으로 평가함.
② 모형선 허용 오차 범위: Max/Min < 1%
③ 로그함수를 이용하여 25 knots에서 저항값을 예측하여도, 모든 도료가 ±1.5% 내외의 마찰저항 증감을 가짐.
④ 선속이 증가할수록 표준 도료에 수렴하며, 마찰저감 3% 이상 도료는 없음.

4. 표면 조도

1) 표면조도가 마찰 저항의 가장 큰 요인으로 작용함.
2) 평가 방법(HRA, Stylus 및 3D 표면분석)에 따라 표면 조도가 상이함 (조도의 크기 및 파장).
3) 현업에서 사용중인 HRA 측정 방법을 표준으로 함.
4) 표면 조도는 도료의 점도, 표면에너지 등의 영향도 있지만, 도장거리, 작업자의 기량, 온도 및 풍량 등 도장 환경이 매우 중요함

구분	표면조도(㎛)			비고
	HRA	Stylus	현미경	
A	40	20	21	
B	43	12	15	
C	40	11	17	
D	50	13	21	
E	46	14	17	
F	47	7	21	
G	-	8	19	
H	28	10	20	

5) 방오 성능 평가 결과

① 침적 1개월 부터 표면에 식물성 파울링이 생성되기 시작함.
② 침적 6개월에 BN 케미칼 방오도료를 제외하고 모든 제품에서 동물성 파울링이 생성되기 시작함(다대포 및 거제).
③ 방어진(KCC), 다대포(BN), 거제도(IP)의 해양환경 차이로 해양생물의 부착 속도 차이가 발생함.
- 동해에 근접한 방어진에서는 5개월 까지 동물성 파울링이 없음.
- 남해안 환경에 가까운 다대포 및 거제도는 동물성 파울링 발생 속도가 빨라짐

④ 마찰 저감 방오도료가 대조군 대비 유사한 방오성능을 가짐.
⑤ G, H 도료는 모든 환경에서 우수한 방오 성능을 확보하고 있어, 기존 도료와 비교 검토 후 확대 적용이 기대됨.

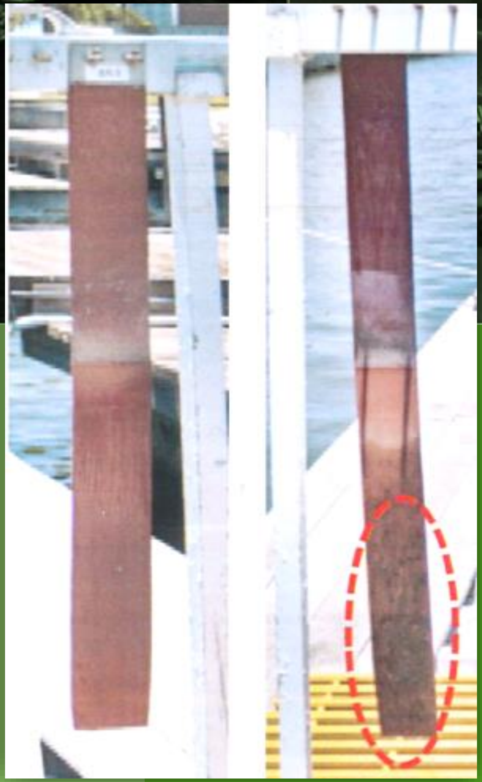
Luxury Charter Yachts > Sailing Yachts for Charter > Seahawk

SEAHAWK

- Period : Apr. ~ Sep. 2017 (5 months)
- Place : Florida / USA
- Owner : Erik Norrie(CEO), Mario Garneau(CTO)

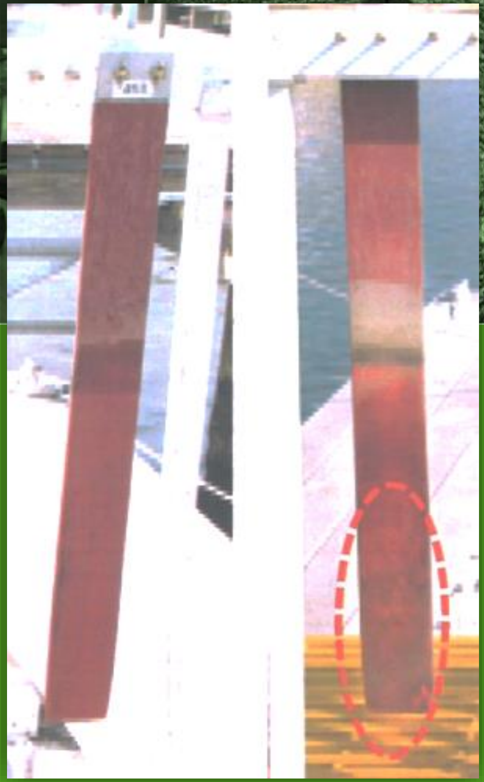
enorrie@seahawkpaints.com/mario@seahawkpaints.com

2 months exposure



Very light and loosely attached algae

5 months exposure



Very light.
No barnacles growing

“I have never had to scrub with any pressure to remove algae. it is always one or two light passes with the soft side of a sponge and panel looks brand new the waterline cleans easily, and i have never witnessed more than 1 barnacle growing” (commented by Mario garneau on Sep.30’17)

Static Immersion Test (During 2 years)

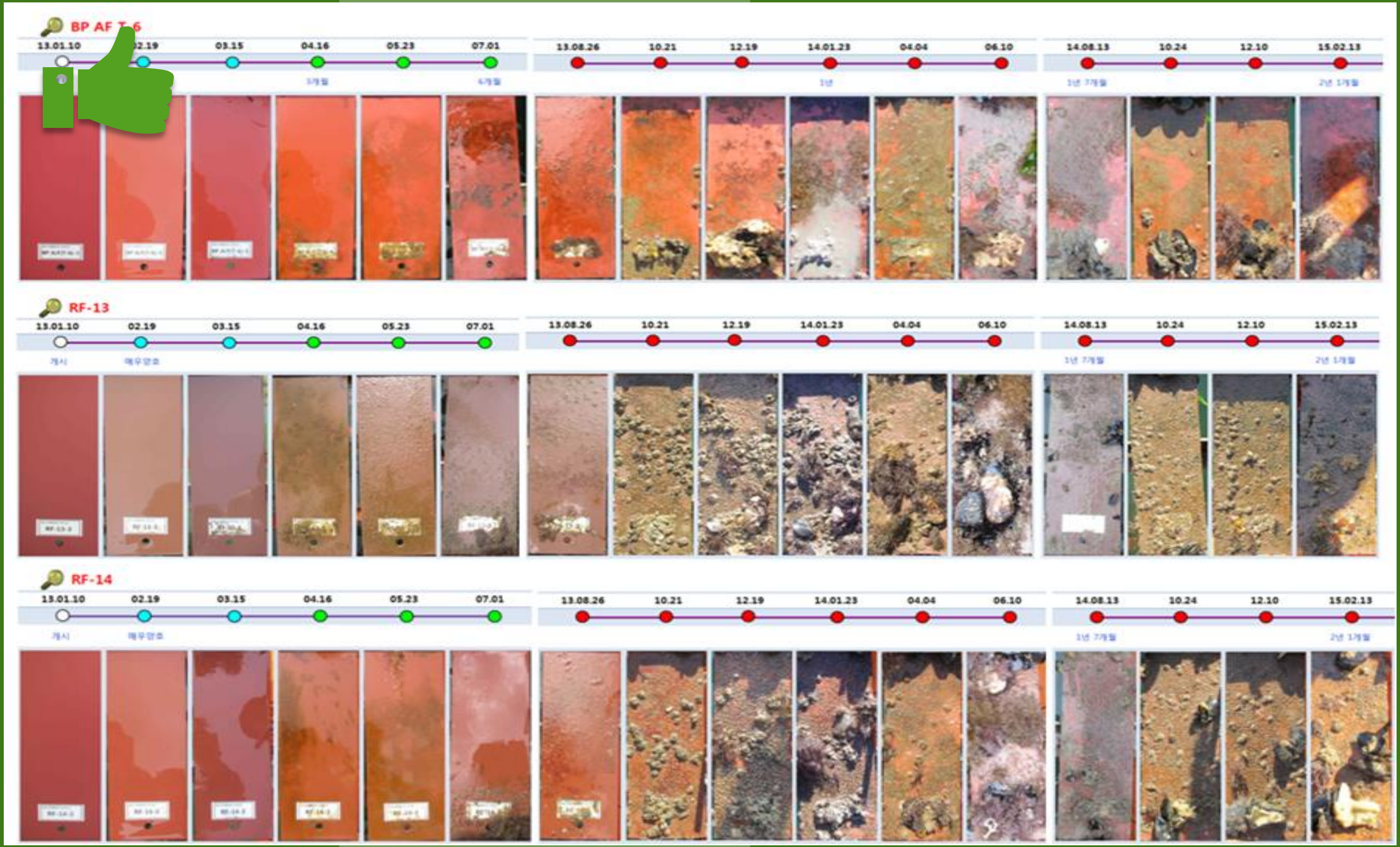
4

❖ **Period**
- 2 years
  (1 Jan. 13 ~ 13 Feb.15)

❖ **Method**
- Long term Immersion

❖ **Place**
- Dadaepo/Busan

❖ **Sample (3 makers)**
- functional low-friction paint
- Our product 1 type
- Global maker 2 type

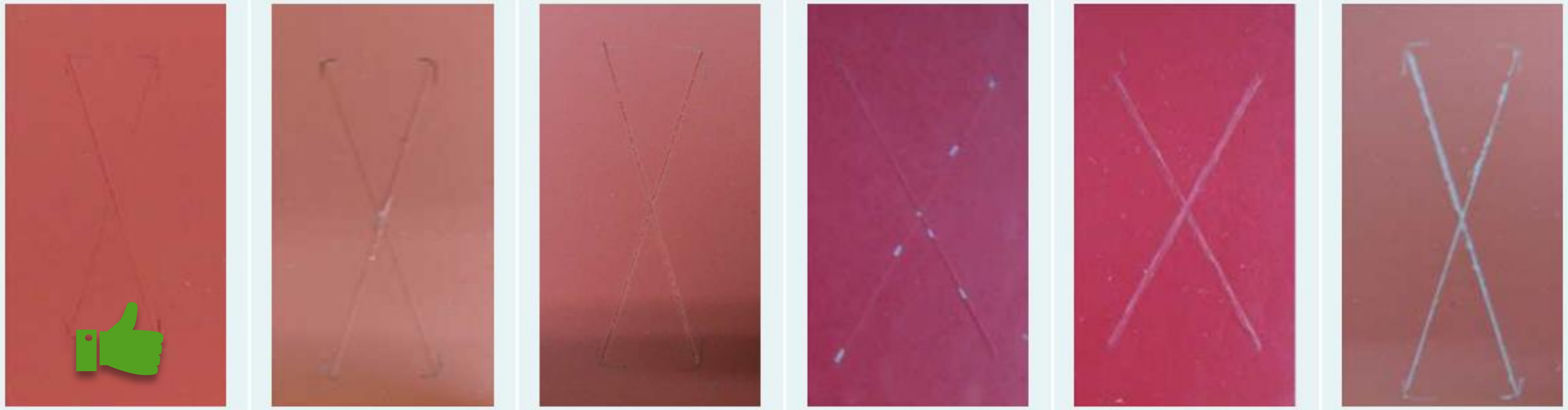


Adhesive performance

It is very good (Grade 5A) for compatible adhesion with other maker products.

Specimen	Viscosity (KU)	Specific Gravity	Solid Volume Ratio (SVR, %)	Sagging Res. (W.F.T, μm)	Particle size (μm)	Non-volatility (N.V, %)
T-2	89.3	1.72	62.9	350	30	80.67
T-5	104.1	1.73	55.9	600	35	75.99
T-6	102.5	1.55	53.3	500	40	72.65
T-6A	96.0	1.58	65.0	500	30	81.43

Specimen			Commercial Control		
T-2	T-5	T-6A	RF-05	RF-13	RF-14
5A	4A	4A	3A	5A	3A

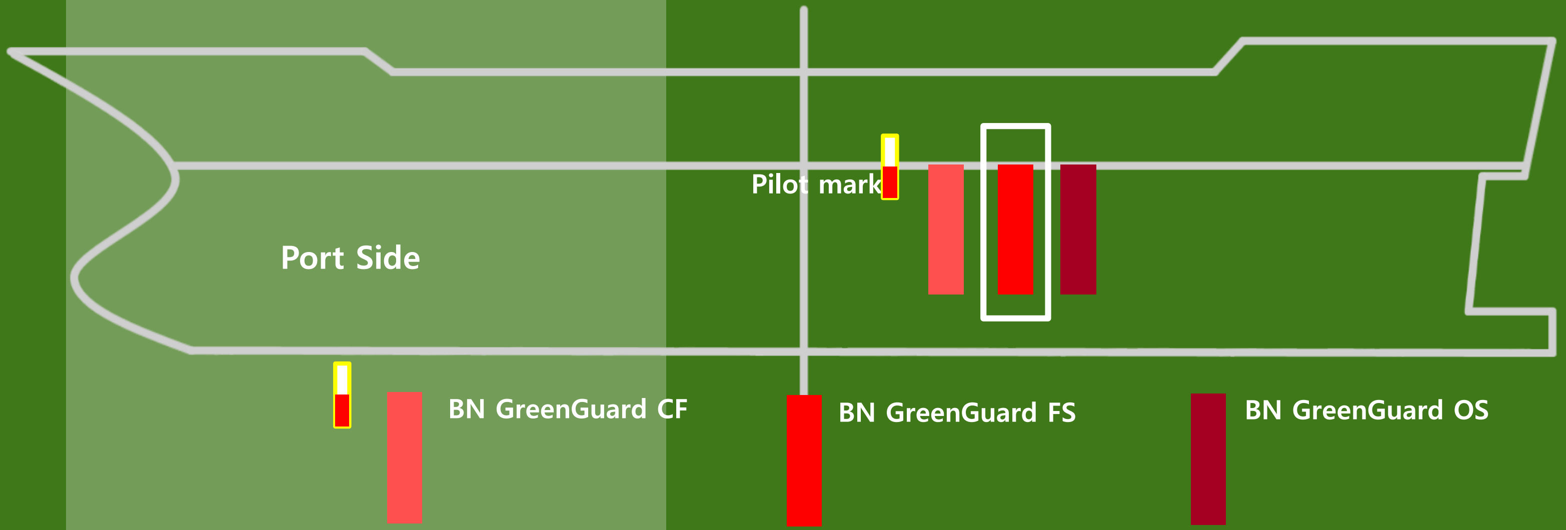


Patch Test (Antifouling Performance Test) / 181K Bulk Carrier

5-1

- Name of vessel : M/V “NEW JOY”
- Tonnage : DWT 149,297(Cape size)
- Test Period : Dock(‘13 Jun) to Next Dock
- Manag. company : STX MARINE SERVICE
- Place of dockyard : Shanhaikwan in China
- Apply : BN GreenGuard Series (2m x 10m)
- Method : Visual inspection

  Spot patch up test (During 36 months)



Patch Test (Antifouling Performance Test) / 181K Bulk Carrier

5-2

Port Side

Starboard Side

Patch Test (Antifouling Performance Test) / 176K Bulk Carrier

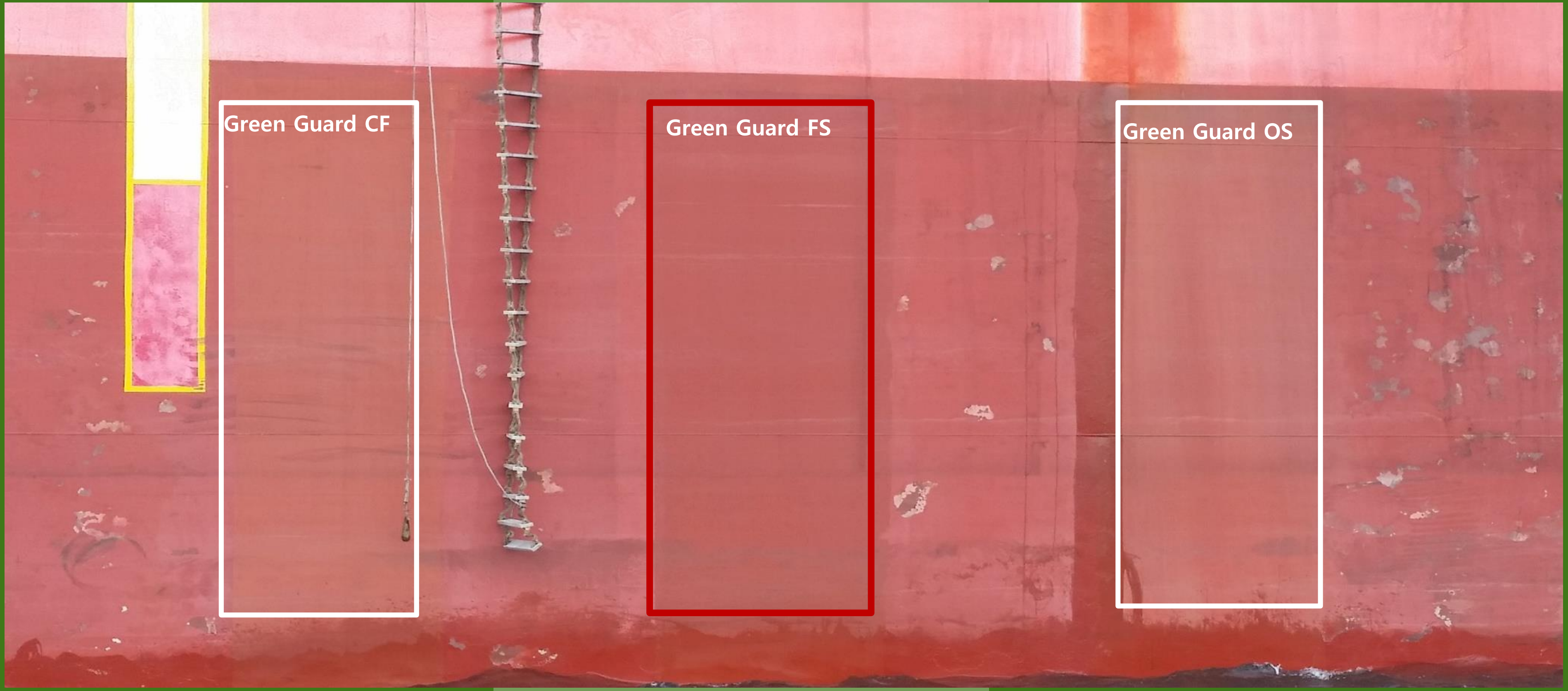
5-3

▶ **Intermidiate Inspection ('15. August)**

· Keep a reliable Antifouling Condition

After 31 months

Excellent condition



Port Side

Existing Vessel Verification by ISO 19030

6-1

- ✓ Ship Yard : NTS
- ✓ LOA(m) : 291.8 , Breadth(m); 16.6
- ✓ Deadweight(M/T): 175,132.6(S.S.W)   Designed Speed(kts): 14.9
- ✓ M/E Engine: MAN B&W 6S70MC (16,860kW x 91RPM)

Event	Time/period	AF Coating	Voyage no.
SPMS Installation (Ship Performance Monitoring System)	Nov. 2014		
1 st service period (5years, data available only for the 5th year after SPMS installation)	Dec.2014 ~ Nov.2015	Conventional	Ballast / Laden 29~37
Relative wind speed and direction	Nov. 2015		
Ship heading	Nov.2015~Nov.2018	FDF	Ballast / Laden 38~63
Shaft revolutions	Dec. 2018		
Static draught fore and aft	Jan. 2019~Dec.2019	Conventional	Ballast / Laden (64~75)

Existing Vessel Verification by ISO 19030

6-1

Data Exclusion Conditions

- Abnormal data (sensor malfunction, fault, etc.)
- Data with large variation (during acceleration/deceleration, turning, etc.)
- After dividing the data into 10-minute increments to obtain the mean value and standard deviation, remove the Outlier using Chauvenet's Criteria

Collected data

Items	Unit	Filtering	Validation R1)	Correction
Speed over ground	[knots]	10.0 ~ 16.5	Standard deviation less than 0.5knots	-
Shaft Power	[kW]	4,000~20,000	-	-
Relative wind speed and direction	[knots],[°]	Less than 15.6 knots (Less than BF 4)	- [°]	Using a correction method ISO1506
Ship heading	[°]	-	-	-
Shaft revolutions	[min^{-1}]	-	Standard deviation Less than 3 RPM	-
Static draught fore and aft	[m]	-	-	-
Water depth	[m]	-	-	-
Rudder angle	[°]	± 5 °	Standard deviation Less than 1 °	-
Seawater temperature	[°]	More than 2 °	-	-

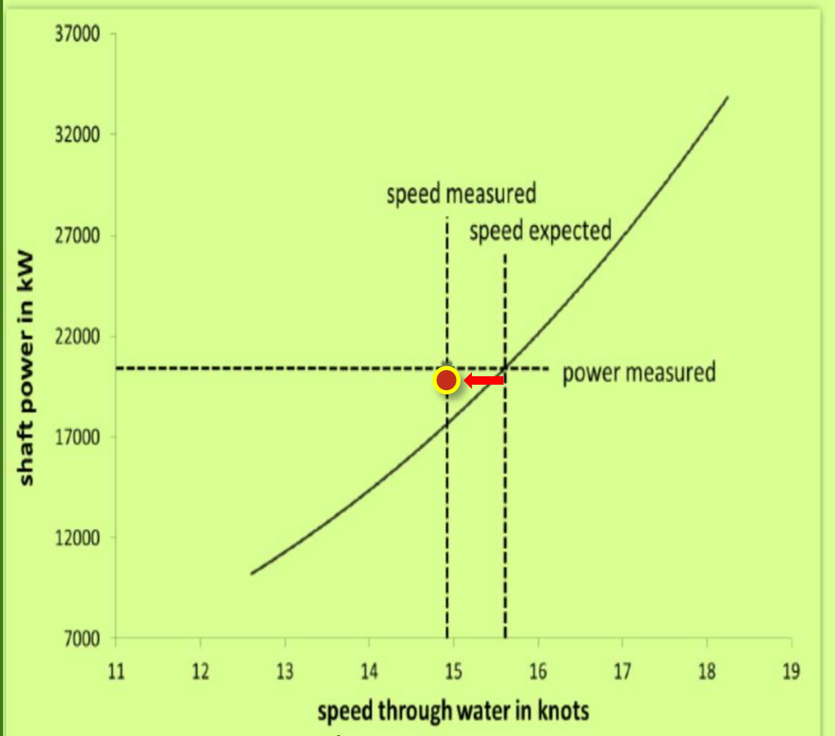
1) Validation R1): If the standard deviation of each block does not meet the above criteria, the entire block is removed by dividing the data into blocks in 10-minute increments
2) Speed-power displacement can be calibrated with an Admirality formula within the actual displacement ± 5%
3) Speed-Power Trim is only available if it is within ±Lpp, ± 0.2% of the actual Trim

Existing Vessel Verification by ISO 19030

6-2

Performance Value Calculation

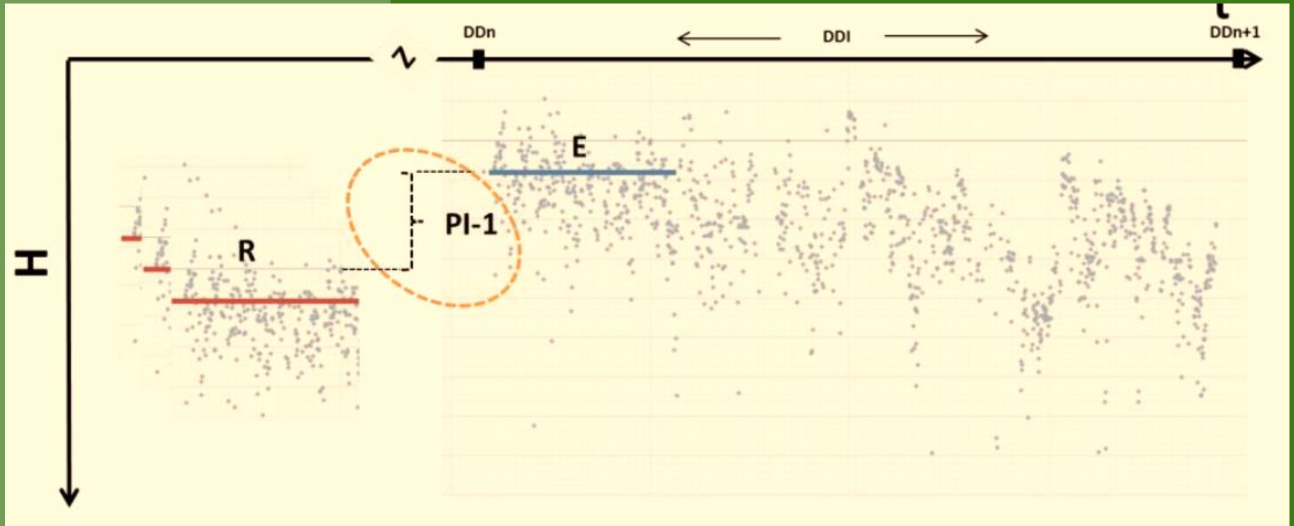
- ✓ Performance Value : (measured speed-expected speed)/expected speed x 100(%)
- ✓ Speed –power curve
  - ISO15016에 부합하는 방법으로 수행한 시운전 결과
  - 모형 시험 결과



[Speed – Power Curve]

<u>ISO/DIS 19030</u> : Standard for the in-service performance analysis

- ✓ Ships and marine technology — Measurement of changes in hull and propeller performance
- ✓ The relationship between the condition of a ship's underwater hull and propeller and the power required to move the ship through water at a given speed



$$P_D = \frac{R_T V}{\eta_D}, \quad R_T = R_{SW} + R_{AA} + R_{AW} + R_{AH}$$

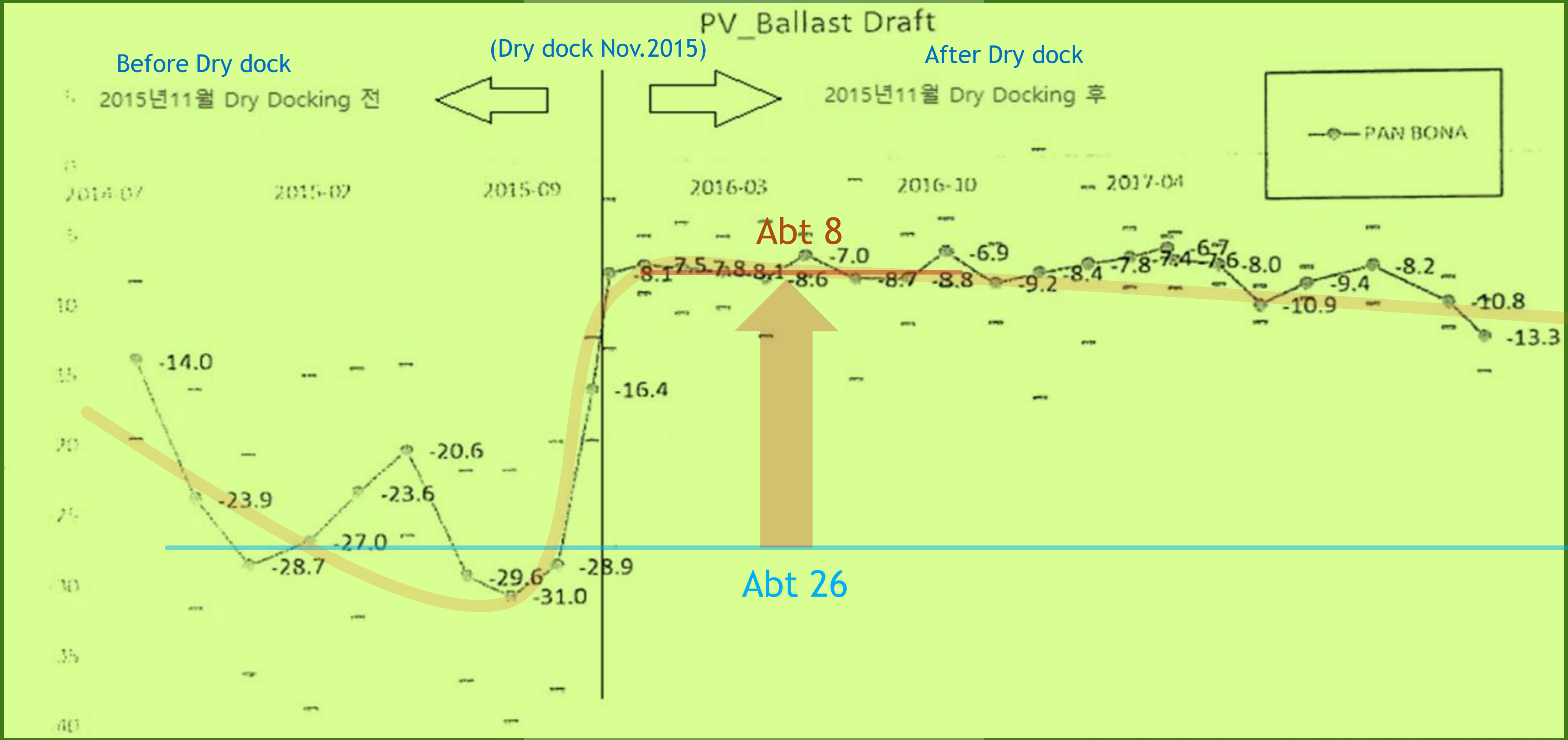
$$R_{AH} = \frac{P_D \times \eta_D}{V} - (R_{SW} + R_{AA} + R_{AW})$$

Existing Vessel Verification by ISO 19030

6-3

- Results after 32 months of solid line application
- Confirmation of performance improvement when comparing PV values before and after BN GreenGuard FS painting.

〔Confirmation of Friction Resistance Reduction〕



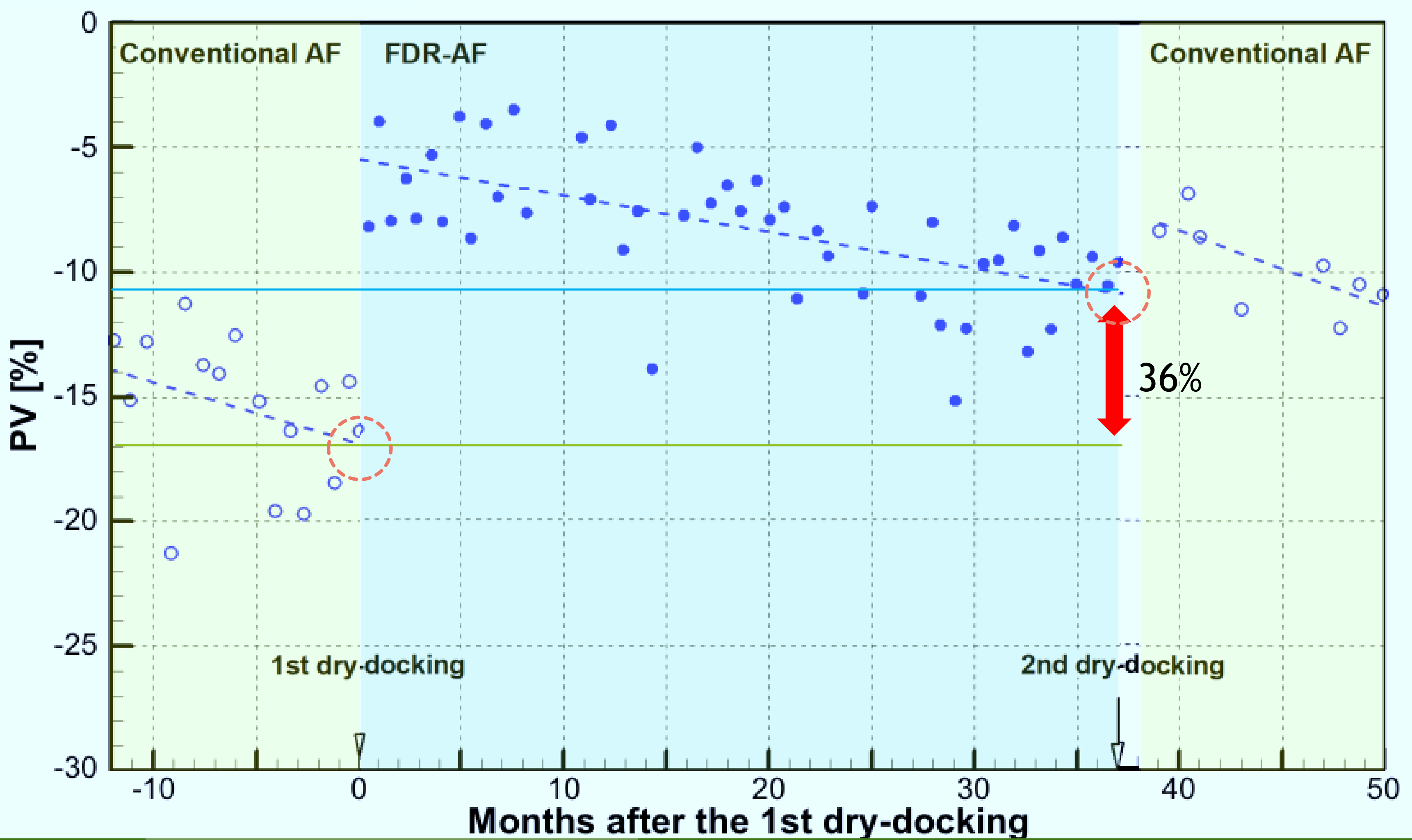
Existing Vessel Verification by ISO 19030

6-4

PV

Average 36% Improvement

Comparison before DD



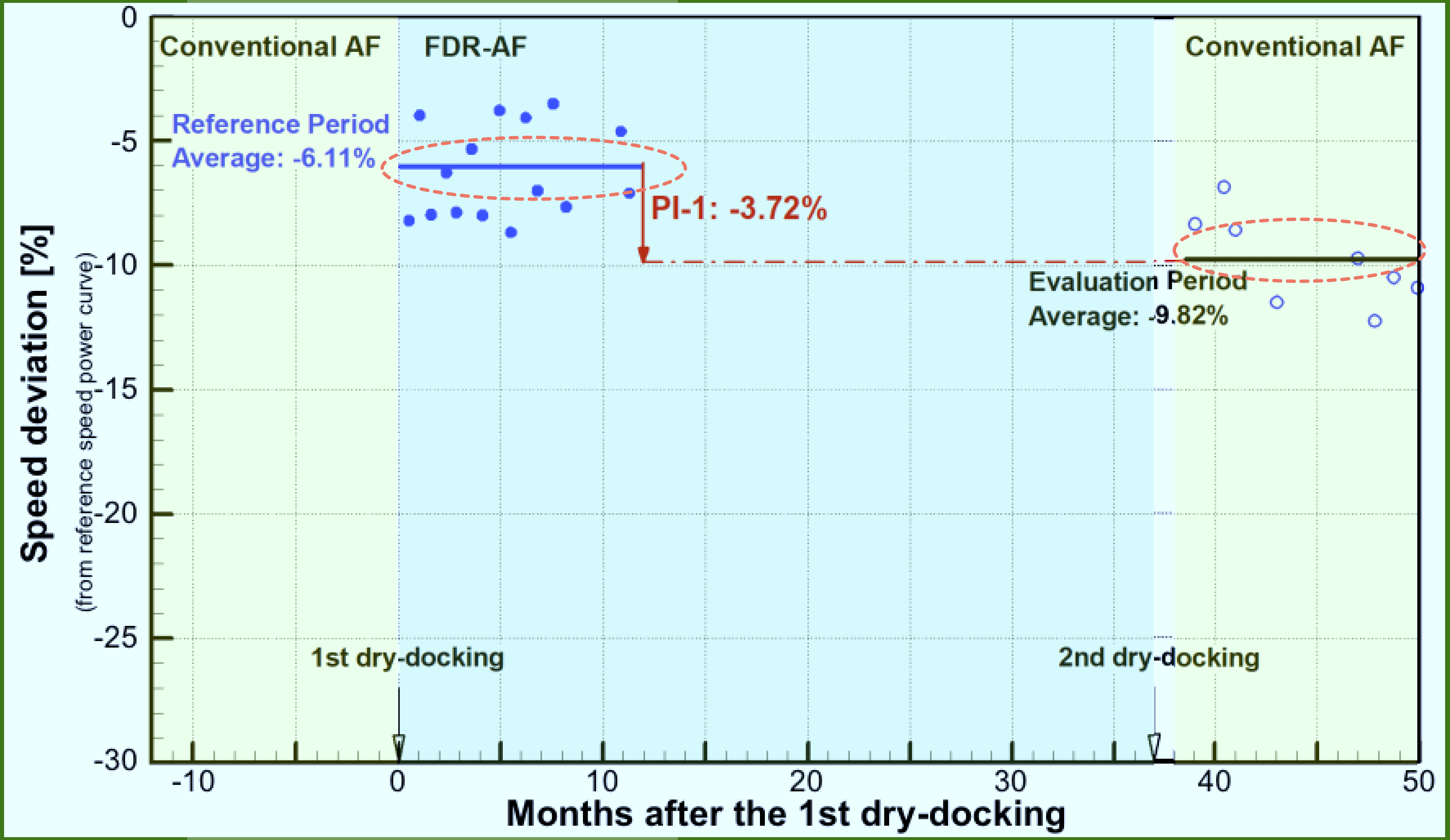
Existing Vessel Verification by ISO 19030

6-5

SPEED

Average 3.72% Improvement

Aft Dry dock



Existing Vessel Verification by ISO 19030

6-6

SPEED

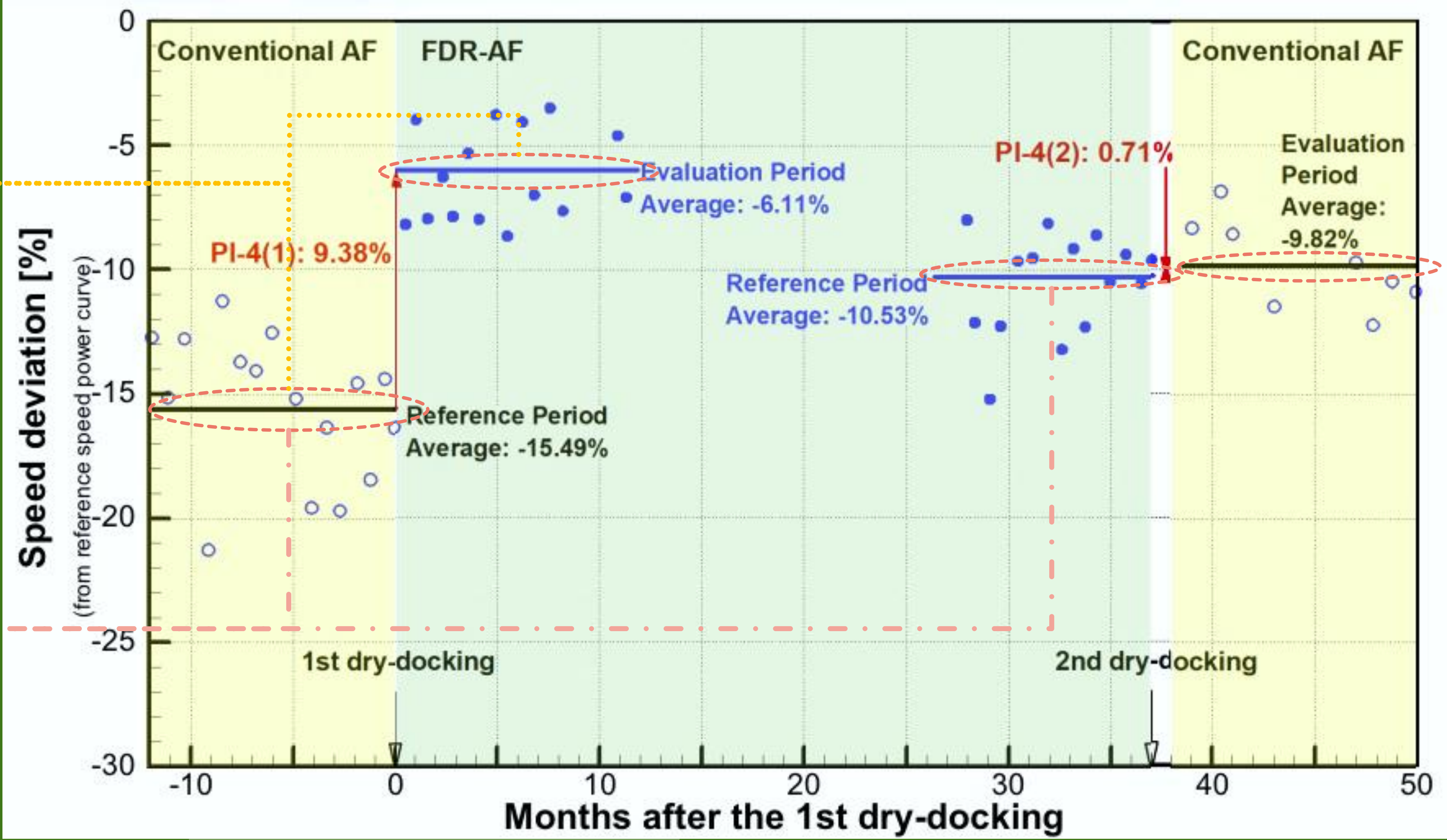
Average 9.38% Improvement

Before/After Dry dock

SPEED

Average 4.96% Improvement

before Dry dock



Existing Vessel Verification by ISO 19030

6-7

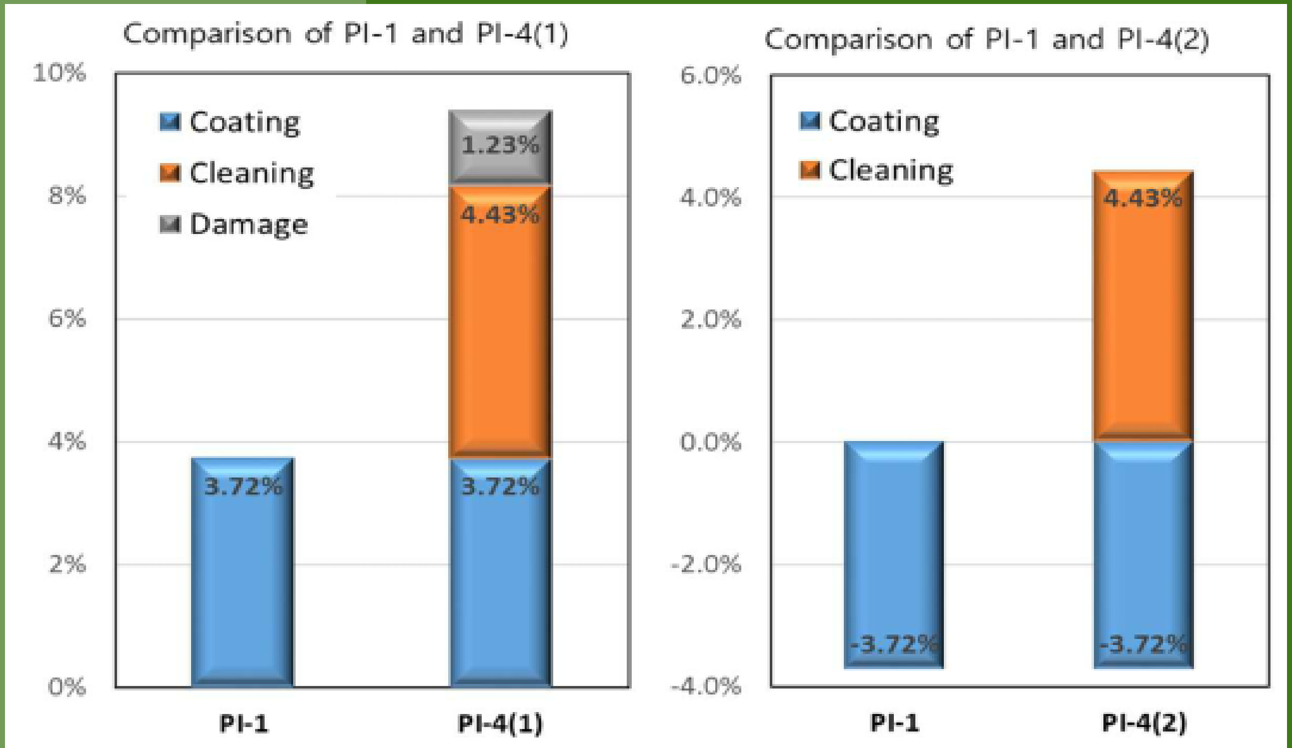
Power saving

11.7 %

Quantification of fuel efficiency improvement

- Speed drop (△V/V) and the power increase (△P/P)
- n: determined by the vessel type and draft (n=1.91, 2.40 for VLCC for the laden & ballast respectively)
- Power saving by FDR-AF coating (n=2.16) → (△P/P) = 11.7% (from △P/P = 3.72%)

- Cleaning effect: differences in surface conditions before and after dry docking
- Damage Recovery effect: compensate for the effects of initial coating damage before dry docking

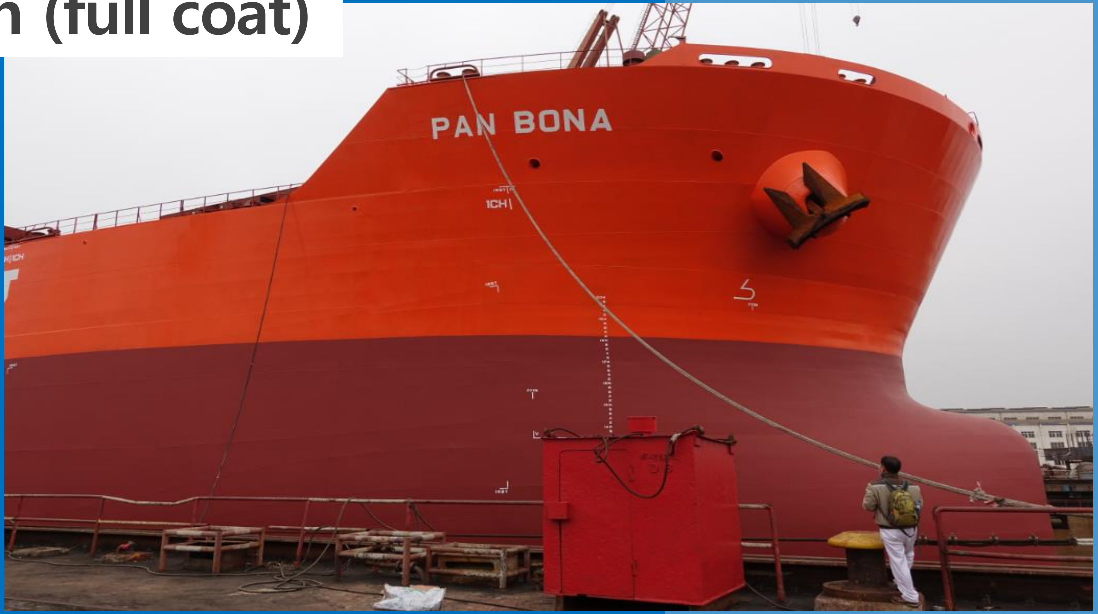


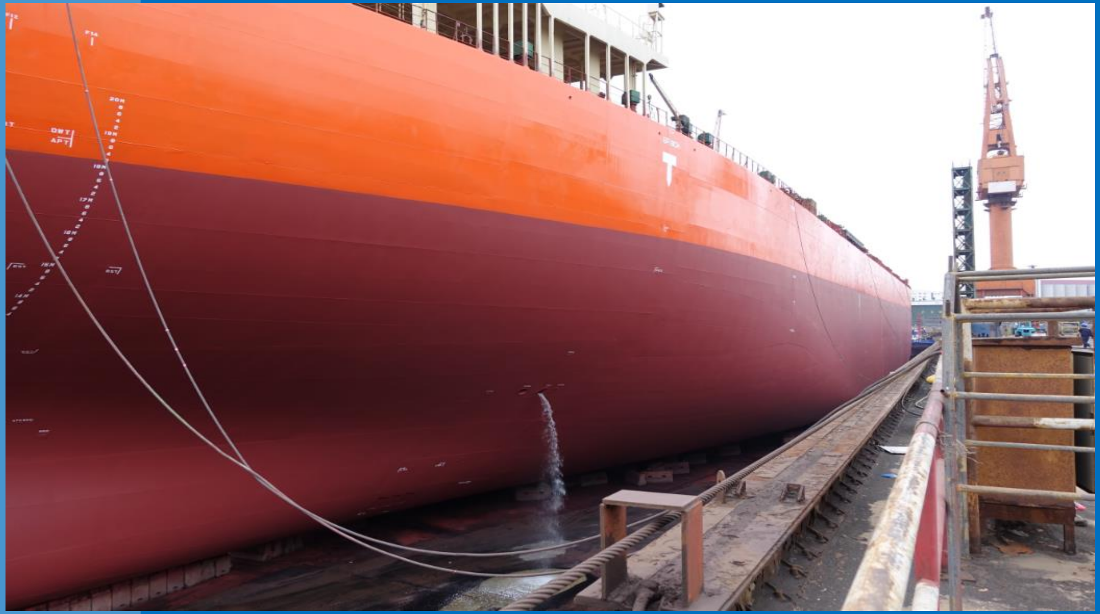
PI−4(2) = − Coating Effect+ Hull Cleaning Effect
(0.71 = -3.72 + 4.43)

PI−4(1) = Coating Effect+ Hull Cleaning Effect + Damage Recovery Effect
(9.38 = 3.72 + 4.43 + 1.23)

Application

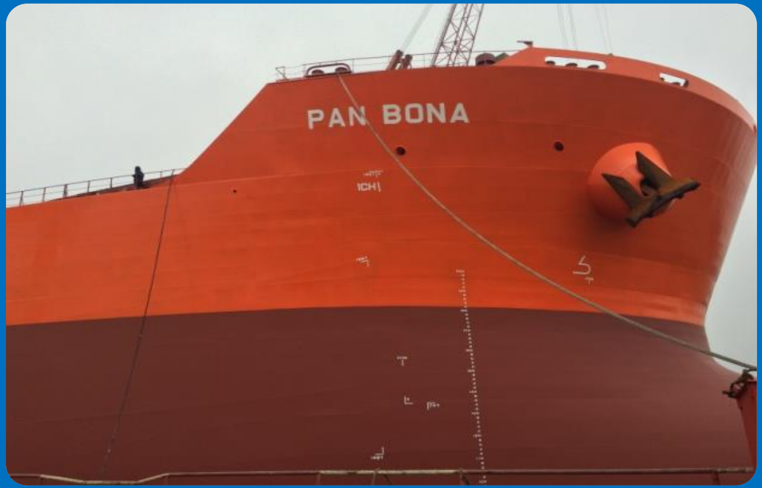
Application (full coat)





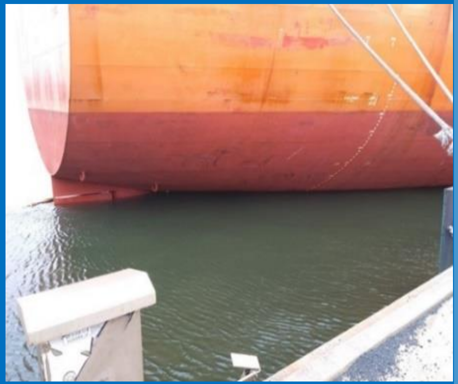
- Name of vessel : M/V “PAN BONA”
- Tonnage & Type : DWT 175,401 Bulk carrier
- Apply : BN GreenGuard FS
- Ship’s owner : PANOCEAN
- Ship’s operator : STX MARINE SERVICE
- Date of dockyard : November 2015
- Place of dockyard : Shanhaikwan in China

Application (full coat)

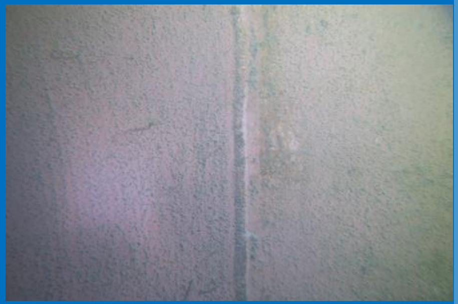


<After 32 months>

Upper side of waterline



Under water side



Application (full coat)

✓ Name of vessel : M/V "SEA INDONESIA"

✓ Tonnage & Type : DWT 404,389 & ORE carrier

✓Ship's owner

- PANOCEAN

✓ Ship's operator

- BERNHARD SCHULTE SHIPMANAGEMENT

✓ Date of dockyard : Aug. 2017

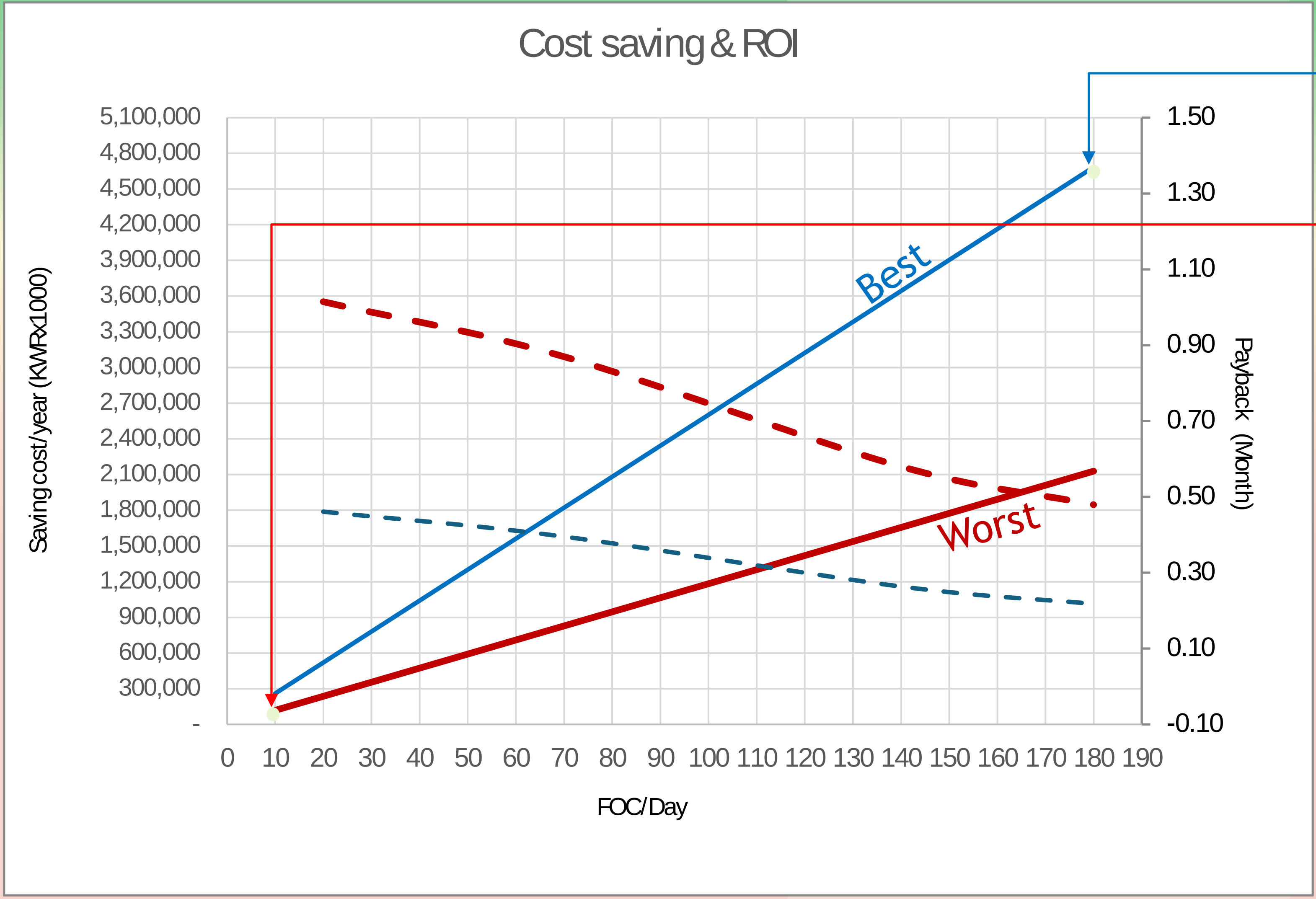
✓ Place of dockyard

- PAX OCEAN SHIPYARD / CHINA

Application (full coat)

Korean Coast Guard's high-speed ship
8 vessel (May 2016)

Simulation of Cost saving & ROI



ROI : 55 times

P.B : 0.2 month

ROI : 11.8 times

P.B : 1 month

FOC_Ton/day	Saving Amt	Saving cost_USD	Saving cost_KRW	Investment/year	Pay back	ROI
10	241	192,720	260,172			
20	482	385,440	520,344	20,000	0.46	26.0
30	723	578,160	780,516			
40	964	770,880	1,040,688			
50	1,205	963,600	1,300,860			
60	1,445	1,156,320	1,561,032			
70	1,686	1,349,040	1,821,204	60,000	0.40	30.4
80	1,927	1,541,760	2,081,376			
90	2,168	1,734,480	2,341,548			
100	2,409	1,927,200	2,601,720			
110	2,650	2,119,920	2,861,892			
120	2,891	2,312,640	3,122,064			
130	3,132	2,505,360	3,382,236			
140	3,373	2,698,080	3,642,408	80,000	0.26	45.5
150	3,614	2,890,800	3,902,580			
160	3,854	3,083,520	4,162,752			
170	4,095	3,276,240	4,422,924			
180	4,336	3,468,960	4,683,096	85,000	0.22	55.1

- ✓ 박현, 이인원, 전호환, 2015, 친수성 폴리머를 포함하는 공중합체 및 이를 포함하는 마찰저항 저감용 조성물, 등록번호 10-1524729-0000, 등록일자 2015.05.26
- ✓ 전호환, 이인원, 박현, 2012, 마찰저항 저감 코팅 조성물, 등록번호 10-1133078-0000, 등록일자 2012.03.28
- ✓ Chun, H. H., Lee, I., Park, H., Chung, W. S. and Jo, N. J., 2011, “Antifouling Paint Composition", 미국특허 7,989,520 B2, 등록일자 2011. 8. 2.


특허증
CERTIFICATE OF PATENT

특 허 Patent Number	제 10-1524729 호
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친수성 폴리머를 포함하는 공중합체 및 이를 포함하는 마찰저항 저감용 조성물

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등록사항란에 기재

위의 발명은 「특허법」에 따라 특허등록원부에 등록되었음을 증명합니다.
This is to certify that, in accordance with the Patent Act, a patent for the invention has been registered at the Korean Intellectual Property Office.

2015년 05월 26일

특허청장
COMMISSIONER,
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Thank you for your attention.

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