

Eco-friendly
Economic
Efficient



De-SOx SYSTEM

PaSOxTM smart v3.0

ENGLISH

PANASIA

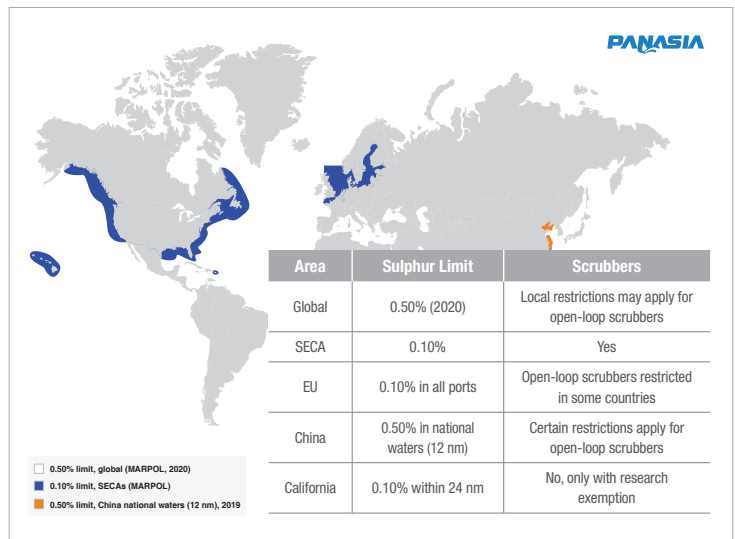
Desulfurization System for Ships

International Maritime Organization (IMO) has set the maximum allowable content of sulfur in fuel used by ships through MARPOL 73/78 ‘International Convention for the Prevention of Pollution from Ships’ that entered into force in 2005. All ships operating in SECA (Sulfur Emission Control Area) have been required to use fuel with the sulfur content of 1% or less since July 2010 and to use fuel with the sulfur content of 0.1% or less since 2015. In addition, regulatory requirement of using fuels with the sulfur content of 0.5% or less in all oceans throughout the world is to take effect in 2020.

To meet the requirements on the permitted sulfur levels in ships’ fuels, ships must use fuels with low sulfur content or be equipped with the desulfurization system equivalent to meet IMO, MARPOL 73/78 regulations. Low sulfur fuel is a viable option on a short term basis but are too expensive to use which makes the flue gas desulfurization system combined with a continued use of existing high sulfur fuels an optimal alternative in terms of long-term operating costs while meeting environmental regulations.

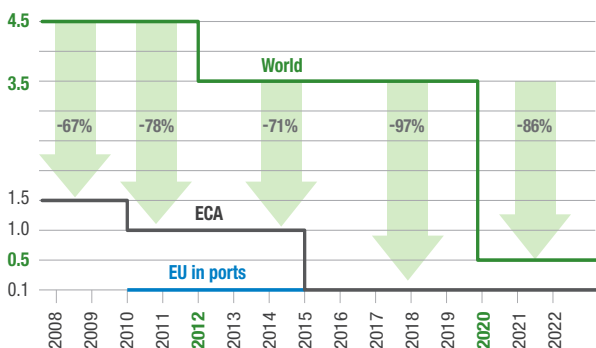
Emission Control Area

- International Maritime Organization (IMO) adopted “Prevention of Pollution from Ships” on September 26, 1997 at its London headquarter, and it controls the use of fuel oil, with low sulfur contents, to decrease SOx emission.
- SOx emissions control areas reported to IMO are the North sea, the Baltics, the North American seas. In addition, IMO adopted Res. MEPC. 202(62) and the U.S. Caribbean region has been additionally designated as NOx and SOx emission control areas. Moreover, as a measure to control smog within China, the Chinese government has designated Yangzi River (Shanghai), Pearl River (Hong Kong, Macao) and Bohai Bay as the emission control areas, and intend to expand the regulation in stages.



SOx Regulation MARPOL 73/78 Annex VI Regulation 14 - Sulphur Oxides (SOx)

IMO Timeline For Reduction In Fuel Sulphur Content



Fuel Oil Sulphur Content (% m/m)	Ratio Emission SO ₂ (ppm)/CO ₂ (% v/v)
4.50	195.0
3.50	151.7
1.50	65.0
1.00	43.3
0.50	21.7
0.10	4.3

Table 1: Fuel oil sulphur limits recorded in regulations 14.1 and 14.4 and corresponding emissions values

• Target

All ship fuel oil used by main and sub equipments (including boiler and generator) as defined in Regulation 2.9

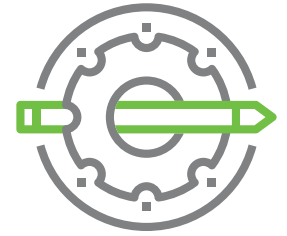
• Purpose

Set maximum sulfur content for ship’s fuel oil (Emission control areas and other regions)

• Regulation 4.1 (equivalent)

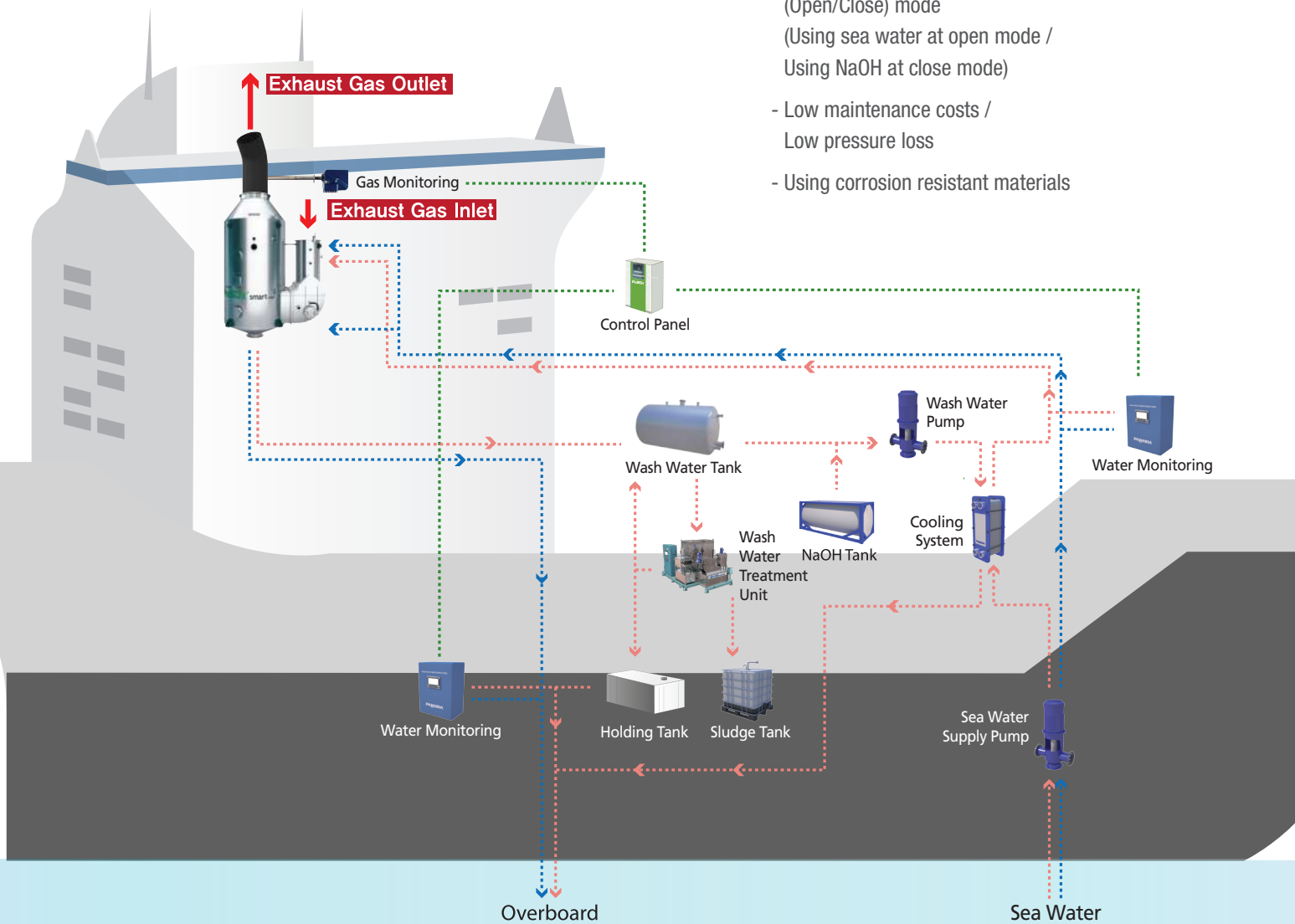
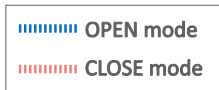
If an attachment, material, equipment or machines are effective as required by this annex, a competent agency could allow a substitute equipment to be installed on a ship according to the regulation (MEPC 184(59)), and the agency allowing such substitute (scrubber) must notify IMO to be circulated among member nations.

Overview of PaSOx™ System

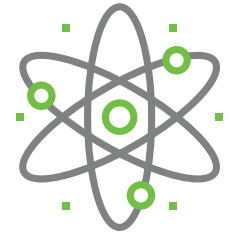


Solution Benefits

- Lower/remove pollutive materials (SOx, PM) from ship's emission
- Method of dissolving in liquid form by contacting SOx with water
- Designed to operate in hybrid (Open/Close) mode (Using sea water at open mode / Using NaOH at close mode)
- Low maintenance costs / Low pressure loss
- Using corrosion resistant materials



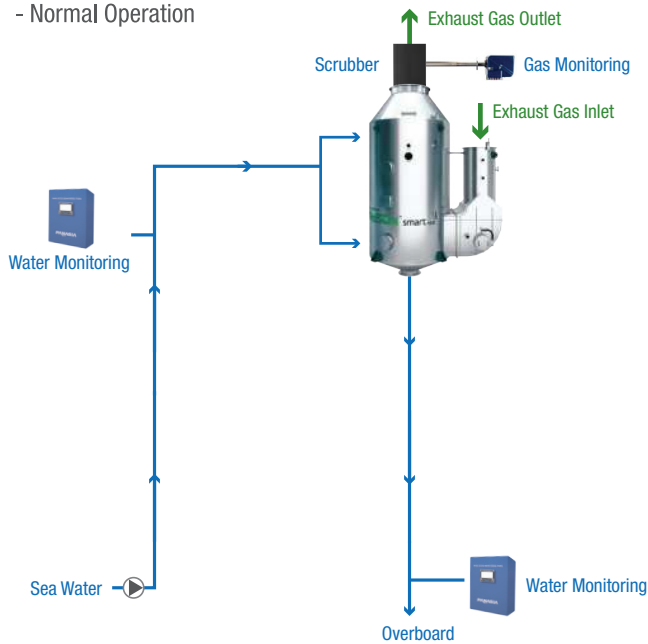
System Diagram



PANASIA PaSOx™ Exhaust Gas Cleaning System which removes sulfur oxides for the marine environment is mainly classified into Open Mode, Close Mode, and Hybrid Mode. In Open Mode, Sea water is used as Wash water, in Close Mode, Alkali solution is used as Wash water and in Hybrid Mode, mode switch between Open Mode and Close Mode is available.

Open Mode

- Normal Operation

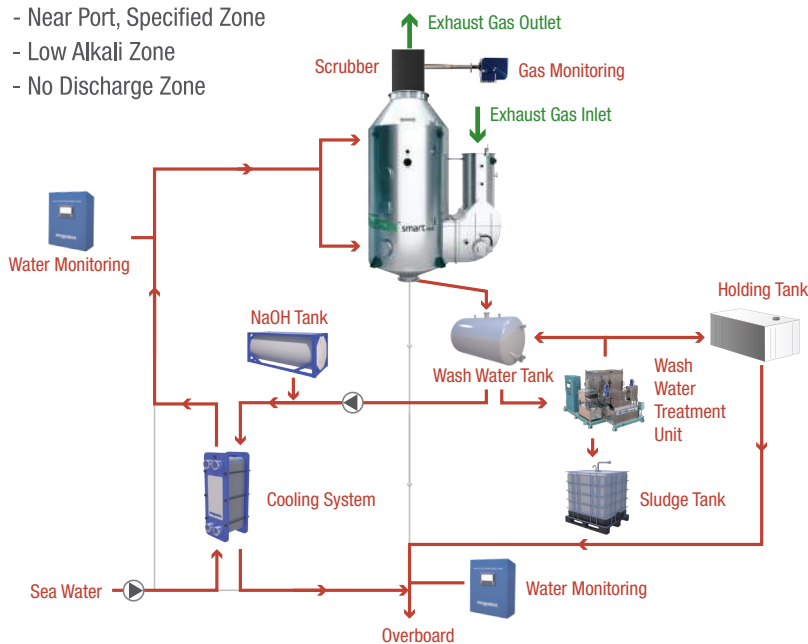


Open Mode System

In Open Mode, Sea water is used as Wash water. Natural features of sea water removing sulfur dioxide are the main mechanism of Exhaust Gas Cleaning Process. In Open Mode System, Sea water is provided by Sea Water Supply Pump. The wash water coming out from the scrubber is discharged to the sea, and the water quality of discharged water is monitored through the wash water monitoring system. Sulfur dioxide eliminated exhaust gas is also monitored through a gas monitoring system.

Close Mode

- Near Port, Specified Zone
- Low Alkali Zone
- No Discharge Zone



Close Mode System

Close mode system circulates wash water in wash water tank. Wash Water passes through the Cooler via the Wash Water Pump and is supplied to the Scrubber at a constant temperature. The used wash water coming out from the scrubber is collected back into the wash water tank and reused. pH value of wash water is monitored with automatic Alkali (NaOH or MgOH) dosing control to maintain the ability to remove sulfur oxides. During the reuse process, wash water is cleaned through Wash Water Cleaning System. The wash water cleaned through the Wash Water Cleaning Unit is either re-supplied to the wash water tank, discharged, or stored in the holding tank (discharge restricted area). Sludge is generated in the water purification process of the wash water cleaning unit, and it is stored in the sludge tank. During the scrubber cleaning process, the temperature rise of the wash water is managed by the cooler.

Components



Wash Water Treatment Unit (**WATER**COMMANDER™)

Hydrocarbon and combustion products are collected in the wash water, which is circulated while operating in close mode. The Wash Water Treatment Unit which is installed to remove (purify) impurities, consists of a sludge settling tank and device that removes moisture from the sludge, for the maximum performance. A high speed coagulator using an inclined slate is applied with the precipitation device and the condensed facility of sludge contained in scrubber wash water, and this equipment is based on the fact that precipitation area has a greater effect on precipitation efficiency than duration time. The sludge, which is condensed in the settling tank, is re-condensed and the water and sludge are separated and the separated water is stored in the wash water tank and holding tank while the sludge is dehydrated again to decrease water content and minimize the amount of sludge that is discarded.



Water Monitoring System

A sample of wash water of the scrubber is collected, and the state of the wash water is monitored and analyzed through each sensor. This sensor is installed in the wash water inlet and outlet. The data continuously measured and analyzed are transferred to Main Control Panel and recorded for 18 months.



Gas Monitoring System

The gas finally exhausted through the scrubber is sampled through the Heated Sample Probe and Sample Hose, and transported to the Gas Monitoring System. It is a device to analyze, monitor and record SO₂ and CO₂ gas through the Gas Analyzer (NDIR, Non-Dispersive Infrared) by removing the moisture and impurities mixed in the gas in the pre-processing stage. It has many functions including calculation of SO₂ / CO₂ ratio, monitoring and alarm display, storing data and history, zero collection for gas analyzer, and calibration.

Certificates For Water & Gas Monitoring System



KR
Type Approved
Aug. 2018



NK
Type Approved
Feb. 2019



ABS
Type Approved
Apr. 2019



DNV-GL
Type Approved
May. 2019



LR
Type Approved
Jun. 2019

PaSOx™ Scrubber Brand Line-up

Version 3.0 of the Scrubber has been launched, upgrading the design based on the maximum gas flow depending on the ship's operating conditions. PANASIA PaSOx™ Scrubber is mainly divided into U-Type and I-Type. Depending on the configuration of main engine, aux. engine and boiler etc., U-Type is composed of Single Inlet System and Multi Inlet System respectively and I-Type is classified into Single Stream System and Combined Stream System.



New Line-up - 1

U-Type

The Footprint in U-Type Scrubber is wider in width and shorter in height than that in I-Type. In U-Type Scrubber System, each exhaust gas discharge medium (ex. main engine, aux. engine and boiler) has its own bypass line, and dry mode is not applicable. Packing is used in the inside of Scrubber.



16.5%
Footprint Down



1-80MW

Capacity	PaSOx smart V2.0		PaSOx smart V3.0		Reduction(%)	
	MW	Footprint(m ²)	Volume(m ³)	Footprint(m ²)	Volume(m ³)	Footprint(m ²)
5	9.12	70.68	7.72	51.19	15.3	27.5
10	17.68	156.46	14.65	108.52	17.1	30.6
15	26.77	261.05	21.9	176.84	18.2	32.2
20	32.9	345.45	28.44	242.34	13.5	29.8
30	50.31	593.65	42.07	397.22	16.4	33
40	66.48	851.04	55.38	562.73	16.7	33.8

I-Type

The Footprint in I-Type Scrubber is more narrow in width and higher in height than that in U-Type. In I-Type Scrubber System, Dry mode is available and Bypass Valve is not applied. And Packing is not used in the inside of Scrubber. I-Type is recommended if customers are concerned about cargo loss due to the lack of the space.



46% Volume Down



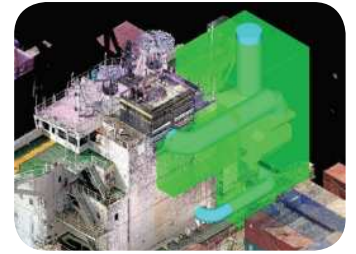
1-80MW

Capacity	PaSOx smart V2.0			PaSOx smart V3.0			Reduction(%)	
	MW	Diameter(m)	Height(m)	Volume(m ³)	Diameter(m)	Height(m)	Volume(m ³)	Height(m)
5	2.25	11.35	45.13	1.85	11.17	30.04	1.5	33.4
10	3.1	13.4	101.14	2.5	12.06	59.20	10	41.5
15	3.75	14.95	165.12	3.05	12.84	93.81	14.1	43.2
20	4.3	16.15	234.53	3.5	13.46	129.50	16.6	44.8
30	5.2	18.25	387.58	4.25	14.32	203.15	21.5	47.6
40	6	20.1	568.31	4.85	15.24	281.55	24.1	50.5

New Line-up - 2

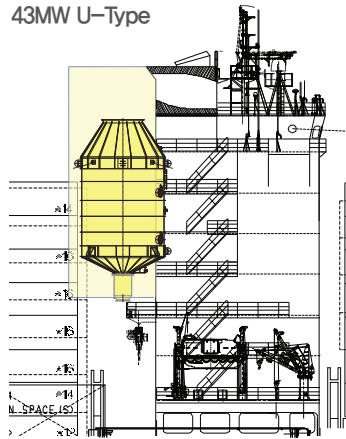
PaSOx™ smart v.SQ

It provides a perfect solution for the characteristics of each ship regardless of whether the vessel is small or large. For certain shape of ships, a square-shaped Scrubber is provided to minimize cargo loss.



7~70MW

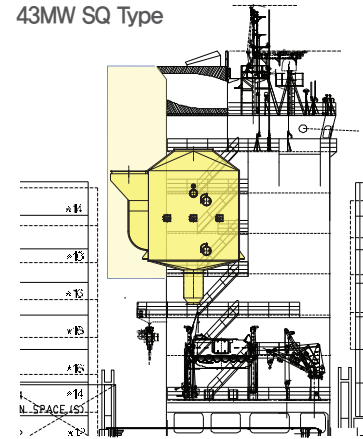
43MW U-Type



PaSOx™ smart v3.0

Footprint : 66m²

43MW SQ Type



PaSOx™ smart v.SQ

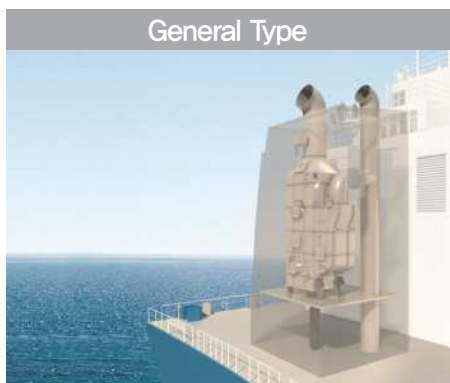
Footprint : 49.7m²

New Line-up - 3

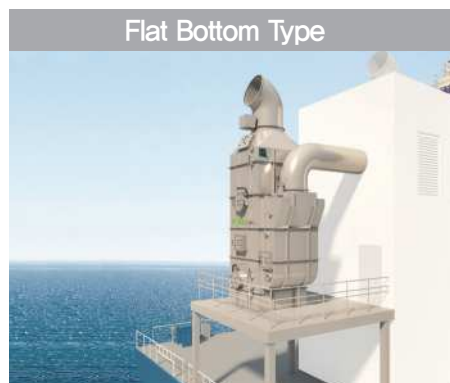
PaSOx™ smart V.MCR

Panasia Scrubber PaSOx™ V.MCR is a compact desulfurization equipment(1~6MW) for small and medium sized ships, which provides various solutions for the ship's limited installation space. It will be the best option to the regulation of sulfur oxide environment.

• Installation Application



- General method by installing a Scrubber inside the funnel
- Minimized installation space
- Can be installed on new and retrofitting ship
- Can be inspected while sailing



- Short installation period required
- Low installation cost
- Installation on weather deck
- Platform must be installed for inspection while sailing



- A package consisting of pipes, GMS, WMS, Control Panel etc., is supplied for installation
- Innovatively reduced installation period and cost
- Equipment protected from the external environment

Scrubber Body Material



**All 6 Molybdenum
Stainless Steel
UNS NO.N08367**

6 Moly Group	UNS NO.	*PREn	Max. Temp. Of Use
	N08367	48	427
	S31254	40	399

Super Duplex Group	UNS NO.	PREn	Max. Temp. Of Use
	S32750	40	315
	S32760	40	315

Duplex Group	UNS NO.	PREn	Max. Temp. Of Use
	S31803	33	300
	S32205	33	300

Stainless Steel Group	UNS NO.	PREn	Max. Temp. Of Use
	SUS316	24.9	-
	SUS304	19.8	-

* PREn : Pitting Resistance Equivalent Number



Corrosion Test Result

6 Moly for Scrubber Body



N08367 Most Competitors S31254



Green Death

Solution : Mixture of sulfuric acid, hydrochloric acid, sodium

Experiment Method : Leave for 3 days and check results

G48-C

Solution : 6% Iron Chloride

Experiment Method : Starting from 45 degrees, increase 5 degrees each, every 24 hours and examine when pitting first occurs until the temperature reaches a maximum of 85 degrees

Research & Test Apparatus (Scrubber Test Facility)



For optimum design and performance, tests are conducted by installing a hybrid of an I-type and U-type Scrubber on PANASIA's Barge ship and using HFO and sea water for simulating operating conditions of the Scrubber on an actual ship, in order to continuously increase product performance.

Test Facility Specification

Design Engine Power	400kW 4-Stroke MAN B&W 5L23/30
Max Exhaust Gas Flow	5,100kg /hr
Engine Load Control	Load Bank
Scrubber Test	<ul style="list-style-type: none"> · U-Type : Packing · I-Type: Non-Packing

PaSOx™ Case Study

PANASIA's scrubber can be tailored to suit any ship

New Building



PROJECT	STX S1763	CLASS	ABS
SHIP'S TYPE	50K MR TANKER	SCRUBBER TYPE	U-TYPE, OPEN MODE (HYBRID READY)
DESIGN BASE	MAIN ENGINE 1 SET =7.82MW AUX. ENGINE 3 SETS =1.02MW COMPOSITE BOILER 1SET=1.2T		



PROJECT	HMD H4112	CLASS	NK
SHIP'S TYPE	1,800 TEU CONTAINER	SCRUBBER TYPE	U-TYPE, OPEN MODE
DESIGN BASE	MAIN ENGINE 1 SET =11.96MW AUX. ENGINE 3 SETS =4.62MW		



PROJECT	HMD H8269	CLASS	LR
SHIP'S TYPE	38K LPG CARRIER	SCRUBBER TYPE	U-TYPE, OPEN MODE
DESIGN BASE	MAIN ENGINE 1 SET =6.39MW AUX. ENGINE 2 SETS =0.9MW BOILER 1 SET =3T		



PROJECT	SCT0001	CLASS	KR
SHIP'S TYPE	6.6K OIL & CHEMICAL TANKER	SCRUBBER TYPE	U-TYPE, OPEN MODE
DESIGN BASE	MAIN ENGINE 1 SET =3.3MW AUX. ENGINE 3 SETS =0.61MW BOILER 1 SET =6T		



PROJECT	HSHI H8004	CLASS	KR
SHIP'S TYPE	325K VLOC	SCRUBBER TYPE	U-TYPE, OPEN MODE (HYBRID READY)
DESIGN BASE	MAIN ENGINE 1 SET =21MW AUX. ENGINE 1 SETS =1.67MW		



Retrofit



PROJECT	LEANNE	CLASS	DNV_GL
SHIP'S TYPE	19,000 TEU CONTAINER	SCRUBBER TYPE	I-TYPE, HYBRID MODE
DESIGN BASE	MAIN ENGINE 1 SET =60.85MW AUX. ENGINE 2 SETS =4.5MW, AUX. ENGINE 2 SETS = 4MW, BOILER 1 SET =6.27		



PROJECT	TACOMA	CLASS	KR
SHIP'S TYPE	6,350 TEU CONTAINER	SCRUBBER TYPE	U-TYPE, OPEN MODE
DESIGN BASE	MAIN ENGINE 1 SET =62.92MW AUX. ENGINE 4 SETS =2.64MW		



PROJECT	TAMARA	CLASS	ABS
SHIP'S TYPE	SUEZMAX TANKER	SCRUBBER TYPE	U-TYPE, OPEN MODE
DESIGN BASE	MAIN ENGINE 1 SET =16.86MW AUX. ENGINE 3 SETS =2.82MW		



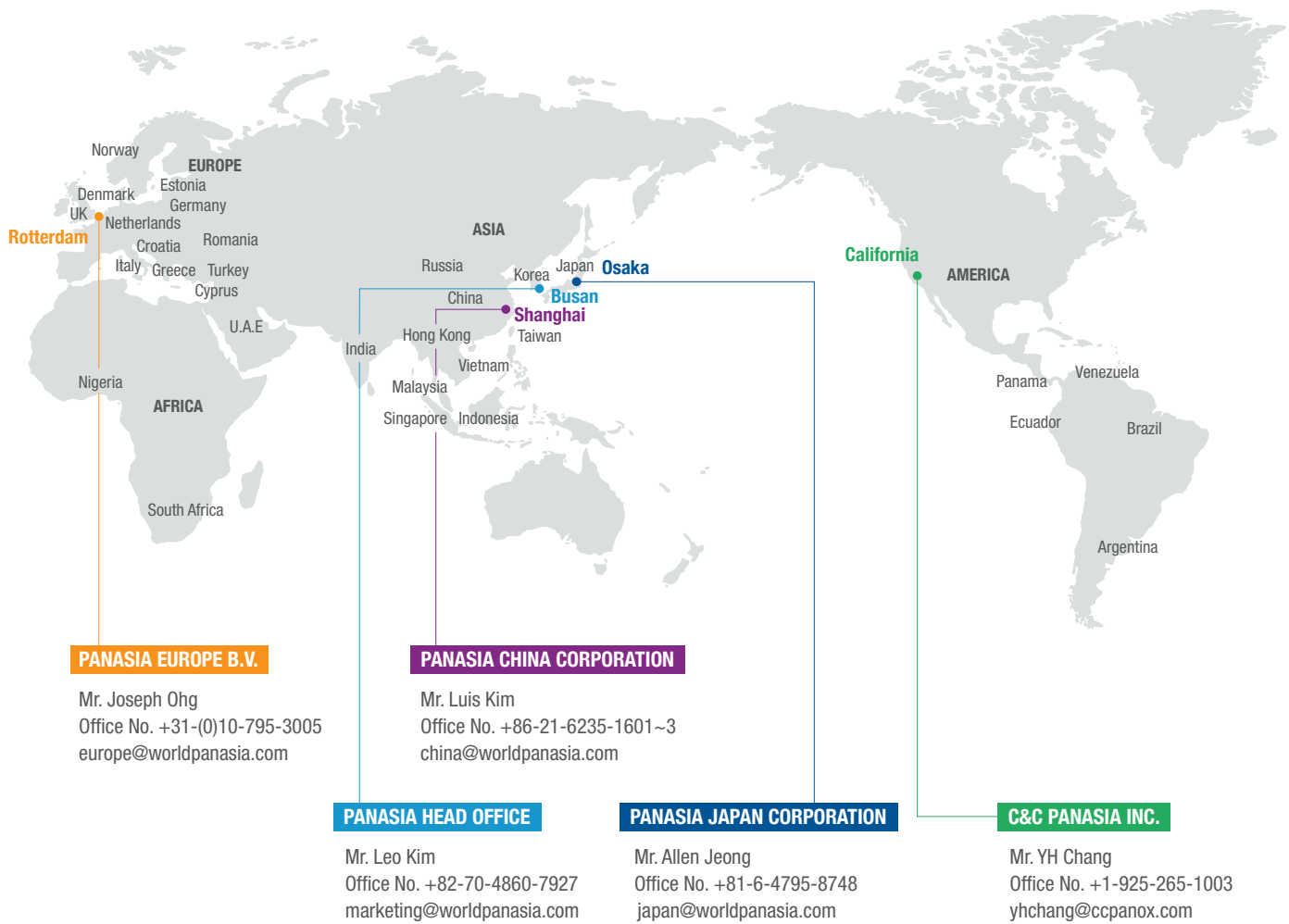
PROJECT	HL-SINES	CLASS	NK
SHIP'S TYPE	180K BULKER	SCRUBBER TYPE	U-TYPE, OPEN MODE
DESIGN BASE	MAIN ENGINE 1 SET =18.66MW AUX. ENGINE 3 SETS =0.8MW		



PROJECT	SALDANHA	CLASS	NK
SHIP'S TYPE	76K BULKER	SCRUBBER TYPE	U-TYPE, OPEN MODE
DESIGN BASE	MAIN ENGINE 1 SET =8.97MW AUX. ENGINE 1 SET =0.45MW		

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