De-SOx SYSTEM

PaSOx™ smart V2.0

ENGLISH

PANASIA

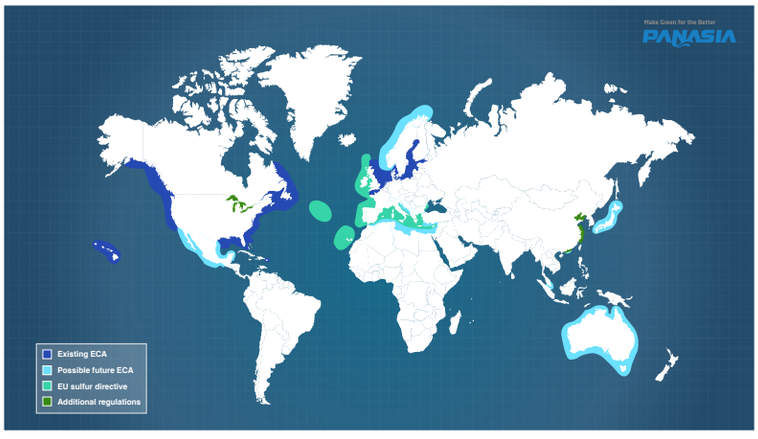
Desulfurization System for Ships

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.

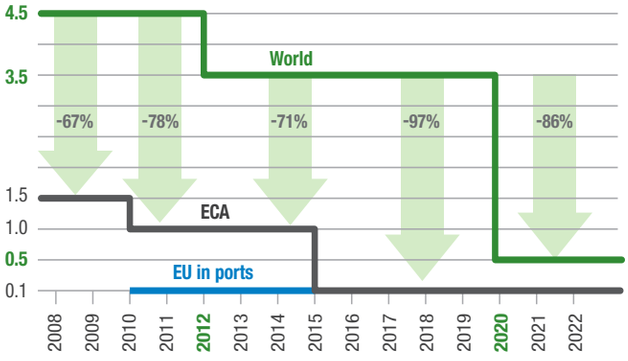
Emission Control Area

- 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 and 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

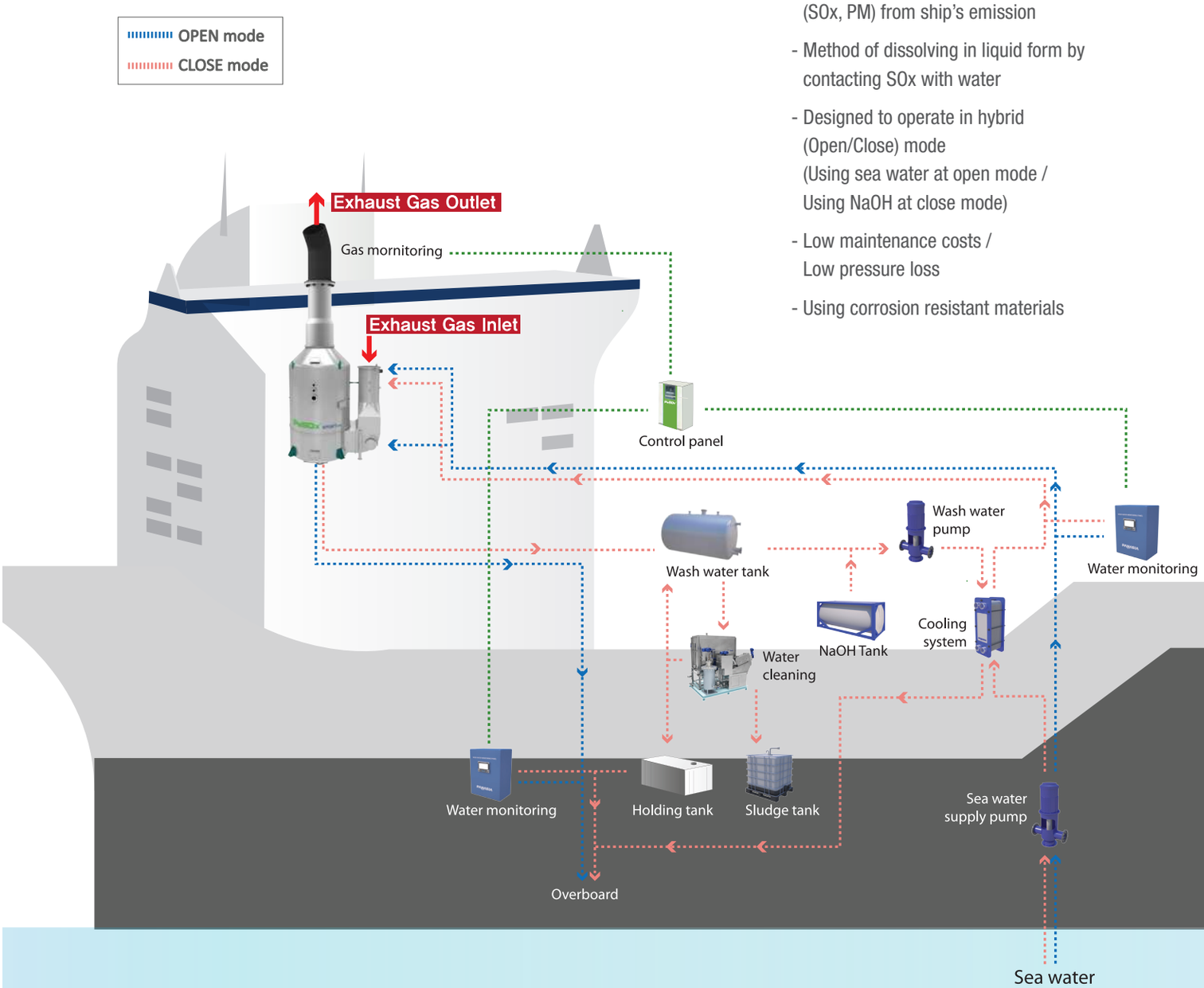
Table 1: Fuel oil sulphur limits recorded in regulations 14.1 and 14.4 and corresponding emissions values

- **Target**
  All ship fuel oil used by main and sub equipments (including boiler and generator) as defined in Regulation 2.9
- **Purpose**
  Set meximum 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.

Over view 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

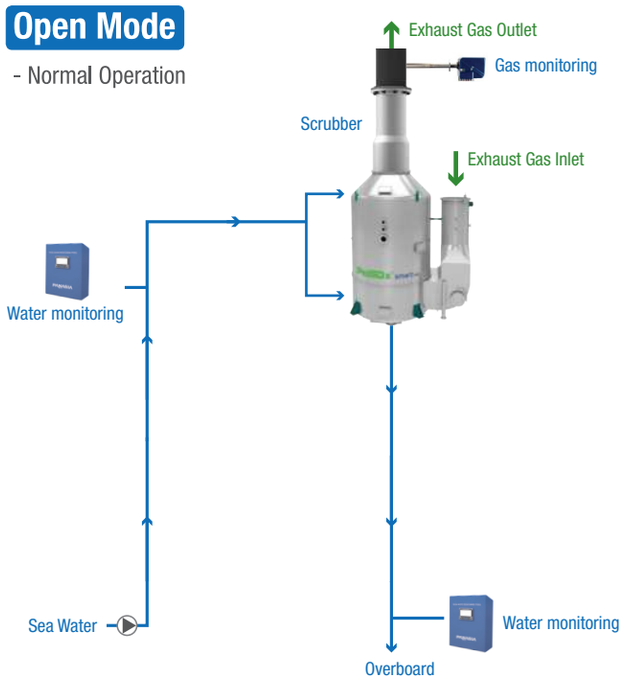


System Diagram

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

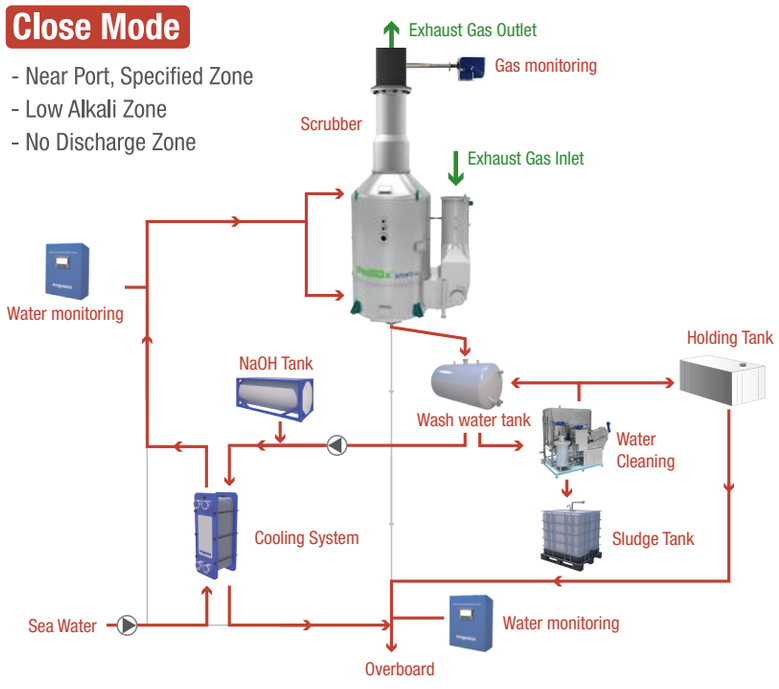


Open mode System

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 is supplied to the scrubber by the wash water pump through the cooler. 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) 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.

PaSOx™ Scrubber Types

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.

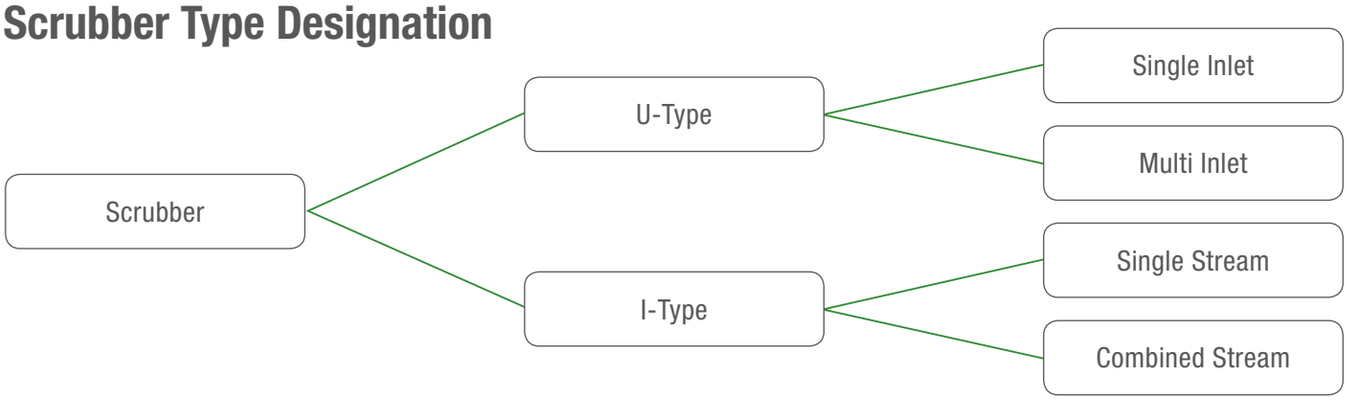
U-Type

The Foot Print 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.

I-Type

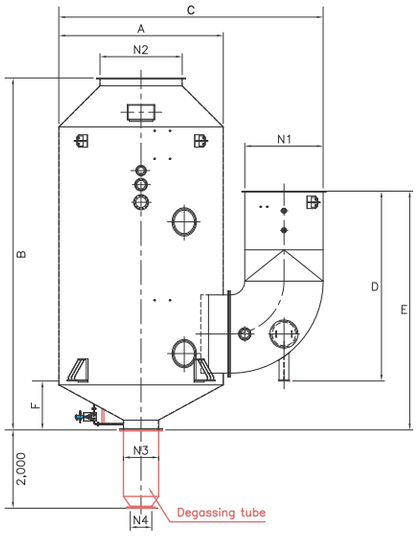
The Foot Print in I–Type Scrubber is more narrow in width and higher in height than that in U-Type. In I–Type Scrubber System, Dry mode is available and Bypass Valve is not applied. And Packing is not used in the inside of Scrubber. I-Type is recommended when there is no enough space for Bypass line in Funnel and the difference in the total gas exhaust flow of the combustion engine is not significant.

Scrubber Type Designation



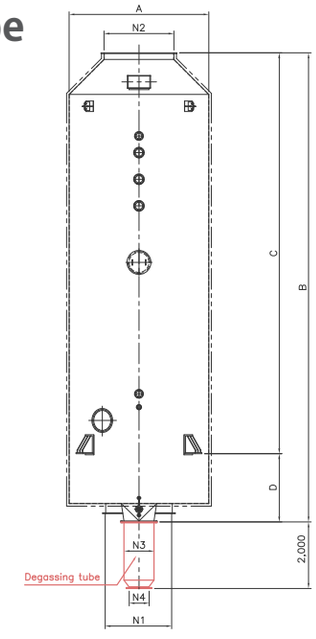
Scrubber Line-up

U-Type



U-TYPE		5 MW	10 MW	15 MW	20 MW	25 MW	30 MW	40 MW
	EXHAUST GAS MASS FLOW (kg/s)	10.52	21.05	31.57	42.09	52.61	63.14	84.18
A	SCRUBBER DIAMETER (mm)	2,200	3,100	3,800	4,350	4,900	5,350	6,150
B	ABSORBER HIGHT (mm)	7,450	8,300	9,150	9,650	10,300	10,850	11,700
C	LENGTH (mm)	3,600	4,600	5,600	6,300	7,000	7,700	8,800
D	GAS INLET HIGHT (mm)	4,500	5,050	5,500	5,800	6,150	6,500	7,000
E	PRE ABSORBER HIGHT (mm)	5,275	5,950	6,600	7,000	7,500	7,975	8,650
F	SUPPORT DISTANCE (mm)	775	900	1,100	1,200	1,350	1,475	1,650
N1	GAS IN (mm)	850	1,200	1,500	1,700	1,900	2,100	2,400
N2	GAS OUT (mm)	1,050	1,500	1,800	2,100	2,300	2,550	2,950
N3	ABSORBER DRAIN (mm)	450	650	800	900	1,000	1,100	1,250
N4	DRAIN CONNECTION (mm)	300	400	500	600	650	700	800
	DRY Weight (kg)	5,153	8,943	14,477	19,262	24,235	32,339	42,702
	WET Weight (kg)	5,668	9,837	15,925	21,188	26,659	35,573	46,972

I-Type

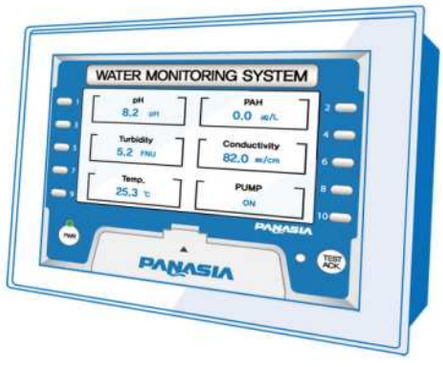


I-TYPE		5 MW	10 MW	15 MW	20 MW	25 MW	30 MW	40 MW
	EXHAUST GAS MASS FLOW (kg/s)	11	21	32	42	53	63	84
A	SCRUBBER DIAMETER (mm)	2,000	2,800	3,400	4,000	4,450	4,900	5,600
B	ABSORBER HIGHT (mm)	10,500	11,700	12,850	13,650	14,500	15,150	16,350
C	GAS OUTLET HIGHT (mm)	9,150	9,800	10,550	10,950	11,500	11,850	12,600
D	SUPPORT DISTANCE (mm)	1,350	1,900	2,300	2,700	3,000	3,300	3,750
N1	GAS IN (mm)	850	1,200	1,500	1,700	1,900	2,100	2,400
N2	GAS OUT (mm)	1,050	1,500	1,800	2,100	2,300	2,550	2,950
N3	ABSORBER DRAIN (mm)	500	700	900	1,000	1,150	1,250	1,400
N4	DRAIN CONNECTION (mm)	350	450	550	650	700	800	900
	DRY Weight (kg)	4,869	7,961	13,151	16,001	19,790	26,299	33,703
	WET Weight (kg)	5,356	8,757	14,466	17,601	21,769	28,929	37,073

Components

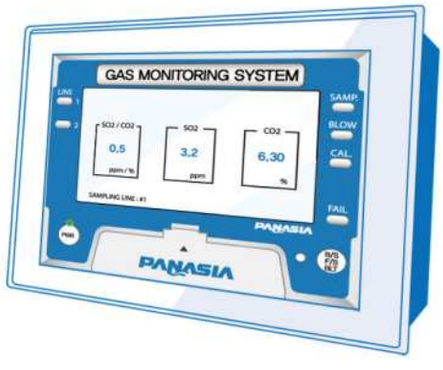
PAN-CROSSFLOW Filter System
(Wash Water Cleaning System)

Hydrocarbon and combustion products are collected in the wash water, which is circulated while operating in close mode. In order to remove (clean) such impurities, the wash water cleaning system is composed of a combination of a sludge settling tank, filter, and sludge dehydrator to achieve optimum 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 filter promotes the safety of the system by applying the method of the cross-flow type and it minimizes the area of installation by securing the maximum cross section area of limited space through wrinkling phenomenon of the filter. This device is also system for maintenance by applying the automatic back flushing features. The sludge, which is condensed in the settling tank, is re-condensed and the water and sludge are separated and the separated water is divided to 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 stored for 18 months.

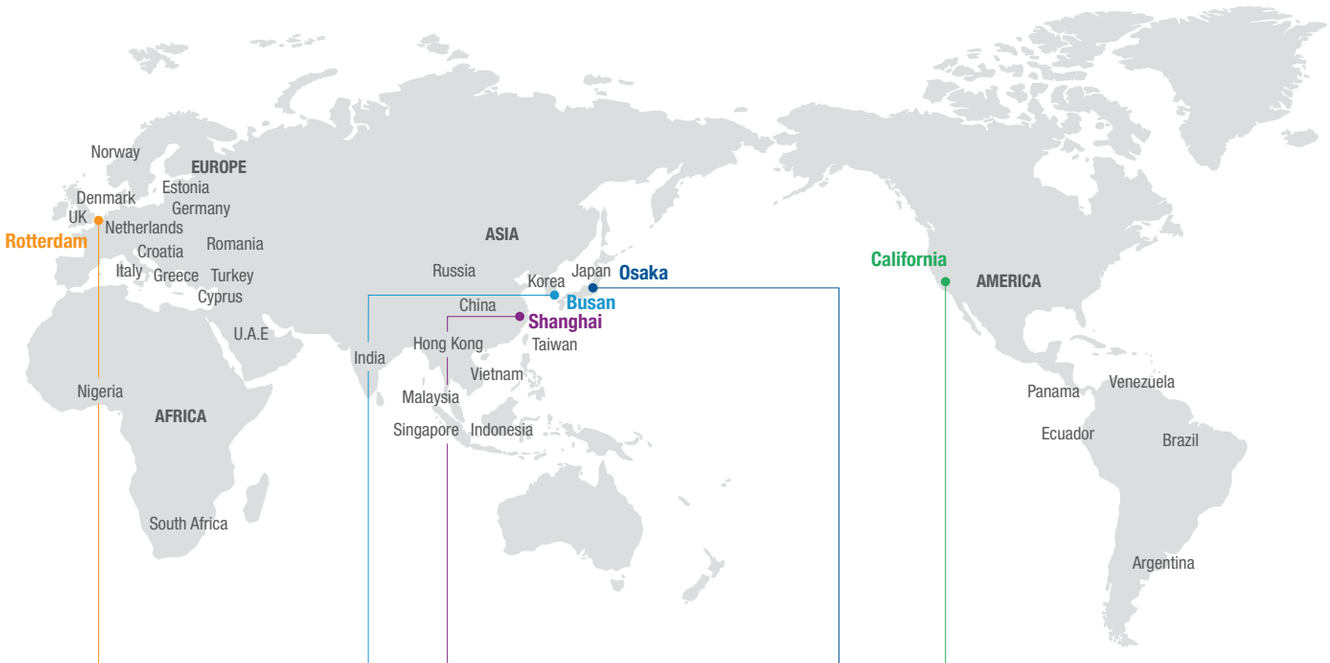


Gas Monitoring System

The gas finally exhausted through the scrubber is sampled through the Heated Sample Probe and Sample Hose, and transported to the Gas Conditioning System. It is a device to analyze, monitor and record SO_2 and CO_2 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 SO_2 / CO_2 ratio, monitoring and alarm display, storing data and history, zero collection for gas analyzer, and calibration.

Worldwide Service Network

Effective Follow-up Service, Prompt Action for Spare Parts



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