

Particulate Emission Characteristic of Two Stroke Marine Diesel Engine

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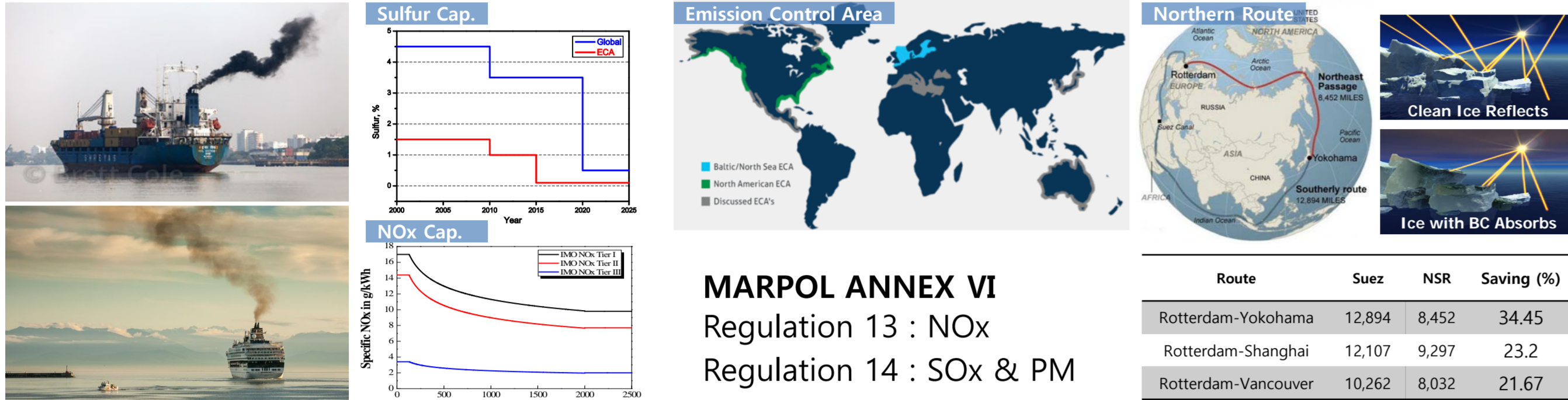
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Introduction

Background

- IMO(International Maritime Organization) restricted discharging ship's harmful substances to sea by 73/78 MARPOL Convention(International Convention for the prevention of Pollution from ship)
- The Main air pollutants emitted from ships are regulated by ANNEX VI(Reg.12 ~ 15)



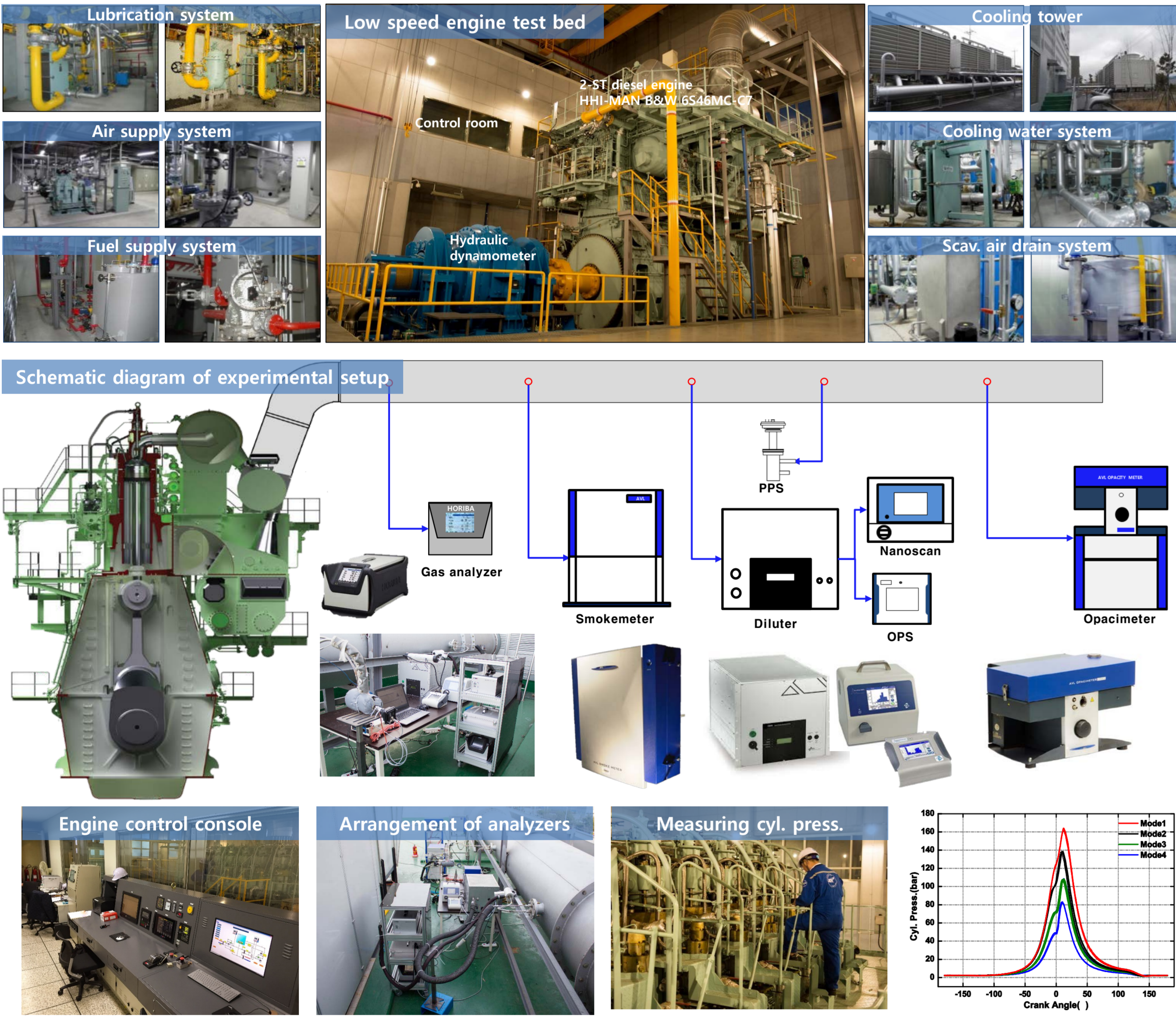
- MEPC of IMO is progressing to adapt regulation to reduce particulate emission(especially BC; Black Carbon)
 - IMO approved the definition of Black Carbon for international shipping
- * BC is Distinct type of carbonaceous material, formed only in flames during combustion of carbon-based fuels.
- Strongly absorbs visible light with a mass absorption cross section of at least 5m²g⁻¹ at a wavelength of 550 nm;
 - Is refractory; that is retains its basic form at very high temperatures, with vaporization temperature near 4,000 K;
 - Is insoluble in water, in organic solvents including methanol and acetone, and in other components of atmospheric aerosol; and
 - Exists as an aggregate of small carbon spherules.
- (Refer: Bond et al. definition)

Objectives

- Measurement methods are different depending on the physical properties of the black carbon.
- This study can give an information on data of BC measurement with various methods for identifying the most appropriate measurement methods.

Experiment

Experimental setup



Engine specifications

Item	Specifications
Engine type	2 Stroke, X-Head, T/C
Rating output [kW/rpm]	7400/129
Displacement [cc]	14,618
Cyl. Number - bore x stroke [mm]	6 - 460 x 1932
Max. fuel consumption [kg/h]	1393

Fuel properties

Property	Method	Result
Density @ 15°C [kg/m ³]	ISO 12185	912.2
Viscosity at 40°C [mm ² /s]	ISO 3104	6.802
Sulfur [% (m/m)]	ISO 8754	0.28
Water content [% (v/v)]	ISO 3733	< 0.05
LHV [kcal/kg]	ASTM D240	9953

Measurement methods

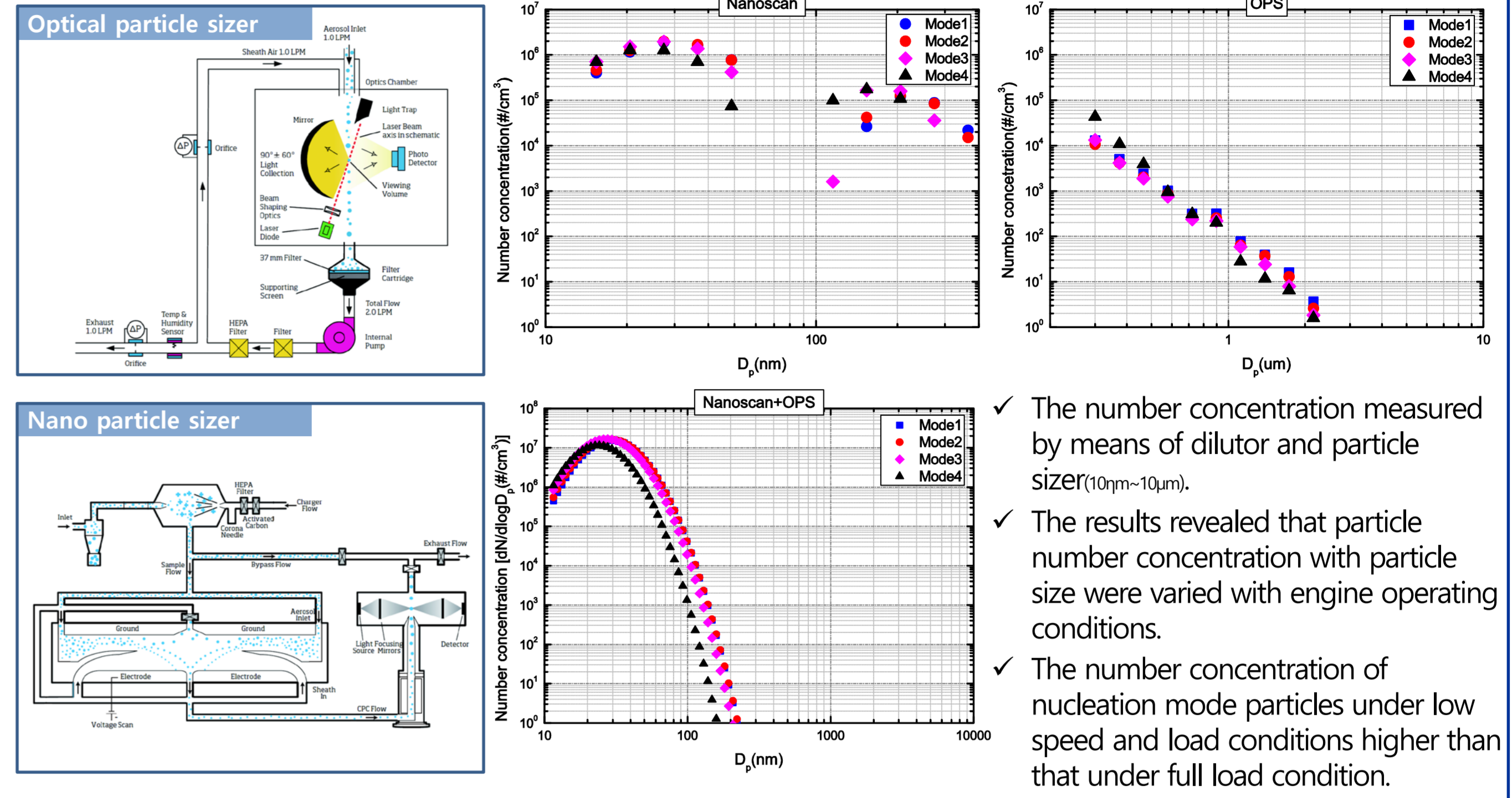
Measurement method	Physical properties of Black Carbon (defined by bond et al.)				Dilution required
	Light absorption	Refractory	Insolubility	Morphology	
Filter smoke number (FSN)	○				
Photo-acoustic spectrometry (PAS)	○				○
Multi Angle Absorption photometry	○				○
Laser Induced Incandescence (LII)	○	○			○
Opacity	○				
Particle number					○

Experimental Conditions

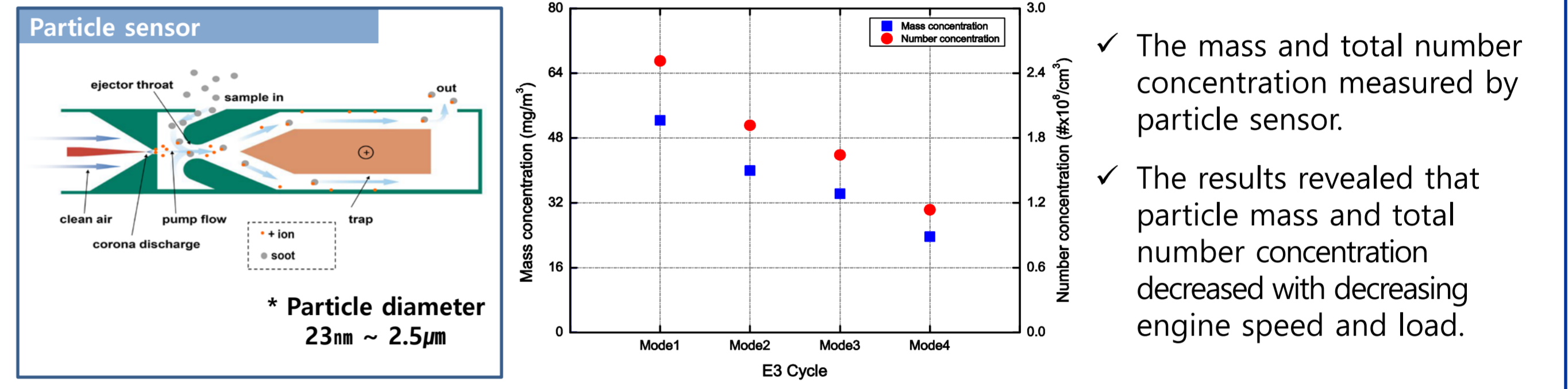
Test cycle				
Cycle	E3 cycle			
Power [%]	100	75	50	25
Speed [%]	100	91	80	63
Weighting Factor	0.2	0.5	0.15	0.15
6S46MC-C7				
Power [kW]	7,400	5,550	3,700	1,850
Speed [rpm]	129.0	117.2	102.4	81.3
Torque [kNm]	547.8	452.2	345.0	217.3
Mode	1	2	3	4

Results

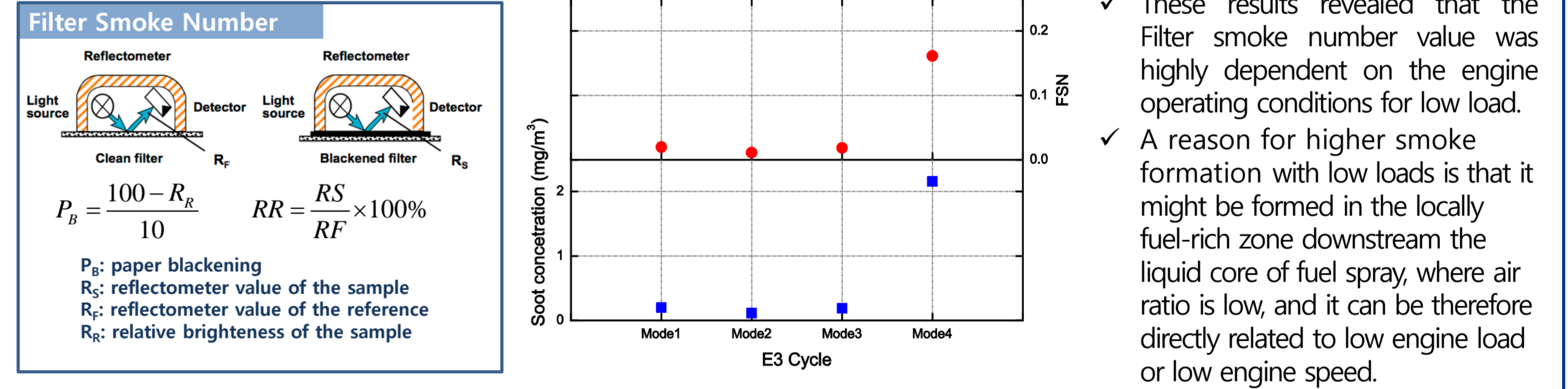
Number concentration



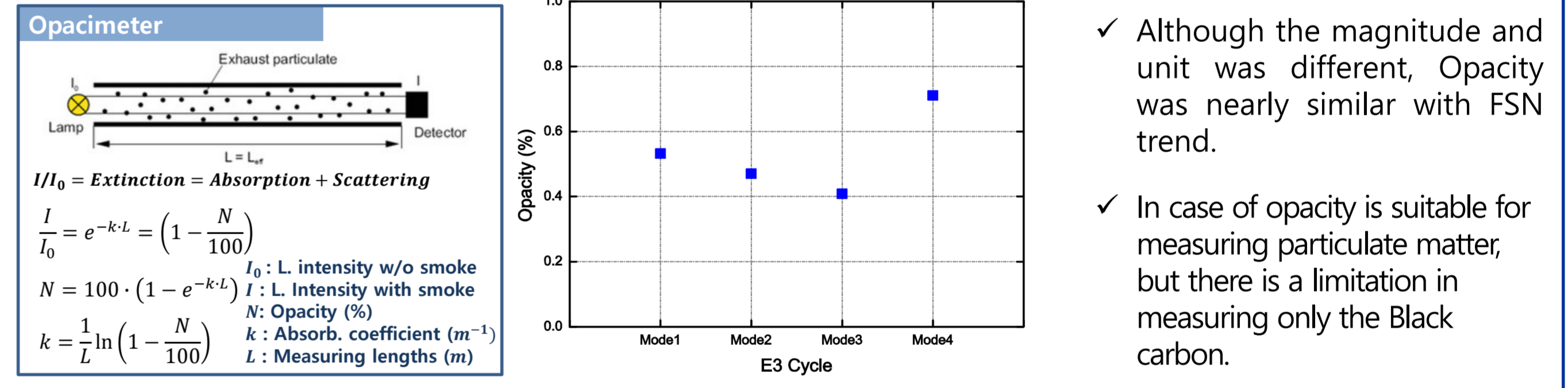
Mass & Total number concentration



Soot concentration & FSN



Opacity



Summary

- Analysis on characteristics of black carbon emission emitted from marine engine is different depending on the measurement methods of black carbon. Also the unit of measurement value vary depending on measurement methods.
 - There is need to select the representative measurement method for analysis on characteristics of black carbon emission like CLD method for measuring NOx emission by IMO. To do that IMO gathers data of black carbon measuring results on various ships and engine test bed.
 - Before seleting the representative measurement method, there is need to compare to the results with measurement methods and measurement results on any fuels, experimental conditions and engine characteristics(type, purpose and etc.,).
- * Acknowledgements: This study has been funded by the Ministry of Oceans and Fisheries of KOREA. Also this study is conducting in government project "Quantitative assessment for PM&BC to climate change and development of reduction technology for PM, BC from ships.

Future Work

