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THE INTERNATIONAL COUNCIL ON COMBUSTION ENGINES

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Agenda

1. Comparison of Emission Legislations
2. Analysis of Technical solutions and Cost
3. Suggestions

Emission Standards Compare

Stage 1

- Emission standard (draft) stage I from MOT will be implemented in 2016.

Stage I (2016.1.1) (Numbers in '()' represent emission of gas engine) .

Nominal Power PN (kW)	NOx (g/kWh)	CO (g/kWh)	HC (g/kWh)	PM (g/kWh)
37 ≤ PN <75	8	5(8)	1.3(10)	0.4
75 ≤ PN <130	7	5(8)	1(8)	0.3
130 ≤ PN <560	7	3.5(6)	1(8)	0.2
PN ≥ 560	n≥3150, =7.0 343≤n<3150, =45×n^(-0.2)-2 n<343, =12	3.5(6)	1(8)	0.2

speed	NOx (g/kW.h)
350	11.94
750	9.97
1150	8.99
1750	8.11
2150	7.70
3150	7.00

- Ship engine exhaust emission limits and measurement methods (draft for comment) stage I from MEP will be implemented in 2017.

Stage I(2017.1.1), (For NG engine, we use NMHC instead of HC) .

ship engine type	Displacement per cylinder SV (L/cylinder)	Net power (kW)	CO (g/kWh)	HC+NOx (g/kWh)	PM (g/kWh)
Type 2	SV<0.9	P≥37	5	7.5	0.4
	0.9≤SV<1.2		5	7.2	0.3
	1.2≤SV<5		5	7.2	0.2
Type 2	5≤SV<15		5	7.8	0.27
	15≤SV<20	P<3300	5	8.7	0.5
		P≥3300	5	9.8	0.5
	20≤SV<25		5	9.8	0.5
	25≤SV<30		5	11	0.5

Small Gap between two standards for Stage 1

Emission Standards Compare

Stage 2

- Emission standard (draft) stage Ⅱ from MOT will be implemented in 2020.

Stage II (2020.1.1) (Numbers in '()' represent emission of gas engine)

Nominal Power PN (kW)	NOx (g/kWh)	CO (g/kWh)	HC (g/kWh)	PM (g/kWh)
37 ≤ PN <75	3.3	2.5	0.19(3)	0.025
75 ≤ PN <130	2	2.5	0.19(2)	0.025
130 ≤ PN <560	2	1	0.19(2)	0.025
PN ≥ 560	n≥3150, =2.0 343≤n<3150, =45×n^(-0.2)-7 n<343, =7.0	1	0.4(2)	0.1

speed	NOx (g/kW.h)
350	6.94
750	4.97
1150	3.99
1550	3.35
1950	2.89
2350	2.53
3150	2.00

- Ship engine emission limits and measurement methods from MEP (draft for comment) stage Ⅱ will be implemented in 2020.

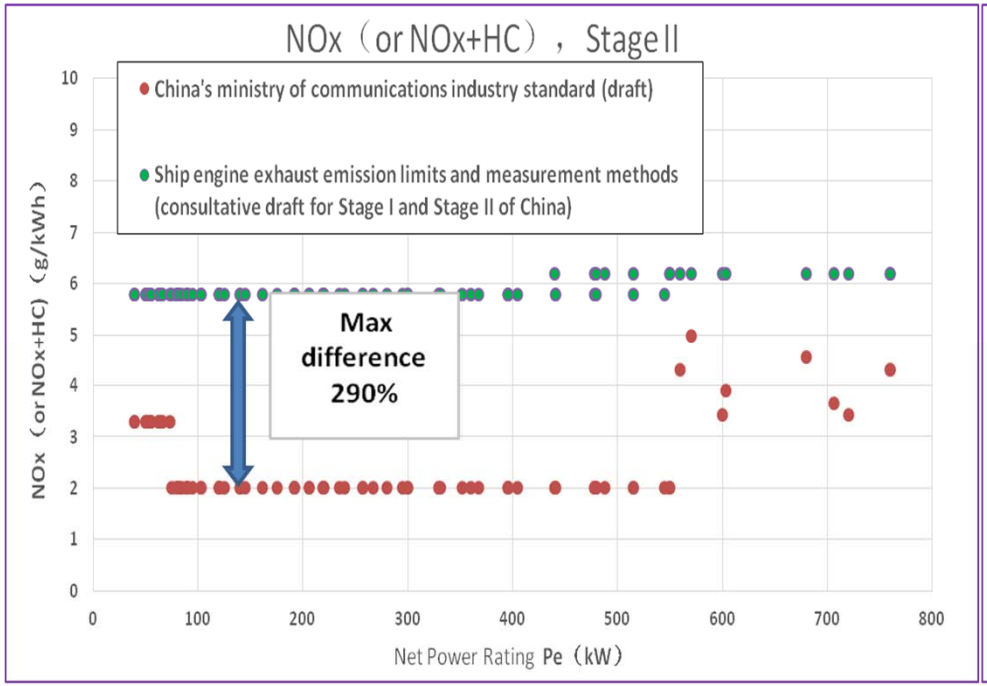
Stage 2(2020.1.1), (For NG engine, we can choose NMHC instead of HC)。

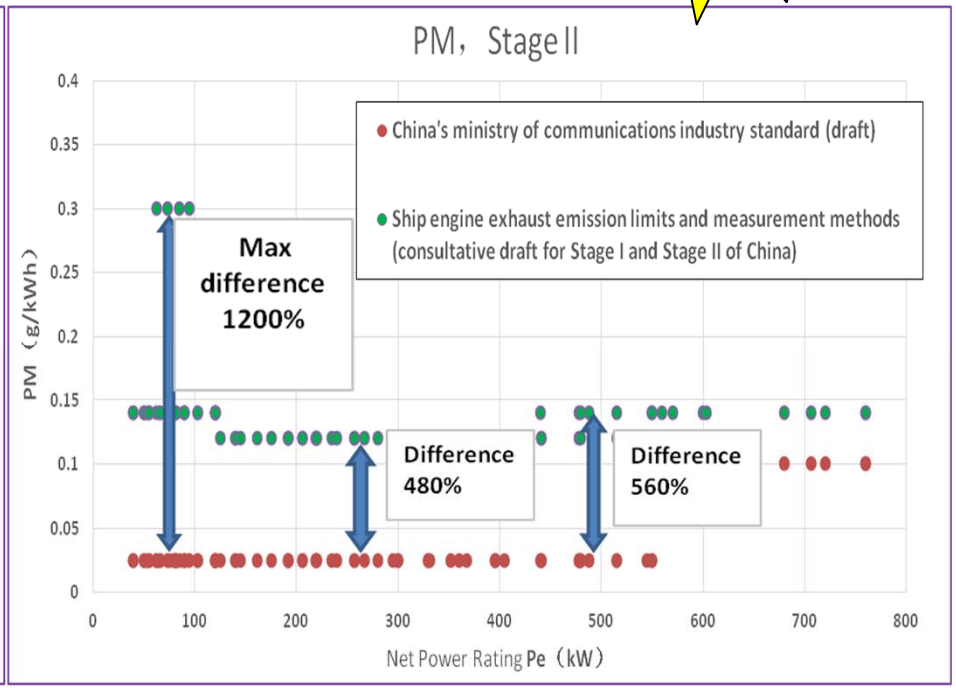
ship engine type	Displacement per cylinder SV (L/cylinder)	Net power (kW)	CO (g/kWh)	HC+NOx (g/kWh)	PM (g/kWh)
Type 1	SV<0.9	P≥37	5	5.8	0.3
	0.9≤SV<1.2		5	5.8	0.14
	1.2≤SV<5		5	5.8	0.12
Type 2	5≤SV<15	P<2000	5	6.2	0.14
		2000≥P<3700	5	7.8	0.14
		P≥3700	5	7.8	0.27
	15≤SV<20	P<2000	5	7	0.34
		2000≥P<3300	5	8.7	0.5
		P≥3300	5	9.8	0.5
	20≤SV<25	P<2000	5	9.8	0.27
		P≥2000	5	9.8	0.5
	25≤SV<30	P<2000	5	11	0.27
		P≥2000	5	11	0.5

Very Big Gap between two standards for Stage 2

Stage 2

Emission Standards Compare



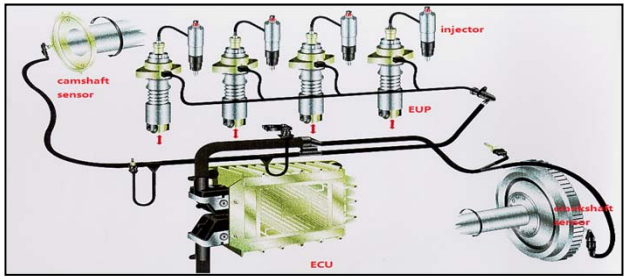


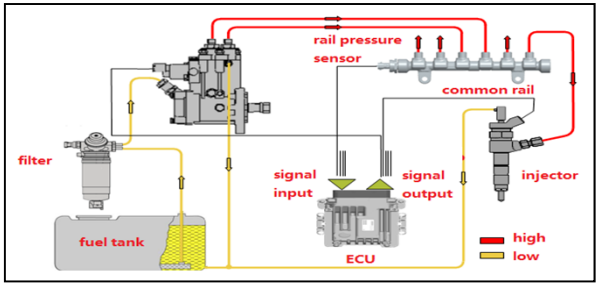
1. NOx (+HC): MEP STD is about 290% of MOT STD
2. PM: MEP STD is about 1200% of MOT STD.
3. In summary: MOT STD is more strict. It will cause a large impact on technology solutions for different Standards.

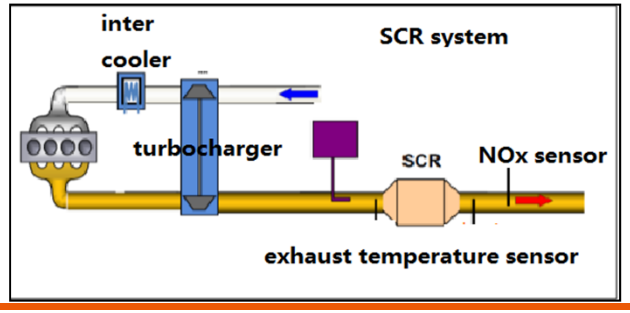
Question: Which legislation should be the mandatory regulations?

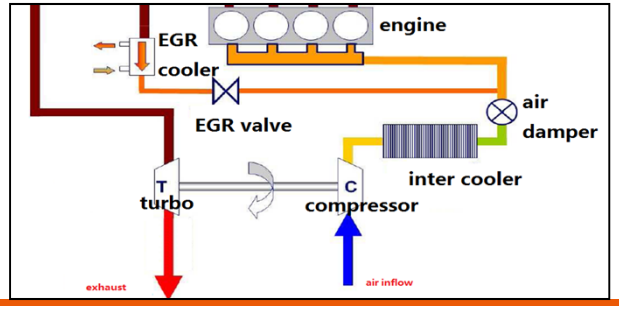
Analysis of technical solutions

Standard	Stage Ⅰ	Stage Ⅱ
MOT	Mechanical FIE	EGR + CRS/EUP（>1400bar）
		SCR + CRS/EUP（≈1400bar）
MEP	Mechanical FIE	CRS/EUP
		CRS/EUP









Analysis based on MOT STD stage Ⅱ vs. Stage Ⅰ for diesel engines

Power PN（kW）	Technical solution （diesel engine）	Fuel Consumption	Reliability	Fuel Sensitivity	Convenience	Maintainance	cost
37 ≤ PN ＜ 75	EGR + Electronic Pump（>1400bar)	+	-	+	0	0	+
	SCR + Electronic Pump （≈1400bar）	0	0	++	-	0	++
75 ≤ PN ＜ 130	EGR + Electronic Pump（>1400bar)	+	-	+	0	0	+
	SCR + Electronic Pump （≈1400bar）	0	0	++	-	0	+
130 ≤ PN ＜560	EGR + Electronic Pump（>1400bar)	+	-	+	0	0	+
	SCR + Electronic Pump （≈1400bar）	0	0	++	-	0	+
PN ≥ 560	EGR + Electronic Pump（>1400bar)	+	-	+	0	0	++
	SCR + Electronic Pump （≈1400bar）	0	0	++	-	0	++++

Notes: “+” means increase, “-” means decrease, “0” means equal

Analysis based on MEP STD stage Ⅱ vs. Stage Ⅰ for diesel engines

engine type	SV	Net Power PN（kW）	Technical Solution	Fuel Consumption	Reliability	Fuel Sensitivity	Convenience	Maintenance	Cost
Type 1	SV＜0.9	P≥37	EUP / CRS	0	+	+	+	0	+
	0.9≤SV＜1.2		EUP / CRS	0	+	+	+	0	+
	1.2≤SV＜5		EUP / CRS	0	+	+	+	0	+
Type 2	5≤SV＜15	P＜2000	EUP / CRS	0	+	+	+	0	+++
		2000≥P＜3700	EUP / CRS	0	+	+	+	0	+++

Notes: “+” means increase, “-” means decrease, “0” means equal

Suggestions

1. MOT and MEP should discuss with each other and try to achieve consensus out of conflict.
2. MOT stage II is more strict and better for environment protection. But it will vastly increase the cost.
3. The government should find a trade-off solution for environment and cost, otherwise it will not be accepted by end customers.
4. Both the FIE system and aftertreatment are sensitive to fuel quality. To meet the emission requirement, fuel quality should be guaranteed.

Thank you for your attention!