POLICY UPDATE

MARCH 2017

MARINE ENGINE EMISSION STANDARDS FOR CHINA'S DOMESTIC VESSELS

ICCT **POLICY UPDATES** SUMMARIZE REGULATORY AND OTHER DEVELOPMENTS RELATED TO CLEAN TRANSPORTATION WORLDWIDE.

On August 30, 2016, China's Ministry of Environmental Protection (MEP) and the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) jointly released the first-ever national emission standards for marine engines used in domestic shipping in China.[1] Phase I standards will take effect on July 1, 2018, and stricter Phase II standards will take effect on July 1, 2021.

The standards apply to marine engines rated at or above 37 kW but with no more than 30 L/cylinder of displacement. Affected vessel types include ships navigating in inland waterways and coastal waters; those used for emergency and rescue purposes are exempt.

China's MEP estimated that the Phase I engine standards will cut particulate matter (PM) emissions from marine engines by 70% and nitrogen oxide (NO_X) emissions by more than 20%, and Phase II engine standards will provide additional reductions of 40% and 20% for PM and NO_X, respectively.[2]

If all river ships use regular diesel (10 ppm sulfur content) and all coastal ships use low-sulfur fuel (less than 5,000 ppm sulfur content) during Phase I, sulfur oxide (SO_X) emissions could be cut by 540,000 tonnes per year and PM by 40,000 tonnes per year. Subsequently, if all coastal ships use fuel with less than 1,000 ppm sulfur content during Phase II, emissions will be further reduced by 110,000 and 10,000 tonnes per year for SO_X and PM, respectively.

1 China's Ministry of Environmental Protection. (2016, August). Limits and measurement methods for exhaust pollutants for marine engines (China I, II) (GB15097-2016). Retrieved from http://kjs.mep.gov.cn/hjbhbz/bzwb/dqhjbh/dqydywrwpfbz/201608/W020160830363480359441.pdf, hereafter referred to as "marine engine standards."

2 China's Ministry of Environment. Explanation of the new marine engine standards. Accessed November 15, 2016, at http://www.mep.gov.cn/xxgk/zcfgjd/201608/t20160830_363308.shtml

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BACKGROUND

SHIPPING IN CHINA

Among the world's 10 leading container ports, seven are located in China, altogether handling about one quarter of world container throughput in 2015.[3] China's inland and coastal waters are comparably busy. In 2015, 152,500 river vessels and 10,721 coastal vessels moved 3.75 trillion tonne-kilometers (tkm) of freight[4] through Chinese waters, not including the country's large fleet of 694,900 motorized fishing vessels.[5] For context, in 2016, the global oceangoing fleet consisted of about 116,000 vessels[6] moving about 99.2 trillion tkm of freight in 2015, according to the United Nations Conference on Trade and Development.

AIR POLLUTION FROM MARINE ENGINES

Marine engines are designed to use dirtier fuels (Figure 1) and therefore emit much more SO_X and PM than on-road diesels. Diesel engines, in general, also emit large amounts of NO_X because of their high combustion temperatures relative to other engines.

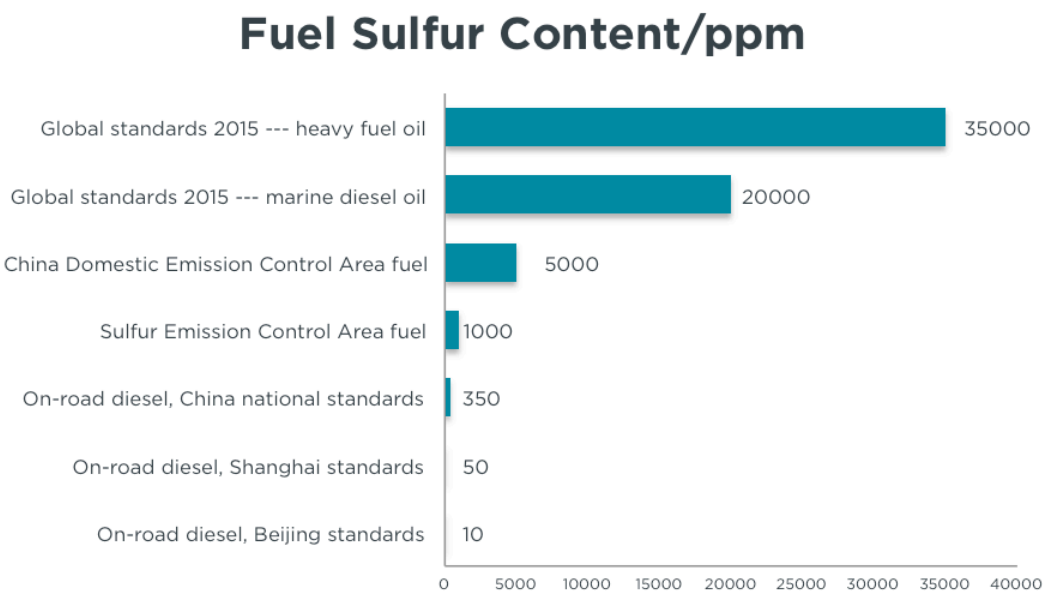

Figure 1. Fuel sulfur requirements of various policies (the Domestic Emission Control Area was designated by China Ministry of Transport to control ship emissions[7]).

3 United Nations Conference on Trade and Development. (2015). Review of Maritime Transport 2015. Retrieved from http://unctad.org/en/PublicationsLibrary/rmt2016_en.pdf

4 Ministry of Transport of the People's Republic of China. (2016). 2015 Transport Industry Statistical Communiqué. Retrieved from http://zizhan.mot.gov.cn/zfxxgk/bnssj/zhghs/201605/t20160506_2024006.html

5 Ministry of Agriculture of the People's Republic of China. (2014). Year book of China fishery 2014. Retrieved from http://www.cafs.ac.cn:81/fishpdf/2014.pdf

6 Data purchased from IHS Global Inc. IHS provides commercial access to its IHS Maritime World Register of Ships, one of the most comprehensive global ship databases.

7 International Council on Clean Transportation. (2016). Action plan for establishing ship emission control zones in China. Retrieved from http://www.theicct.org/establishing-ship-ECZs-in-china

According to MEP, in 2013, approximately 8.4% of SO_x emissions and 11.3% of NO_x emissions in China came from marine engines.[8] Ship emissions are making a much greater contribution to local air pollution in port cities. For example, in 2014 in Hong Kong, around 33% of NO_x and 44% of SO_x emissions were attributed to navigation.[9]

Emissions from domestic shipping have been less studied than those from international shipping, especially in China. A recent emission inventory conducted at the Port of Shanghai estimated that river vessels and coastal vessels together contributed nearly 15% of SO_x emissions and 55% of NO_x emissions from all ships entering the port.[10] Another recent study in the Pearl River Delta region attributed 32% of SO_x emissions and 42% NO_x emissions to those inland and coastal vessels.[11]

CURRENT EMISSION REGULATIONS FOR SHIP ENGINES AND FUELS

There are currently two levels of regulations available to control air emissions from ships. The International Maritime Organization (IMO)—the United Nation specialized agency that regulates international shipping—sets global regulations on air emissions from ships in the International Convention for the Prevention of Pollution from Ships (MARPOL).[12] All nations that have ratified a MARPOL annex are legally bound to its requirements. Under MARPOL Annex VI, the global sulfur cap is currently set at 3.50% and will be reduced to 0.50%, effective from January 1, 2020.[13] MARPOL Annex VI also sets marine engine NO_x emission limits by tiers.[14] Generally speaking, the IMO sets the highest allowable NO_x emissions for larger (greater than 130 kW) engines on oceangoing vessels, with each country given discretion to set its national standards equivalent to the IMO standards or make them more stringent. However, emission limits of other pollutants from engine exhausts are not regulated by IMO so far.

Because China ratified MARPOL Annex VI, prior to these new standards, IMO NO_x standards apply to Chinese flagged oceangoing vessels and foreign flagged vessels operating within Chinese waters. In the United States, federal regulations apply to U.S.-flagged in-use and new marine compression-ignition engines and vessels.[15] The EU regulates emissions from non-road mobile machinery under Directive 97/68/EC as amended,[16] which sets four stages of emission levels phased in from 1998 to 2014. Stage III standards introduced emission limits for engines used in inland waterway vessels.

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8 China's Ministry of Environment. Explanation of the new marine engine standards. Accessed November 15, 2016, at http://www.mep.gov.cn/xxgk/zcfgjd/201608/t20160830_363308.shtml

9 Hong Kong Environmental Protection Department. (2014). 2014 Hong Kong emission inventory report. Retrieved from http://www.epd.gov.hk/epd/english/environmentinhk/air/data/emission_inve.html

10 Qingyan Fu (2016). *Progress on Ship Emission Inventory in Shanghai Port.* Presented at the Green Ports and Vessels Initiative Workshop, June 13–16, 2016, Shanghai, China.

11 Li, C., Yuan, Z., Ou, J., Fan, X., Ye, S., Xiao, T., . . . Zheng, J. (2016). An AIS-based high-resolution ship emission inventory and its uncertainty in Pearl River Delta region, China. Science of The Total Environment, 573, 1–10.

12 International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), 12 ILM 1319 (1973); TIAS No. 10,561; 34 UST 3407; 1340 UNTS 184.

13 International Maritime Organization. Prevention of Air Pollution from Ships, International Maritime Organization. Retrieved December 14, 2016, from http://www.imo.org/en/OurWork/environment/pollutionprevention/airpollution/pages/air-pollution.aspx

14 Ibid.

15 U.S. Environmental Protection Agency. (2004). Overview of EPA's emission standards for marine engines. Retrieved from https://nepis.epa.gov/Exe/ZyPDF.cgi/P1002K40.PDF?Dockey=P1002K40.PDF

16 Directive 97/68/EC of the European Parliament and of the Council of 16 December 1997 on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery, 1997 O.J. L 27/02/1998 P. 0001–0086. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1997L0068:20130110:EN:PDF

Additionally, there are special areas where more stringent standards apply. At the international level, IMO designates Emission Control Areas (ECAs) where more stringent SO_x or NO_x (or both) emission limits apply.[17] There are currently four ECAs: the North American Emission Control Area, the U.S. Caribbean Sea Emission Control Area, the North Sea Emission Control Area, and the Baltic Sea Sulfur Emission Control Area.[18] Domestically, in 2015, China designated three Domestic Emission Control Areas (DECAs), where more stringent marine fuel sulfur caps apply.[19] These region-specific regulations apply to all ships traveling within them.

OVERVIEW OF NEW STANDARDS

APPLICABILITY

The marine engine standards cover both compression-ignition engines and spark-ignition engines, including duel-fuel engines. They define three categories of marine engines, which are essentially identical to the marine engine categories set by the U.S. Environmental Protection Agency, and establish limits for carbon monoxide, methane, and PM in addition to IMO's NO_x limits already in effect for larger engines.[20]

- Category 1: net power greater than 37 kW and less than 5 L/cylinder
- Category 2: 5–30 L/cylinder
- Category 3: more than 30L/cylinder

The new standards apply to Category 1 and 2 marine engines installed on river vessels, coastal vessels, river-sea ships, channel ships, and fishing vessels with more than 37 kW net power. Smaller engines, with net power less than 37 kW, are subject to a separate engine regulation for non-road machinery.[21] Larger marine engines greater than 130 kW are already subject to NO_x regulations set by the IMO. The recently enacted DECAs[22] add additional control measures of SO_x emissions for all ships traveling in three key coastal regions: the Pearl River Delta Region, Yangtze River Delta Region, and Bo Sea Region.

EXHAUST EMISSION LIMITS

Tables 1 and 2 summarize emissions limits for newly built or installed marine engines.

17 International Maritime Organization. Prevention of Air Pollution from Ships, Retrieved December 14, 2016, from http://www.imo.org/en/OurWork/environment/pollutionprevention/airpollution/pages/air-pollution.aspx

18 International Maritime Organization. Special areas under MARPOL. Retrieved December 14, 2016, from http://www.imo.org/en/OurWork/Environment/SpecialAreasUnderMARPOL/Pages/Default.aspx

19 International Council on Clean Transportation. (2016). Action plan for establishing ship emission control zones In China. http://www.theicct.org/establishing-ship-ECZs-in-china

20 U.S. Environmental Protection Agency. (2004). Overview of EPA's emission standards for marine engines. Retrieved from https://nepis.epa.gov/Exe/ZyPDF.cgi/P1002K40.PDF?Dockey=P1002K40.PDF

21 China's Ministry of Environmental Protection. (2014). Limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (China III, IV) (GB20891-2014). Retrieved from http://kjs.mep.gov.cn/hjbhbz/bzwb/dqhjbh/dqydywrwpfbz/201405/t20140530_276305.htm

22 International Council on Clean Transportation. (2016). Action plan for establishing ship emission control zones In China. http://www.theicct.org/establishing-ship-ECZs-in-china

Table 1. Phase I emission limits for marine engines from 7/1/2018

Engine type	Per-cylinder displacement (L)	Rated net power (kW)	CO (g/kWh)	HC+NO_x (g/kWh)	CH_4* (g/kWh)	PM (g/kWh)
Category 1	<0.9	≥37	5.0	7.5	1.5	0.40
	0.9–1.2		5.0	7.2	1.5	0.30
	1.2–5		5.0	7.2	1.5	0.20
Category 2	5–15		5.0	7.8	1.5	0.27
	15–20	<3,300	5.0	8.7	1.6	0.50
		≥3,300	5.0	9.8	1.8	0.50
	20–25		5.0	9.8	1.8	0.50
	25–30		5.0	11.0	2.0	0.50

*Only applies to marine engines running on natural gas (including duel fuel).

Table 2. Phase II emission limits for marine engines from 7/1/2021

Engine type	Per-cylinder displacement (L)	Rated net power (kW)	CO (g/kWh)	HC+NO_x (g/kWh)	CH_4* (g/kWh)	PM (g/kWh)
Category 1	<0.9	≥37	5.0	5.8	1.0	0.30
	0.9–1.2		5.0	5.8	1.0	0.14
	1.2–5		5.0	5.8	1.0	0.12
Category 2	5–15	<2,000	5.0	6.2	1.2	0.14
		2,000–3,700	5.0	7.8	1.5	0.14
		≥3,700	5.0	7.8	1.5	0.27
	15–20	<2,000	5.0	7.0	1.5	0.34
		2,000–3,300	5.0	8.7	1.6	0.50
		≥3,300	5.0	9.8	1.8	0.50
	20–25	<2,000	5.0	9.8	1.8	0.27
		≥2,000	5.0	9.8	1.8	0.50
	25–30	<2,000	5.0	11.0	2.0	0.27
		≥2,000	5.0	11.0	2.0	0.50

*Only applies to marine engines running on natural gas (including duel fuel).

This standard also sets limits on fuel sulfur content to control SO_x emissions from ship engines. Specifically, the standard requires that

- River vessels, sea-river ships, and fishing vessels operating in inland waterways must use ultra-low-sulfur diesel fuel with maximum sulfur content of 10 ppm beginning on January 1, 2018. Currently, those vessels are permitted to use diesel fuel with a sulfur content between 50 and 350 ppm.

- Coastal vessels, channel ships, and fishing vessels operating in coastal regions that run on marine fuel oil must use low-sulfur fuel oil guided by appropriate national standards and regulations, although currently there are no specified sulfur caps for those fuels. Compliance can also be demonstrated through the use of other SO_x emission-control technologies, like a scrubber, that provide equivalent SO_x reductions to low sulfur fuels.

The fuel quality requirements apply to both new and in-use vessels. As mentioned above, ships operating within DECAs must comply with more stringent SO_x emissions regulations (fuel sulfur content limit of 5,000 ppm), regardless of ship type or flag state.

TYPE TEST

Manufacturers should submit a parent engine[23] to a certified approval authority for a type-approval test. Dual fuel marine engines must conduct type tests on both fuel types. Special purpose engines used for exhibition, rescue, and emergency response are exempted from the regulation provided that manufacturers gain permission from their regulatory agencies.

CONFORMITY OF PRODUCTION

Manufacturers should make sure each engine is produced in conformity with the approved type granted by the type-approval test. To ensure conformity, the regulatory agencies are entitled to conduct spot checks on engines in production. If the sampled engine does not conform, manufacturers can ask for a retest of multiple samples (including the non-conformable one). The average specific emissions (g/kWh) are used to check for conformity.

DURABILITY

Durability tests help to ensure that engines meet emission standards throughout their useful lives. They are carried out during the type-approval tests. The test engines are kept running for a determined amount of hours with regular maintenance. Only when emission levels do not exceed limits throughout the test will the engine granted type approval. For the Category 1 and 2 engines covered by this standard, engines must be run for a minimum of 2,500 hours, with the exception of leisure ships, which must be run for 500 hours. The emission deterioration factors, or the anticipated increase in emission factors over time, are determined after the durability tests.

REBUILDING AND REPLACING MARINE ENGINES

When a marine engine is being rebuilt or being replaced, it must be rebuilt or replaced to a configuration that is equivalent to or outperforms, from an emission standpoint, the old one. The new standards apply to these rebuilt or replaced engines as well.

23 *Parent engine* refers to an engine with emission levels that are representative of its engine family.