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The updated China IV non-road emission standards

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In December 2020, the Ministry of Ecology and Environment (MEE) of China updated the China IV non-road tailpipe emission standards, setting new requirements for particle number (PN) limits, the use of Global Positioning System (GPS) tracking systems, and portable emissions measurement system (PEMS) testing for improved real-world compliance. The new requirements were released in the form of amendments to the Limits and Measurement Methods for Exhaust Pollutants from Diesel Engines of Non-Road Mobile Machinery (China III, IV) (GB 20891-2014).[1] The updated China IV standards will phase in from December 2022 for all diesel non-road equipment with engine sizes smaller than 560kW, and for diesel three-wheeler trucks.[2] In addition, the MEE released Emissions Control Technical Requirements of Non-Road Diesel Mobile Machinery (HJ 1014-2020) as supplemental guidance regarding technical specifications.[3]

BACKGROUND

As the market for non-road equipment in China has grown, so have tailpipe emissions. By 2019, the country's stock of construction equipment had reached about eight million units and agricultural equipment totaled about 40 million units. Those two segments account for about 90% of the non-road market.[4] Nitrogen oxide (NO_x) emissions from construction and agricultural equipment reached more than 3.3 million tons in 2019, and particulate matter (PM) emissions totaled some 0.2 million tons.[5] That equates to almost 56% of the PM emitted by all mobile sources. For comparison, the 340 million on-road vehicles contributed 24% of total PM emissions

1 Ministry of Ecology and Environment, 非道路移动机械用柴油机排气污染物排放限值及测量方法(中国三、四阶段)修改单 (Revision on limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (III, IV)) (2020). China III and China IV were announced in the same regulatory document in 2014, and China III was implemented a few years later. The amendments released in 2020 apply specifically to China IV.

2 The implementation timeline for engines larger than 560 kW will be released later.

3 Ministry of Ecology and Environment, 非道路柴油移动机械污染物排放控制技术要求 (Emissions control technical requirements of non-road diesel mobile machinery), (2020), retrieved from http://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/dqhjbh/dqydywrwpfbz/202012/W020201231458195863147.pdf.

4 Vehicle Emission Control Center, Ministry of Ecology and Environment (VECC), 一图读懂"非道路移动机械国四标准"("China IV non-road mobile machinery equipment standards"), (2020), Retrieved from https://mp.weixin.qq.com/s/XrJSJZrlmVZ1RYtVNj4ieg.

5 Vehicle Emission Control Center, Ministry of Ecology and Environment (VECC), 中国移动源环境管理年报2020 (China mobile source environmental management annual report 2020), Ministry of Ecology and Environment, 2020.

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from mobile sources.[5] The high levels of PM from construction and agricultural equipment highlight the urgent need to reduce particle emissions.

China has followed the European pathway in regulating tailpipe emissions of non-road equipment, rolling out regulations in stages:

- *China I and II*. The country's efforts started in 2007, with adoption of the Limits and Measurement Methods for Exhaust Pollutants from Diesel Engines of Non-Road Mobile Machinery (China I and II) (GB20891-2007).[6] China I phased in starting in October 2007, with China II beginning in October 2009. Those standards generally followed the requirements of European Union (EU) Stage I and II non-road emission standards, though with some amendments.
- *China III and IV*. In 2014, the MEE released the Limits and Measurement Methods for Exhaust Pollutants from Diesel Engines of Non-Road Mobile Machinery (China III and IV) (GB 20891-2014), with limits and measurement methods set for China III, which was equivalent to Euro Stage IIIA non-road emission standards.[7] These China III standards were phased in from October 2014. That document included advance notice of emission limits for the next regulatory step, China IV (Euro Stage IIIB equivalent), but without an implementation timeline.
- *Amendments to China IV*. In 2020, the government updated the China IV regulations to strengthen standards for non-road tailpipe emissions. The new standards, with implementation scheduled for December 2022, will be the equivalent of Euro IIIB limits, but upgraded to meet some requirements of Euro Stage V standards. These new amendments are the focus of this policy update. (Table 1.)

Table 1. Timeline of China's regulatory regime for non-road tailpipe emissions standards

Regulatory standards	Date of implementation	Equivalent standards
Limits and Measurement Methods for Exhaust Pollutants from Diesel Engines of Non-Road Mobile Machinery (China I and II) (GB20891-2007)	October 2007 for China I	EU Stage I
	October 2009 for China II	EU Stage II
Limits and Measurement Methods for Exhaust Pollutants from Diesel Engines of Non-Road Mobile Machinery (China III and IV) (GB 20891-2014)	October 2014 for China III	EU Stage IIIA
	China IV scheduled for December 2022 in amendment	EU Stage IIIB for limits, and some other requirements from EU Stage V

Led by the EU, many countries have moved to establish more stringent standards for non-road equipment. The United States has adopted U.S. Tier 4 final standards, and Japan and South Korea have implemented equivalent measures. Standards in the three countries are in the same class as EU Stage IV standards. The EU began implementation of Stage V non-road emission standards (type approval) in 2018; they are recognized as the world's toughest emission standards for non-road mobile machinery.[8] The Stage V regulations were the first non-road tailpipe emission standards to set PN limits, and in addition established the lowest PM limits for engines with rated power between 19 and 560 kW. To meet the stringent limits set

6 Ministry of Ecology and Environment, 非道路移动机械用柴油机排气污染物排放限值及测量方法(中国Ⅰ、Ⅱ阶段) (Limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (I, II), (2007), http://kjs.mee.gov.cn/hjbhbz/bzwb/dqhjbh/dqydywrwpfbz/200704/t20070416_102751.shtml

7 Ministry of Ecology and Environment, 非道路移动机械用柴油机排气污染物排放限值及测量方法(中国三、四阶段) (Limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (III, IV), (2014), http://english.mee.gov.cn/Resources/standards/Air_Environment/emission_mobile/201605/t20160511_337514.shtml.

8 The International Council on Clean Transportation, *European Stage V non-road emission standard*, (ICCT: Washington, DC, 2016), https://theicct.org/sites/default/files/publications/EU-Stage-V_policy%20update_ICCT_nov2016.pdf.

by Stage V, manufacturers will be required to equip non-road engines with diesel particulate filters (DPFs) similar to those used in on-road heavy-duty engines. India also adopted EU Stage V-equivalent emission standards in 2018, with implementation to begin in April 2024.[9]

Given the urgent need to reduce emissions from China's non-road equipment, and the availability of advanced technology, the amendments to the China IV non-road standards set a new implementation timeline of increased ambition. The China III non-road standards, in place for more than five years, could be made more stringent, judging from standards set elsewhere. The successful adoption of the EU Stage V standards in European countries, driven by the need to meet PN limits, confirms that the best available control technology for particulate emissions from diesel engines can be used broadly in non-road applications. Thus, the MEE amendments include some specifications from the EU Stage V standards as well as state-of-the-art approaches (use of the best available PM control technology) for achieving much-needed emission reduction goals.

KEY ENGINE-RELATED IMPROVEMENTS

To reduce elevated PM emissions in the non-road sector, the amendments define a PN limit for engines between 37 and 560 kW of 5×10^{12}/ kWh (see Table 2). Although the PN limit is slightly looser than that in the EU Stage V (1×10^{12}/ kWh), China is the first country to introduce the PN requirements with pre-EU Stage V standards.

Table 2. Emission limits for updated China IV non-road tailpipe emission standards

Engine Size (kW)	CO (g/kWh)	HC (g/kWh)	NO_x (g/kWh)	HC+NO_x (g/kWh)	PM (g/kWh)	NH_3 (g/kWh)	PN (#/kWh)
P>560	3.5	0.40	3.5, 0.67[(1)]	-	0.10	25[(2)]	-
130≤P≤560	3.5	0.19	2.0	-	0.025		5×10^{12}
75≤P<130	5.0	0.19	3.3	-	0.025		
56≤P<75	5.0	0.19	3.3	-	0.025		
37≤P<56	5.0	-	-	4.7	0.025		
P<37	5.5	-	-	7.5	0.60		-

(1) Applies to mobile generator sets with engine size over 900kW
(2) Applies to diesel engines that use reagents

The amendments also provide deterioration factors that allow manufacturers to calculate their compliance with the standards. To reduce compliance costs, manufacturers can apply a set of deterioration factors rather than calculate values from equipment durability tests, which normally require manufacturers to test their engines over a representative duty cycle (near real-world conditions that include driving and doing work such as lifting) of one-fourth or more of the useful life. The deterioration factors provided (see Table 3) are generated based on real-world diesel engine testing. This approach could potentially reduce manufacturers' testing costs.

Table 3. Assigned deterioration factors in the updated China IV standards

Pollutants	CO	HC	NO_x	PM	PN	NH_3
Assigned deterioration factors	1.3	1.3	1.15	1.05	1.0	1.0

9 The International Council on Clean Transportation, *India Bharat Stage IV and V non-road emission standard*, (ICCT: Washington, DC, 2018), https://theicct.org/sites/default/files/publications/India_Stage_IV_V%20Policy_Update%20_21080604.pdf.

KEY IMPROVEMENTS RELATED TO EQUIPMENT

IN-SERVICE TESTING

The amendments require manufacturers to use portable emission measurement systems (PEMS) for in-service testing, measuring ozone precursors (CO and NO_x) in real-world operations. By contrast, neither the non-road transient cycle (NRTC) nor the non-road steady cycle (NRSC) used in certification testing approximates real-world conditions, because they focus on the performance of the engine, as opposed to the equipment. The updated China IV standards are consistent with EU Stage V norms, in requiring that PEMS tests be performed on non-road equipment in a normal, real-world operating cycle. In addition, CO_2 and fuel consumption data must be recorded for NRTC and NRSC, along with the test results for CO, HC, NOx, PM, PN and NH3. Thus, testing results under the China IV amendments will be more representative of real-world emissions, which could help ensure in-use compliance of the equipment.

NO_x AND PARTICULATE CONTROL DIAGNOSTIC SYSTEM

The amended China IV regulations now require that non-road engines have NO_x control diagnostic (NCD) systems and particulate control diagnostic (PCD) systems to ensure full compliance, meaning that equipment will be prevented from running if after-treatment systems are not working. This is consistent with the requirements set in EU Stage V standards. The NCD and PCD systems are designed to activate warning and inducement torque reduction functions if a failure and/or malfunction of NO_x and/or PM control systems is identified. This can ensure that after-treatment systems required in non-road equipment perform as designed.

GPS TRACKING SYSTEM AND REMOTE EMISSION MONITORING

For equipment with engines between 37 and 560kW, the amendments require installation of a GPS tracking system that allows a management platform to track the location (latitude and longitude) of the equipment over its lifetime. Coupled with the platform, the GPS systems will help to track and manage non-road equipment in use, thereby addressing a longstanding hole in emissions monitoring. For construction equipment, the regulation requires that a terminal used to monitor emissions remotely, and to identify equipment location, be in place and ready for future use, following the norms used in the China Stage VI heavy-duty vehicle standards.[10] The monitored exhaust emissions will help to identify high emitters in the non-road sector.

DISCLOSURE OF INFORMATION AND EQUIPMENT LABELING

The amendments integrate information disclosure and equipment labeling requirements for non-road equipment into the new China IV standards. In 2016, the MEE announced that it would require disclosure of key emission control information from all manufacturers of on-road vehicles and non-road equipment, replacing the type approval required in previous standards.[11] For newly produced or imported non-road equipment, manufacturers are responsible for releasing pollution control technology information (relevant to the standards certified) and emission inspection information.[12] In addition, the announcement requires each unit of equipment to bear a machinery environmental information label and a unique Machine Environmental

10 The International Council on Clean Transportation, *China's Stage VI emission standard for heavy duty vehicles (final rules)*, (ICCT: Washington, DC, July 2018), https://theicct.org/sites/default/files/publications/China_VI_Policy_Update_20180720.pdf.

11 Ministry of Ecology and Environment, 关于开展机动车和非道路移动机械环保信息公开工作的公告 (Announcement on launching environmental protection information disclosure work for motor vehicles and non-road mobile machinery), (2016), https://www.mee.gov.cn/gkml/sthjbgw/qt/201608/t20160826_363005_wh.htm.

12 Emission inspection information includes type inspection, production consistency inspection, in-use conformity inspection and factory inspection information, including inspection results, inspection conditions, instrument equipment, inspection agency information, etc.

Identification Number (MEIN). The label should cover key information about the equipment and its engine and about its key emission control technology. The information disclosure and equipment labeling strategy has already led to the supervision of in-use non-road equipment worldwide, while the amendments further formalize the process in the updated China IV standards.

EXPANDED SCOPE

In addition to the diesel engines used in construction and agricultural equipment as previously regulated, the amendments further require diesel three-wheelers and waterway vessels with diesel engines smaller than 37 kW to comply with the updated China IV standards. Diesel three-wheelers are trucks with maximum design speed of 50km/hour or less. Those trucks are popular in rural areas because of their low price and high performance; more than two million are produced annually.[13] Diesel three-wheelers were regulated along with the low-speed trucks, which China I implemented from 2006 and China II from 2007.[14] However, the regulations were very loose. Since 2017, low-speed trucks have been regulated more strictly by China V light-duty emission standards, while diesel three-wheelers still lag behind. The updated non-road China IV standards serve as a start for the technical upgrade of the three-wheeler industry, although the improvement is still limited due to the minimal stringency improvements expected for engines smaller than 37kW.

EXPECTED IMPACTS

The more stringent emission limits and in-use compliance requirements will lead to the use of improved emission control technologies in the non-road sector. The added PN limits will require adoption of DPFs, particularly for equipment with engine size between 37 kW and 560 kW, which is expected to increase costs by 10-15%.[15] The technology upgrade for equipment with engine size smaller than 37 kW is relatively minor, with minimal cost increases expected.

The new China IV non-road standards are expected to help reduce overall tailpipe emissions, even as the market grows. If China IV is implemented as scheduled in December 2022, NO_x and PM levels from non-road vehicles are expected to fall by 12.5% and 19.3%, respectively by 2025, and by 35.0% and 46.8%, respectively, by 2030 when compared with current standards (China III).[16]

13 Ministry of Ecology and Environment, 三轮汽车及其装用的柴油机排气污染物排放限值及测量方法 (中国第三阶段) 》（征求意见稿) (Limits and measurement methods for exhaust pollutants from diesel engines of tri-wheel (China III), (2018), retrieved from http://www.gepresearch.com/uploads/soft/180419/9_1152398191.pdf.

14 Ministry of Ecology and Environment (2005), GB19756-2005《低速货车与三轮汽车用柴油机排气污染物限值及测量方法 (中国 I、II 阶段) (Limits and measurement methods for exhaust pollutants from diesel engines of tri-wheel & low-speed goods vehicles (China I, II), https://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/dqhjbh/dqydywrwpfbz/200601/t20060101_67487.shtml.

15 Ministry of Ecology and Environment, China, 《非道路移动机械用柴油机排气污染物排放限值及测量方法 (中国第三、四阶段) (GB 20891-2014) 修改单》及《非道路柴油移动机械污染物排放控制技术要求》(HJ1014-2020) 的解读 ("Non-road mobile machinery diesel engine exhaust pollutant emission limits and measurement methods (China III, IV) (GB 20891-2014) amendments" and "non-road diesel mobile machinery pollutant emission control technical requirements" (HJ1014) -2020) interpretation) January 2021, http://www.mee.gov.cn/zcwj/zcjd/202101/t20210104_816001.shtml.

16 Ministry of Ecology and Environment, China《非道路移动机械用柴油机排气污染物排放限值及测量方法 (中国第三、四阶段) (GB 20891-2014) 修改单》及《非道路柴油移动机械污染物排放控制技术要求》(HJ1014-2020) 的解读 ("Non-road mobile machinery diesel engine exhaust pollutant emission limits and measurement methods (China III, IV) (GB 20891-2014) amendments" and "non-road diesel mobile machinery pollutant emission control technical requirements" (HJ1014) -2020) interpretation) , January 2021, http://www.mee.gov.cn/zcwj/zcjd/202101/t20210104_816001.shtml.