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On-Board Diagnostic (OBD) Checks for Inspection and Maintenance in India

CURRENT STATE OF INSPECTION AND MAINTENANCE

Poor air quality across Indian cities threatens the health of millions,[1] and pollution levels have remained at dangerous levels throughout the last decade.[2] To address the urban air quality crisis, officials have targeted motor vehicles, a major source of pollution in urban areas. Actions to-date have emphasized cleaner fuels and technology for new vehicles, recently culminating in the Ministry of Road Transport and Highways (MoRTH) adopting stringent BS VI standards to be implemented in 2020. With a roadmap for clean vehicles and fuels in place, regulators can shift their focus to reducing emissions from vehicles currently on the road and ensuring that vehicles continue to meet emission standards throughout their lifetime. The nation's vehicle inspection and maintenance (I/M) program is instrumental in meeting these goals. This briefing proposes improvements to India's current I/M program, based on international experience and best practices, that take advantage of new technologies to adapt the program to the quickly modernizing fleet.

1 SS Lim, et al, "A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease study 2010," *Lancet* 380 (2012): 2224–2260.

2 "National Ambient Air Quality Status & Trends in India—2010," Central Pollution Control Board, Ministry of Environment & Forests, Jan. 2012, http://www.cpcb.nic.in/upload/NewItems/NewItem_192_NAAQSTI.pdf.

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Vehicles that are poorly maintained or malfunctioning are important contributors to air pollution.[3] The goal of an inspection and maintenance program is to ensure that vehicles remain safe, in good working order throughout their lifetime, and do not produce excess pollution. At the core of an I/M program is the requirement that vehicle owners regularly submit their vehicles for a standardized inspection. If the vehicle fails inspection, it needs be repaired and re-inspected before it returns to normal operation. I/M fits within a larger vehicle emissions reduction scheme based on investments in cleaner fuels and new emission control technologies. I/M extends the benefits of these investments by ensuring timely detection of failure or malfunction of in-use emission control systems and requiring their repair. In theory, I/M will result in greater emission reductions from new vehicle standards because the emission control systems continue to operate at high control efficiency through the vehicle's useful life. I/M also improves emissions from the current fleet of older vehicles with less advanced control technology during the transition to more stringent standards.[4]

In practice, many I/M programs fall short of their potential to reduce emissions from in-use vehicles due to implementation challenges and problems with program design. The current I/M program in India, the Pollution Under Control (PUC) program, suffers from both outdated test methods and enforcement problems.[5] These shortcomings were recognized as early as 2002,[6] and while specific reforms were suggested and some improvements made.[7] a recent report by Lakshmi et al. finds that many of the same problems persist.[8] The outdated test methods will become increasingly ineffective at identifying vehicles in need of repair as vehicles with advanced emission control technologies become more common in the in-use fleet, following implementation of more stringent emission standards for new vehicles (culminating in BS VI in 2020).

Near-term reforms to the PUC program are needed to meet the I/M needs of the current, quickly modernizing fleet in India. New vehicle technology and testing methods provide major opportunities to reform and improve upon current vehicle inspection and maintenance practices. India could take advantage of a key technology, on-board diagnostic (OBD) systems, to improve the I/M process for vehicles meeting more stringent emission standards. Including OBD checks as a supplement to the current test procedures is a change that can be implemented relatively quickly and

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3 Francisco Posada, Zifei Yang, Rachel Muncrief, "Review of Current Practices and New Developments in Heavy-Duty Vehicle Inspection and Maintenance Programs," The International Council on Clean Transportation, 2015, http://www.theicct.org/review-current-practices-and-new-developments-heavy-duty-vehicle-inspection-and-maintenance-programs.

4 Karl Hausker, Lennart Erlandsson, June Taylor, John Armstrong, "Vehicle Inspection and Maintenance Programs: International Experience and Best Practices," USAID, 2004 http://pdf.usaid.gov/pdf_docs/Pnadb317.pdf; Posada, F, Yang, Z, Muncrief, R. 2015; Freda Fung, Bryan Suen, *"A Review of the Hong Kong Inspection and Maintenance Programme for On-road Vehicles,"* Civic Exchange, Aug. 2013, https://www.academia.edu/11297612/A_Review_of_the_Hong_Kong_Inspection_and_Maintenance_Programme_for_On-road_Vehicles.

5 C Sita Lakshmi, Sumit Sharma, S Sundar, B Bhanot, "Establishing a National In-use Vehicle Testing Programme in India," Shakti Sustainable Energy Foundation, 2014, shaktifoundation.in/wp-content/uploads/2014/02/National-in-use-vehicle-testing-programme-in-India.pdf.

6 John Rogers, "Assessment of the Pollution Under Control Program in India and Recommendations for Improvement," The World Bank, 2002, http://siteresources.worldbank.org/PAKISTANEXTN/Resources/UrbanAir/MainReport.pdf.

7 "Making Vehicle Emissions Inspection Effective—Learning From Experience in India," South Asia Urban Air Quality Management Briefing Note No. 9, The World Bank, 2002, http://siteresources.worldbank.org/PAKISTANEXTN/Resources/UrbanAir/EmissionInspection.pdf; Michael Walsh, "Motor Vehicle Inspection and Maintenance: The Worldwide Experience," http://www.walshcarlines.com/pdf/SIAT2005%20IM.pdf.

8 Lakshmi et al. 2014.

will lay the foundation for a stronger, more effective program of inspection and maintenance in the future.

OBD systems are a component of the electronic hardware installed in a vehicle. Electronic control units are included in all modern vehicles to control a variety of functions, including fuel timing and the operation of emission control devices. The OBD system processes readings from sensors in the engine and along the exhaust system to monitor and record indicators of engine performance, performance of the fuel delivery system, and functioning of the emission control system. This monitoring covers nearly all potential sources of excess vehicle emissions due to emission control component malfunctions.[9] Current OBD systems record faults and performance data in a standardized way, and can provide technicians with this record via a diagnostic device that plugs into an easily-accessed serial port, or the OBD port, which is standard to all vehicles. The data downloaded from the OBD indicates whether the emission control system is functioning properly and furthermore it identifies the specific element of the system that may be malfunctioning. For the purposes of inspection and maintenance, the data provided by the OBD system is as valuable as the results of the free acceleration smoke (FAS) tests currently required by PUC.

The simpler OBD I systems were introduced with BS III standards for new cars and trucks. The more comprehensive OBD II systems are required for cars and trucks meeting BS IV standards, and the proposed BS VI standards increase OBD II requirements. Complementing current I/M tests for vehicles with advanced emission control systems with OBD checks introduces a relatively simple inspection process that addresses the shortcomings of current test procedures and brings India's program more in line with international best practices.[10]

International experience with integrating OBD into I/M procedures comes mainly from the United States. The U.S. Environmental Protection Agency sets guidelines for states to follow in designing and running I/M programs as per the 1990 amendment to the Clean Air Act. These guidelines mandate that OBD checks be integrated into any state's I/M program for light-duty vehicles, and specify a seven-step check procedure that should be followed, which is included for reference in the appendix.[11] Because OBD system requirements for heavy-duty vehicles were not specified at the time of the amendment, OBD checks are not yet mandatory for heavy-duty I/M programs in the United States. However, states have requested additional guidance for heavy-duty OBD checks, and EPA has acknowledged the possibility that there may be guidelines proposed in the future for heavy-duty OBD in I/M programs.[12] South Korea has designed its light-duty OBD system requirements to include anti-tampering features

9 Allen Lyons, "On-Board Diagnostics (OBD) Program Overview," California Air Resources Board, April 2015, http://www.theicct.org/sites/default/files/6_ARB_OBD.pdf.

10 David Vance Wagner, and Dan Rutherford, "Survey of Best Practices in Emission Control of In-Use Heavy-Duty Diesel Vehicles," The International Council on Clean Transportation, Aug. 2013, http://www.theicct.org/sites/default/files/publications/ICCT_HDV_in-use_20130802.pdf.

11 "Performing Onboard Diagnostic System Checks as Part of a Vehicle Inspection and Maintenance Program," U.S. EPA, 2001, http://www3.epa.gov/obd/r01015.pdf

12 "Regulations Requiring Onboard Diagnostic Systems on 2010 and Later Heavy-Duty Engines Used in Highway Vehicles Over 14,000 Pounds; Revisions to Onboard Diagnostic Requirements for Diesel Highway Vehicles Under 14,000 Pounds. Summary and Analysis of Comments," U.S. EPA. 2005, http://www3.epa.gov/obd/regtech/420r08018.pdf.

so that I/M programs can rely on OBD checks.[13] Few other countries with mature I/M programs have fully integrated OBD checks; among the members of the European Union, only the Netherlands includes OBD checks, and the I/M program guidelines in Japan do not specifically include OBD checks. India has an opportunity to take a leadership position in developing methods for integrating OBD into I/M programs for all vehicle types.

If adequate safeguards are put in place to prevent tampering with OBD data, OBD checks could replace conventional testing for new vehicles.[14] Using OBD checks paired with technology to remotely collect OBD data[15] can provide quick screenings of many newer, clean vehicles, and can reduce the testing burden for vehicle owners and I/M stations. This will create the opportunity to target current I/M tests to the vehicles to which they are most suited: older high-emitters. Along with the introduction of OBD-based testing, the program can introduce additional training and the oversight of test administration. These changes require little additional infrastructure, and can be taken as a first step in paving the way for more comprehensive improvements to the PUC program.

REMAINING GAPS IN THE INDIA I/M PROGRAM

The Pollution Under Control (PUC) program has been in place for more than 25 years. The Central Motor Vehicle Rules of 1989 established the requirement that every motor vehicle carry a valid PUC certificate.[16] The implementation of PUC, including the administration of vehicle testing and the enforcement of PUC certificate requirements, is delegated to the Regional Transport Offices (RTO). While test methods are specified at the national level, each RTO may specify the frequency of inspections. Checks are required at least once per year, and some regions have increased the requirement to four times per year. Lakshmi et al. give more detail about the structure and requirements of the PUC program. The PUC program provides an important function in India's overall strategy to control vehicle emissions by enabling authorities to identify high-emitting vehicles and compelling vehicle owners to perform the necessary repairs. However, it needs major reforms if it is to operate effectively. Two major problems the PUC faces are outdated test methods and inconsistent implementation.

One major criticism Lakshmi et al. have of the PUC program is that the test methods specified for inspections are outdated and are poor indicators of high-emitting vehicles. The current test procedure involves a free acceleration test and measurement of two or three pollutants, depending on fuel type (carbon monoxide (CO) and hydrocarbons (HC) for petrol engines, and smoke opacity for diesel engines). The free acceleration test provides a very crude representation of engine operation and

13 Posada, F, and German, J. 2016. *Review of LDV OBD requirements under the European, Korean and Californian emission programs.* The International Council on Clean Transportation. Retrieved from http://www.theicct.org/review-ldv-obd-requirements-under-european-korean-and-californian-emission-programs.

14 Posada F., and German, J. 2016; Francisco Posada, Anup Bandivadekar, "Global overview of on-board diagnostic (OBD) systems for heavy-duty vehicles," The International Council on Clean Transportation, 2015, http://www.theicct.org/global-overview-board-diagnostic-obd-systems-heavy-duty-vehicles.

15 This strategy has been implemented in the state of Oregon, and is being considered for adoption in other U.S. states. "DEQ Too Home," Oregon Department of Environmental Quality. 2016, https://www.deqtoo.org/.

16 "Central Motor Vehicles Rules 1989, Rule 115," India Ministry of Road Transport and Highways, 1989, http://admis.hp.nic.in/himpol/Citizen/LawLib/Amendments/Cen_motor_vehi_rules_1989/MAIN.htm.

does not represent real-world driving conditions. Although the test will positively identify some high-emitting vehicles, it will not identify vehicles that emit high levels of pollution only during certain driving conditions. The tests do not measure two major pollutants of concern, fine particulate matter ($PM_{2.5}$) and oxides of nitrogen (NOx), so although vehicles may be tuned to produce lower levels of CO and HC, and thus will pass inspection, they may still emit high levels of $PM_{2.5}$ or NOx. Finally, the measurement technique is not sensitive enough to detect substandard performance of emission control technology in vehicles meeting BS IV, V, and VI norms. The MoRTH revised the limit values for the tests in 2013 to account for emission control technology,[17] but without additional changes to test procedures these changes do not significantly improve the ability to identify high-emitting new technology vehicles.

Another major criticism of PUC is that it is poorly implemented in a number of regions. An audit of inspection sites found that some test technicians are not sufficiently trained, and inconsistent application of test methodology produces unreliable results (passing poorly-maintained vehicles and failing low-emitting vehicles).[18] These issues erode public confidence in the program and stand in the way of fulfilling the programs underlying purpose: to inform vehicle owners of problems with their cars and requiring the necessary repairs. These problems were acknowledged in the 2003 Auto Fuel Policy road map, but the stated plans to overhaul the program have not yet been carried out.

In addition, the rapid growth in the number of vehicles on the road is overwhelming the capacity of existing testing facilities to perform annual tests of all vehicles. MoRTH is setting up ten inspection and maintenance centers with lanes designed for streamlined vehicle inspection, and has proposed to increase the number of such facilities to 300 by 2020. The cost of constructing an upgraded inspection lane is estimated at INR 1-1.5 crore, and it is estimated that 4,500 upgraded lanes would be necessary to perform annual inspections of all vehicles in the 2020 fleet.[19] These costs are estimated for facilities built to perform emission tests under the current procedures, which do not replicate real-world driving conditions or measure all pollutants of concern. Once the MoRTH has taken the necessary step of specifying new test procedures for the PUC program, facilities will need additional equipment. They will either need the conventional chassis dynamometer setup required to perform loaded mode emissions tests, or a lower-cost alternative, currently in development, that captures an exhaust plume over a brief acceleration cycle while running the vehicle under a partially enclosed structure.[20]

A full overhaul of the PUC program is a necessary but burdensome undertaking, complicated by the need to accommodate vehicles of several modes, from heavy-duty trucks to motorcycles, and vehicles meeting a wide range of emission control levels. Two major changes are necessary for PUC to function well for new vehicles with advanced emission control technology: new test procedures must be adopted and

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17 Automotive Research Association of India. 2013. "AMENDMENT No. 1 TO Doc. No.: MoRTH/CMVR/ TAP-115/116: Issue No.: 4," Automotive Research Association of India, 2013, https://www.araiindia.com/CMVR_TAP_Documents/Amendment%201%20to%20Tap%20Issue%204_1.pdf.

18 Lakshmi, CS, Sharma, S, Sundar, S. 2014.

19 Lakshmi, CS, Sharma, S, Sundar, S. 2014.

20 Donald H. Stedman, "System and method for quantifying the presence of components in the exhaust of commercial and/or heavy-duty vehicles," US 8429957 B2, 2013, http://www.google.com/patents/US8429957.

testing facilities must be upgraded to perform these tests. There is not yet a proposed timeline for either of these actions, and waiting for these may delay improvements to PUC by years. The upfront investment required from private test facilities—both the construction of new equipment and the training needed for test operators—presents a substantial hurdle. While these investments would be recouped over time through vehicle inspection fees, the construction would require initial capital and time for planning and constructing the new facilities. Using OBD checks as an alternative or supplemental test protocol that can be implemented quickly with low infrastructure investment is an intermediate step that moves PUC reforms forward while the financial and regulatory details of long-term improvements remain under discussion.

ROLE OF OBD CHECKS IN IMPROVING I/M

Integrating checks of on-board diagnostic (OBD) systems is a straightforward first step in improving the PUC program. It makes use of technology already included in millions of light- and heavy-duty vehicles on the road,[21] so implementation of OBD checking procedures can proceed immediately once they are included in the PUC program. In addition, the new inspection procedures require very small investments in new equipment at private testing facilities and minor additional training requirements for inspection technicians. Training can be paired with a refresher course on current testing procedures. Finally, it is a forward-looking change that will grow more relevant as vehicles with advanced emission control technology make up an increasingly large share of the on-road fleet.

OBD checks could be substituted for emissions testing requirements in alternating years, or for several consecutive years. During early stages of implementation, inspections including emissions testing should concurrently collect OBD data to ensure that results agree, and vehicles failing emissions tests would not pass inspection based on OBD alone. OBD check procedures should include measures to prevent fraudulent practices, including connecting the scanning tool directly to the vehicle and computer so the inspector cannot modify data during the inspection and ensuring that the vehicle identification number is reported in the OBD data so that it can be matched to the vehicle being inspected. Vehicles should also be required to display the readiness indicator during testing to ensure that any error codes have not been recently cleared. Once OBD checks have been demonstrated to be effective, they can be increasingly substituted for emissions testing.

On-board diagnostic systems are already mandatory in all new light-duty vehicles in India. Bharat III vehicles must include a simplified OBD system corresponding to the United Nations Economic Commission for Europe (UNECE)'s OBD Stage I requirements, while Bharat IV vehicles must include systems meeting UNECE OBD Stage II requirements, similar to OBD II used in Europe. Heavy-duty vehicles meeting BS IV standards are also required to meet OBD Stage II specifications. With the implementation of BS IV and BS VI standards, vehicles will include more sophisticated OBD systems to accommodate complex emission control equipment. The specifications of OBD systems at different emission standards are detailed by Posada

21 Full OBD requirements have been mandatory for both light- and heavy-duty four-wheeled vehicles meeting Bharat IV standards since 2013. Assuming conservatively that 30% of vehicles sold meet BS IV, approximately 2 million of the 6.4 million vehicles sold in 2013-2014 and 2014-2015 fiscal years are equipped with OBD II (based on SIAM sales data, http://www.siamindia.com/statistics.aspx?mpgid=8&pgidtrail=14)

et al.[22] Two- and three-wheeled vehicles are not currently required to be equipped with OBD, but OBD requirements will be put in place for these vehicles from the BS VI standards in 2020 as well. As manufacturers introduce electronically managed fuel injector systems in a larger proportion of these vehicles, inclusion of OBD systems become more practical.[23]

The investment in equipment to integrate OBD II data collection into I/M testing facilities is very small compared to the cost of upgrading emissions testing equipment. The retail cost of a basic OBD II scanning tool can be as low as US$20,[24] although inspection facilities would require scanning devices that are more durable and provide a more advanced user interface than these simple models. The Data Acquisition Device Specifications issued by the California Bureau of Automotive Repair (BAR) provides an example of the durability and functionality requirements for scanning tools operated at certified inspection facilities.[25] The state has certified three vendors to provide scanning systems meeting these specifications,[26] and BAR estimates that the data acquisition devices themselves would cost approximately US$1,500, varying by vendor and system options.[27] One approved vendor has published a price of US$1,295 for the device alone, and a total system cost of US$2,813 or INR1.9 lakh (including additional computer hardware and mounting equipment).[28] Using OBD data collection to reduce the frequency of inspection for many vehicles, thus reducing the number of I/M lane upgrades necessary, would provide substantial savings.

The use of OBD checks in the PUC program provides several further advantages. OBD checks are a simpler, faster process than emissions testing, and can improve vehicle owners' satisfaction with the PUC program. After integrating OBD checking procedures into the I/M process, MoRTH and state authorities may explore further technologies to reduce vehicle testing burden, such as the use of take-home OBD data loggers or remote OBD data transfer, currently in pilot phase implementation in some U.S. states.[29] In addition, OBD checks and I/M testing could be complemented with remote sensing of emissions, where light-based measurement equipment is set up roadside and can provide a "clean screening," or detecting clean vehicles and waiving or postponing their required I/M tests. By employing more efficient procedures for inspecting newer, cleaner vehicles, MoRTH can reduce infrastructure costs and focus resources on targeting high-emitting vehicles.

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22 Posada, F, and Bandivadekar, A. 2015; Posada, F, and German, J. 2016.

23 Narayan Iyer "Emissions and fuel consumption reduction potential from two- and three-wheelers in India," The International Council on Clean Transportation, 2012, http://www.theicct.org/two-and-three-wheelers-india-iyer-report.

24 "Autel MaxiScan MS300 CAN-BUS OBDII Check Engine Auto Diagnostic Code Scanner Tool," Newegg.com, May 20, 2016, http://www.newegg.com/Product/Product.aspx?Item=9SIA0XA0851767.

25 "Bar OBD Inspection System: Data Acquisition Device Specifications," State of California Bureau of Automotive Repair, Oct. 2012, https://www.bar.ca.gov/pdf/DADSpecification.pdf.

26 Greg Coburn, "BAR-OIS/BAR-97 Update," State of California Bureau of Automotive Repair, Department of Consumer Affairs, April 22, 2015, www.smogcheck.ca.gov/pdf/BAR-OIS_BAR-97_Updates.pdf.

27 "Q&As: BAR On-Board Diagnostic Inspection System (BAR-OIS)," State of California Bureau of Automotive Repair, 2013, https://www.bar.ca.gov/Industry/Q&As_BAR_On-Board_Diagnostic_Inspection_System_BAR-OIS.html.

28 "DIY Cart," Drew Technologies, 2016, http://www.drewtech.com/emissions/products/diy-cart.html.

29 Oregon Department of Environmental Quality, 2016.

RECOMMENDATIONS

Due to the pressing need to improve the PUC program, India should consider implementing OBD checks to identify malfunctioning emissions control systems in new vehicles and lower the burden on testing facilities. In line with these goals, we offer these recommendations:

- Immediately implement a pilot program integrating OBD checks as a screening procedure alongside current PUC checks for Bharat IV and newer vehicles.
- Based on findings from the pilot program, evaluate whether OBD checks could replace free-acceleration testing for Bharat VI vehicles. The decision should include recommendations for regulatory measures to prevent tampering with OBD data.
- Conduct training for OBD checks.
- Evaluate the feasibility of a remote sensing system based the on-road heavy-duty vehicle emissions monitoring system (OHMS) in India.
- Expand OBD-based I/M practices to include two- and three-wheeled vehicles meeting Bharat VI standards.

APPENDIX: ELEMENTS OF AN OBD I/M CHECK

From U.S. EPA, "Performing Onboard Diagnostic System Checks as Part of a Vehicle Inspection and Maintenance Program," 2001, https://www3.epa.gov/otaq/regs/im/obd/r01015.pdf.

An OBD-I/M check consists of two types of examination: A visual check of the dashboard display function and status (also known as the MIL and/or bulb check) and an electronic examination of the OBD computer itself. These two examinations, taken together, comprise the seven step procedure outlined below.

1. Initiate an official test by scanning or manually inputting the required vehicle and owner information into the reporting medium (i.e., PC-based electronic reporting system or manual test report).
2. Visually examine the instrument panel to determine if the MIL illuminates briefly when the ignition key is turned to the "key on, engine off" (KOEO) position. A brief period of illumination of the MIL at start-up is normal and helps confirm the bulb is in proper, operating condition. This portion of the test procedure is also known as the "bulb check." Enter the results of the bulb check into the reporting medium.
3. Locate the vehicle's data link connector (DLC) and plug a scan tool into the connector. While it is recommended that this step be performed with the ignition in the "off" position, this step can also be performed with the ignition running. Given the variety of locations manufacturers have chosen in practice, locating the DLC may well be the most time-consuming element of the inspection. We will discuss the issue of atypical DLC location elsewhere in this guidance.
4. Start the vehicle's engine so that the vehicle is in the "key on, engine running" (KOER) condition. The MIL may illuminate and then extinguish during this phase. Continued illumination while the engine is running is cause for failure. Also, if the MIL illuminates during this phase but was not observed in step 2, the vehicle should not be failed for step 2.
5. With the scan tool in the "generic OBD" mode, follow the scan tool manufacturer's instructions to determine:
    a. Vehicle readiness status
    b. MIL status (whether commanded on or off), and
    c. Diagnostic Trouble Codes (DTCs) for those vehicles with MILs commanded on.
6. Record the results of the OBD inspection in the appropriate medium. Depending upon the design and feature requirements of the program, this may be an automated process.
7. Without clearing DTCs or readiness codes, turn off the vehicle ignition, and then disconnect the scan tool10. Clearing codes—if such is necessary—should be reserved for the repair portion of the program (even though in test-and-repair programs, the same personnel may be engaged in both activities). These codes (and the associated "freeze-frame" data) are important for the performance of proper diagnostics prior to repair.