FACT SHEET: INDIA

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

DRIVERS AND OPERATORS

WHAT TO EXPECT FROM BHARAT STAGE VI DIESEL VEHICLES?

India will transition to Bharat Stage (BS) VI emissions standards across all on-road vehicle platforms starting on April 1, 2020. BS VI is comparable with the Euro 6/VI emission standards that went into effect in the European Union in 2014. Most significantly, the BS VI standards require reductions in tailpipe emissions of nitrogen oxides (NO_x) and particulate matter (PM), which will require nearly all diesel engine manufacturers to use both a diesel particulate filter (DPF) and a selective catalytic reduction (SCR) system. These are integrated with the rest of the exhaust assembly into what is commonly referred to as the 'aftertreatment system.' In some cases, a third component, an ammonia slip catalyst (ASC), may also be added, depending on the manufacturer. These components are added to the aftertreatment system so that it can operate efficiently, and they add complexity to the overall exhaust system. Such technologies are carefully calibrated by manufacturers for optimized emissions reduction without affecting performance. Owing to the substantial cost of replacing failed parts, the continuous, appropriate inspection and maintenance of vehicle components has become more critical than ever with the introduction of BS VI standards.

Component addition for BS VI compliance	Associated critical components
diesel particulate filter (DPF)	differential pressure sensor (inlet)
	exhaust temperature sensor (inlet)
	exhaust temperature sensor (outlet)
	fuel injector (inlet)/hydrocarbon doser (usually placed at the pre-diesel oxidation catalyst [DOC] to aid soot oxidation through active regeneration)
	on-board diagnostics (OBD) indicators and warning lights
selective catalytic reduction (SCR)	urea storage tank or aqueous urea solution (AUS) storage tank
	urea injector
	NO_x sensor
	exhaust temperature sensor (inlet)
	on-board diagnostic indicators and warning lights
ammonia slip catalyst (ASC)	—

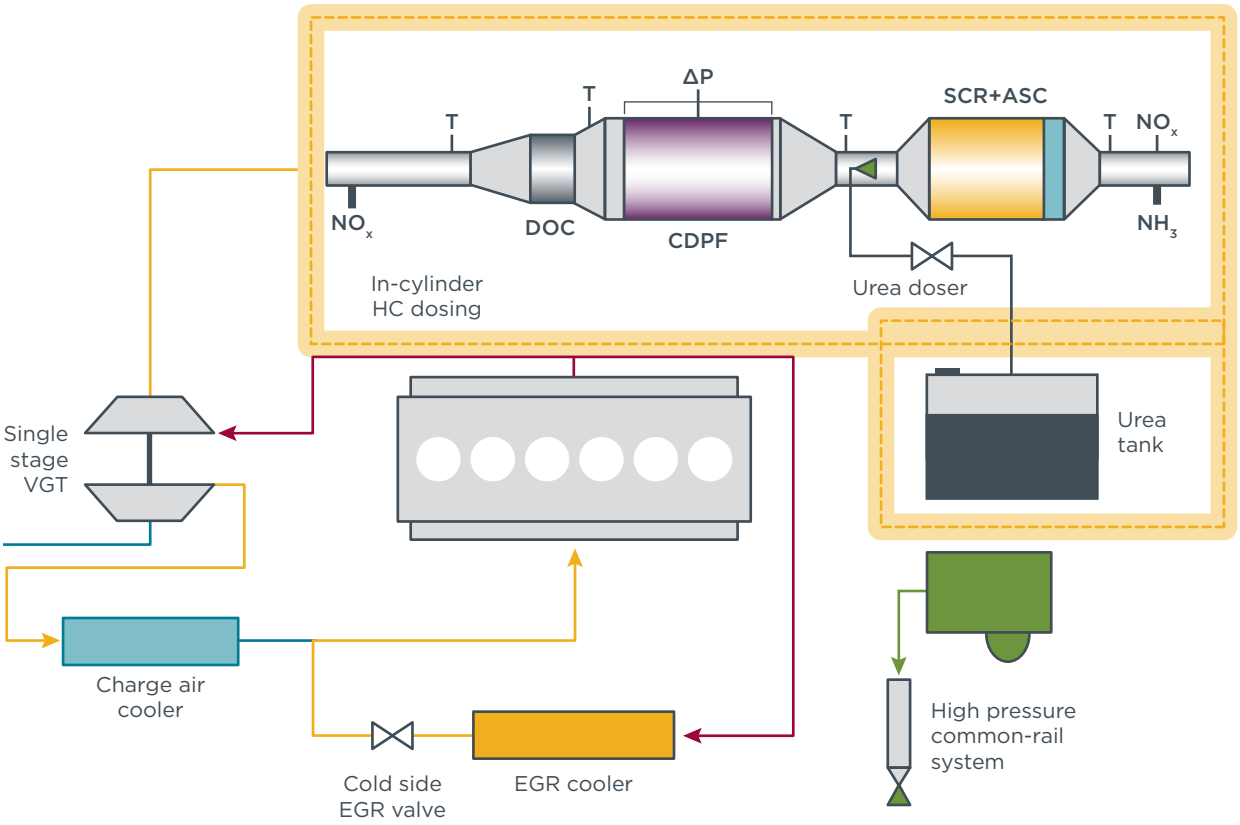
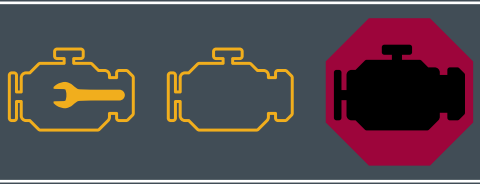


Figure 1. Schematic (not to scale) of Euro VI and expected BS VI aftertreatment systems. In the above figure T, NH_3, NO_x and ΔP refer to temperature, ammonia, nitrogen oxide and differential pressure sensors, respectively. Picture Courtesy: Dieselnet

DRIVERS AND OPERATORS SHOULD BE MINDFUL OF THE FOLLOWING CHANGES AND VEHICLE REALITIES:

1. BS VI buses and trucks will be equipped with DPFs, which trap soot in the exhaust. DPFs perform soot oxidation through passive regeneration without any operator input. However, active regeneration (thermally), which requires operator input, is periodically required to oxidize the soot and prevent excessive engine backpressure from the DPF. Significantly elevated tailpipe temperatures (>600°C) should be expected during active DPF regeneration events. The regeneration frequency can range between zero and three times per day, depending on the DPF and the operating conditions.
2. The fuel economy of BS VI vehicles is sensitive and dependent on proper operation of the SCR and DPF. This makes regular and proper maintenance of these systems critical. Increased frequency of DPF regeneration combined with increased backpressure on the engine due to soot build-up on the DPF can result in greater fuel consumption; additionally, SCRs are optimized for high-efficiency operation at high and medium-high engine loads. Low engine loads like transit buses are less favorable conditions for SCR operation in terms of temperature and flowrate, and thus, to achieve low engine-out NO_x emissions, manufacturers may have to yield fuel economy.
3. The fuel at pumps should be only BS VI fuel (10 parts per million sulfur diesel) starting on April 1, 2020. Still, drivers and operators should make a conscious effort to verify that it is BS VI fuel before filling up tanks. It is illegal to adulterate fuel. Doing so is detrimental to the vehicle and will increase maintenance costs.
4. Expect changes in the driver display console with additional LEDs/incandescent bulbs and buttons and switches:

Possible OBD dashboard indicators	Possible description
	• Warning light for ***EGR malfunction*** • Warning light for ***EGT sensor (exhaust gas temperature)***-relevant malfunctions. • Warning light for high EGT due to active DPF regeneration without enough air flow.
	• Warning light for ***tampering***-relevant activity like DPF removal, ***operator negligence*** in response to malfunctions and OBD requests (e.g., DPF regeneration or AUS refill).
	• Warning light for DPF half full status. • Warning light for ***DPF full and ready for regeneration***. *This* prompts the driver to complete regeneration pre-requisites.
	• ***AUS level low*** or critically low and requires refill, or ***incorrect AUS refilled***.

A DPF regeneration-inhibit switch or button will be available to drivers. Note that the malfunction indicator lights, OBD indicators, and other warning lamps can trigger individually or in combination, and they can produce either a constant light or a flashing light. Each indicates a specific condition, status, or malfunction, and it is critical that all drivers and operators are fully familiar with the ***manufacturer manual and guidance brochures***.

5. Drivers may experience loss of power, loss of torque, and even vehicle shutdown while driving if maintenance requests are not completed on time and/or they are not appropriately fulfilled. Inducement strategies are included by the engine manufacturer to protect the engine and aftertreatment system from irrecoverable failures.

DRIVERS AND OPERATORS NEED TO BE AWARE OF ON-BOARD REQUESTS AND TAKE THE APPROPRIATE ACTIONS:

1. Drivers should request cheat sheets from the maintenance crew, and these should be near the driver's console for easy viewing. Drivers should familiarize themselves with the cheat sheet for control switches and how to read warning lights so they can immediately interpret on-board requests coming from the operator display console and respond with appropriate action.
2. Operators and drivers should keep an eye out for the "***DPF regeneration***" warning light and familiarize themselves with its symbol and color. This light indicates that the DPF is full of soot and will enter regeneration mode. The vehicle will automatically go into this mode if all preconditions set by the manufacturer are met.
3. Operators and drivers should keep an eye out for the "***DPF full***" warning light and familiarize themselves with its symbol and color. This indicates that the DPF is full of soot and needs to be regenerated, but the vehicle cannot automatically enter regeneration mode. This happens when one or more of the necessary pre-conditions is not met and it requires the driver to aid in the process. To accomplish this:
   a. Drivers must have completed training and have knowledge of all the preconditions necessary for DPF regeneration mode, as recommended by the manufacturer.
   b. With vehicles such as transit buses, failure to meet the minimum vehicle speed requirement may happen more often due to the stop-and-go duty cycle. Therefore, the bus driver must plan to take the vehicle above the required

speed for regeneration while being cognizant of the stops along the route.

c. Drivers in most vehicles will also have a "***DPF inhibit***" switch available to them. This is to interrupt and terminate an ongoing DPF regeneration process or to ignore the request to regenerate. Typically, drivers should not inhibit ongoing regeneration; doing so causes unwarranted thermal stress, and an incomplete regeneration process leads to frequent soot and ash buildup. The inhibit option should only be used in cases of emergency—for instance, if the vehicle goes into regeneration mode at a bus stop or a traffic signal and the exhaust temperature potentially creates safety concerns for bystanders, pedestrians, etc.

d. Ignoring a request for DPF regeneration for too long can cause backpressure on the engine. This can lead to increased fuel consumption, loss of power, and, in extreme cases, engine damage and permanent DPF failure. As mentioned above, to protect the engine and aftertreatment system, manufacturers often create inducement strategies that cut power to the engine or even shut the engine down. This forces the operator to perform parked regeneration to restore normal vehicle operation. A forced or ***parked regeneration*** usually results in vehicle downtime.

4. Operators and drivers should keep an eye out for the "***AUS refill***" warning light. This light is programmed by the manufacturer based on the level of the AUS tank, which stores AUS used for SCR activity, and it prompts the operator to refill periodically. Because of manufacturer inducement strategies, failure to refill promptly can cause power loss and possible vehicle downtime. Lack of AUS for injection can cause SCR saturation and deterioration, which leads to a shorter useful life for SCR.

5. It is recommended that drivers and operators note the AUS level in the tank at the start of each shift. It is important that the levels are noted accurately, as this measurement supports the monitoring of AUS usage and refill intervals, which in turn determine SCR efficiency and can act as indicators of other potential maintenance issues.

6. Operators and drivers should be familiar with all AUS-available stations along their routes to be able to fill upon seeing an "***AUS refill***" warning light during mid-shift.

7. Operators and drivers should only add the manufacturer-recommended amount of AUS and should do so at an approved station. Approved stations can be found by looking for "***Adblue***" or "***AUS32***" markings at the refill station. Adulterated or contaminated (low-grade) AUS can have detrimental effects on the SCR and associated components and can lead to major maintenance issues.

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