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ORIGINAL CONTRIBUTION

A Study on Breakdown Problems of High-Speed Diesel (HSD) Euro 6-Vehicles (Tata motors, Toyota, Hyundai, Mahindra, Eicher, Kia and Ashok Leyland) in BHUTAN

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ABSTRACT

This study investigates the breakdown issues associated with High-Speed Diesel (HSD) Euro 6-compliant vehicles in Bhutan, focusing on leading automobile brands including Tata Motors, Toyota, Hyundai, Mahindra, Eicher, Kia, and Ashok Leyland. The research aims to identify the root causes of frequent mechanical failures and operational inefficiencies in these advanced diesel vehicles operating under Bhutan's unique topographical, climatic, and fuel-quality conditions. Using a mixed-method approach—comprising vehicle diagnostics data, maintenance records, and expert interviews—the study uncovers key challenges such as poor fuel compatibility, inadequate servicing infrastructure, and engine management system faults. Additionally, variations in performance across brands and models are analyzed to provide comparative insights. The findings highlight the need for localized technical adaptations, improved after-sales support, and policy interventions to enhance the reliability and sustainability of Euro 6 vehicles in Bhutan's transport sector.

KEY WORDS:

1. INTRODUCTION

The Country, Bhutan relies on India for all its necessary petroleum products (PoL), sourcing them through three main oil marketing companies such as IndianOil Corporation Limited (IOCL), Bharat Petroleum Corporation Limited (BPCL) and Hindustan Petroleum Corporation Limited (HPCL). Any policy changes in India's petroleum sector will similarly affect Bhutan.

The Department of Trade (DoT) within the Ministry of Industry, Commerce and Employment (MoICE) works to ensure a consistent supply of high-quality petroleum products by maintaining regular bilateral relations with the key suppliers in India. A memorandum of understanding (MoU) regarding

the supply of petroleum products has been signed with the Government of the Republic of India. This MoU provides a legal framework for the supply of PoL products from India's primary oil companies.

Since April 2020, India has implemented EURO VI fuel, meaning that fuels below this standard are no longer available in any Indian states. BIS VI (EURO VI) is the established minimum benchmark for fuel quality across all Indian states, including metropolitan areas. Bhutan receives fuel of the same quality, as we import finished products from India. As noted earlier, Bhutan lacks an oil refinery, allowing it to benefit from this provision offered by the Government of India.

In India, the term BIS VI corresponds to EURO VI, which has a sulfur content of 10 PPM (parts per million), primarily aimed at reducing emissions of NO_x and SO_x, thus supporting the BIS VI vehicle model in addressing climate change.

An article titled “Diesel Vehicles of Tata, Toyota, Hyundai, Mahindra, Eicher, Kia and Ashok Leyland face breakdown problems after adopting Euro 6 standard engines,” published in The Bhutanese on July 20, 2024, prompted to investigate the reasons behind the reported vehicle breakdowns. These issues could stem from either the fuel quality available in Bhutan or from mechanical failures. To determine the actual cause, comprehensive studies have been conducted, as outlined below.

2. FUEL QUALITY

I have conducted research on the breakdown of Euro 6 vehicles in Bhutan, specifically examining the correlation between fuel quality and BS VI engines. Since Bhutan imports finished petroleum products, it is not possible to modify the fuel's sulfur content, which is the key determinant of Euro 6 fuel standards.

However, fuel quality may be compromised through potential adulteration with other solvents or kerosene. That said, the likelihood of kerosene adulteration is highly unlikely, given that kerosene's market price is at par with diesel (HSD). Moreover, kerosene contamination can be easily detected when the fuel is received, as dealers are required to conduct field tests before decanting the product into underground (U/G) tanks. These field tests assess density, physical appearance, and water content in the fuel. The presence of other solvents or impurities can also be detected during these tests. Should dealers or Regional Inspectors have doubts about fuel quality; samples can be sent to the Fuel Laboratory in Thinchupangkha for further analysis based on Euro 6 fuel specifications.

In Bhutan, all fuel pumps are electronic, making tampering by dealers impossible. Meter sealing is conducted by technical experts from the relevant oil companies in the presence of our Regional officials. Additionally, RoICE officials

carry out regular inspections at all fuel stations to ensure fuel quality complies with BIS VI specifications. I also consulted with representatives from India's principal oil companies to confirm the fuel quality in both India and Bhutan. Notably, numerous Euro 6 engine vehicles in India use the same fuel available in Bhutan.

To definitively rule out fuel quality as the cause of vehicle breakdowns, further analysis should be conducted based on the following data.

1. Type of vehicle
2. Manufacturer Company's name
3. EURO 6 or 4
4. If EURO VI vehicles, then last vehicle maintenance report is required
5. Fuel sample drawn from vehicle or from the underground (U/G) tanks
6. Lab report has to be validated including its accreditation, and etc

The news that appeared in TheBhutanese might have been to draw attention of the fuel dealers and the vehicles dealers in Bhutan considering only 10 vehicles facing breakdown problems. It has become like blame-game vehicles dealers vs. fuel dealers and vice versa.

The above findings suggested that the vehicle's breakdown may not be due to the quality of fuel that is available in Bhutan. The other possibility could be due to the vehicles engines associated with the type of Euro 6 engines.

3. BIS VI (EURO VI) VEHICLES ENGINE

Most of the Euro 6 vehicles engines require a special liquid called diesel exhaust fluid (DEF), which is made up of deionized water and urea. DEF helps in converting Nitrous Oxide type of emission from diesel engines into Nitrogen and Water. DEF helps in the chemical reaction that keeps these gases produced during the operation of the diesel engine out of the environment and helps in combating climate change to some extent. DEF is used with nearly every diesel engine vehicle; which is the reducing agent in the

chemical reaction that occurs in selective catalytic reduction (SCR) systems of the euro 6 engines. Some Euro 6 engines do not require DEF but those engines have other system in place which is called Diesel Particulate Filter (DPF). DPF is a device which is designed to remove these diesel particulate matter or soot from the exhaust gas of a diesel engine, which means that DPF is devices that physically capture HSD particulates via filtration process to prevent their release to the atmosphere.

3.1 Types of Diesel Exhaust Fluid (DEF)

This DEF emissions control technology incorporates and reacts with the engine’s exhaust. It propagates DEF injection via a catalyst into the exhaust stream where DEF is chemically reacted and transforms nitrogen oxide into nitrogen, water, and a little carbon dioxide that is expelled in the tailpipe and is eco-friendly.

Nitrogen oxide contributes to the pollution, which can lead to many issues like acid rain, nutrient pollution, and harms in human health, most especially respiratory problems.

The SCR system creates an oxidizing atmosphere that is ideal for a nitrogen oxide reduction reaction. This is low cost and fuel efficient technology helps in battling the

4. HD (Heavy Duty) Emission Norms

Table 1: HD (Heavy Duty) Emission Norms

(WHTC i.e. World Harmonized Transient-Cycle) (ETC i.e. Engine Transient Cycle)							% Emission Reduction table			
Emission level in BS Std	Test procedure followed	Carbon Monoxide (gm per KWH)	Methane (gm per KWH)	NMHC(g m per KWH)	NOx (gm per KWH)	PM(gm per KWH)	Carbon Monoxide	HC	NOx	PM
BS IV	ETC	4.0	1.10	0.55	3.50	0.03	0	55	87	67
BS VI	WHTC	4.0	0.50	0.16	0.46	0.01				

emissions and environmental destruction. SCR technology can reduce nitrogen oxide emissions up to 90%, in addition with other harmful gases, therefore contributing to controlling pollution. In addition to pollution reduction, SCR and DEF can also increase fuel economy.

3.2 Types of DEF and some known facts of DEF

The people call it as DEF, AdBlue, AUS32, SERVO, MAK and etc which has the following properties:

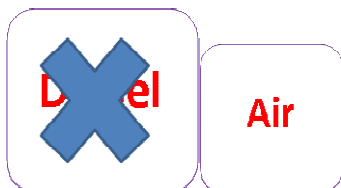
- Reduces Nox emission by >90 % in SCR catalytic converter
- DEF is safe to handle, not toxic, flammable or hazardous and so not harmful in head, shoulders and toes DOWN WHICH side does it go STOP It is not a fuel additive, so the means of transport it must not whether transverse DIESEL Witnesses confirm that ALL DEF parts of speech covered the hole was dug and concealed.
- Urea used for DEF is not FERTILIZER Urea, it is made out of Special Grade Urea
- DEF is NOT supplied to the engine, it is injected into the exhaust pipe previously SCR.

Other Limits introduced in BS VI standard are:

PN- 6.0×10^{11} #/kWh; NH₃ – 10 ppm

- Also the result shows that both BS IV & BS VI heavy duty emission norms neutral to fuel
- BS VI and NO_x emission were reduced by 87%
- There is a big reduction on HC and PM emissions simultaneously.

4.1 NO_x Emission Formation



The Components of Air are N₂ (Nitrogen) = 79% and O₂ (Oxygen) = 21% by volume.

During combustion, the cylinder temperature is very High (>1500 °C)

NO_x Emissions reduction:

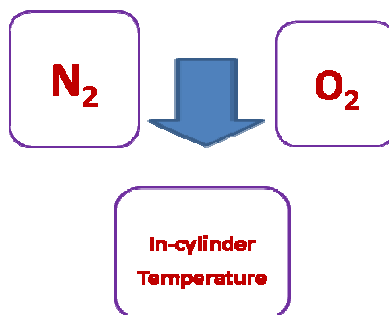


Figure 1:Exhaust Gas Recirculation (EGR)

Issues with EGR alone NOx control technology in BS VI regime

- High level of reduction in NOx emissions is not feasible
- Increase in PM emissions and Engine oil contamination
- Reduced life of the engine

5. WHAT IS THE MEANING OF SCR?

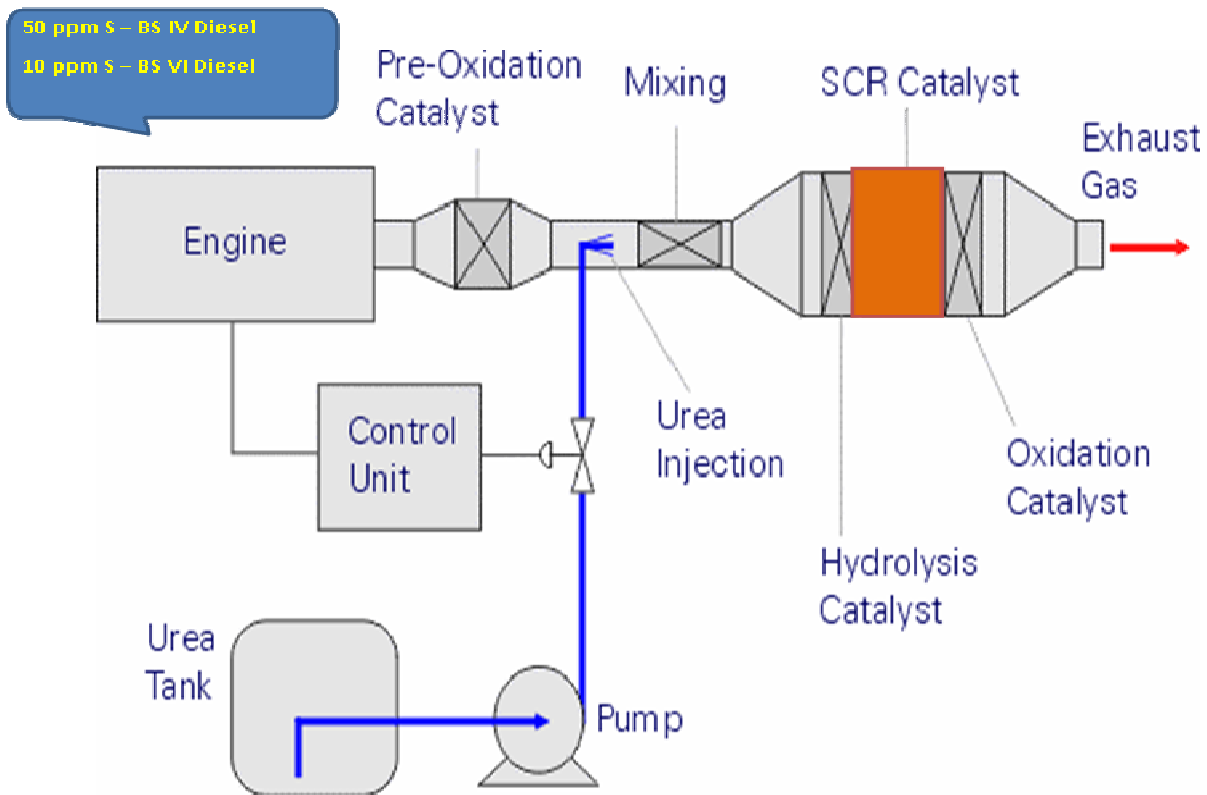


Figure 2: Meaning of SCR

SCR equipped vehicle offer **typically 5% improved fuel economy** since it allows engine to operate at high engine-NO_x conditions where thermal efficiency is much high.

5.1 Selective Catalytic Reduction - (Exhaust Gas After-treatment)

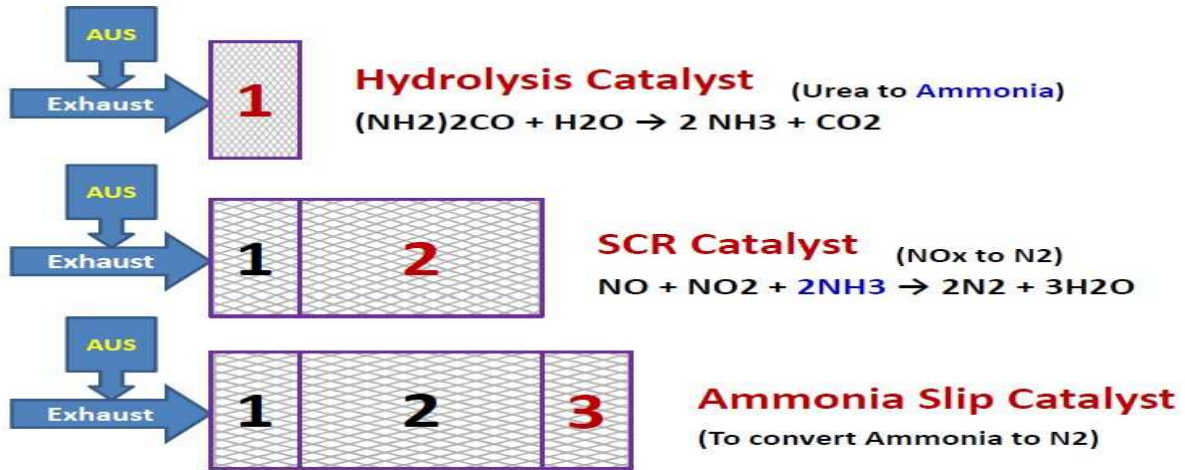


Figure 3: Selective Catalytic Reduction



Figure 4: Bosch Denoxtronic urea injection system - Major components

A: Supply system; B: Dosing system; C: Injection nozzle unit



DEF Tank adj. to Fuel Tank

Consumption of AUS32 in vehicle \square ~ **5% of diesel consumption**

Figure 5: Supply system; B: Dosing system; C: Injection nozzle unit

6. TECHNICAL SPECIFICATIONS OF DEF

- Name: AUS-32
- Aqueous Urea Solution containing urea of 32.5% by weight

Other names given by various Companies in India

- AdBlue – Trademark of VDA (German Automobile Manufacturers Association)
- DEF – Commonly called as Diesel Exhaust Fluid (DEF) in countries like USA and others

Quality standards (specification)

- DIN 70070 : 2005
- ISO 22241 : 2019
- IS 17042 : 2018

6.1: AUS 32 - Quality Requirements as per standard ISO 22241-1

Table 2: AUS 32 - Quality Requirements as per standard ISO 22241-1

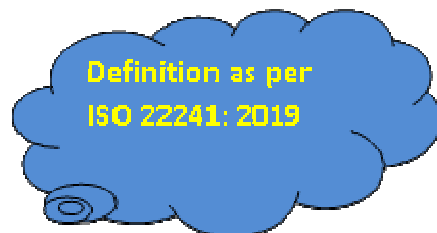
Urea content		31.8 – 33.2	% by weight
Alkalinity as NH ₃	maximum	0.20	% by weight
Biuret	maximum	0.30	% by weight
Insoluble	maximum	20.0	mg per kg
Aldehyde	maximum	5.0	mg per kg
Phosphate (PO ₄)	maximum	0.50	mg per kg
Aluminum	maximum	0.50	mg per kg
Calcium	maximum	0.50	mg per kg
Iron	maximum	0.50	mg per kg
Copper	maximum	0.20	mg per kg
Zinc	maximum	0.20	mg per kg
Chromium	maximum	0.20	mg per kg
Nickel	maximum	0.20	mg per kg
Magnesium	maximum	0.50	mg per kg
Sodium	maximum	0.50	mg per kg
Potassium	maximum	0.50	mg per kg
Density at 20°C		1087.0 - 1093.0	kg/m ³
Refractive index at 20°C		1.3814 - 1.3843	(-)
Identity		identical to reference	(-)

6.2: Quality of DEF is important:

A. Use of Contaminated / Off-specification of DEF will lead to following issues

- The development of deposits within the urea supply and dosing system.
- Clogging of injectors.
- Suffocation of a catalyst causing irreversible harm or decline in productivity.
- SCR System warranty is null and void
- Certificate of Fitness was denied

6.3: Raw Materials



Technically pure urea is:

- Industrial grade Urea produced with traces of biuret, ammonia and water only,
- Free of aldehydes or other substances such as anticaking agent and
- Free of contaminants such as sulfur and its compounds, Chloride, Nitrate or other compounds

Pure Water is:

- Water which is very low in inorganic, organic or colloidal contaminants, produced by single distillation, deionisation, ultra-filtration or reverse osmosis.

Production of DEF



Figure 6: Production of DEF

Serious destruction to the ecosystem:

6.4: DEF - Test Equipments and Methods

Table 3: DEF - Test Equipments and Methods

Characteristics	Test Method	Measurement Method	Equipment
Urea	ISO 22241-2 Annex B	Total nitrogen Method	Automatic nitrogen analyzer
Density at 20°C	ISO 3675 or ISO 12185	Specific gravity method or Oscillation frequency method	Glass hydrometer or U-tube density meter
Refractive index at 20°C	ISO 22241-2 Annex C	Refractive index **	Refractometer
Alkalinity as NH ₃	ISO 22241-2 Annex D	Potentiometric titration of free ammonia	Potentiometer
Insolubles	ISO 22241-2 Annex G	Gravimetric method	Analytical balance
Biuret	ISO 22241-2 Annex E	Photometric method	Spectrophotometer
Aldehyde	ISO 22241-2 Annex F	Photometric method for Formaldehyde	
Phosphate (PO ₄)	ISO 22241-2 Annex H	Photometric method or Spectrometry Method	Spectrophotometer /ICP
Calcium	ISO 22241-2 Annex I	Spectrometry Method	Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES).
Iron			
Copper			
Zinc			
Chromium			
Nickel			
Aluminium			
Magnesium			
Sodium			
Potassium			
Identity	ISO 22241-2 Annex J	IR spectrometry	IR spectrometer or FTIR

**** For Urea content - Refractive index method can be used for urea content.**

6.5 Quality Check (On site)



Figure 7: Handheld Digital Refractometers for on-site quality check

6.6 Storage of DEF

Table 4: Storage of DEFISO 22241-3

Ambient storage temp. (°C)	Minimum Shelf Life Months
≤ 10	36 months (3 years)
≤ 25	18 months (1 and half years)
≤ 30	12 months (1 year)
≤ 35	6 months
> 35	Check every batch before use

6.7 Material for DEF containers: Stainless Steel / HDPE

❖ Metals

- ✓ Stainless Steel, eg. UNS S30400, S30403, S31600, S31603, S31625 and S32100
- ✓ Titanium
- ✓ Hastelloy C-276

❖ Polymers (free of additives that affect SCR system)

- ✓ Polyethylene (PE)
- ✓ Polypropylene (PP)
- ✓ Polyisobutylene (PIB)
- ✓ Perfluoroalkoxy alkane (PFA)
- ✓ Polyfluoroethylene (PFE)
- ✓ Polyvinylidene fluoride (PVDF)
- ✓ Polytetrafluoroethylene (PTFE)
- ✓ Copolymers of PVDF and hexafluoropropylene (HFP)

6.8 DEF Packaging system:



Figure 8: DEF Packaging system

6.9 DEF Storage system:

Freezing of DEF

- DEF freeze @ -11°C
- Optimum urea concentration: 32.5% which provides lowest freezing point
- Addition of anti-freeze agents in AUS 32 - NO
- Freezing does not degrade the quality of AUS 32
- Solidified The volume of DEF increases by approximately 7% when solidified than the liquid form
- Packaging needs to take care additional volume increase of AUS 32 in case of freezing (Freeze-proof design).
- The design of Vehicles is such that it generally equipped to handle freezing issues of AUS 32



Figure 9: Fill Right Quality DEF while you fill Right Quality Diesel

7 CONCLUSION

Bhutan began importing BIS 6 engine vehicles in January 2021, but the launch was postponed to January 2022 due to global supply chain disruptions caused by the pandemic. In February 2024, the first complaints regarding BIS 6 vehicles were reported by 18 transporters to the Department of Environment and Climate Change (DECC).

In response to these complaints, DECC allowed the interim import of vehicles adhering to BIS 4 and above emission standards from May 2024 until April 2027 (for three years). This decision was based on the challenges reported by importers and the Bhutanese media, and aimed to give vehicle importers time to adjust to the higher emission standards.

During consultations with vehicle dealers, Samden Vehicles reported that BIS 6 Tata commercial vehicles were also facing issues, requiring engine overhauls. The dealers attributed these problems to substandard fuel quality, which was tested and found incompatible with BIS 6 vehicles by external Indian experts. However, no test reports were provided to support these claims.

Bhutan Hyundai indicated that the issues with BIS 6 vehicles were due to Bhutan's slow driving environment, which causes the Diesel Particulate Filter (DPF) to choke. For automatic regeneration of the DPF, vehicles need to maintain a speed of 60 km/h for 30 minutes a condition that is often ignored or not feasible in Bhutan.

Based on the feedback from vehicle dealers, it appears that there is a general lack of awareness about the technical requirements, operation, and maintenance (O&M) of BIS 6 engines.

STCBL's Insights

STCBL, the only state-owned enterprise dealing with vehicle imports, reported multiple factors contributing to the issues with BIS 6 vehicles:

1. DPFs tend to stop functioning above 3000 feet altitude.

2. Non-availability of Diesel Exhaust Fluid (DEF or AdBlue) due to export restrictions from India.
3. Bhutan's road infrastructure makes it difficult to maintain the required speed of 60 km/h for 30 minutes.
4. Low fuel quality (high chloride content), as per a test conducted in Germany, though the test report could not be validated.

Dealers have requested the Ministry of Energy and Natural Resources (MoENR) to allow the import of BIS 4 vehicles without DPF and Exhaust Gas Recirculation (EGR). They also highlighted a lack of awareness about the appropriate DEF quality and the proper O&M of DPFs, which are essential for BIS 6 engines. Using inferior or expired DEF can lead to BIS 6 engine breakdowns.

The Indian government introduced BIS 6 fuel quality standards for both diesel and gasoline engines in April 2020 and no breakdowns have been reported for petrol engines.

Technological Differences between Brands

It was observed that certain car brands are equipped with both EGR and DPF systems, while others are not. This suggests that technological differences between brands play a role, making a blanket approval for import without EGR and DPF unsuitable for all vehicles.

Fuel Quality Concerns

The claim that low fuel quality is the primary cause of BIS 6 vehicle issues remains unconfirmed. The Department of Trade (DoT) regularly tests fuel, and Oil Marketing Companies (OMCs) assert that all fuel parameters meet BIS 6 specifications. OMCs also raised concerns about the methodology used to collect and ship fuel samples for testing. If samples are not collected by authorized personnel and tested in recognized labs, OMCs do not acknowledge the results.

Additionally, the possibility of fuel adulteration cannot be entirely ruled out, though the motivation to adulterate fuel using kerosene is low since its price is now comparable to diesel.

However, adulteration could still occur before the fuel enters Bhutan.

Given these multiple factors, it is difficult to definitively state that fuel quality in Bhutan is responsible for the BIS 6 vehicle issues. Moreover, with only one source of fuel imports, making accusations about fuel quality without sufficient evidence may not be in Bhutan's best interest.

8 Way Forward

1. **MoICE** should continue bilateral discussions with OMCs to ensure a better quality of fuel in collaboration with relevant stakeholders.
2. **MoICE**, in consultation with OMCs or DRCs, should ensure fuel is free from adulteration during transit between Bhutan and the source.
3. Vehicle dealers need to be sensitized about BIS 6 engine requirements as outlined in the manufacturer's logbook.

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