



Diagnostics for Selective Catalyst Reduction (SCR)

On-Board Diagnostics (OBD)

U.S. Update Symposium

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**EVERY
TIME.**

Presenter

- Jim Nebergall
 - Technical Specialist, OBD
 - Cummins, Inc

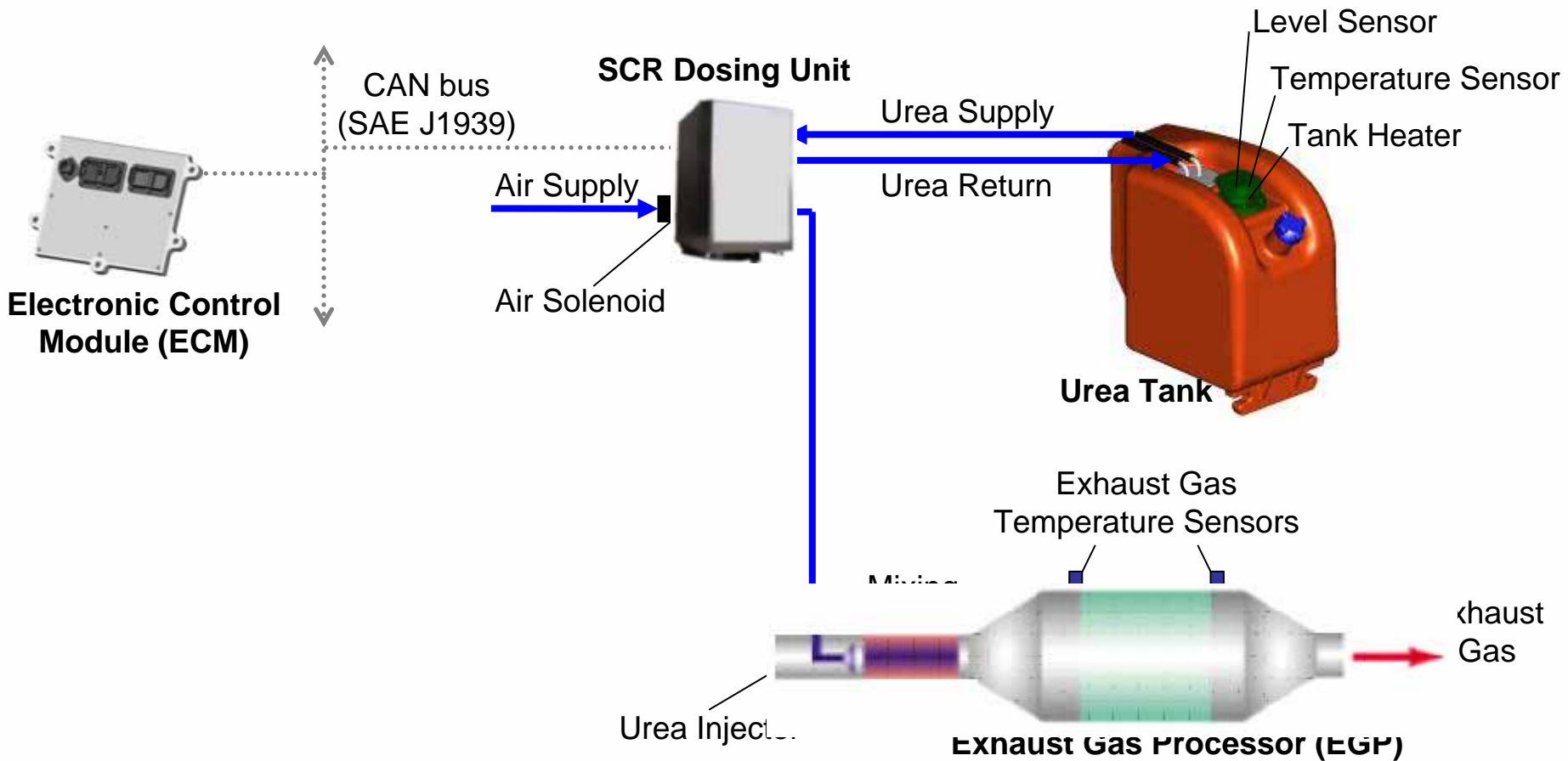
Abstract

- Review challenges of diagnosing an SCR system based on Euro 4 OBD regulations
- Consider the future challenges of SCR diagnostics that lie ahead in North American

Overview

- Selective Catalyst Reduction (SCR)
- Diagnostic Challenges
- Future Diagnostic Challenges for North America
- Conclusions

Selective Catalyst Reduction (SCR)



Selective Catalyst Reduction (SCR)

- Capable of up to 90% NO_x conversion
- Increased fuel economy
- Traditionally used in stationary diesel applications
- Heavily used in Europe to meet Euro 4 heavy duty diesel emission standards

Diagnostic Challenges

- Open-Loop Control
- SCR System Monitor
- SCR Catalyst Monitor

Diagnostic Challenges

- **Open-Loop Control**
- SCR System Monitor
- SCR Catalyst Monitor

Diagnostic Challenges: Open-Loop Control

- Challenge
 - The technology for closed-loop performance feedback was not mature enough for production applications
 - NOx Sensor
 - Detect exothermic reaction with temperature sensors

Diagnostic Challenges

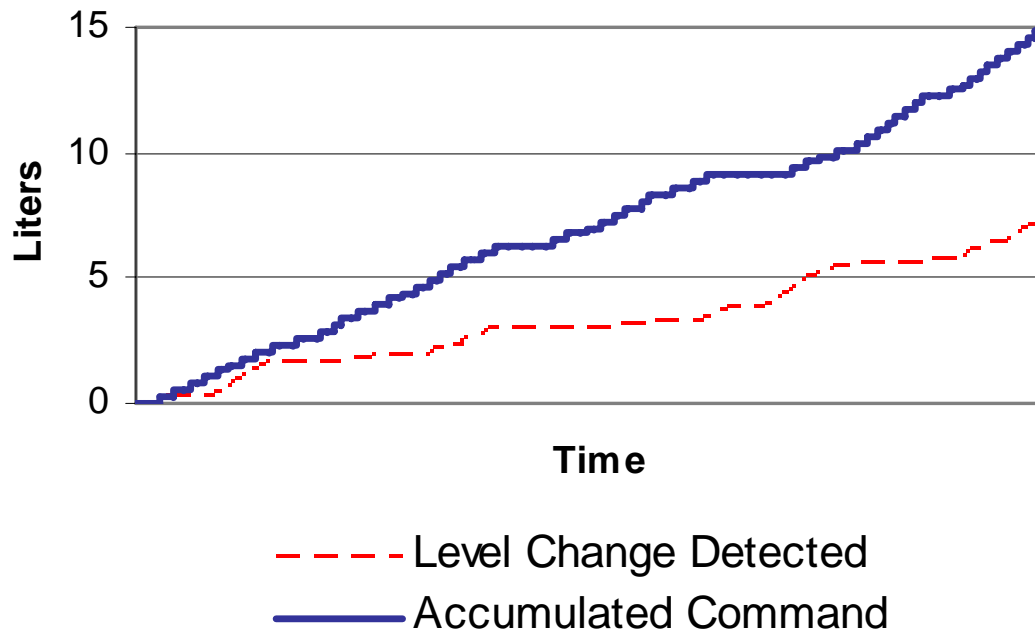
- Open-Loop Control
- **SCR System Monitor**
- SCR Catalyst Monitor

Diagnostic Challenges: SCR System Monitor

- Challenge
 - No feedback of system performance
 - Monitor the air/urea mixture injected into the exhaust
 - Cost effective method does not exist
- Solution
 - Rationality diagnostic
 - Compare injection quantity (commanded) to the change in tank volume (actual)
 - An error is set when a 50% deviation is detected after 15L of urea is either injected or consumed

Diagnostic Challenges: SCR System Monitor

- Failure Detection Example

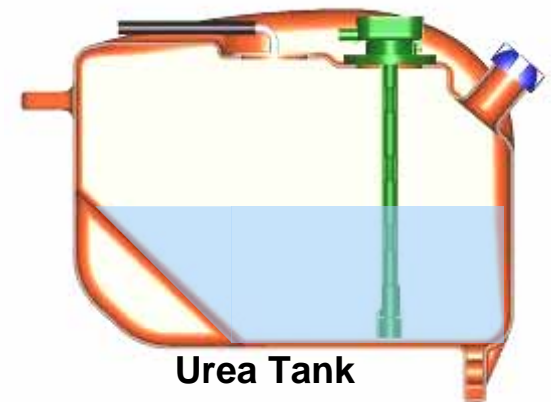


Diagnostic Challenges: SCR System Monitor

■ Solution Needs

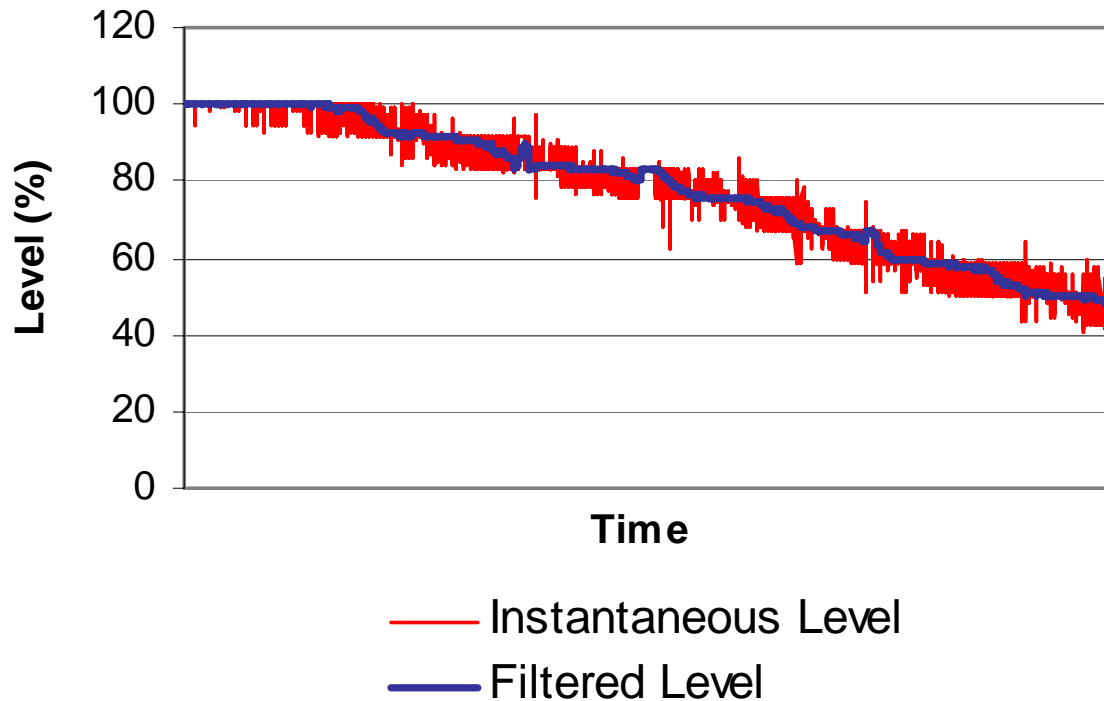
- Accurate measure of desired urea injected (command)
 - Satisfied by accurate dosing control
- Accurate measure of the volume change in the urea tank (actual)
 - Challenges
 - Variability in tank design
 - Terrain

SCR Dosing Unit



Diagnostic Challenges: SCR System Monitor

- Urea Level Sensor Filtering

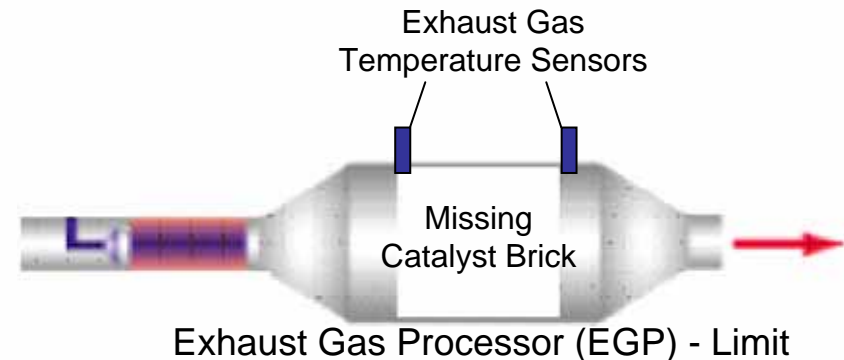
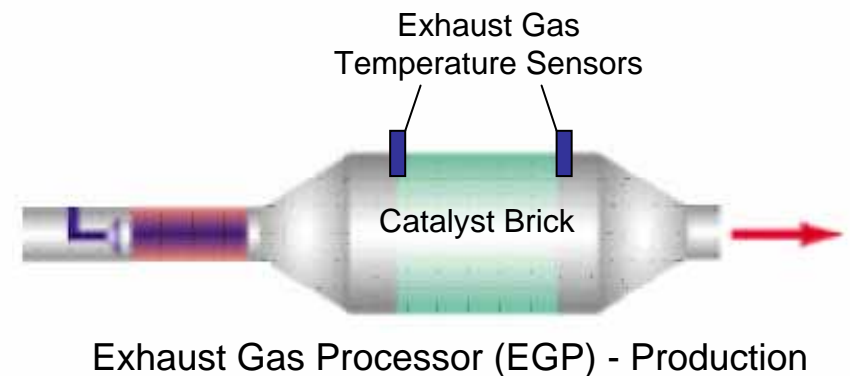


Diagnostic Challenges

- Open-Loop Control
- SCR System Monitor
- **SCR Catalyst Monitor**

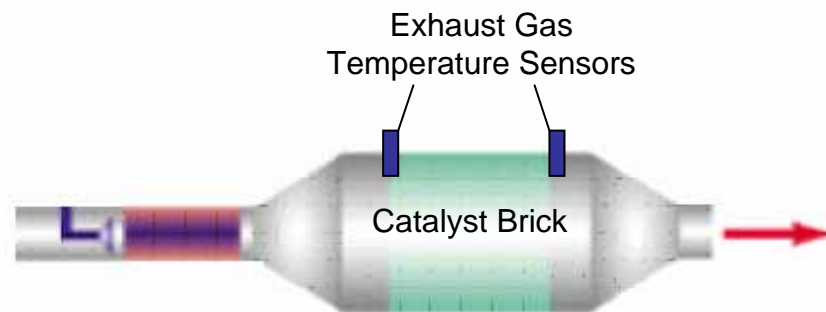
Diagnostic Challenges: SCR Catalyst Monitor

- Detect Major Functional Failure
 - Complete removal
 - Replacement with faulty system



Diagnostic Challenges: SCR Catalyst Monitor

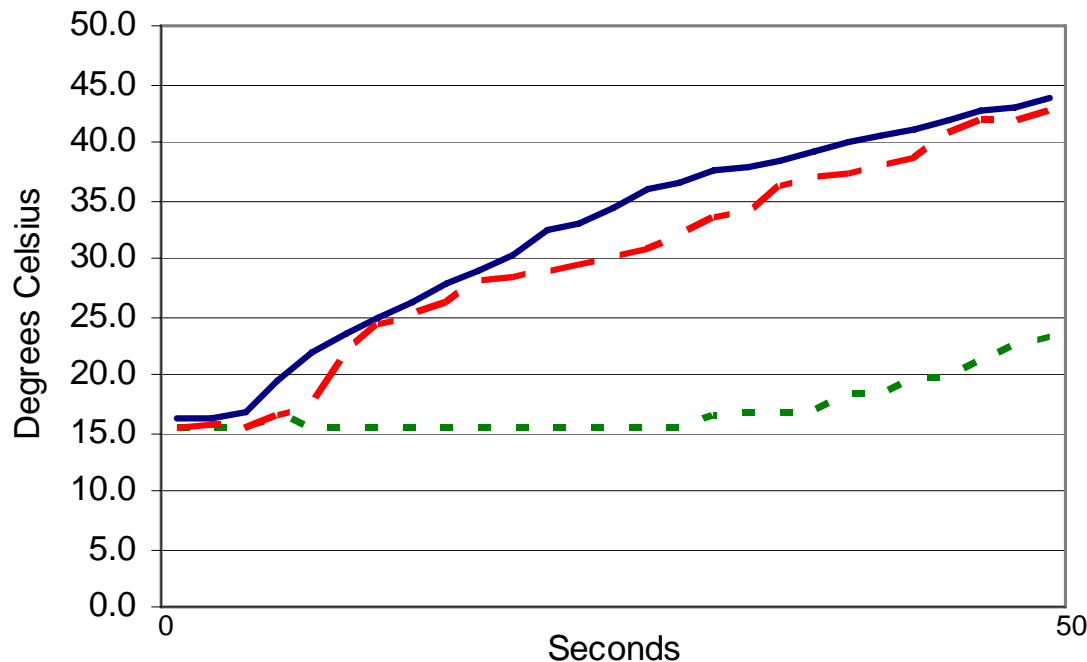
- Challenge
 - No closed-loop performance feedback
- Solution
 - Monitor catalyst temperature sensors for a catalyst warm-up temperature signature



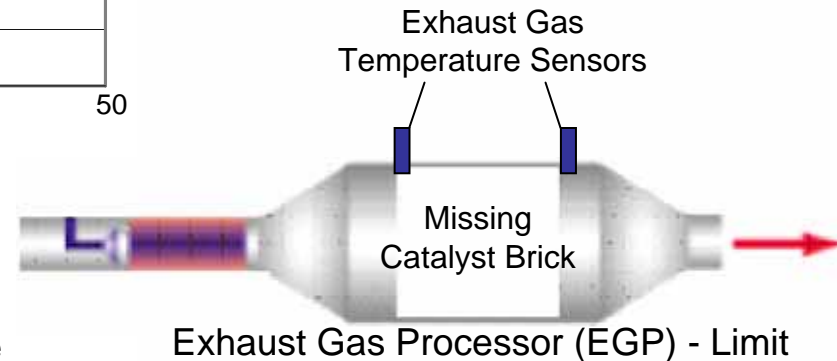
Exhaust Gas Processor (EGP) - Production

Diagnostic Challenges: SCR Catalyst Monitor

■ Catalyst Temperature Signature



- SCR Catalyst Inlet Temperature
- - - SCR Catalyst Outlet Temperature
- - - Limit SCR Catalyst Outlet Temperature



Future Diagnostic Challenges for North America

- Closed-Loop Performance Feedback
- System Tampering
- Fault Accommodation

Future Diagnostic Challenges for North America

- **Closed-Loop Performance Feedback**
- System Tampering
- Fault Accommodation

Future Diagnostic Challenges for North America: Closed- Loop Performance Feedback

- Closed-Loop performance feedback would be necessary to ensure proper diagnosis of an SCR system for 2010 OBD
- Potential Solution
 - NOx Sensor
 - Provides necessary feedback
 - Hurdles
 - Durability requirements
 - Compensating for sensor shift
 - Vehicle duty cycle

Future Diagnostic Challenges for North America

- Closed-Loop Performance Feedback
- **System Tampering**
- Fault Accommodation

Future Diagnostic Challenges for North America: System Tampering

- Incentive for tampering
 - Urea costs
- Simple tampering modes
 - Electrical disconnections
- Complex tampering modes
 - Rerouting urea injector lines back to urea tank
 - Filling tank with a cheaper solution than urea
- Highlights need for performance feedback
 - Feedback mechanism may become the target of tampering

Future Diagnostic Challenges for North America

- Closed-Loop Performance Feedback
- System Tampering
- **Fault Accommodation**

Future Diagnostic Challenges for North America: Fault Accommodation

- Create an incentive for maintaining the SCR system
 - How should the OBD system react to a failure in the SCR system that adversely affects NOx conversion?
 - Potential Solution
 - Switch the engine into a lower power / lower NOx compliant recipe

Future Diagnostic Challenges for North America: Fault Accommodation

■ Special Fault Handling

– Empty Urea Tank

- Condition does affect emissions
- Condition does not require a service event

– Potential Solution

- Extinguish MIL immediately upon refilling urea tank
- Deviation from the North American OBD regulations, but it needs to be explored

Conclusions

- Many challenges existed for Euro 4 OBD, primary contributor was lack of mature technologies for closed-loop feedback
- A cost effective and reliable feedback mechanism is necessary to validate SCR system performance for the 2010 heavy-duty diesel market
- North American OBD regulations need to be addressed to enable alternate fault accommodation strategies

Questions?

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