Diagnostics for Selective Catalyst Reduction (SCR)

On-Board Diagnostics (OBD)
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EVERY TIME.

Presenter

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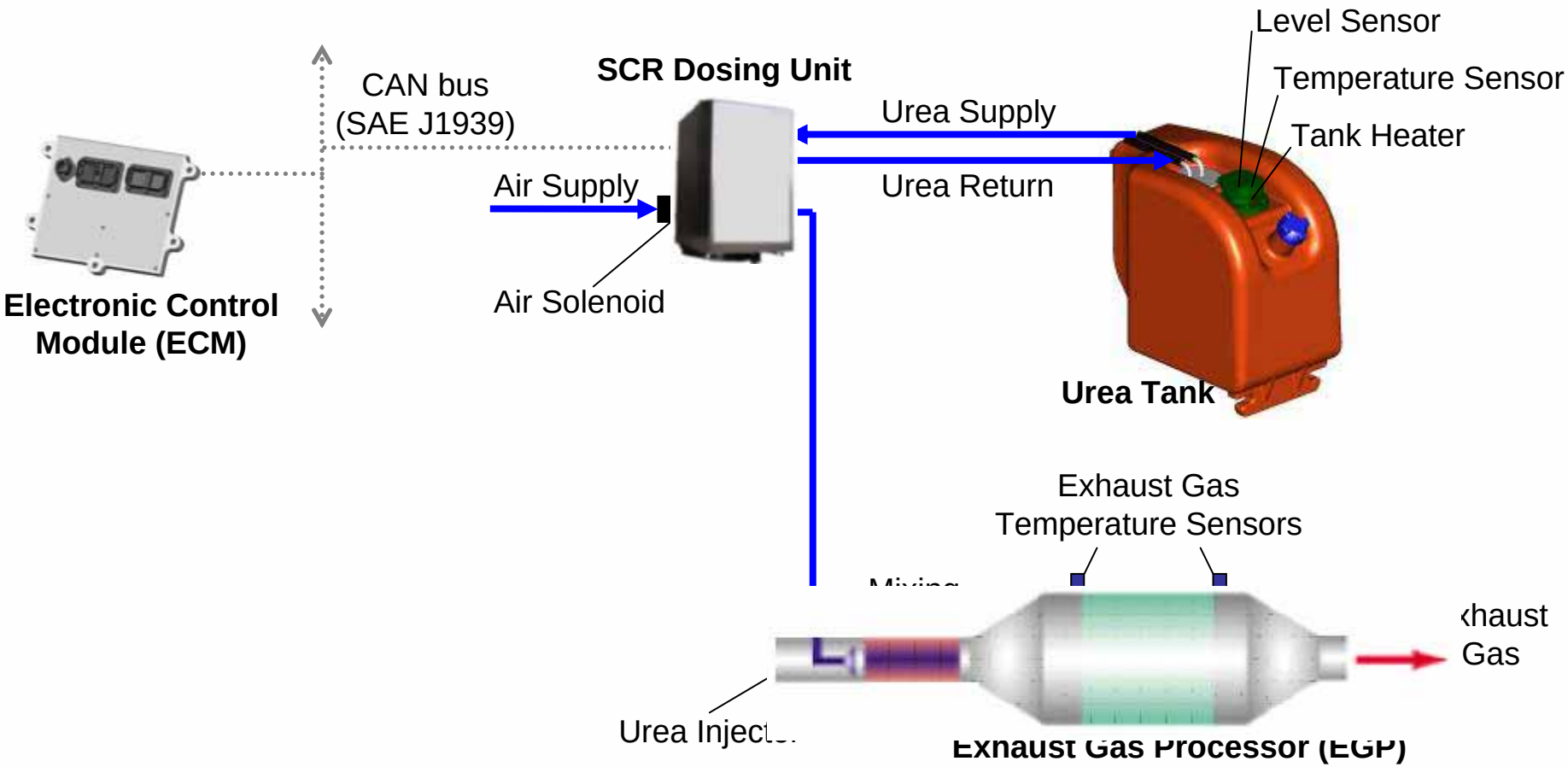
Abstract

- 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% NOx 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

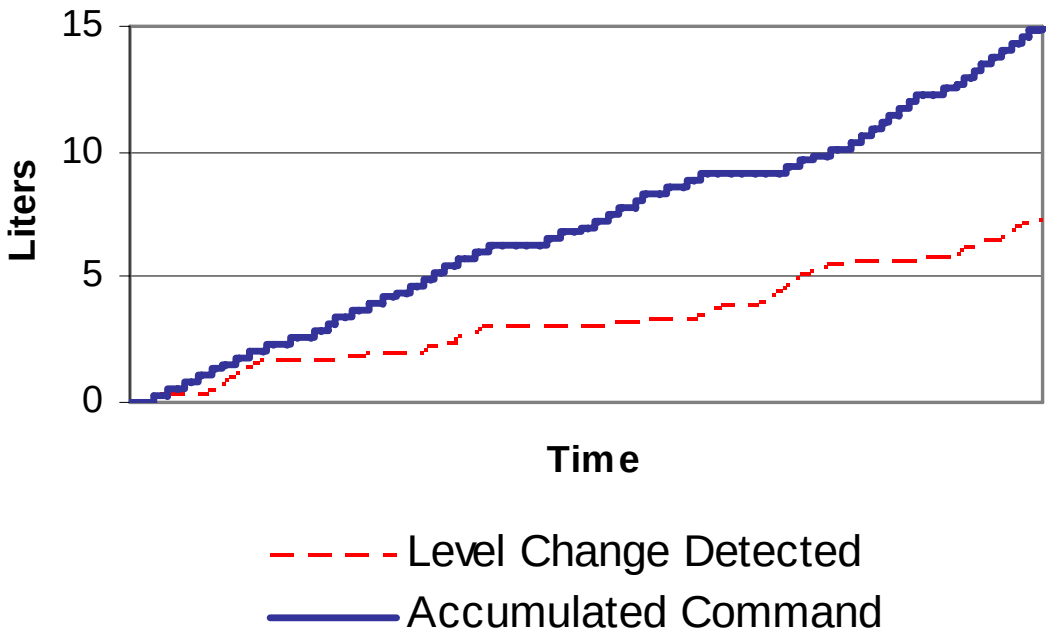
- Open-Loop Control
- **SCR System Monitor**
- SCR Catalyst Monitor

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

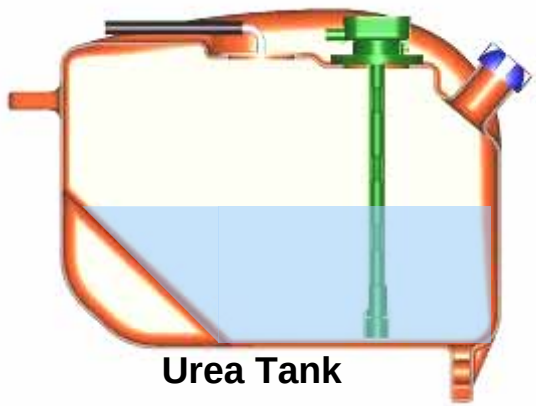
- Failure Detection Example



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

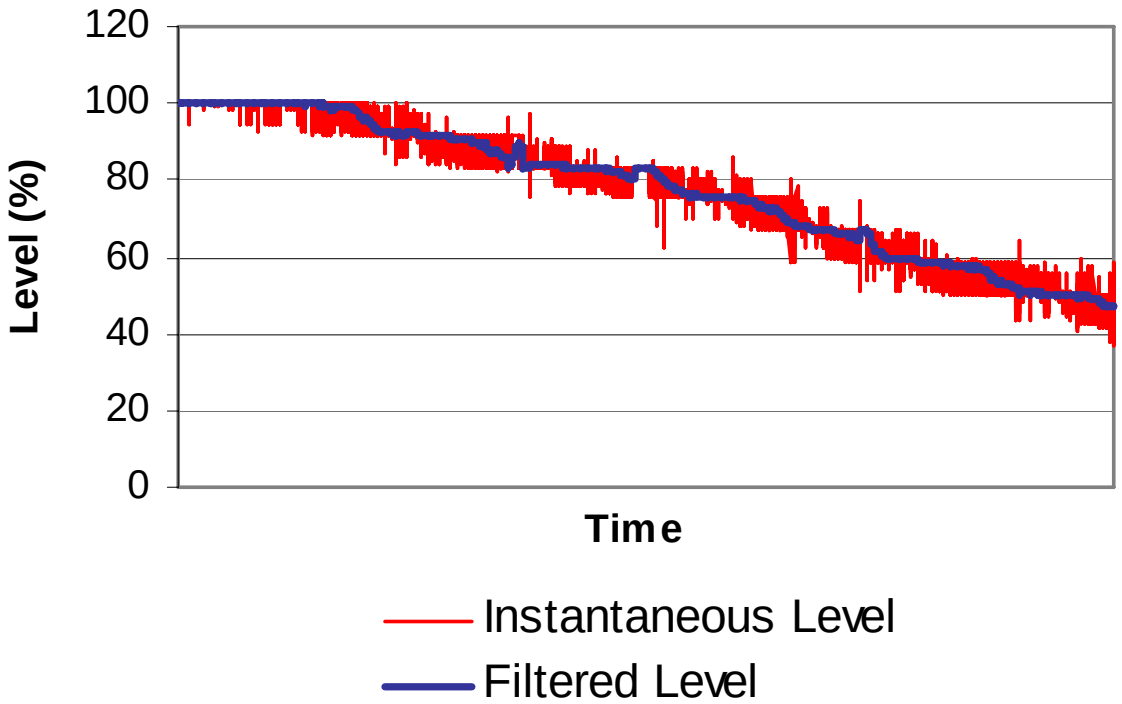
SCR Dosing Unit



Urea Tank

Diagnostic Challenges: SCR System Monitor

- Urea Level Sensor Filtering

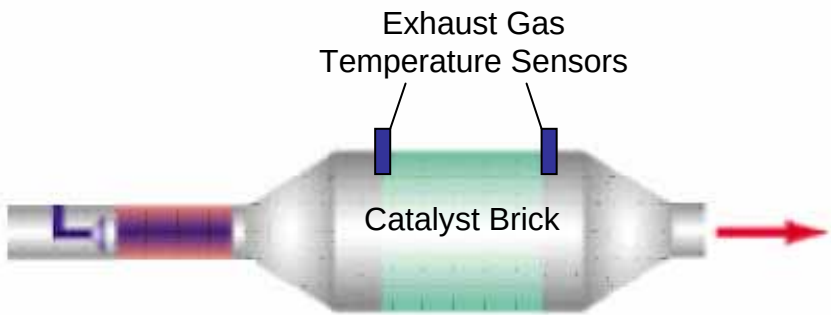


Diagnostic Challenges

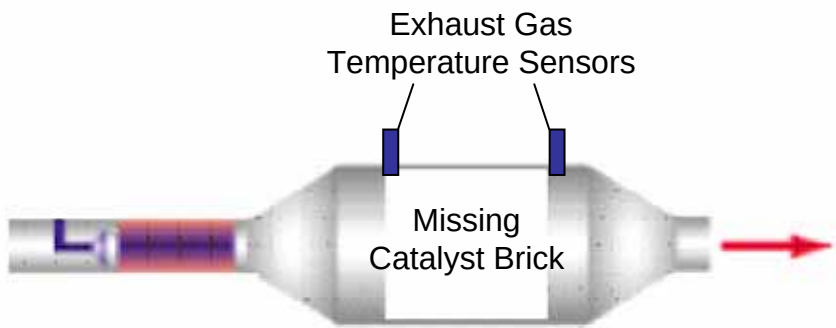
- Open-Loop Control
- SCR System Monitor
- **SCR Catalyst Monitor**

Diagnostic Challenges: SCR Catalyst Monitor

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



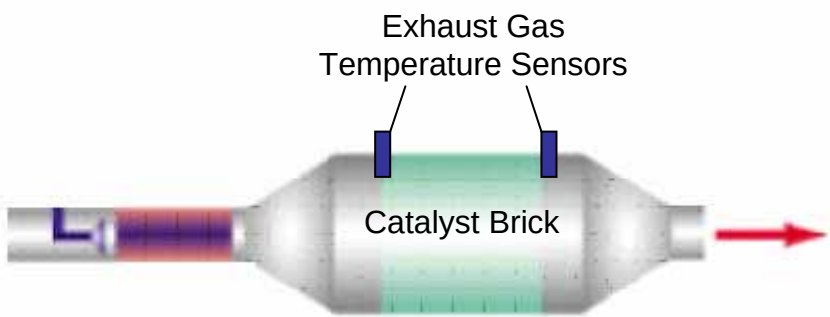
Exhaust Gas Processor (EGP) - Production



Exhaust Gas Processor (EGP) - Limit

Diagnostic Challenges: SCR Catalyst Monitor

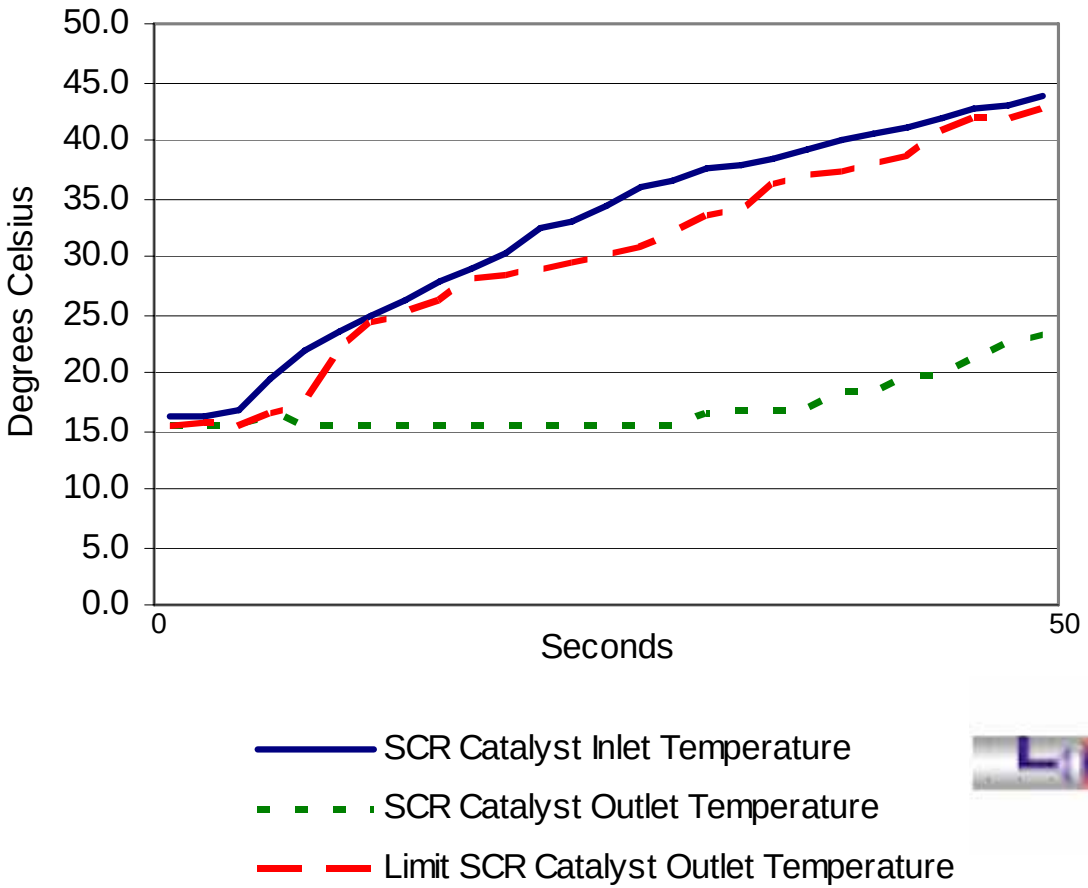
- Challenge
  - No closed-loop performance feedback
- Solution
  - Monitor catalyst temperature sensors for a catalyst warm-up temperature signature

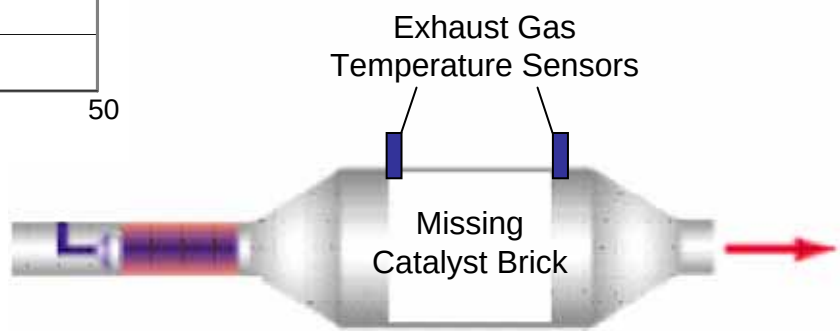


Exhaust Gas Processor (EGP) - Production

Diagnostic Challenges: SCR Catalyst Monitor

- Catalyst Temperature Signature





Exhaust Gas Processor (EGP) - Limit

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
    - Hurtles
      - 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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