

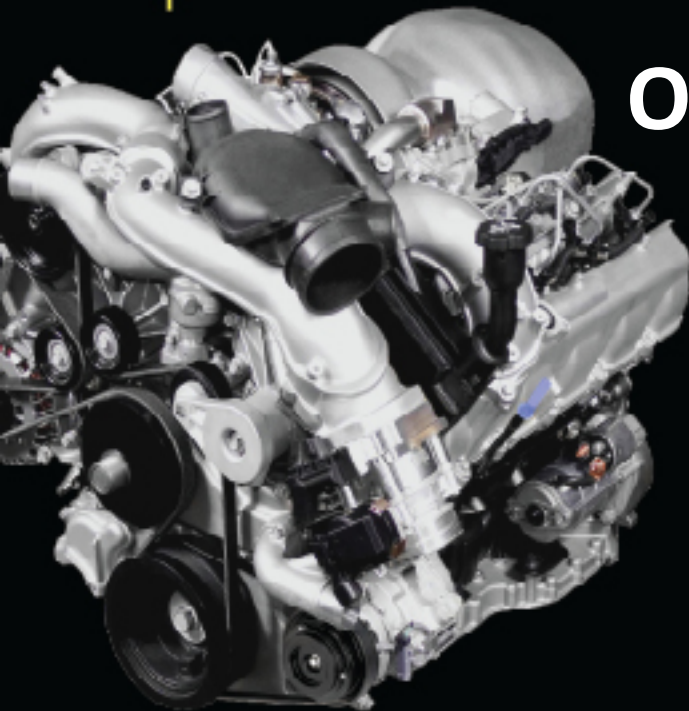


SAE 2009 **On-Board Diagnostics** Symposium

Update on Light and Heavy Duty Vehicle

September 22-24, 2009 • Indianapolis Marriott Downtown • Indianapolis, IN

OBD Vehicle Integration OEM Variation Management 2009 SAE OBD Symposium



Jeff Potts

Cummins Inc

September 22, 2009



SAE 2009 On-Board Diagnostics Symposium

Update on Light and Heavy Duty Vehicle

September 22-24, 2009 • Indianapolis Marriott Downtown • Indianapolis, IN

Agenda

- Heavy Duty On-Board Diagnostics (HD OBD)
- OBD Challenges for Engine Manufacturers
- OEM Integration Management Process
- Example OEM Integration Management: Cooling System Monitor
- Summary



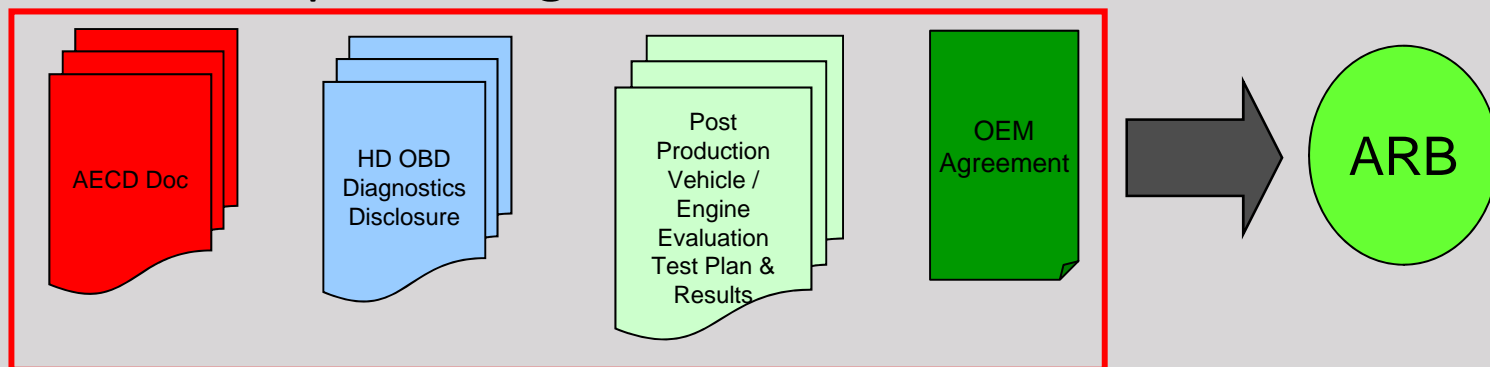
Heavy Duty On-Board Diagnostics

- OBD is a system
 - Detects failures which adversely affect emissions
 - Illuminates a dashboard light (Malfunction Indicator Lamp) to inform the driver of a fault
 - Provides standard and unrestricted access for diagnosis and repair
- OBD monitors examples:
 - Engine: EGR flow rationality
 - Aftertreatment: DOC efficiency
 - Vehicle level: Cooling system monitor



HD OBD Regulation Requirements

- HD OBD requirements driven by CCR 1971.1
 - Applicable for Automotive Heavy Duty On-Highway vehicles with GVW > 14,000 lb
 - Timeline: One diesel engine family in 2010 (EMD+ for remaining diesels in 2010), then all diesels in 2013
 - Cummins certify engines as an OBD product with OEM compliance agreement





OBD Challenges for Engine Manufactures - Light Duty vs. Heavy Duty

- Accommodation for the variations on vehicle configuration and engine / aftertreatment installation
 - Different than light duty industry which has relatively small variation of applications
 - Heavy Duty has many different type of vehicle applications
 - Line Haul
 - Vocational
 - Oil & Gas
 - School Bus
 - Emergency Vehicle



OBD Challenges for Engine Manufacturers - OEM Installation Variations

- Vehicle configurations: line haul, vocational, Oil & Gas, School bus, Emergency Vehicle
 - Engine packaging (e.g. front engine, rear engine, exhaust system)
 - Cooling system (e.g. heat draw)
 - Sensor locations (e.g. coolant level, VSS, AAT, Throttle)
 - Aftertreatment system packaging
 - Transmission: automatic, AMT, manual (Inertia effects on diagnostic monitors)
 - 3rd party vehicle components: multiplexed throttle
 - Lamp strategy (hardwired vs. datalinked, MIL placement)
- **To account for variation engine manufacturers must provide application guidelines to ensure OBD diagnostics function as intended**



SAE 2009 On-Board Diagnostics Symposium

Update on Light and Heavy Duty Vehicle

September 22-24, 2009 • Indianapolis Marriott Downtown • Indianapolis, IN

OBD Challenges for Engine Manufacturers - Examples of OBD Implications with OEM Installations

- False alarm of cooling system monitor due to excessive OEM Heat draw
- Temperature sensor inaccuracy due to heat influence. e.g. APU
- SCR out NOx sensor response time vs. exhaust transportation delay due to large aftertreatment system volume

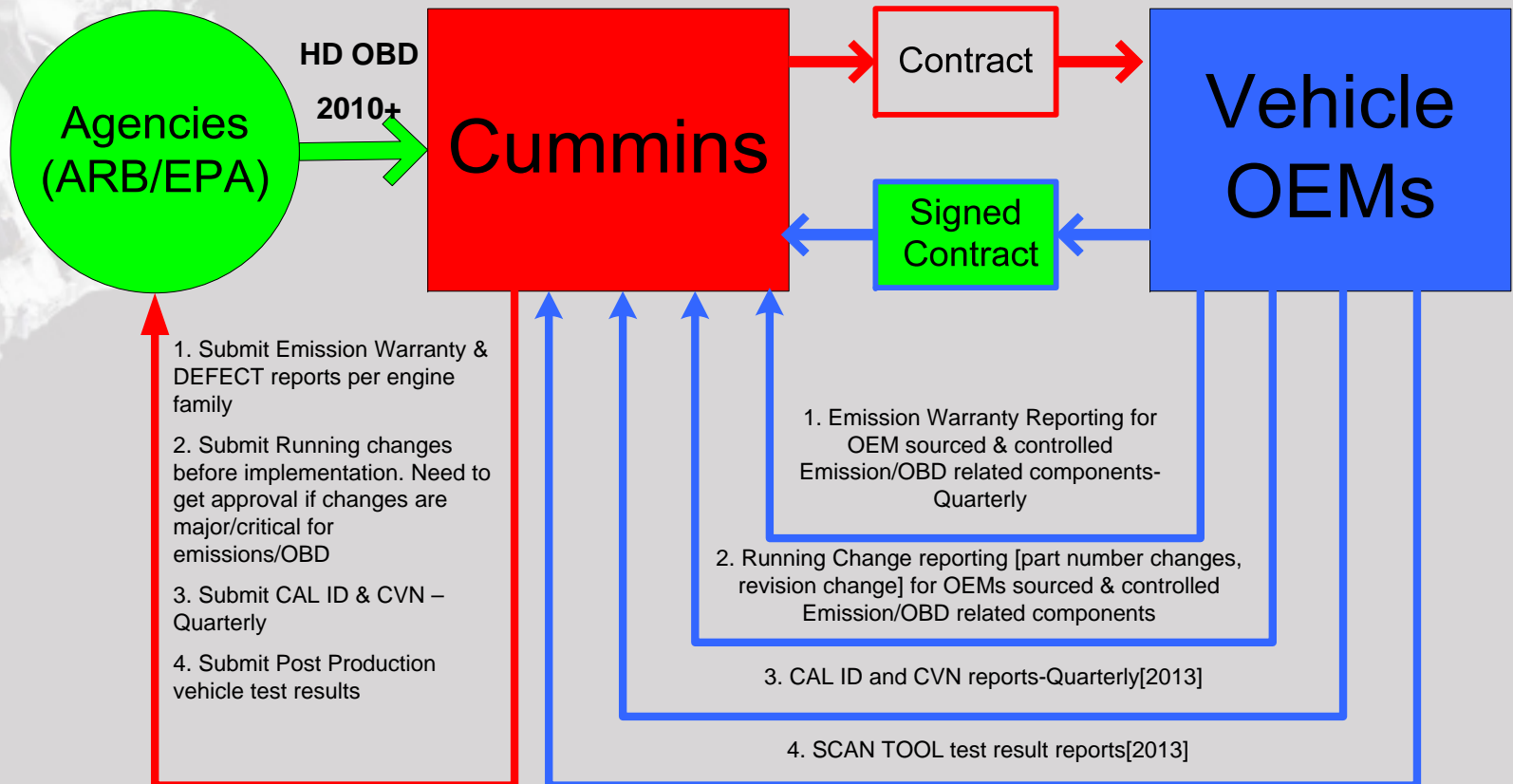


SAE 2009 On-Board Diagnostics Symposium

Update on Light and Heavy Duty Vehicle

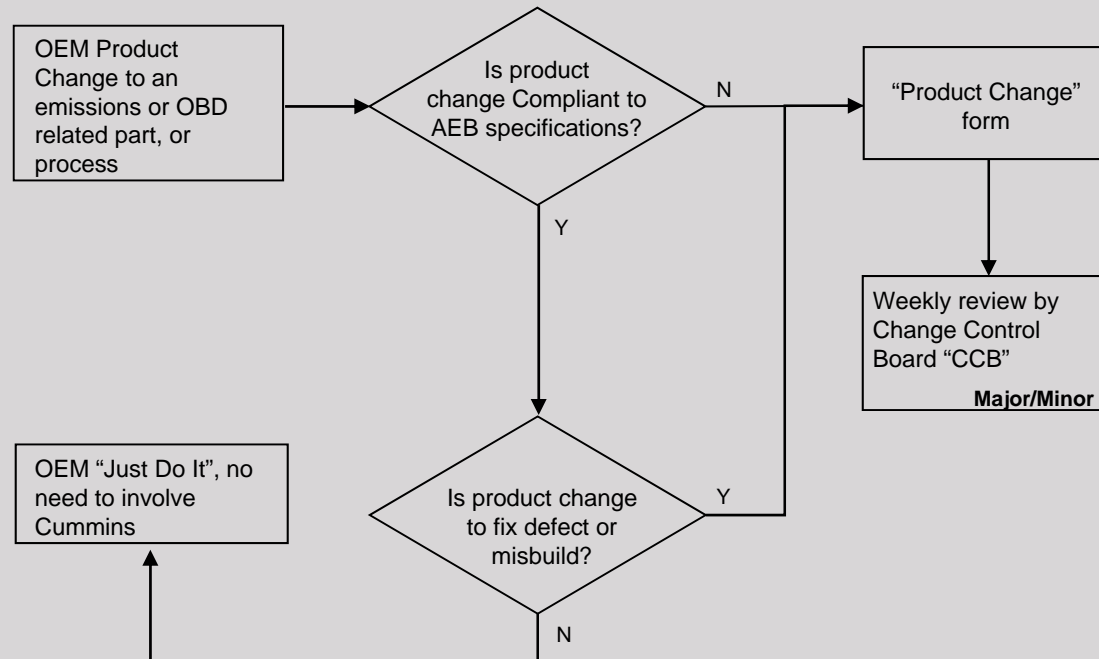
September 22-24, 2009 • Indianapolis Marriott Downtown • Indianapolis, IN

OEM Integration Management Process





OEM Integration Management Process Change Control Process





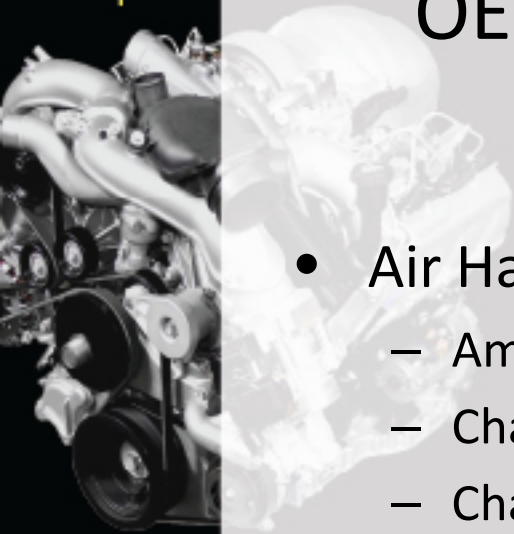
SAE 2009 On-Board Diagnostics Symposium

Update on Light and Heavy Duty Vehicle

September 22-24, 2009 • Indianapolis Marriott Downtown • Indianapolis, IN

OEM components covered for Charge Control - example

- Air Handling System and Associated Plumbing
 - Ambient Air Temperature Sensor
 - Charge Air Cooler
 - Charge Air Cooler plumbing, e.g. hose, pipe, clamps, etc..





SAE 2009 On-Board Diagnostics Symposium

Update on Light and Heavy Duty Vehicle

September 22-24, 2009 • Indianapolis Marriott Downtown • Indianapolis, IN

OEM Integration Management Process – Keys to Success

- Strong Communication/Working relationship with engine manufacturer and OEM
- OEM processes need to be put into place to support the transfer of information
- Signed agreement outlining engine manufacturer and OEM responsibilities



Example of OEM Integration Management – Cooling System Monitor

- Problem: OEM variation can cause diagnostic decision errors
- Solution: Identify and manage key design parameters jointly with OEMs
- Example: Maximum OEM heat draw limit to avoid false alarm of cooling system monitor
 - Capability study to measure the false alarm margin
 - Specification of maximum allowable OEM heat draw



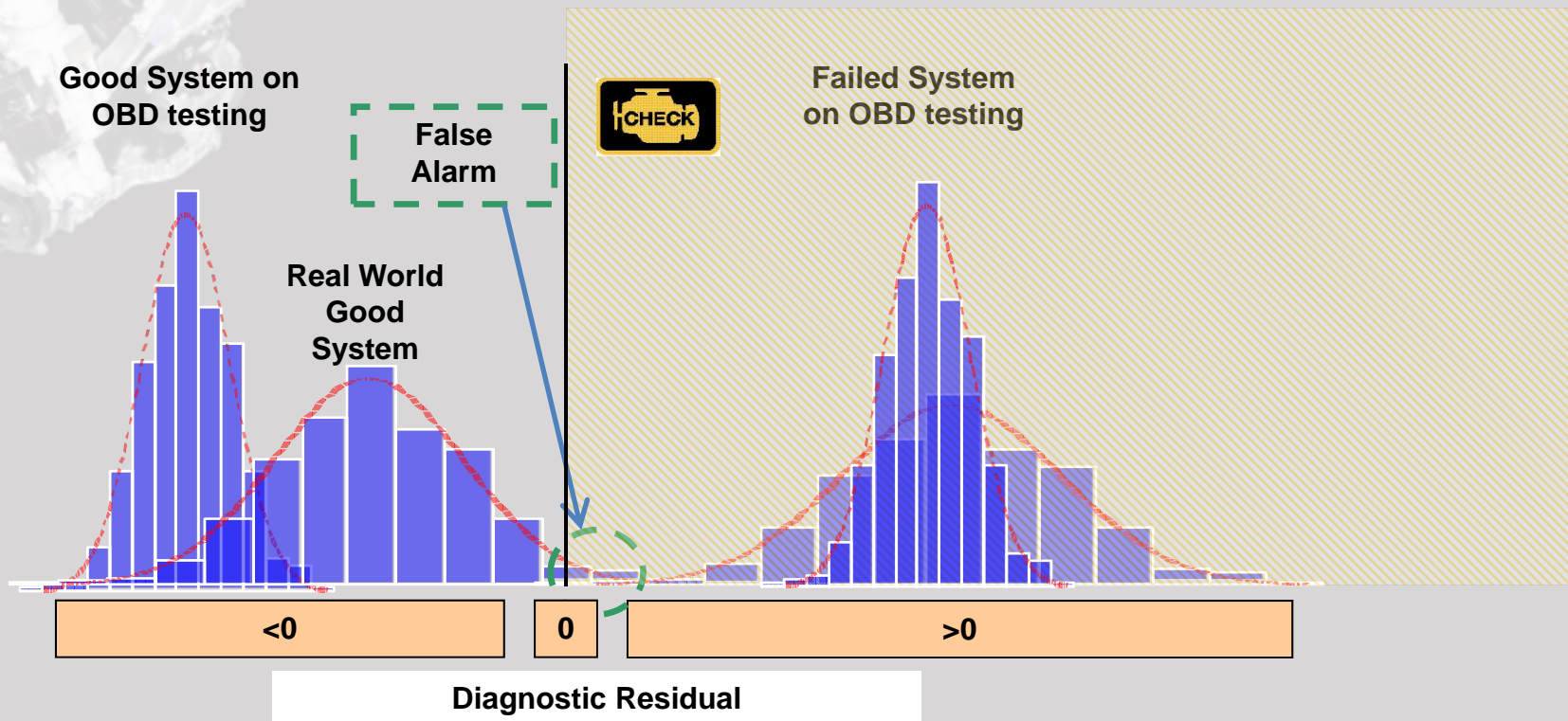
SAE 2009 On-Board Diagnostics Symposium

Update on Light and Heavy Duty Vehicle

September 22-24, 2009 • Indianapolis Marriott Downtown • Indianapolis, IN

OBD Monitor Capability

- Capability analysis on false alarm margin.
- Diagnostic residual = OBD signal – OBD threshold





SAE 2009 On-Board Diagnostics Symposium

Update on Light and Heavy Duty Vehicle

September 22-24, 2009 • Indianapolis Marriott Downtown • Indianapolis, IN

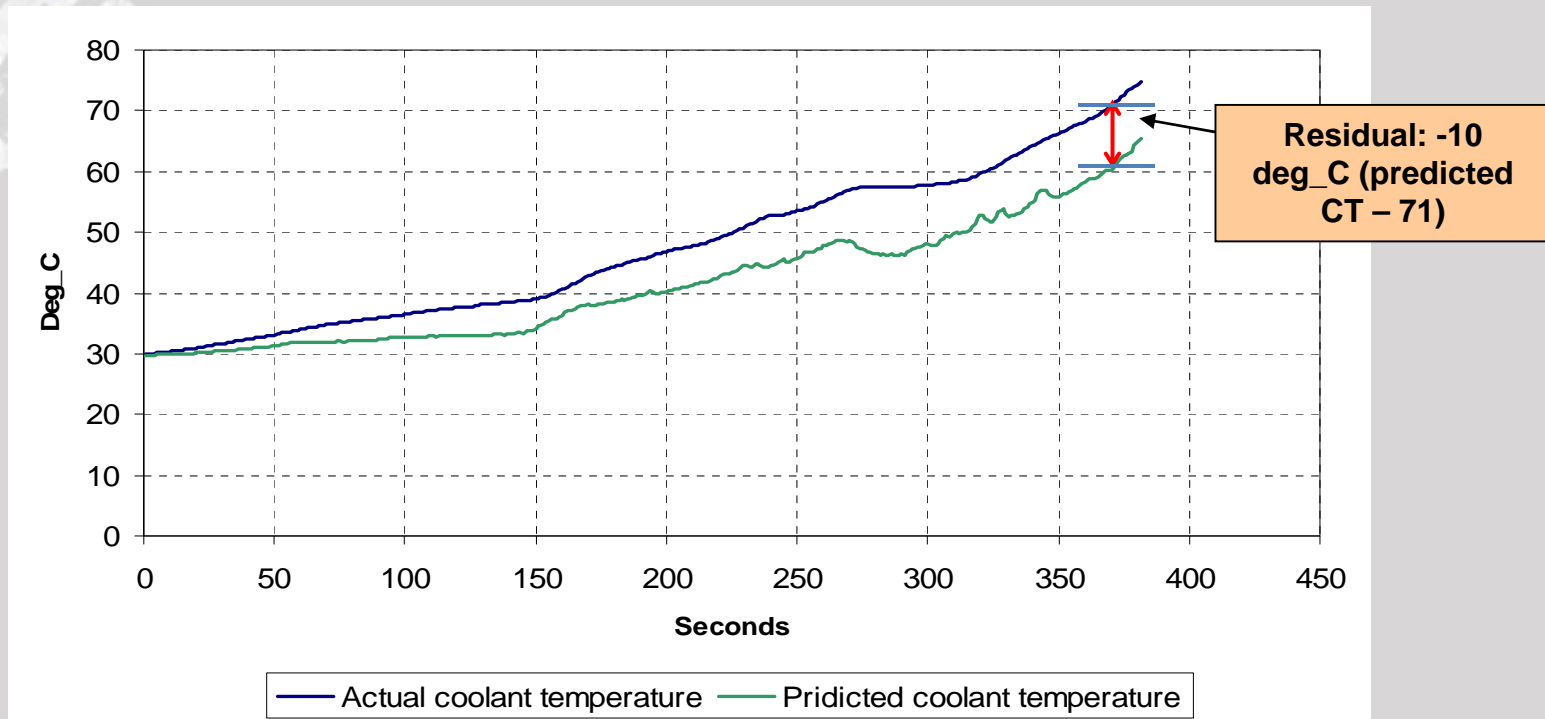
Example - Cooling System Monitor

- Engine warmup malfunction
 - Requirements:
 - The OBD system shall detect a malfunction if, when within a Regulatory Agency-approved time interval after engine start, the coolant temperature does not reach a temperature within 20 degF of the manufacturer's nominal thermostat regulating temperature.
 - Concept:
 - Error detected when the predicted coolant temperature reaches the warmed up threshold (71 degC) before actual coolant temperature does.
 - Predicted coolant temperature is a function of fuel burnt, etc.



Example Cooling System Monitor Residual

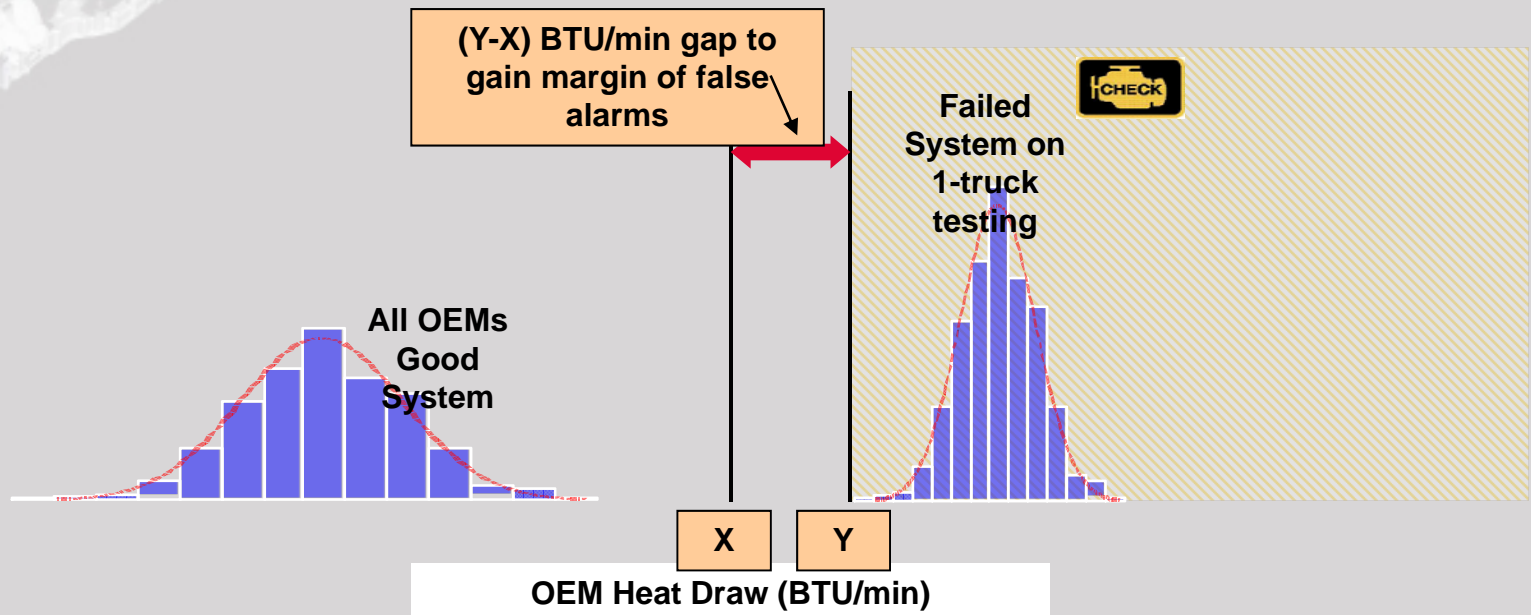
- Engine warmup malfunction
 - (good system): actual coolant temperature reaches 71 degC before predicted coolant temperature does





OEM Heat Draw Requirements

- AEB Maximum OEM heat draw < X BTU/min.
- Y BTU/min is the OBD threshold based upon 1 truck data.
- How are we doing?
 - Build margins between OEM requirements and OBD thresholds.
 - Collect Installation Quality Assurance data on OEM heat draw





SAE 2009 On-Board Diagnostics Symposium

Update on Light and Heavy Duty Vehicle

September 22-24, 2009 • Indianapolis Marriott Downtown • Indianapolis, IN

Summary

- OBD presents unique challenges for engine manufacturers and OEM's in the Heavy Duty Market
- Critical Parameters will effect OBD diagnostics. Key items to consider
 - Cooling System Packaging and Heat Draw
 - Aftertreatment System Packaging
 - Sensor Locations
 - Charge Air Cooler Restriction and Leakage
- OBD requires strong communication between the engine manufacturer and OEM and established processes to transfer information
- Setting OBD Thresholds requires capability analysis to ensure that the monitor works as designed but does not cause false diagnostics