

## DOCKETED

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<b>Project Title:</b>	Fuels and Transportation Merit Review
<b>TN #:</b>	206879
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Cummins Westport  
The Natural Choice



# California Energy Commission Merit Review



2 December, 2015



# Special Thanks to.....



**CALIFORNIA**  
**ENERGY COMMISSION**



# Vehicle Demonstration - Near Zero NOx

AQMD Contract #15626



# Why Near Zero NO<sub>x</sub>?

- California's poor air quality is pushing government to take significant steps for improvement
  - Fund technology development and demonstration
  - Offer end-user incentives to offset incremental vehicle costs, customers will request product!

## Additional Reductions Needed



- Health impacts still significant
- Localized impacts still remain
- Near and long term reductions still needed for air quality and SIP



Federal Non-attainment Areas Ozone

- If the entire on-road fleet complies with 2010 NO<sub>x</sub> standards
  - NAAQS for PM and Ozone will still be exceeded
  - NO<sub>x</sub> creates Ozone
  - NO<sub>x</sub> contributes to secondary formation of PM (nitrates)

# Not Just SoCal ....

## Attainment and Nonattainment Areas in the U.S. 8-hour Ozone Standard

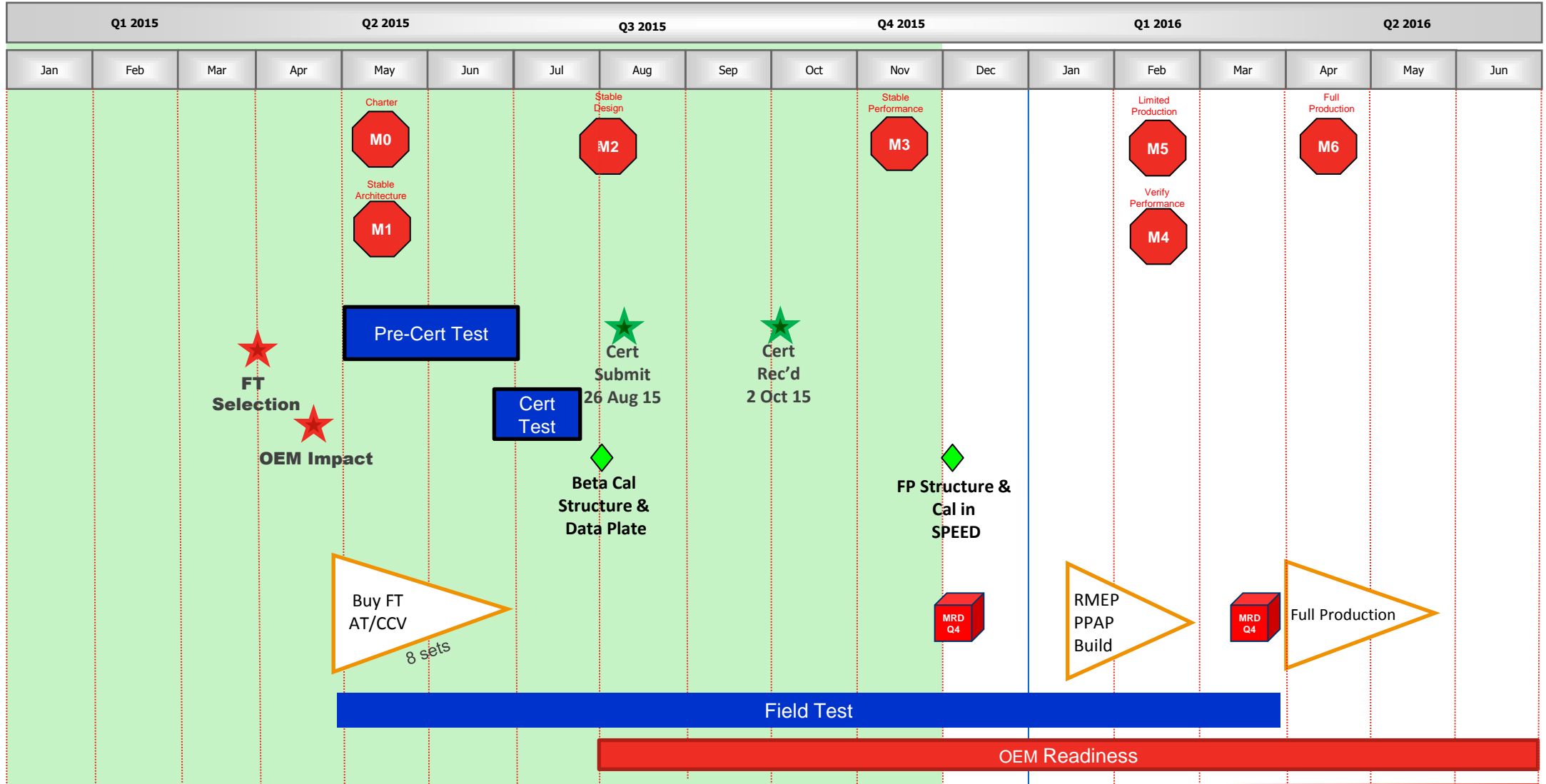


- Attainment (or Unclassifiable) Areas (2668 counties)
- Nonattainment Areas (432 entire counties)
- Nonattainment Areas (42 partial counties)

# Funding Utilization

- **PPT** (Product Proceeding Technology)
  - Advanced Concepts Demonstrations
  - Analysis, Instrumentation
  - Bench Testing, Prototype Hardware, “Buck” engine testing
- **VPI** (Value Package Introduction)
  - Product Development and Validation Process starting with Voice of Customer (VOC)
  - Charter, Contract, Stable Architecture, Design, Performance, Limited Production
  - All functions close coupled with Manufacturing, OEMs, and Customers
- **Production**

# ISL G NZ Program Schedule (VPI)



**Legend**

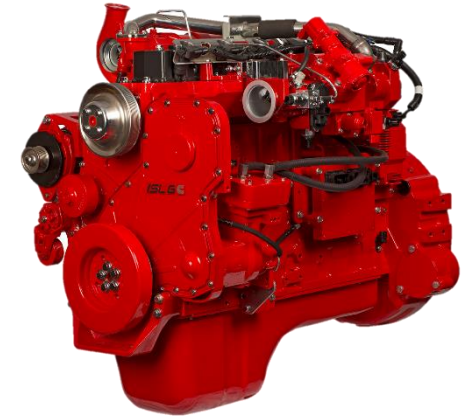
- M Review (Red Octagon)
- Proto Type Build (Yellow Triangle)
- Quality (Yellow Triangle)
- MRD (Red Cube)
- Materials Receipt Date (Red Cube)
- Progress To Date (Green Background)





# ISL G Near Zero Natural Gas Engine

- 8.9 Litre (540 cu. In.)
- In line 6 cylinder
- Charge Air Cooled (CAC)
- Spark ignition
- Peak Rating:
  - HP-320 hp Torque -1000 lb-ft
- Certified to CARB Optional Low NOx 0.02 Standard (Near Zero)
  - NOx: 0.02 g/bhp-hr
  - PM: 0.01 g/bhp-hr
- Certified to 2016 EPA / NHTSA GHG standards
- Three Way Catalyst Aftertreatment
- Manufactured by Cummins in Cummins Engine Plant- Rocky Mount, North Carolina



**ISL G** NEAR ZERO



# ISL G Near Zero - Introduction

## ■ Target Markets

- Transit
- Refuse
- Medium Duty Truck – Class 6-8
- Vocational
- Shuttle Bus
- School Bus



# Certifications – ISL G NZ

ARB

EPA

California Environmental Protection Agency <b>Air Resources Board</b>	CUMMINS INC.	EXECUTIVE ORDER A-021-0629 New On-Road Heavy-Duty Engines Page 1 of 2 Pages
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Pursuant to the authority vested in the Air Resources Board by Health and Safety Code Division 26, Part 5, Chapter 2; and pursuant to the authority vested in the undersigned by Health and Safety Code Sections 39515 and 39516 and Executive Order G-14-012;

IT IS ORDERED AND RESOLVED: The engine and emission control systems produced by the manufacturer are certified as described below for use in on-road motor vehicles with a manufacturer's GVWR over 14,000 pounds. Production engines shall be in all material respects the same as those for which certification is granted.

MODEL YEAR	ENGINE FAMILY	ENGINE SIZES (L)	FUEL TYPE <sup>1</sup>	STANDARDS & TEST PROCEDURE	INTENDED SERVICE CLASS	ECS & SPECIAL FEATURES <sup>3</sup>	DIAGNOSTIC <sup>6</sup>
2016	GCEXH0540LBI	8.9	CNG/LNG		UB	TBI, TC, CAC, ECM, EGR, TWC, HO2S	EMD+
PRIMARY ENGINE'S IDLE EMISSIONS CONTROL EXEMPT							
ADDITIONAL IDLE EMISSIONS CONTROL <sup>5</sup>							
N/A							
ENGINE (L)							
8.9 ISL G 250 / 4836/FR95359 (258), ISL G 280 / 4836/FR95354 (280), ISL G 300 / 4836/FR95351 (300), ISL G 320 / 4836/FR95348 (320)							
<small> <sup>1</sup> not applicable. BWR=gross vehicle weight rating. 13 CCR 999100. 13 California Code of Regulations, Section 999100. 40 CFR 88.abc Title 40, Code of Federal Regulations, Section 88.abc. (a)air, (b)lightduty, (c)mediumduty, (d)heavy.                 </small>							
<small> <sup>2</sup> CNG=LNG=compressed/liquefied natural gas. LPG=liquefied petroleum gas. E85=85% ethanol fuel. MF=metanol fuel. s.k.a. BF=bi fuel. DF=dual fuel. FF=flexible fuel.                 </small>							
<small> <sup>3</sup> LHM=light/medium/heavy heavy-duty diesel; UB=urban bus; HD=heavy duty OTE;                 </small>							
<small> <sup>4</sup> Emission control systems: TWC=three-way oxidizing catalyst; H2C=NOx adsorption catalyst; SCR=U / SCR=NH selective catalytic reduction - urea / - ammonia; WG (pre)air warm-up catalyst; DPF=diesel particulate filter; PTOX=periodic trap oxidizer; HO2S=heated oxygen sensor; H2S=AS=heated air-fuel ratio sensor (a.k.a. universal or linear oxygen sensor); TWC=three-way catalyst; BF=bi-fuel; CAC=charge air cooler; EGR=EGR=exhaust gas recirculation / cooled EGR; PAIR=air-purified secondary air injection; SPL=spark pull limiter; ECM=PCM=engine/powertrain control module; E=engine modifier; J=jet; G=generator; Q=lift/lift/lift series.                 </small>							
<small> <sup>5</sup> E85=engine shutdown system (per 13 CCR 1956.8(a)(9)(A)(1)), 30g+30 g/hr NOx (per 13 CCR 1956.8(a)(9)(C)), APS=internal combustion auxiliary power system; ALT=alternative method (per 13 CCR 1956.8(a)(9)(D)). Example=sampled per 13 CCR 1956.8(a)(9)(B) or the ON-ROAD fuel systems. N/A=not applicable (e.g., Otto engines and vehicles); EMD=engine manufacturer diagnostic system (13 CCR 1971.1); OBD=on-board diagnostic system (13 CCR 1971.1).                 </small>							

Following are: 1) the FTP exhaust emission standards, or family emission limit(s) as applicable, under 13 CCR 1956.8:

in g/bhp-hr	NMHC		NOx		NMHC+NOx		CO		PM		HCHO	
	FTP	SET	FTP	SET	FTP	SET	FTP	SET	FTP	SET	FTP	SET
STD	0.14	0.14	0.02	0.02	*	*	15.5	15.5	0.01	0.01	*	*
CERT	0.01	0.000	0.01	0.004	*	*	1.5	0.3	0.001	0.000	*	*
NTE	0.21		0.03		*		19.4		0.02		*	

<sup>4</sup> g/bhp-hr=grams per brake horsepower-hour; FTP=Federal Test Procedure; SET= Supplemental emissions testing; NTE=Not-to-Exceed; STD=standard or emission test cap; FEL=family emission limit; CERT=certification level; NMHC/HC=non-methane/hydrocarbon; NOx=oxides of nitrogen; CO=carbon monoxide; PM=particulate matter; HCHO=formaldehyde

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
OFFICE OF TRANSPORTATION AND AIR QUALITY  
WASHINGTON, DC 20460

CERTIFICATE OF CONFORMITY  
2016 MODEL YEAR

Manufacturer: CUMMINS INC.	Greenhouse Gas Info.
Engine Family: GCEXH0540LBI	Primary Intended Service Class: VOCATIONAL
Certificate Number: CEX-ONHWY-16-01	Primary Test Configuration FTP (if applicable):
Intended Service Class: URBAN BUS	CO <sub>2</sub> FCL value (g/bhp-hr) 476
Fuel Type: NATURAL GAS	CO <sub>2</sub> FEL value (g/bhp-hr) 490
FELs: G-BHP	N <sub>2</sub> O FEL value (g/bhp-hr) 0.10
NMHC+NOx: N/A	CH <sub>4</sub> FEL value (g/bhp-hr) 0.65
NOx: N/A	Primary Test Configuration Ramped-modal(if applicable):
PM: N/A	CO <sub>2</sub> FCL value (g/bhp-hr)
	CO <sub>2</sub> FEL value (g/bhp-hr)
Effective Date: 9/28/2015	

Byron J. Bunker, Director  
Compliance Division  
Office of Transportation and Air Quality

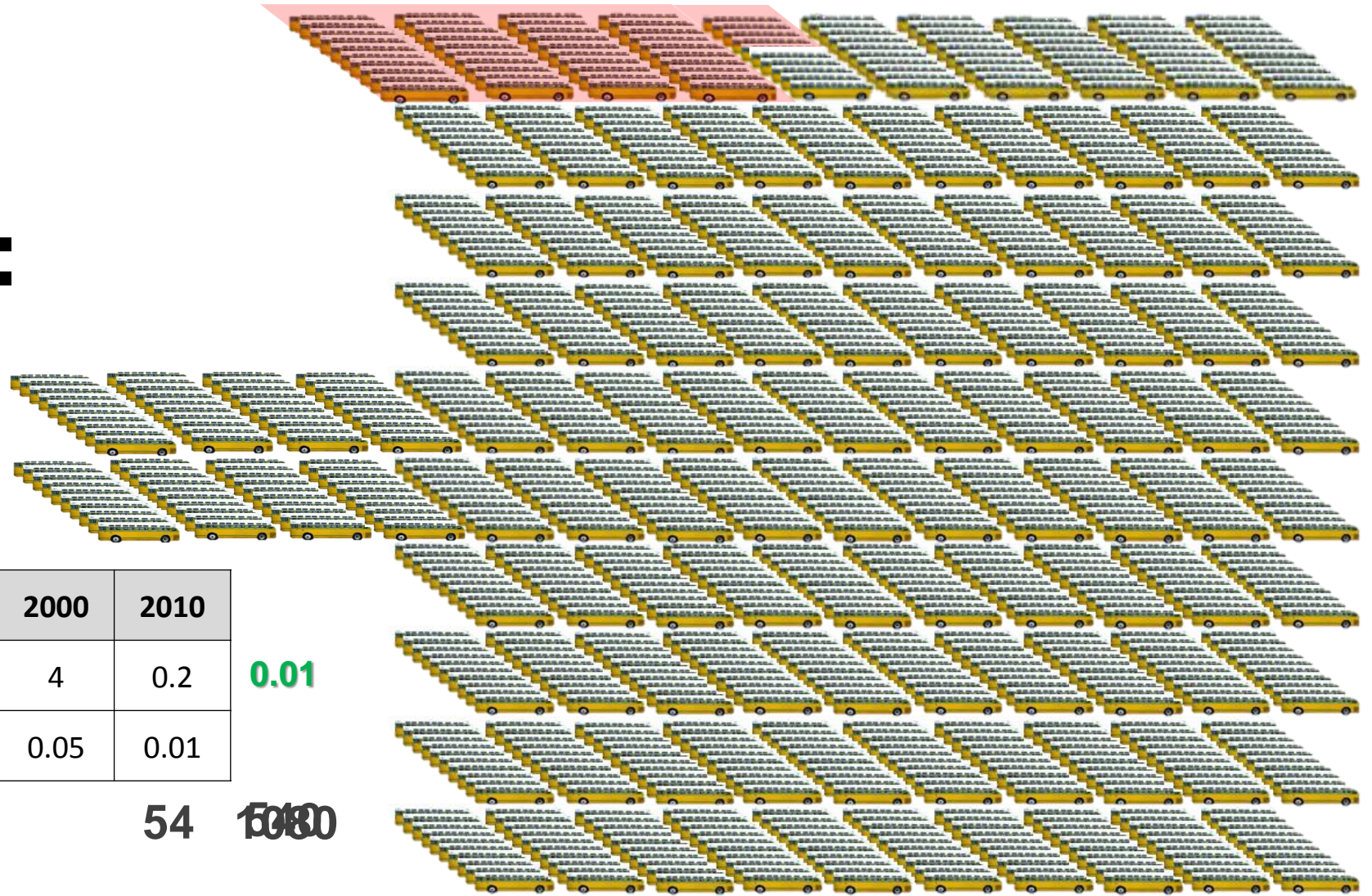
Part 86, and subject to the terms and conditions with respect to the test engines which represent the conditions prescribed in those provisions. which conform in all material respects to the design required by 40 CFR Part 86 and which are produced during the time period specified in the conditions of such a warrant or court order may lead to a violation of 40 CFR Part 86. It is also a term of this certificate that the engine shall be delivered for introduction, into commerce in the U.S.

In g/bhp-hr	EPA CERTIFICATE OF CONFORMITY		PRIMARY INTENDED SERVICE CLASS	
	CO <sub>2</sub>		VOCATIONAL	
	FTP	SET	CH <sub>4</sub>	N <sub>2</sub> O
STD	555	*	0.10	0.10
FCL	476	*	*	*
FEL	490	*	0.65	*
CERT	465	*	0.56	0.02

<sup>4</sup> g/bhp-hr=grams per brake horsepower-hour; FTP=Federal Test Procedure; SET=Supplemental emissions testing; STD = standard or emission test cap; FEL=family emission limit; FCL=family certification level; CERT=certification level; CO<sub>2</sub>=carbon dioxide; CH<sub>4</sub>=methane; N<sub>2</sub>O=nitrous oxide; VOCATIONAL=vocational engine; TRACTOR=tractor engine



# Emissions Reduction Impact - NOx



	1985	1990	1991	2000	2010
NOx (g/hp-hr)	10.8	6	5	4	0.2
PM (g/hp-hr)	0.59	0.59	0.25	0.05	0.01

0.01

54 150180

# Changes from ISL G EPA 2013

- **Certification**

- new Agency Approval (AP) option

- **ECM Calibration**

- 0.02g NOx calibration
- Delegated Assembly protected via catalyst / ECM connection

- **Three Way Catalyst (TWC)**

- Same as ISX12 G and ISL G Euro VI
- Has extra mid bed temperature sensor that must be added to OEM harness

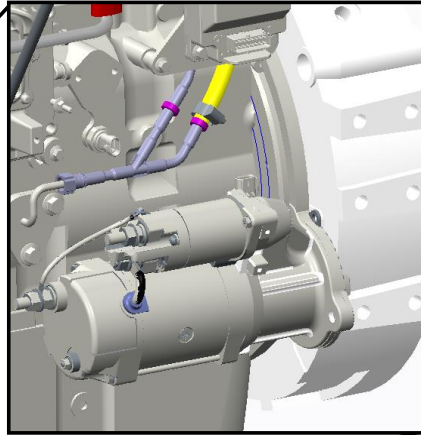
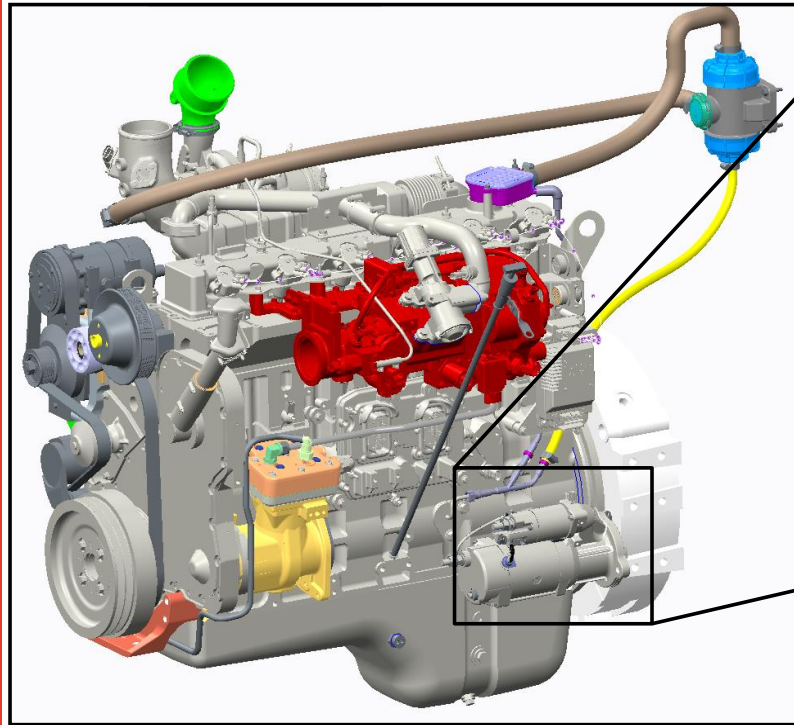
- **New Closed Crankcase Ventilation (CCV) System**

- Remote mount CCV filter – to be installed by OEMs
- Similar to ISL G Euro VI, but with coolant heating (same as ISB6.7 G)
- Requires OEM installed air/oil and coolant plumbing to and from the engine

- **Crankcase Pressure Sensor**

- New for diagnostic and OBD purposes

# Closed Crankcase Ventilation (CCV) System

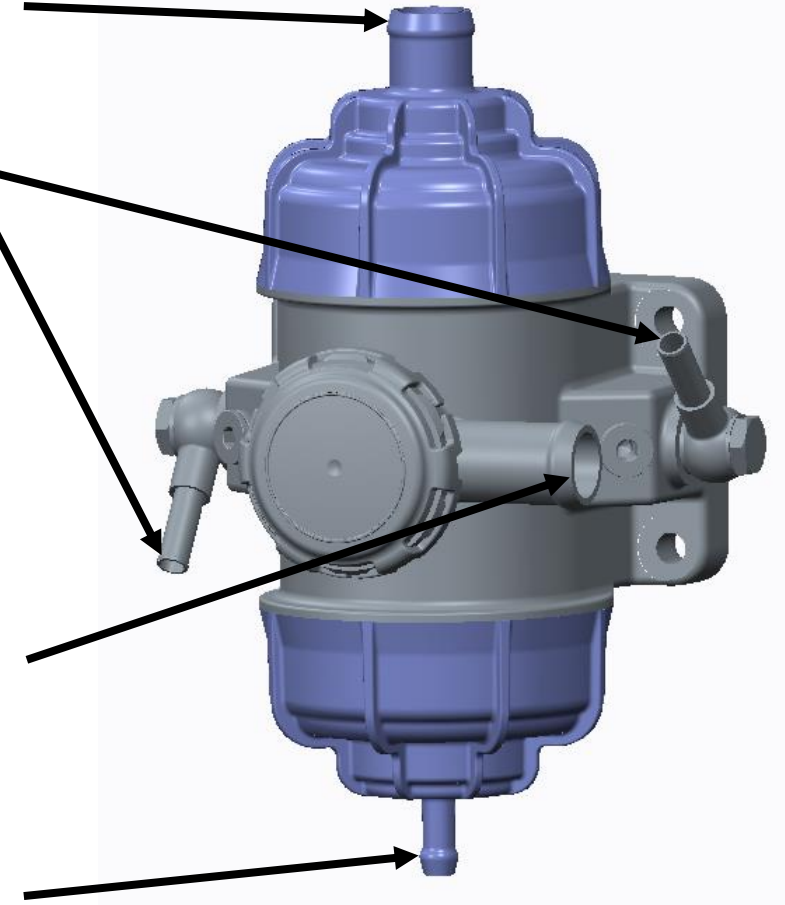


Inlet (from valve cover)

Coolant supply/return

Outlet (to compressor inlet elbow)

Oil drain (to supplied connection on block)



# ISL G Near Zero Ratings (same as MY2015 ISL G)

ENGINE MODEL	ADVERTISED HP(KW) @ RPM	PEAK TORQUE LB-FT @ RPM	GOVERNED SPEED
ISL G NZ 320	320 (239) @ 2000	1000 (1356) @ 1300	2200 RPM
ISL G NZ 300	300 (224) @ 2100	860 (1166) @ 1300	2200 RPM
ISL G NZ 280	280 (209) @ 2000	900 (1220) @ 1300	2200 RPM
ISL G NZ 260	260 (194) @ 2200	660 (895) @ 1300	2200 RPM
ISL G NZ 250	250 (186) @ 2200	730 (990) @ 1300	2200 RPM

# ISL G Near Zero – End Customer Impact

- **Fuel Economy**

- Similar fuel economy as current ISL G through continued use of advanced Stoichiometric cooled Exhaust Gas Recirculation (SEGR) combustion, with Three-Way Catalyst aftertreatment
- Exceeds EPA / DOT 2016 GHG standards
- Clear path to exceed EPA / DOT proposed Phase II GHG standards

- **Drivability**

- Offering same ratings as current ISL G, ideal for shuttle & school bus, urban transit, vocational and medium duty truck and tractor applications
- Same power and torque curves to meet customer demands
- Field tests underway with positive driver feedback



# ISL G Near Zero – End Customer Impact

- **Durability**

- Continued high durability with minimal engine changes and use of existing larger TWC
- Fully compliant with ARB and EPA Heavy Duty engine certification requirements including emissions through engine useful life
- Same Base Warranty and Extended Coverage as current ISL G

- **Maintenance**

- New Closed Crankcase Ventilation system has 2000 hour change interval for CCV filter (see QSOL)
- No other maintenance schedule changes from current ISL G
- Technician certification requirement is same as current ISL G

# ISL G Near Zero Launch Info

## Launch Timing

- ARB & EPA emissions certification received
- Full production from Rocky Mount Engine Plant (RMEP) Q2 2016

## Product Pricing

- Pricing to be conveyed through Cummins account teams in November

Thank You !



**CALIFORNIA**  
**ENERGY COMMISSION**

