

Cummins Westport
The Natural Choice



ISX12 G Overview

June 12, 2013

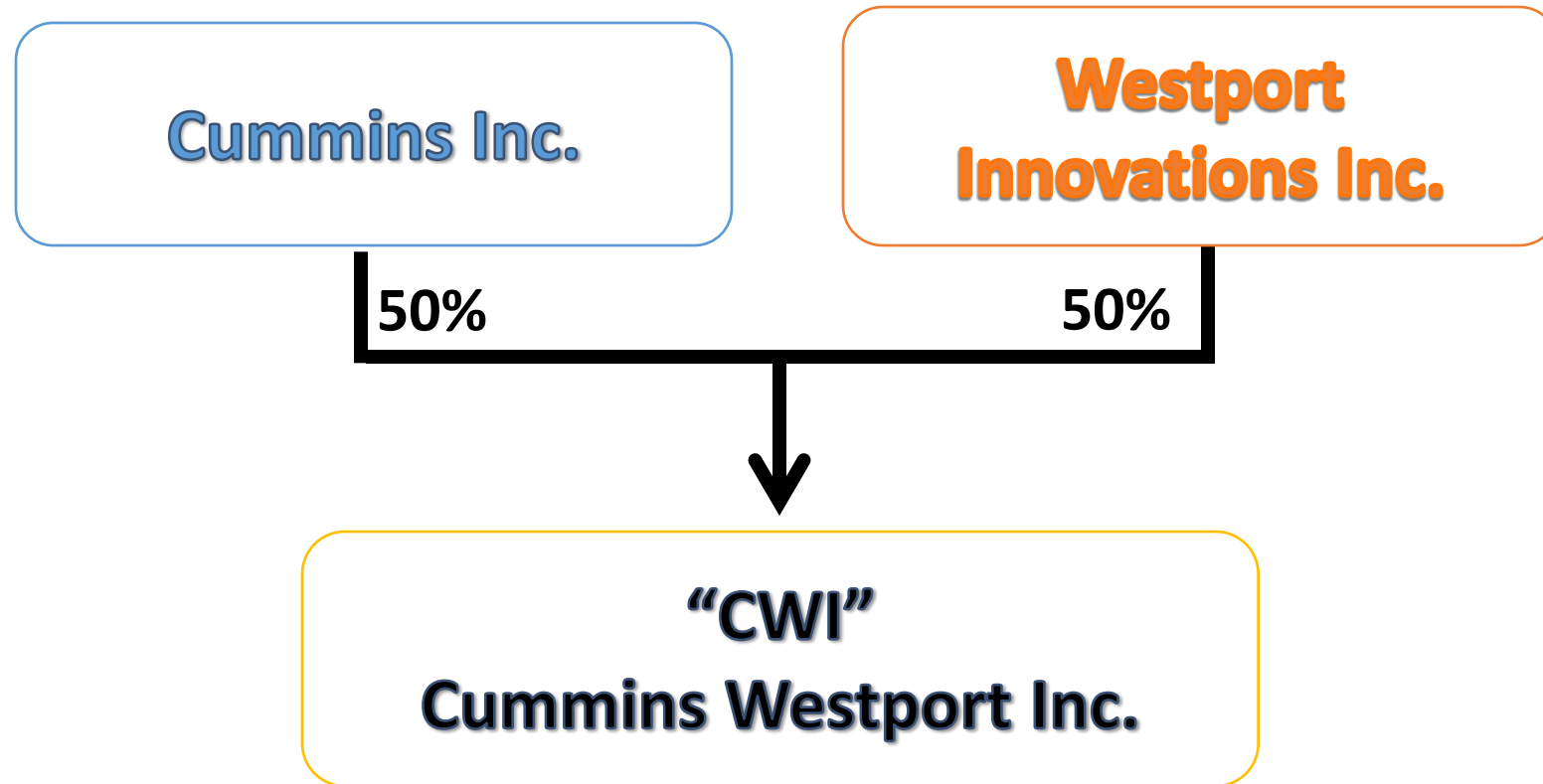
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Director, Product & Market Planning



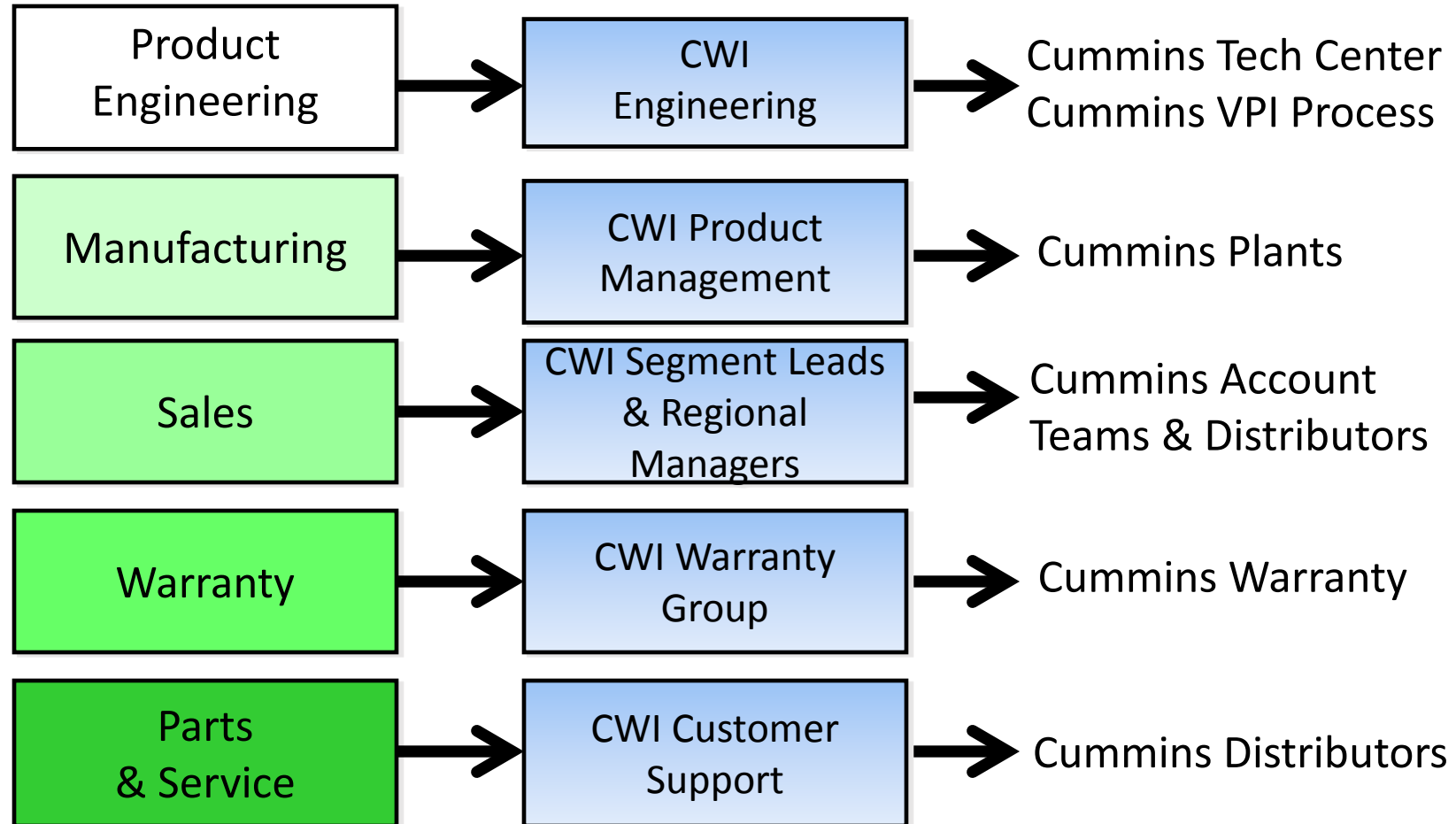
Cummins Westport Inc. (CWI)

A Joint Venture of Westport & Cummins



Delivered over 35,000 engines.
New 10 year Agreement 2012

CWI = 6 to 12 litre automotive natural gas engines, fully integrated with Cummins



ISX12G

Natural Gas Engine Introduction

- **Target Markets**

- Regional haul truck / tractor
- Vocational
- Refuse

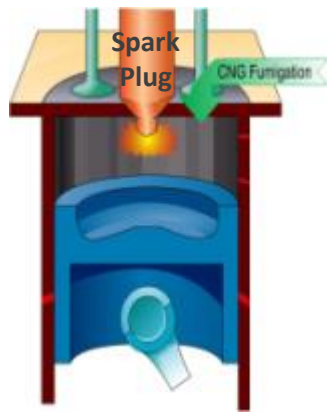
- **Platform & Technology**

- Cummins 11.9 litre ISX12 diesel is base engine
- Utilizing spark-ignition with cooled EGR & three way catalyst (TWC)
 - Same combustion technology as 8.9 liter ISL G engine



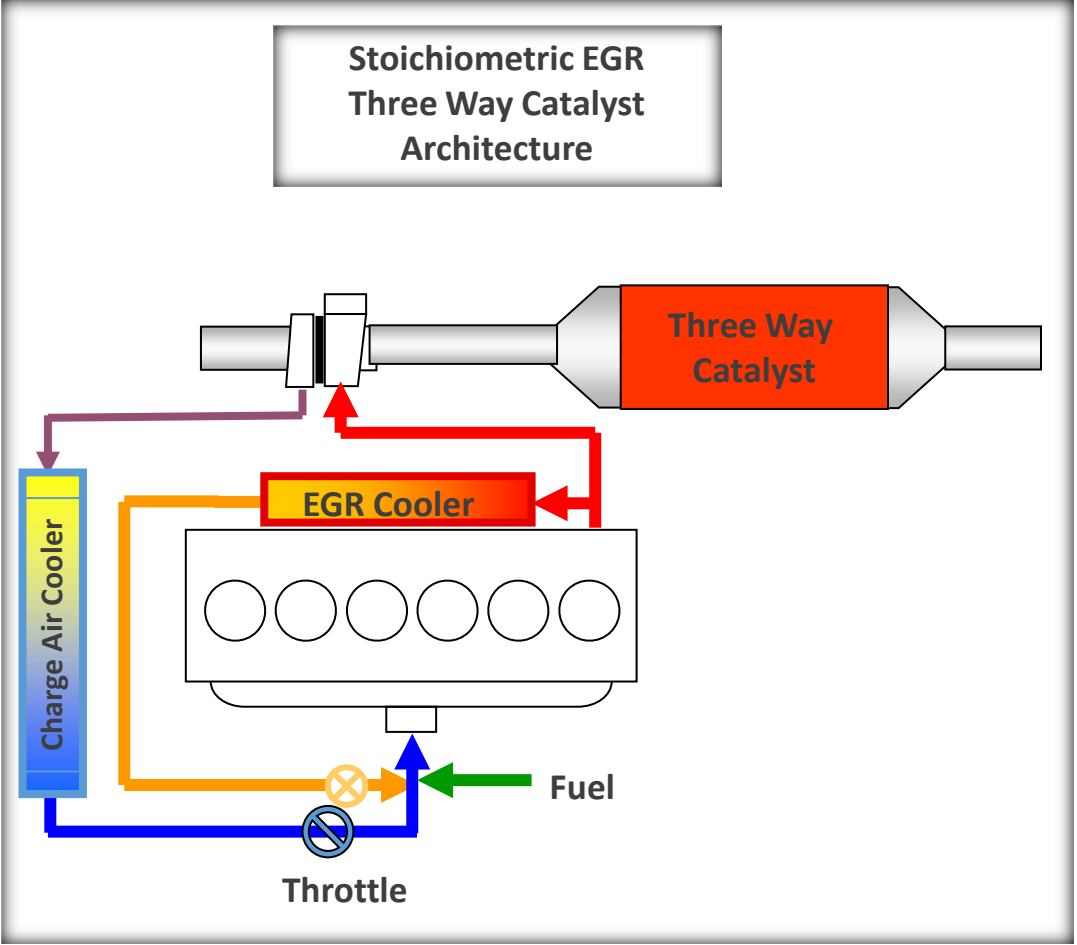
CWI Combustion Technology

Spark Ignited Stoichiometric with Cooled EGR



Spark Ignited

- Fuel, EGR and air are premixed outside the cylinder
- Spark plug ignites the mixture
- Air flow controls fuel flow
- Air/Fuel ratio controls emissions



What is Stoichiometric Combustion?

- Ideal combustion process where fuel is burned completely
 - Ideal air/fuel ratio - chemically correct mixing of fuel and air
 - Consumes all fuel & air without excess of either in exhaust
 - No oxygen in exhaust stream allows Three Way Catalyst to handle NOx control
- Benefits:
 - Increased power density
 - Increased thermal efficiency
 - Decreased emissions



Three Way Catalyst Aftertreatment

- Similar to catalyst on gasoline passenger cars.
- Packaged as a muffler. Vertical or horizontal mount.
- Easy to install
- Weighs ~100 pounds
- Passive device
 - No Regeneration
 - No SCR
 - No Maintenance



ISX12 G

- **Key Product Attributes**

- 11.9 litres
- Spark ignited, in-line 6 cylinder
- Dedicated natural gas engine
 - CNG or LNG
 - Capable of using up to 100% Biomethane
- Engine braking
- EPA/CARB certified including 2013 GHG standards
- Three Way Catalyst after-treatment
- Manual/Automatic Transmission capable
 - Automated manuals anticipated by 2014
- Ratings – 320 to 400 hp, 1150 to 1450 lb-ft
 - Ratings up to 350 hp, 1450 lb-ft in production now
 - 400 / 1450 & 385 /1350 ratings to be released later this year



ISX12 G -Technical Specifications

Advertised Horsepower	320-400 HP	239-298 KW
Peak Torque	1150-1450 lb-ft	1559-1966 N•M
Governed Speed	2100 RPM	
Clutch Engagement Torque	700 lb-ft	949 N•M
Number of Cylinders	6	
System Weight	2750 lb	1247 kg
Engine (Dry)	2650 lb	1202 kg
Aftertreatment System	100 lb	45 kg

2013 ISX12 G Ratings

ENGINE MODEL	ADVERTISED HP(KW)	PEAK TORQUE LB-FT (Nm) @ RPM	GOVERNED SPEED
Line Haul Truck Applications			
ISX12 G 400	400 (298)	1450 (1966) @ 1200	2100 RPM
ISX12 G 385	385 (287)	1350 (1830) @ 1200	2100 RPM
ISX12 G 350	350 (261)	1450 (1966) @ 1200	2100 RPM
ISX12 G 330	330 (246)	1250 (1695) @ 1200	2100 RPM
ISX12 G 320	320 (239)	1150 (1559) @ 1200	2100 RPM
Refuse Truck Applications			
ISX12 G 350R	350 (261)	1350 (1830) @ 1200	2100 RPM
ISX12 G 350R	350 (261)	1450 (1966) @ 1200	2100 RPM
ISX12 G 330R	330 (246)	1250 (1695) @ 1200	2100 RPM
ISX12 G 320R	320 (239)	1150 (1559) @ 1200	2100 RPM
Clutch Engagement Torque – 700 LB-FT (949 Nm) Net Weight (Dry) - 2650 LB (1202 KG)			

Program Status Update

- Nearly 2,000,000 miles of field testing completed
 - Numerous tractor-trailer and refuse collection field test fleets throughout the U.S.
- Limited Production of ISX12 G engines started April 2013
 - Limited Production peak rating is 350 hp / 1,450 lb ft torque
 - These engines are not upratable
- Full availability of the ISX12 G product line expected by August 2013
 - Includes 385 and 400 hp ratings

Service Guidelines

- Recommendation for best reliability and durability is to limit ISX12 G to maximum 80,000 lb GVW applications.
- PowerSpec tool with ISX12 G now available
 - www.powerspec.cummins.com

The screenshot displays the 'Vehicle Gearing' software interface. At the top, there are menu options: Print, Save As..., Help, and Done. Below this is the 'Gearing Recommendation Summary' section, which is divided into 'Selected Gearing' and 'Output'.

Selected Gearing

Input	Value	Unit
Intended Cruise Speed	65	mph
Typical Gross Vehicle Weight (GVW)	100,000	lbs
Transmission Top Gear Ratio	0.87	Allison 4500
Transmission 3rd / Low Gear Ratio	10.8	Allison 4500
Tire Size	811	rev/mile, Michelin XDA ENERGY
Rear Axle Ratio	4.83	Eaton Fuller 2206ST

Output

Value	Unit
Engine RPM at 65 mph Intended Speed	1117 rpm
Engine RPM at 65 mph Checkpoint	1117 rpm
Stability	53 %

Assessment - Consistent with Cummins Recommendations
The selected gearing combination is consistent with Cummins recommendations for the operating profile provided.
To view the Gear Down Protection Heavy / Light Vehicle Speeds, click the [GearDown Protection Calculator](#).

Vehicle Profile

Engine	ISX12
Application	Line Haul Truckload
Gearing Recommendation Type	Heavy Haul
Typical Gross Vehicle Weight (GVW)	85,001 - 110,000 lbs.
What is the Engine's Horsepower?	<= 450
What is the Maximum (Peak) Torque of the engine?	< 1550
Percent time operating off-road or on soft surfaces	< 10%
Percent time spent operating on interstate highways	> 90 %
Intended Cruise Speed	65 mph
Gearing Desired	Balance

Gearing Recommendations Guidelines

1. Select a gearing combination that will result in an engine speed of between **1650 - 1760 rpm** at the vehicle's intended cruise speed (mph).
2. The vehicle is being spec'd to operate at weight of **85,001 - 110,000 lbs.**, select a gearing combination that



ISX12 G Warranty

- Automotive Base warranty for Cummins Westport natural gas engines is same as Cummins diesel base platform
- 2 Year / 250,000 Mile Warranty
 - 100% parts and labor on warrantable failures*
 - Travel or towing when an engine is disabled by a warrantable failure
 - Consumables not reusable due to covered failure
 - Limited progressive damage, including aftertreatment
- Extended Coverage packages are available through Cummins distributors






Maintenance Intervals

- Most maintenance intervals are the same as the ISX12 diesel (e.g. oil drain, filter changes)
- Natural gas related component intervals are similar to ISL G
 - Example: spark plug interval at 1,500 hours
- CES20074 natural gas engine oil is required

OEM Launch Partners



ISX12 G Availability

OEM	Freightliner 	Peterbilt 	Kenworth 	Volvo 	Mack 	Autocar 
Model	Cascadia	320 384 365	W900S T660 T800SH	VNL	Pinnacle	Xpeditor
Application	Tractor	Refuse Tractor Vocational	Tractor Vocational	Tractor	Tractor Vocational	Refuse
Availability	2013 Launch Partner	2013 Launch Partner	2013 Launch Partner	2013 Launch Partner	Late 2013	2013 Launch Partner



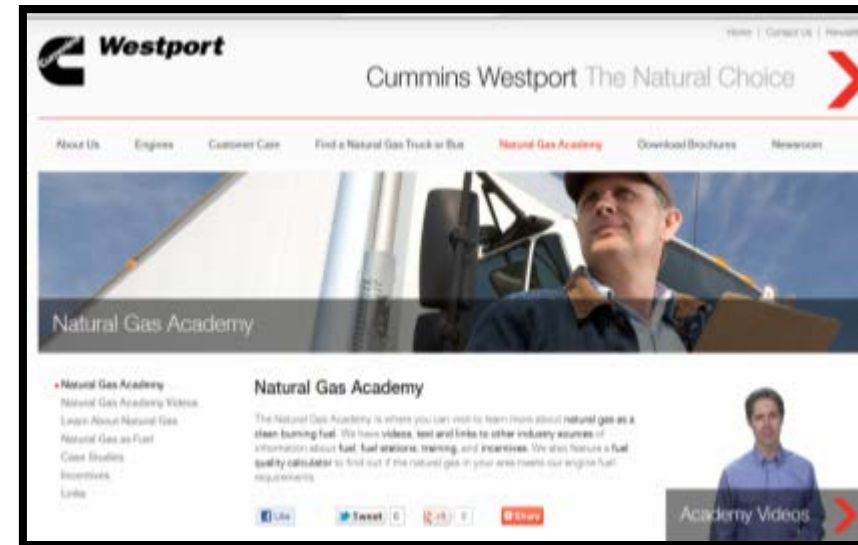
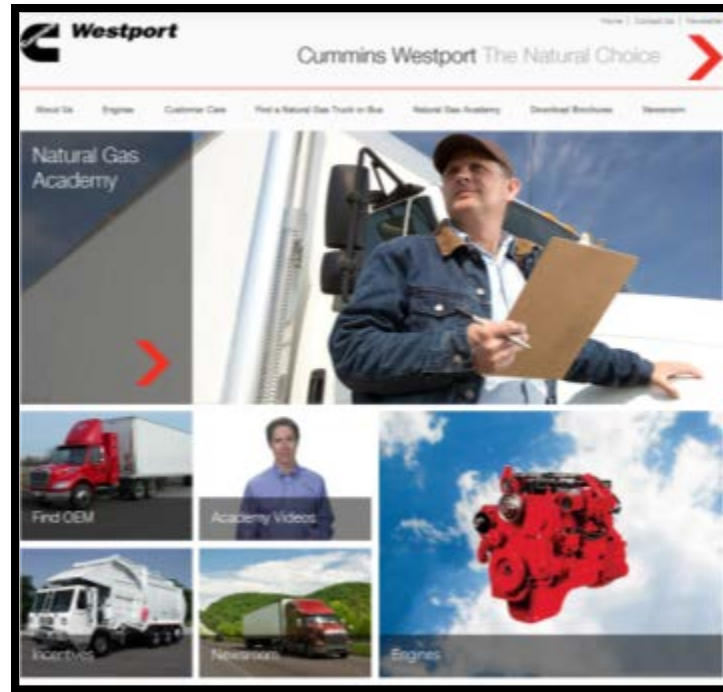
CNG & LNG Fuel Compatibility

- ISX12 G is compatible with natural gas stored onboard the vehicle as CNG or LNG
- End-users can choose CNG or LNG based on each fuel's respective pros / cons & the best fit in the application
 - LNG systems store more fuel for a certain space claim, but fuel will vent if not used regularly
 - CNG systems are typically larger and heavier than LNG systems for the same fuel capacity, but fuel won't vent when vehicle is parked
 - When using fast-fill CNG refueling, the net usable capacity of CNG systems can be quite a bit less than the gross capacity (e.g. 20-30% less)

Near-Zero Emissions Capability

- Cummins Westport plans to further develop the stoich EGR / TWC technology for near-zero NOx emissions
 - Engine development required to achieve 0.02 to 0.05 g/bhp-hr NOx
 - Technology advancements can be deployed throughout Cummins Westport's natural gas engine product line (6 to 12 liters)
- NOx reduction opportunities:
 - Cold-cycle emissions
 - Near-zero NOx has been demonstrated over hot cycles
 - Transient emissions
 - Optimize control system for low NOx during transient events
 - Emissions variability (engine to engine, test to test)

www.cumminswestport.com



- Great source of information about natural gas engines and vehicles.
- Features the *Natural Gas Academy*, a series of instructional videos
 - Designed to provide a general overview of natural gas as a fuel whether it is compressed (CNG) or liquefied (LNG), how it is used with vehicles, engine walk-around videos, and maintenance facility recommendations