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

Product Engineering → CWI Engineering

Manufacturing → CWI Product Management

Sales → CWI Segment Leads & Regional Managers

Warranty → CWI Warranty Group

Parts & Service → CWI Customer Support

Cummins Tech Center
Cummins VPI Process

Cummins Plants

Cummins Account Teams & Distributors

Cummins Warranty

Cummins Distributors
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

- 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

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advertised Horsepower</td>
<td>320-400 HP</td>
<td>239-298 KW</td>
</tr>
<tr>
<td>Peak Torque</td>
<td>1150-1450 lb-ft</td>
<td>1559-1966 N*M</td>
</tr>
<tr>
<td>Governed Speed</td>
<td>2100 RPM</td>
<td></td>
</tr>
<tr>
<td>Clutch Engagement Torque</td>
<td>700 lb-ft</td>
<td>949 N*M</td>
</tr>
<tr>
<td>Number of Cylinders</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>System Weight</td>
<td>2750 lb</td>
<td>1247 kg</td>
</tr>
<tr>
<td>Engine (Dry)</td>
<td>2650 lb</td>
<td>1202 kg</td>
</tr>
<tr>
<td>Aftertreatment System</td>
<td>100 lb</td>
<td>45 kg</td>
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</tbody>
</table>
## 2013 ISX12 G Ratings

<table>
<thead>
<tr>
<th>ENGINE MODEL</th>
<th>ADVERTISED HP(KW)</th>
<th>PEAK TORQUE LB-FT (Nm) @ RPM</th>
<th>GOVERNED SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISX12 G 400</td>
<td>400 (298)</td>
<td>1450 (1966) @ 1200</td>
<td>2100 RPM</td>
</tr>
<tr>
<td>ISX12 G 385</td>
<td>385 (287)</td>
<td>1350 (1830) @ 1200</td>
<td>2100 RPM</td>
</tr>
<tr>
<td>ISX12 G 350</td>
<td>350 (261)</td>
<td>1450 (1966) @ 1200</td>
<td>2100 RPM</td>
</tr>
<tr>
<td>ISX12 G 330</td>
<td>330 (246)</td>
<td>1250 (1695) @ 1200</td>
<td>2100 RPM</td>
</tr>
<tr>
<td>ISX12 G 320</td>
<td>320 (239)</td>
<td>1150 (1559) @ 1200</td>
<td>2100 RPM</td>
</tr>
</tbody>
</table>

**Refuse Truck Applications**

<table>
<thead>
<tr>
<th>ENGINE MODEL</th>
<th>ADVERTISED HP(KW)</th>
<th>PEAK TORQUE LB-FT (Nm) @ RPM</th>
<th>GOVERNED SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISX12 G 350R</td>
<td>350 (261)</td>
<td>1350 (1830) @ 1200</td>
<td>2100 RPM</td>
</tr>
<tr>
<td>ISX12 G 350R</td>
<td>350 (261)</td>
<td>1450 (1966) @ 1200</td>
<td>2100 RPM</td>
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<tr>
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<td>330 (246)</td>
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<td>2100 RPM</td>
</tr>
<tr>
<td>ISX12 G 320R</td>
<td>320 (239)</td>
<td>1150 (1559) @ 1200</td>
<td>2100 RPM</td>
</tr>
</tbody>
</table>

*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
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

<table>
<thead>
<tr>
<th>OEM</th>
<th>Freightliner</th>
<th>Peterbilt</th>
<th>Kenworth</th>
<th>Volvo</th>
<th>Mack</th>
<th>Autocar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Cascadia</td>
<td>320 384 365</td>
<td>W900S T660 T800SH</td>
<td>VNL</td>
<td>Pinnacle</td>
<td>Xpeditor</td>
</tr>
<tr>
<td>Application</td>
<td>Tractor</td>
<td>Refuse Tractor Vocational</td>
<td>Tractor Vocational</td>
<td>Tractor Vocational</td>
<td>Refuse</td>
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<tr>
<td>Availability</td>
<td>2013 Launch Partner</td>
<td>2013 Launch Partner</td>
<td>2013 Launch Partner</td>
<td>2013 Launch Partner</td>
<td>Late 2013</td>
<td>2013 Launch Partner</td>
</tr>
</tbody>
</table>

![CNG and LNG logos]
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)
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