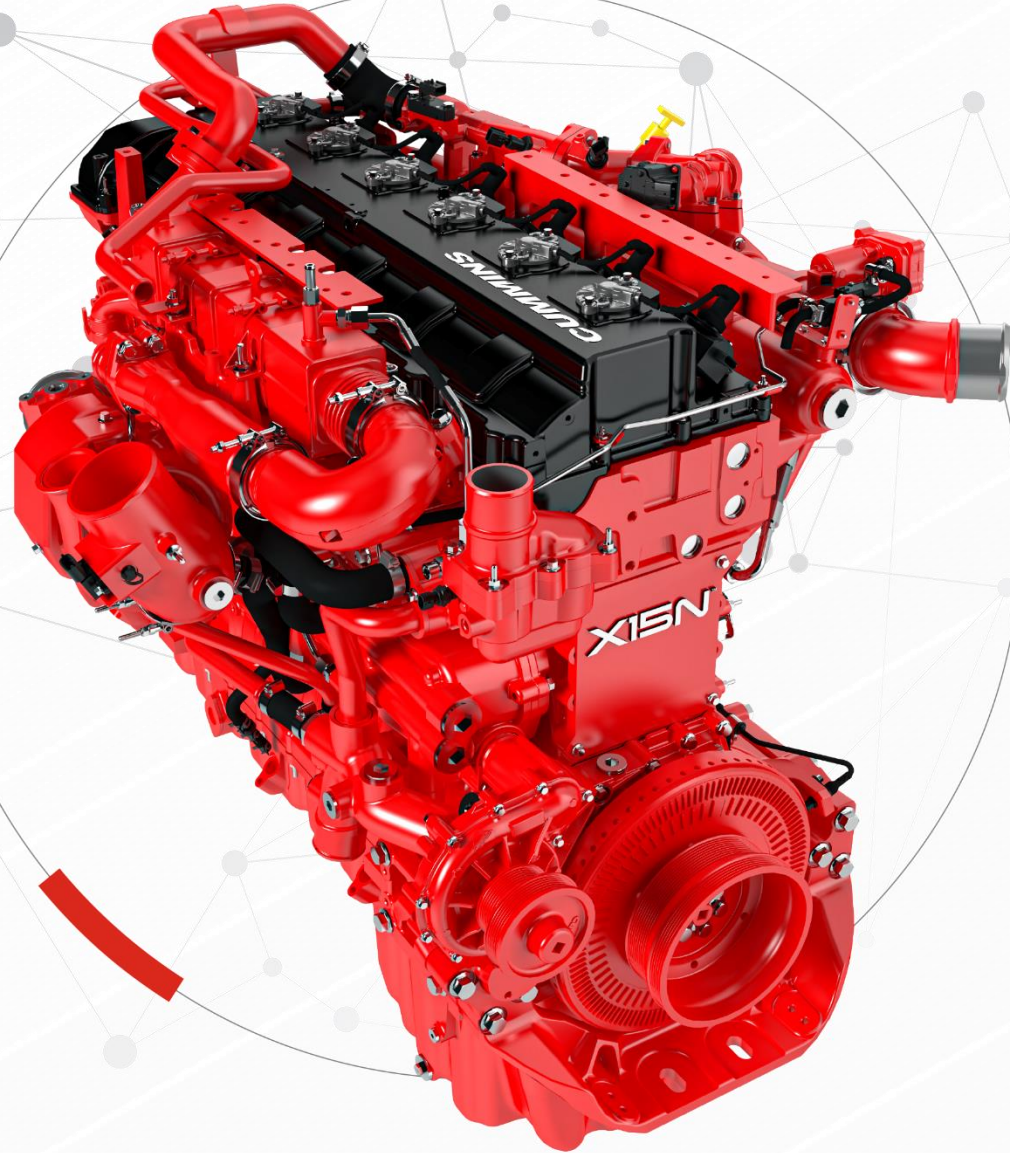


X15 NATURAL GAS



Cummins Natural Gas Fuel Standards

Chad Fohne

Cummins On-Highway Natural Gas Fuel Standards

Table 14, Fuel Standards for Cummins® Natural Gas Engines

Standard	Engine Family			
	B5.9 G, C8.3 G, B6.7 G	ISB5.9 G, B Gas International, B Gas Plus, C Gas Plus, L Gas Plus	ISL G, ISX12 G	B6.7N, L9N, ISX12N, X15N
CES 14604 Minimum Methane Number: 80 Minimum Higher Heating Value: 975 BTU/Standard Cubic Feet	Yes	N/A	N/A	N/A
CES 14624 Minimum Methane Number: 75 Minimum Lower Heating Value: 44194 kJ/kg [19,000 BTU/lbm]	N/A	N/A	Yes	Yes
CES 14608 Minimum Methane Number: 65 Minimum Lower Heating Value: 37448.6 kJ/kg [16100 BTU/lbm]	N/A	Yes	N/A	N/A

CES 14624 Max Impurity Limits

Table 2: Max Allowable Hydrogen, Hydrogen Sulfide, Sulfur, Siloxanes, & Halogens

Components	Requirements	Test Method
Hydrogen (H ₂)	0.03% volume maximum	ASTM D2650
Hydrogen Sulfide (H ₂ S)	0.0006% volume maximum	ASTM D4084
Siloxanes	0.0003% volume maximum	EPA TO-14, 15 GC/ELCD, GC/AED, GC/MS
Sulfur (S)	0.001% weight maximum	Title 17 CCR Section 94112 Method 16
Halogens	0.000082% volume maximum	ASTM D7449

CMI Fuel Quality Calculator

FUEL QUALITY CALCULATOR

NG Default

Sample Name:
NG Default

All values should be entered as mole %, unless otherwise noted

Methane, CH ₄	<input type="text" value="93"/>	%
Ethane, C ₂ H ₆	<input type="text" value="3.1"/>	%
Propane, C ₃ H ₈	<input type="text" value=".31"/>	%
i-Butane, C ₄ H ₁₀	<input type="text" value=".03"/>	%
n-Butane, C ₄ H ₁₀	<input type="text" value=".04"/>	%
i-Pentane, C ₅ H ₁₂	<input type="text"/>	%
n-Pentane, C ₅ H ₁₂	<input type="text"/>	%
n-Hexane, C ₆ H ₁₄	<input type="text"/>	%
n-Heptane, C ₇ H ₁₆	<input type="text"/>	%
n-Octane, C ₈ H ₁₈	<input type="text"/>	%
n-Nonane, C ₉ H ₂₀	<input type="text"/>	%
n-Decane, C ₁₀ H ₂₂	<input type="text"/>	%
Hydrogen, H ₂	<input type="text"/>	%
H ₂ S	<input type="text"/>	ppmv
Carbon Monoxide, CO	<input type="text"/>	%
Carbon Dioxide, CO ₂	<input type="text" value=".84"/>	%
Nitrogen, N ₂	<input type="text" value="2.2"/>	%
Oxygen, O ₂	<input type="text"/>	%
Siloxanes, Si	<input type="text"/>	%
Sulfur, S ₂	<input type="text"/>	% weight



Sample Percentage: 99.52000000000001%

Methane Number: 86.7

Lower Heating Value: 20188 BTU/lbm

Fuel Quality Calculator
is based on CES14624

FUEL QUALITY CALCULATOR

NG Default

Sample Name:
NG Default

All values should be entered as mole %, unless otherwise noted

Methane, CH ₄	<input type="text" value="69.23"/>	%
Ethane, C ₂ H ₆	<input type="text" value="22.14"/>	%
Propane, C ₃ H ₈	<input type="text" value="6.89"/>	%
i-Butane, C ₄ H ₁₀	<input type="text" value=".67"/>	%
n-Butane, C ₄ H ₁₀	<input type="text" value=".46"/>	%
i-Pentane, C ₅ H ₁₂	<input type="text"/>	%
n-Pentane, C ₅ H ₁₂	<input type="text"/>	%
n-Hexane, C ₆ H ₁₄	<input type="text"/>	%
n-Heptane, C ₇ H ₁₆	<input type="text"/>	%
n-Octane, C ₈ H ₁₈	<input type="text"/>	%
n-Nonane, C ₉ H ₂₀	<input type="text"/>	%
n-Decane, C ₁₀ H ₂₂	<input type="text"/>	%
Hydrogen, H ₂	<input type="text"/>	%
H ₂ S	<input type="text"/>	ppmv
Carbon Monoxide, CO	<input type="text"/>	%
Carbon Dioxide, CO ₂	<input type="text"/>	%
Nitrogen, N ₂	<input type="text" value="0.48"/>	%
Oxygen, O ₂	<input type="text" value=".13"/>	%
Siloxanes, Si	<input type="text"/>	%
Sulfur, S ₂	<input type="text"/>	% weight



Sample Percentage: 100%

Methane Number: 57.9

Lower Heating Value: 20722 BTU/lbm

<https://www.cummins.com/engines/natural-gas/fuel-quality-calculator>



Gas Quality, RNG, and Hydrogen Blends

TTP Industry Summit
John Tiquet

Fleet Services



WM's History with CNG

1995 - The first 14 CNG trucks launched in Palm Desert, CA.

1997 - 8 LNG trucks deployed in Lancaster, PA.

2000 - 120 LNG truck project in partnership with PGE in San Diego.

2001-2006 - 405 natural gas trucks deployed in SoCal South Coast Air district.

2007 - WM CEO David Steiner commits to increasing fuel efficiency and reducing emissions by 15% by the year 2020.

2009 - 122 natural gas trucks deployed in the City of Seattle, the largest single municipal refuse launch in US history. Trademarked "Clean N' Green".

2011 - 1,000 CNG trucks in operation, Formalization of the WM CNG Team, commitment to build \$250MM in Stations over the next 5 years.

2012 - Our 2020 efficiency and emission goal accomplished.

2017 - 100 stations completed and 6,000 NGV's in operation.

2020 - 10,000+ CNG trucks in operation and achieved our 2025 emissions goal.



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Gas Quality

Gas quality varies by region and season.

- Obtain gas analysis and history from utility/source before building CNG fueling infrastructure or purchasing fleet equipment for a site.
- Verify compatibility of gas with Cummins Fuel Quality Calculator.
- Other Hydrocarbons in pipeline gas affect Methane Number and Lower Heating Value.

The screenshot displays the Cummins Fuel Quality Calculator interface. At the top, there is a navigation bar with links for Engines, Generators and Power Systems, Components, Parts and Service, Technology, Company, and Support. The main heading is 'FUEL QUALITY CALCULATOR'. Below this, there is a sub-heading 'FUEL QUALITY CALCULATOR' and a 'Print' button.

The calculator shows a dropdown menu set to 'NG Default' and a 'Sample Name' field with 'NG Default' entered. A note states: 'All values should be entered as mole %, unless otherwise noted'. A traffic light icon is shown with the green light illuminated, indicating a 'Sample Percentage: 100%'. Below the traffic light, it shows 'Methane Number: 91.5' and 'Lower Heating Value: 20048 BTU/lbm'.

Component	Value	Unit
Methane, CH ₄	91.91	%
Ethane, C ₂ H ₆	2.02	%
Propane, C ₃ H ₈	2	%
i-Butane, C ₄ H ₁₀		%
n-Butane, C ₄ H ₁₀	15	%
i-Pentane, C ₅ H ₁₂		%
n-Pentane, C ₅ H ₁₂		%
n-Hexane, C ₆ H ₁₄		%
n-Heptane, C ₇ H ₁₆		%
n-Octane, C ₈ H ₁₈		%
n-Nonane, C ₉ H ₂₀		%
n-Decane, C ₁₀ H ₂₂		%
Hydrogen, H ₂		%
H ₂ S		ppmv
Carbon Monoxide, CO		%
Carbon Dioxide, CO ₂	2.24	%
Nitrogen, N ₂	0.48	%
Oxygen, O ₂		%
Siloxanes, Si		%
Sulfur, S ₂		% weight

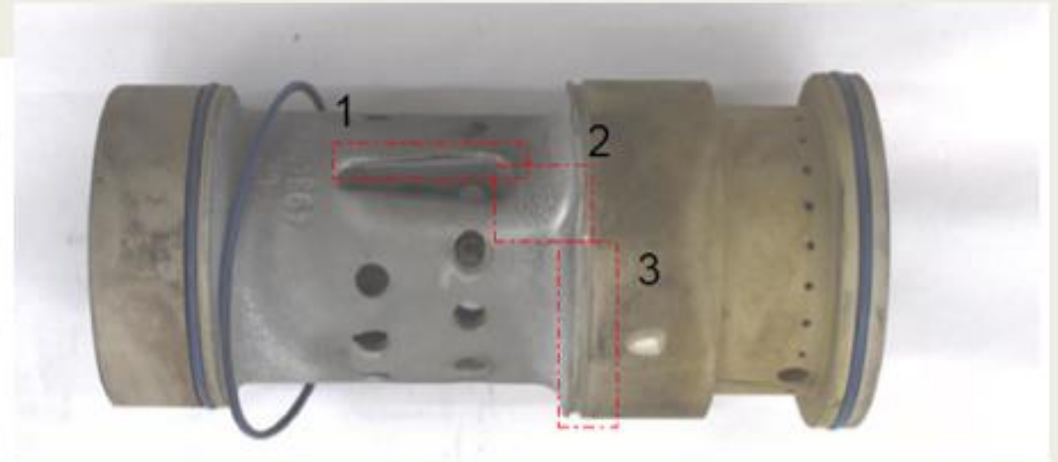
At the bottom, there is a note: '★ Use the full Product Finder to search or filter by product details.'

Effects on Engines

- Some trace compositions in the fuel can cause engine component failures.
- Cummins has stringent limitations on **Hydrogen (H₂)** in their fuel specification, allowing a **maximum of 0.03%** by volume.
- At one location, Chlorine (Cl), Fluorine (F), which are Halogens, along with Sulfur (S), has been found on failed fuel mixers.
- Cummins is updating **CES 14624**, which will now list requirements for Halogens.

Table 2: Maximum Allowable Hydrogen, Hydrogen Sulfide, Sulfur, Siloxanes, and Halogens.

Components	Requirements	Test Method
Hydrogen (H ₂)	0.03% volume maximum	ASTM D2650
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Sulfur (S)	0.001% weight maximum	Title 17 CCR Section 94112 Method 16
Halogens	0.000082% volume maximum	ASTM D7449





Southern California Gas Company overview

TTP Summit June 2024



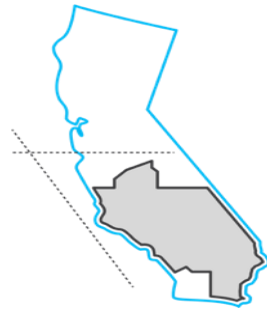


OVER 150 YEARS

of institutional knowledge and expertise

Proud History of Delivering Energy to Southern California

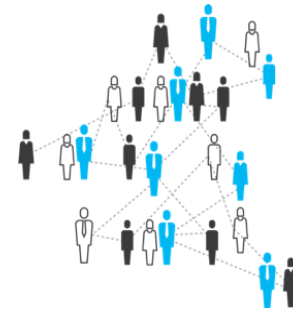
Our Mission is to Build the Cleanest, Safest, and Most Innovative Energy Infrastructure Company in America.



Service territory covers about

24,000
SQUARE MILES

of diverse terrain throughout
Central and Southern
California, from Visalia to the
Mexican border



Largest natural gas distribution
utility in country¹, powering
Southern California with
increasingly clean, safe and
reliable energy delivered to
more than

21+ MILLION
CUSTOMERS

¹ based on number of customers and revenue

Interconnector Gas quality

Table 1 Maximum Constituent Concentrations						
Renewable Gas Injection Constituents				Testing for Gas Source		
	Trigger Level	Lower Action Level	Upper Action Level	Non-Hazardous Landfill	Dairies	Other ⁴
Base Gas Quality Specifications ¹				X	X	X
Health Protective Constituents (HPC) - Non-Carcinogenic ²						
Antimony	0.60 mg/m ³ 0.12 ppmv	6.0 mg/m ³ 1.2 ppmv	30 mg/m ³ 6.1 ppmv	X		
Copper	0.060 mg/m ³ 0.02 ppmv	0.60 mg/m ³ 0.23 ppmv	3.0 mg/m ³ 1.2 ppmv	X		
Hydrogen Sulfide ⁶	30 mg/m ³ 22 ppmv	300 mg/m ³ 216 ppmv	1500 mg/m ³ 1080 ppmv	X	X	X
Lead	0.075 mg/m ³ 0.009 ppmv	0.75 mg/m ³ 0.09 ppmv	3.8 mg/m ³ 0.44 ppmv	X		
Mercaptans (Alkyl Thiols) ⁶	12 ppmv	120 ppmv	610 ppmv	X	X	X
Methacrolein	1.1 mg/m ³ 0.37 ppmv	11 mg/m ³ 3.7 ppmv	53 mg/m ³ 18 ppmv	X		
Toluene	904 mg/m ³ 240 ppmv	9000 mg/m ³ 2400 ppmv	45000 mg/m ³ 12000 ppmv	X	X	X

The Transport Project Industry Summit

Tim Tiger

Emerging Technology and Innovation

Southwest Gas Corporation

Recognition



95% Customer Satisfaction the last seven years



#1 in Customer Satisfaction with Business & Large Residential Natural Gas Utilities in the West, for the fourth year in a row, 2020-2023 by J.D. Power

Emerging Technology and Innovation Department

- Energy Efficiency/Codes & Standards
- Renewable Natural Gas
- Compressed Natural Gas
- Hydrogen
- Technology Readiness Level
 - Equipment and System Evaluation





SOUTHWEST GAS



Studying natural gas-hydrogen blends to ensure safety, performance, system integrity, and reliability.

- Delivers sustainable energy which promotes a diversified economy, contributes to workforce development and environmental and economic justice efforts, and supports community prosperity and growth
- Center for an Arizona Carbon-Neutral Economy (AzCaNE) - SHINE
- Renewable Natural Gas
- Develop an understanding of legislation, global direction, innovation, and technology readiness levels related to hydrogen so Southwest Gas may develop timely regulatory approved services for customers that wish to benefit from the hydrogen economy.



RNG Activities

Gathering



Cleaning



Interconnection



Interstate Pipeline

Southwest Gas Pipeline

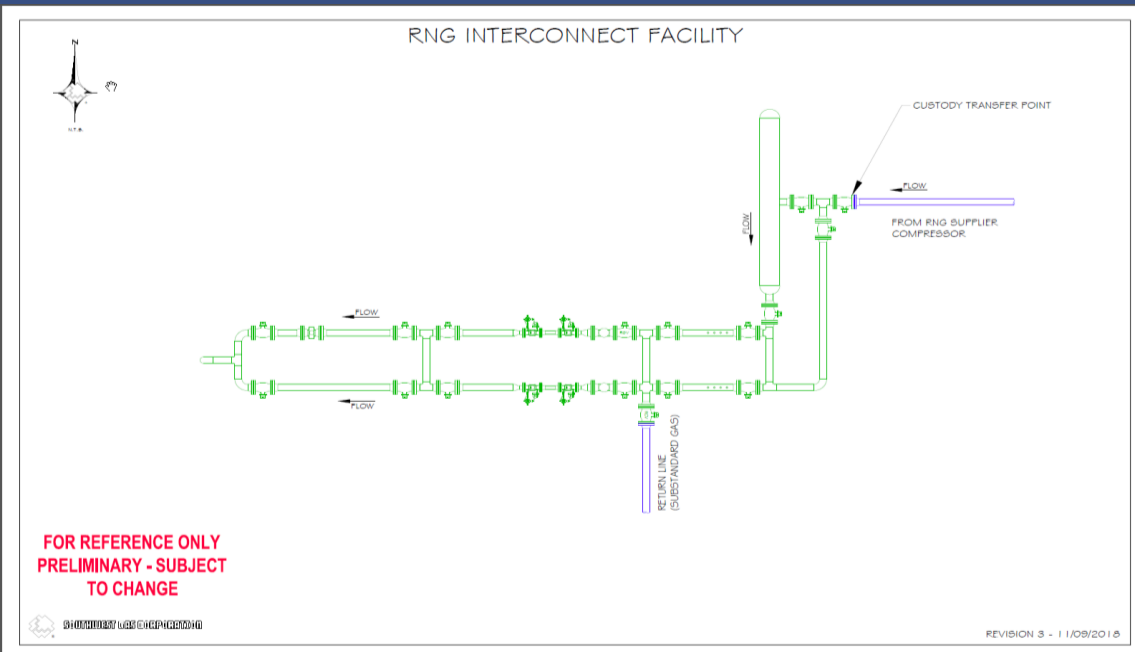
RNG Interconnections (Approved)



- Pima County (WWTP - AZ)
- Sunoma RNG (Dairy - AZ)
- Victor Valley (WWTP - CA)
- Butterfield RNG1 (Dairy - AZ)
- Maricopa RNG1 (Dairy - AZ)

Interconnection – Gas Quality (O&M Agreement)

- Company RNG gas quality policy
- Gas sampling/Lab Testing standards and protocols
- Operating agreement
- Standard design and equipment specifications



- BTU/Wobbe Number
- Sulfur Content/H₂S
- Inerts (O₂, N₂, CO₂)
- Dew point/Water Content
- Bacteria/pathogens/cause harm
- Hazardous substances
- Siloxanes



Thank You & Questions

