



Connecting For Success...

ELECTRIC POWER DAYS 2018

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CATERPILLAR[®]

3516B Diesel Generator Sets with Dynamic Gas Blending™ (DGB™)

Roger Rosborough

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Agenda

- Introduction
- Product Ratings
- Features and Benefits
- System Design
- System Performance/Limitations
- Safety Features
- Sales Support and Product Support
- Retrofit Kits Overview



Introduction – What is Cat[®] Dynamic Gas Blending[™] (DGB[™])

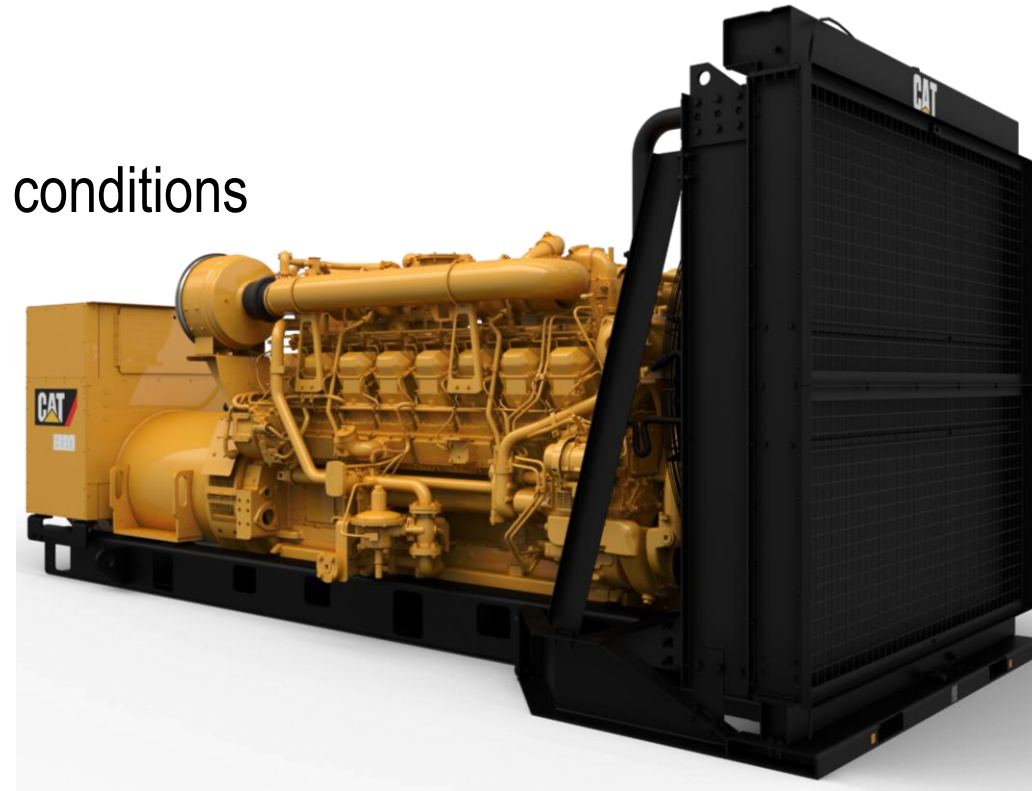
- 100% diesel fuel (diesel mode) **or** mixture of diesel and natural gas (DGB mode)
- Without Compromise
- Proven Technology
- Available as a factory-fitted DGB system or retrofit kit on 3516B

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Intelligent Design

- Cat[®] Dynamic Gas Blending™ system:
 - Continually monitors each cylinder
 - Optimizes substitution rate to suit the load and site conditions
 - **Protecting** the engine,
 - **Maintaining** diesel performance
 - **Maximizing** the diesel substitution rates in any situation.
- All the performance features and benefits of a diesel generator set plus...

Lower running costs, **Reduced** storage, Prolonged Operation



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Product Ratings

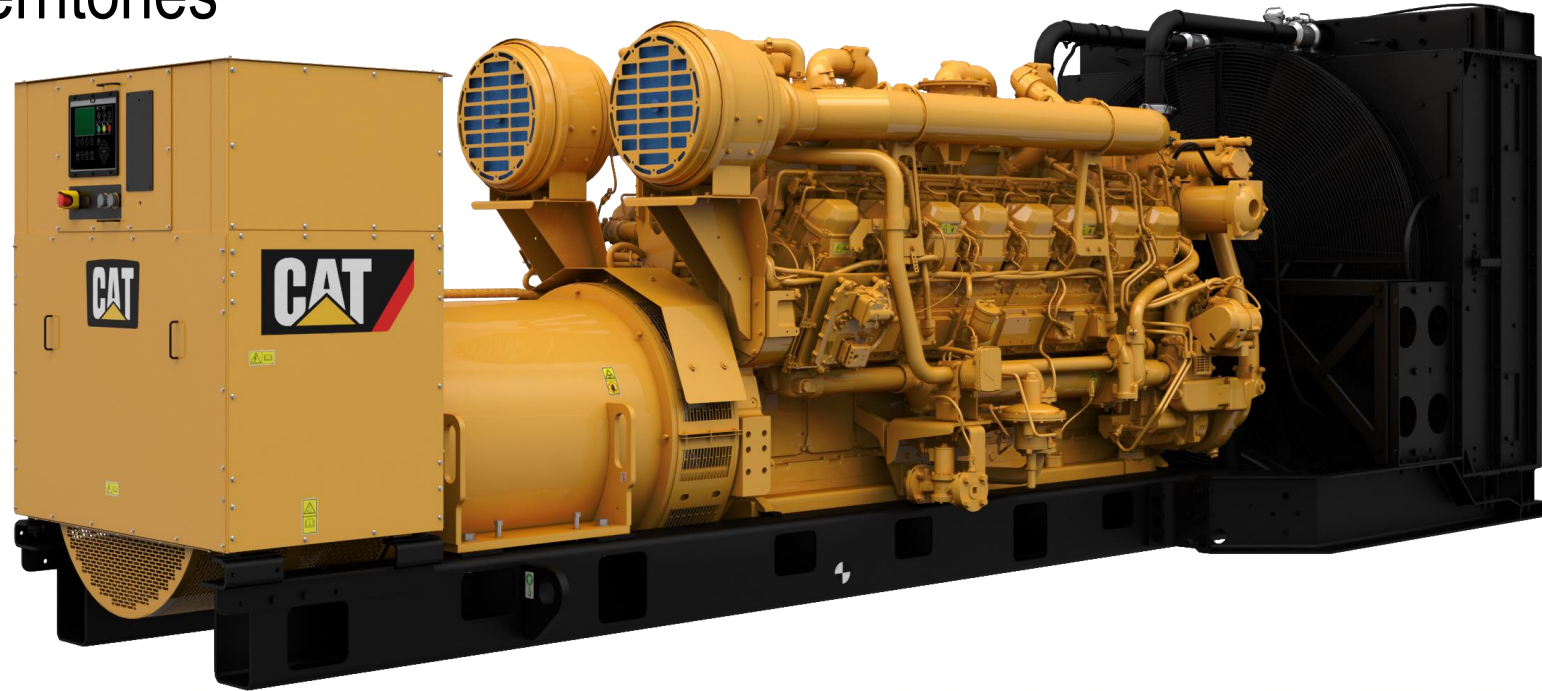
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Ratings Available

Frequency	Application	Rating
60Hz	Prime	1825 kW
	Continuous	1640 kW
50Hz	Prime	2000 kVA
	Continuous	1750 kVA
50Hz	Prime	2275 kVA
	Continuous	2000 kVA

- Optimised for low fuel consumption
- Non-certified – not for use in EPA emissions regulated territories



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Features and Benefits

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Features and Benefits of DGB

- **Maintains Diesel Generator Set Performance**
 - Quick Starts
 - Excellent load acceptance
- **Fuel Cost Savings**
 - Operates with up to 70% diesel substitution
 - No competitor system can match this while respecting Cat engine hardware limits
- **Factory Warranty and Service Intervals**
 - Cat DGB designed specifically to protect Cat Engines
 - Same warranty and service intervals as 3516B diesel generator sets
- **Fuel Flexibility**
 - 100% Diesel or DGB/Bi-Fuel operation
 - Less susceptible to interruption of fuel supply
 - Less on site diesel storage capacity requirement

Features and Benefits: Maintains Diesel Generator Set Performance

Just like a diesel engine...

- Start up and load transfer operation.
- Load acceptance - the control system is constantly monitoring engine parameters and will adjust the substitution rate to achieve optimum performance.

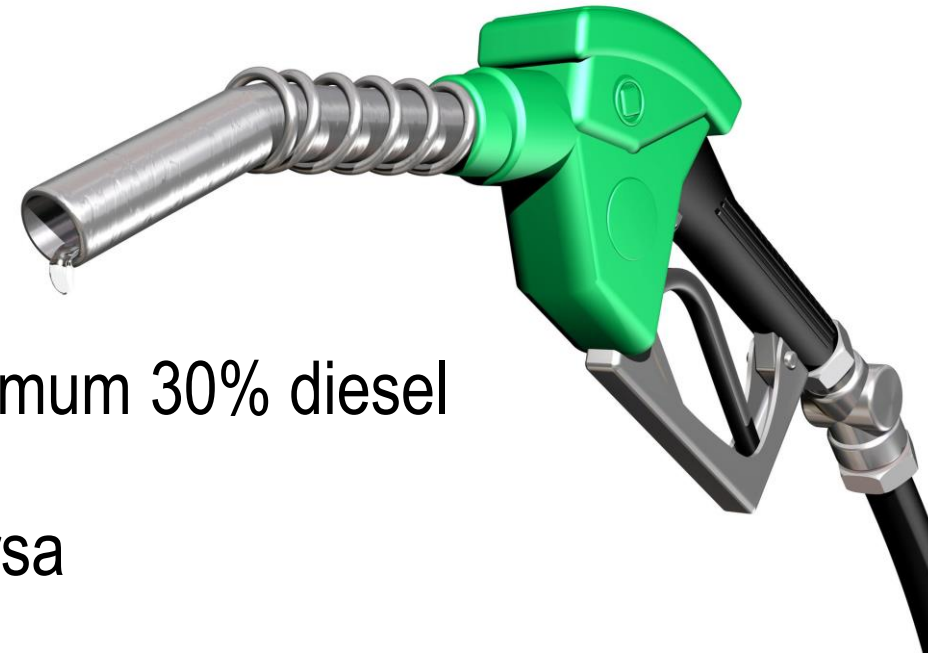


Features and Benefits: Fuel Cost Savings

- Save up to \$100/MWh or more!
- Your dealer can estimate the potential savings based on
 - Application (load profile)
 - Local fuel prices (diesel and gas)
 - Site conditions
- Working capital savings: 60 – 70% less reserve diesel on site.



Features and Benefits: Fuel Flexibility



- Generator set can operate with 100% Diesel or minimum 30% diesel
- Switch from 100% diesel to DGB mode and vice versa
- Less storage capacity required on site for diesel fuel
- Improved reliability of Standby / Emergency applications

Features and Benefits: Fuel Flexibility

- Additional flexibility for mobile units
 - No recalibration needed when generator set relocated
 - Less commissioning time.

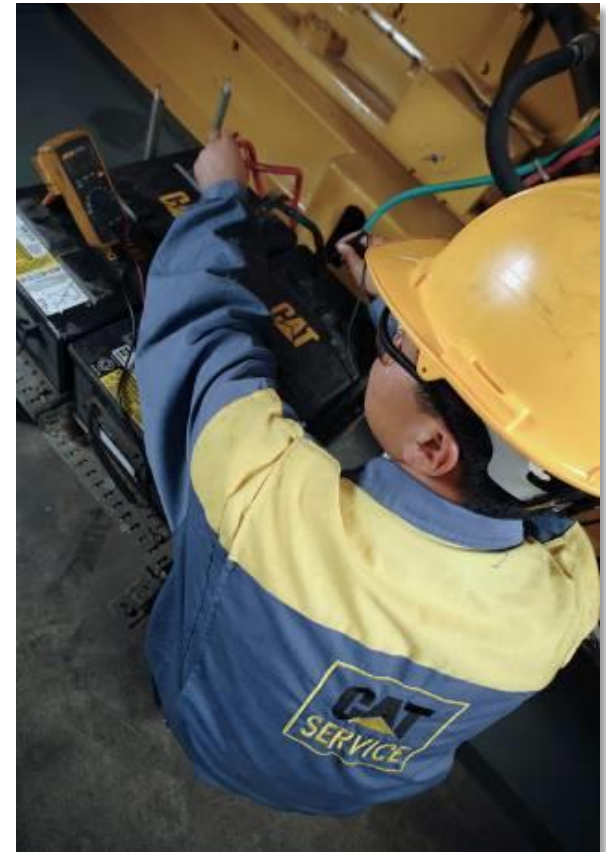
(3rd party kit would require calibration/commissioning with load banks on each new installation)



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Features and Benefits: Factory Warranty and Service Intervals

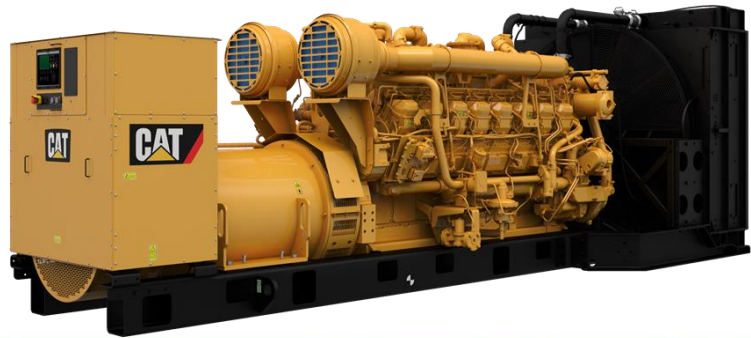
- Standard diesel generator set warranty applies
- Service and overhaul intervals also apply to the DGB generator set.



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DGB vs Spark Ignited Engines

- Transient performance of a diesel engine, able to support high load quickly
- Compression ignition with no spark plugs to replace
- Same power density (ekW/L) as diesel engine
- Altitude and temperature derate same as diesel
- Runs on 100% gas, but sacrifices transient performance, with limitations on load acceptance
- Lower power density (ekW/L) when compared to a diesel engine of same size



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Key Product Benefits

- Achieves up to 70% substitution between 40% and 90% of Prime rated output
- Reliability, durability and factory warranty for prime product and retrofit kits
- Worldwide dealer support
- Reduced on-site commissioning
- Integrated control panel for engine, generator, and gas blending

Potential Project - TCO Analysis

Mine Site

3516B - 1750kVA Continuous

- 6000+ hrs per year @ 85% of rated output
- Diesel 1.2 \$/L, Gas 7.5 \$/mmBTU

TCO Estimates

- Cat DGB (70% Substitution)
 - \$1.2M fuel savings per year



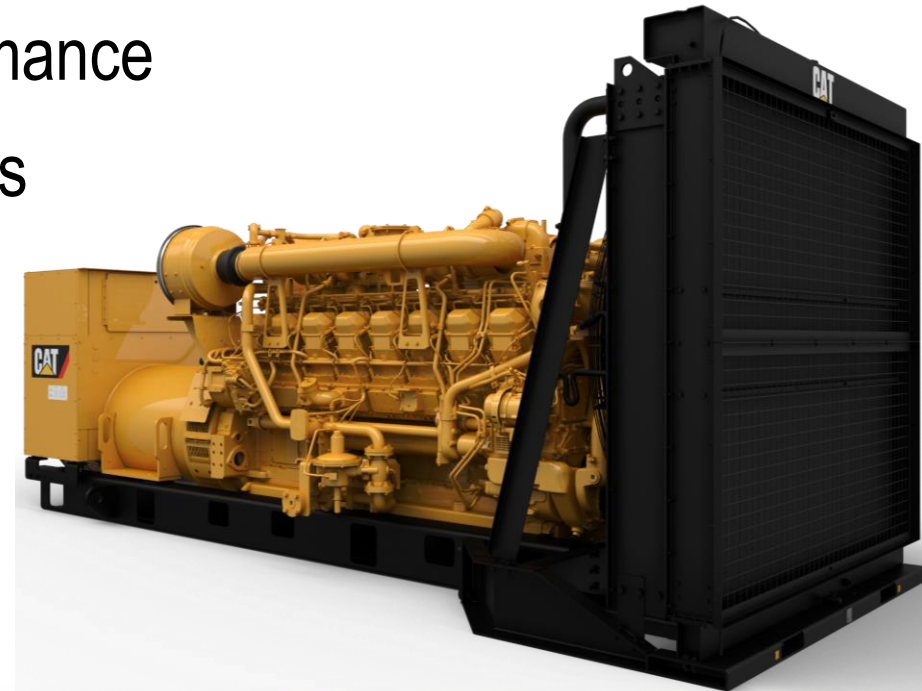
The Cat® Advantage

- Optimized DGB kit design for Cat generator sets
 - Measures important parameters, seamless interface with generator set control system
 - Automatically adjusts to changing gas quality
 - Optimal design for best performance (maximum substitution) while operating within Caterpillar design limits

Protects the engine, providing a **maximum reliability** and **durability**

DGB Generator Set Features & Benefits

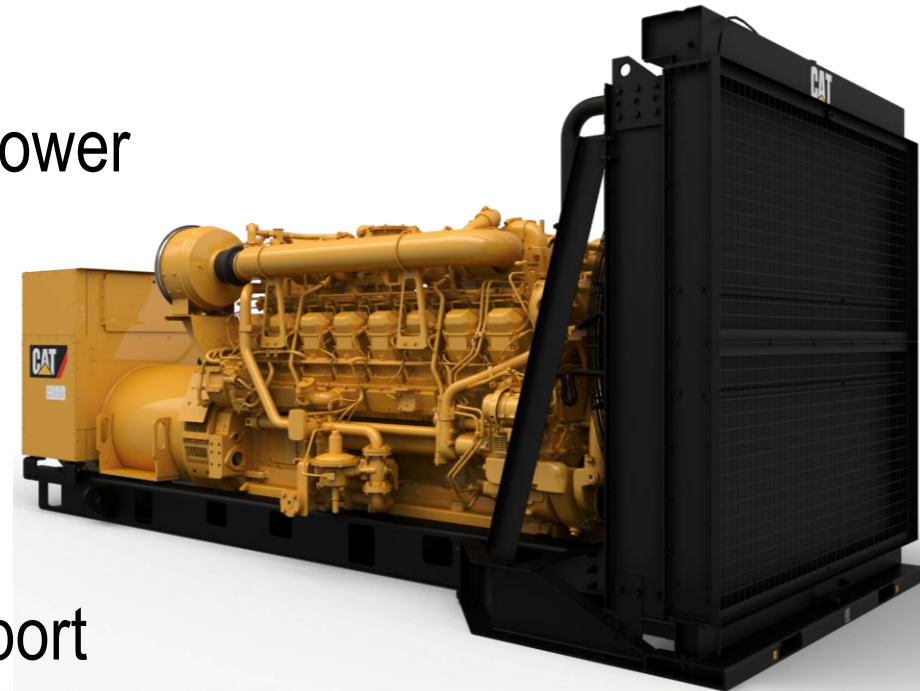
- Fuel Savings (substitution rate up to 70%)
- Natural Gas, Gasified LNG, CNG
- Maintains Diesel Power Rating & Transient performance
- Maintains Diesel Maintenance / overhaul schedules
- Automatically activates once supply pressure is detected (12 – 100 psi)
- No recalibration required when equipment is moved or gas supply changes



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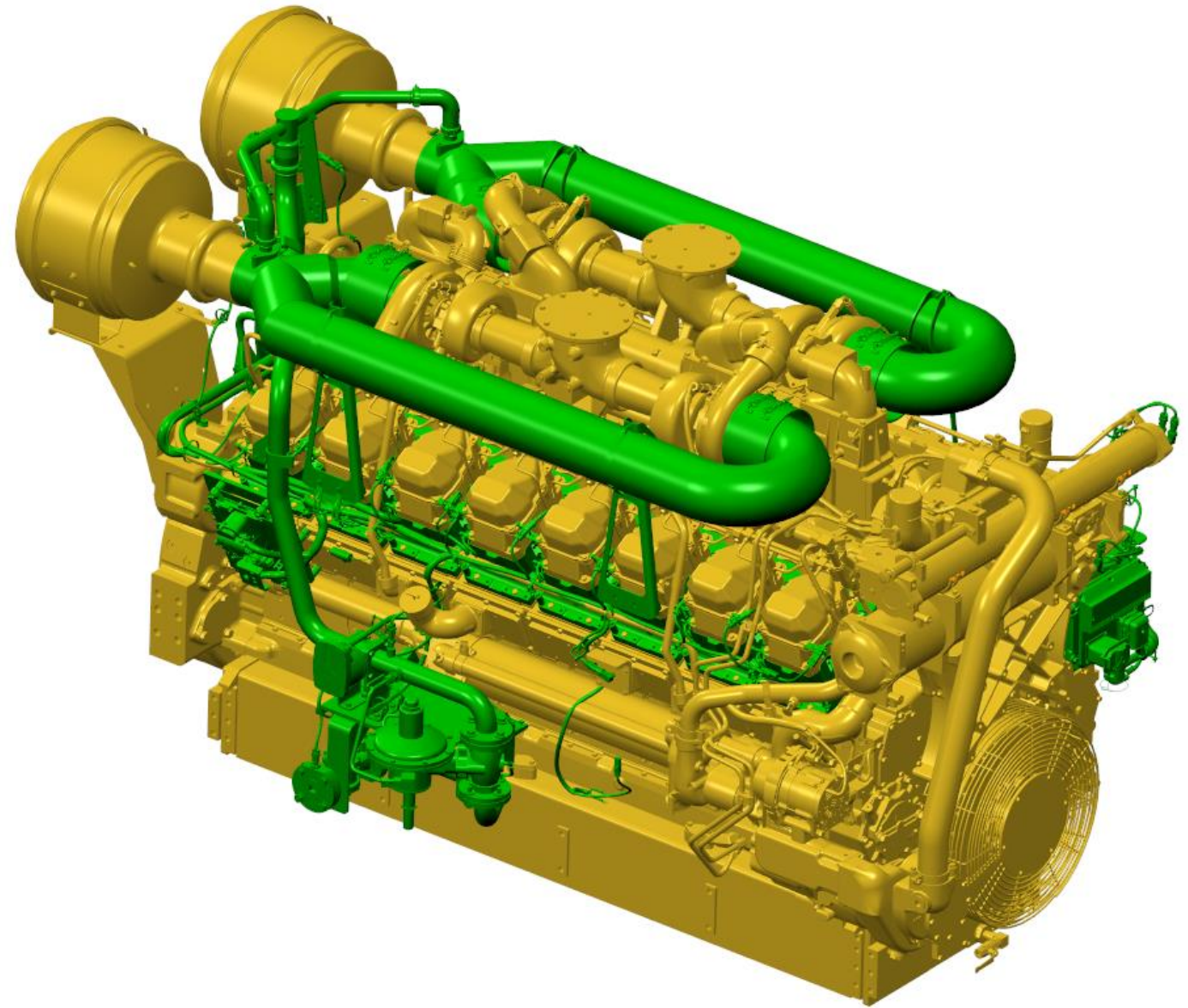
DGB Generator Set Features & Benefits

- Fully automatic and dynamic solution to maximize gas substitution
- Smooth transition between diesel and DGB modes
- Panel Display of DGB parameters:
Gas/Diesel substitution rate, Gas Pressure, Gen Power
- Designed to allow engine to run at maximum substitution while maintaining high level of reliability and durability by keeping the engine within Caterpillar hardware limits.
- Caterpillar Warranty & Global Dealer Network support



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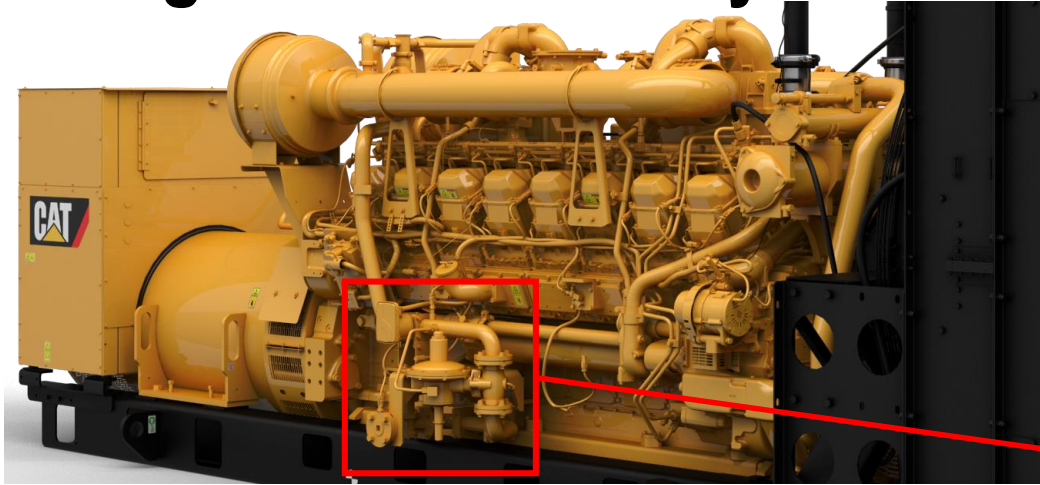
Design



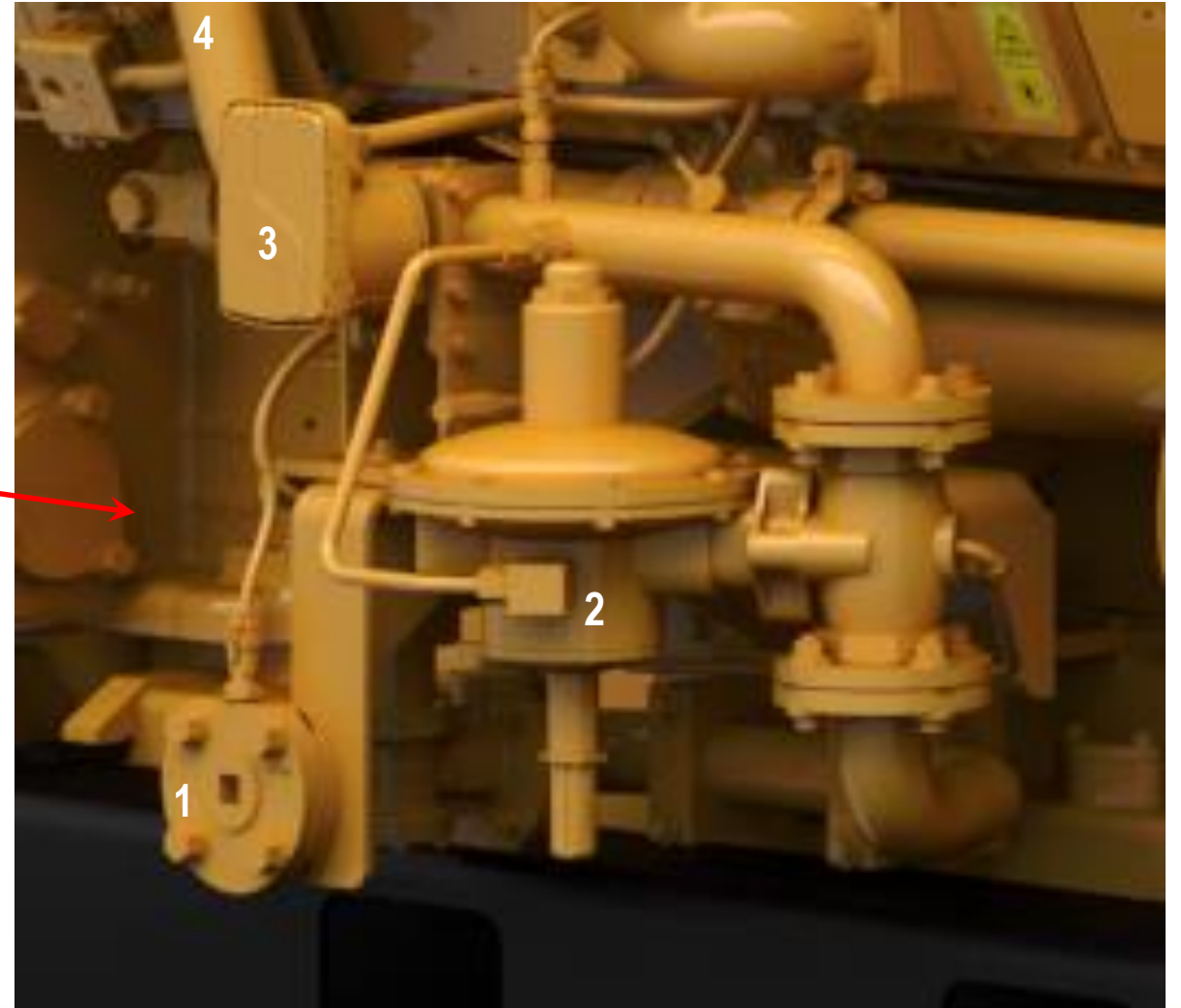
DGB components shown in green

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Design – DGB Fuel System



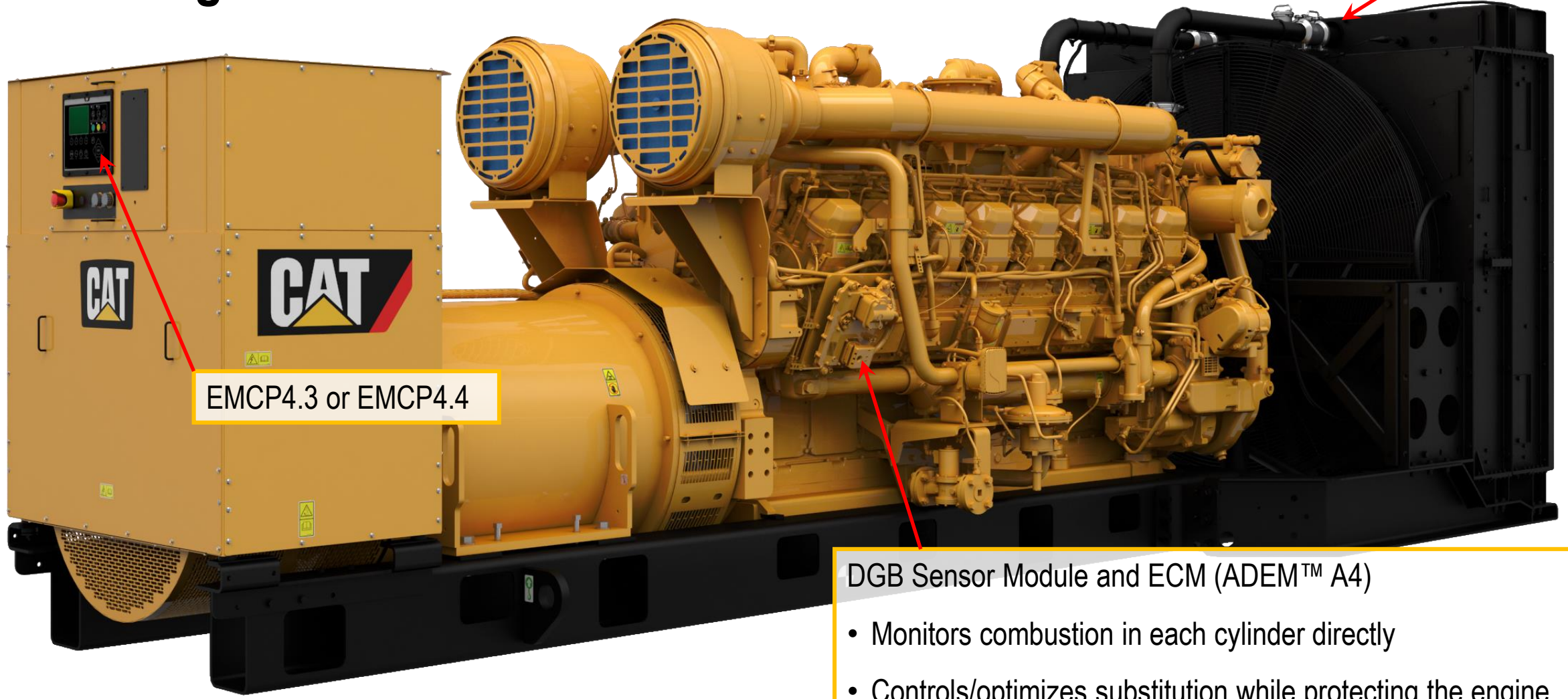
1. Customer connection point
2. Gas shutoff valve & pressure regulator
3. Gas fuel control valve
4. Line supplying metered gas to the intake air stream



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Design – Features

SF44CTS Radiator



EMCP4.3 or EMCP4.4

DGB Sensor Module and ECM (ADEM™ A4)

- Monitors combustion in each cylinder directly
- Controls/optimizes substitution while protecting the engine.

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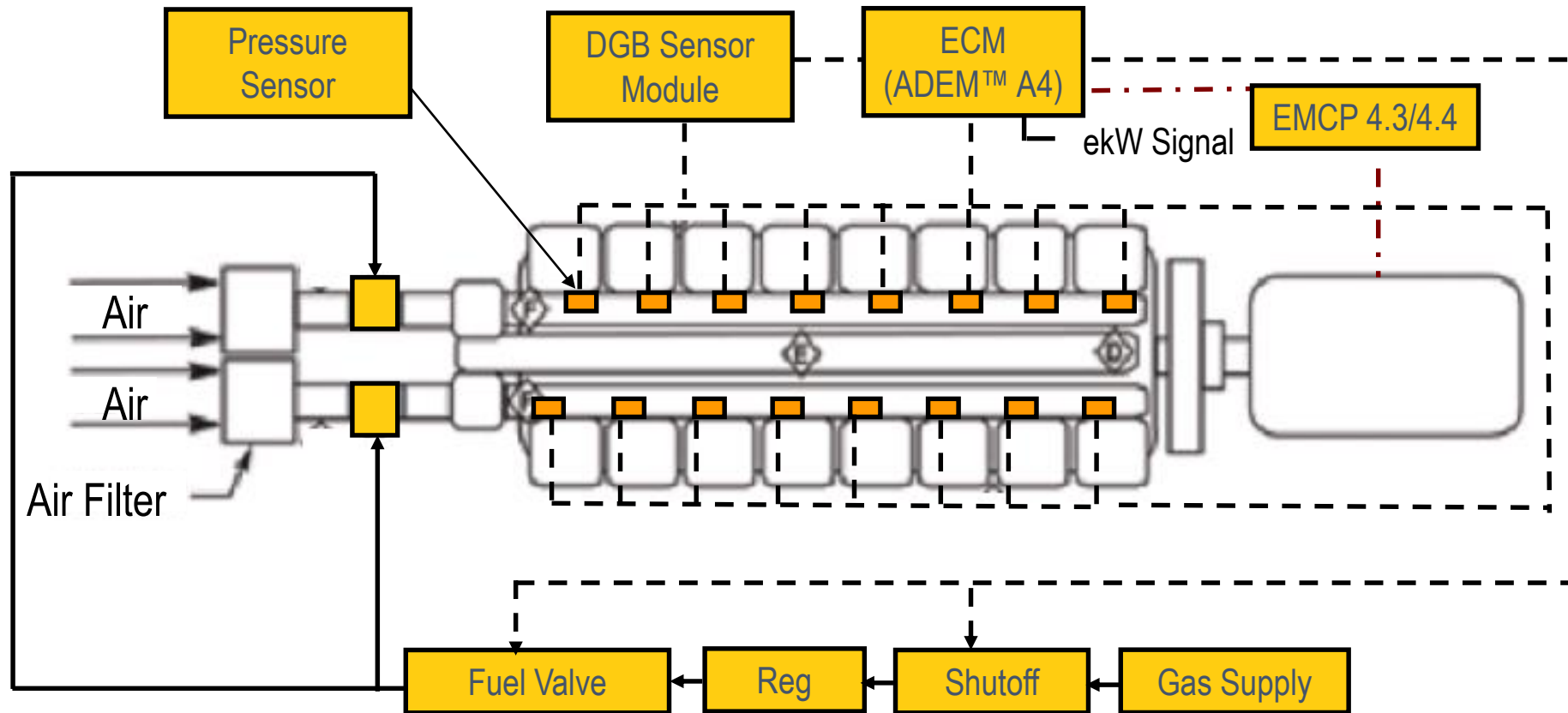
DGB Generator Set Controls (Standard EMCP4.3/4.4 Controller)

- Engine/generator/Dynamic Gas Blending system parameters and system settings
- Full text fault codes and modifiable text strings
- Compatible with relays and customer inputs (MODBUS protocol, Ethernet, or sensors)
 - Customer-supplied gas detection/fire detection
 - Package operated gas shutoff valve
- Compatible with load sharing module
- Paralleling functionality optional (EMCP4.4)
- Engine protection shutdown/startup ability



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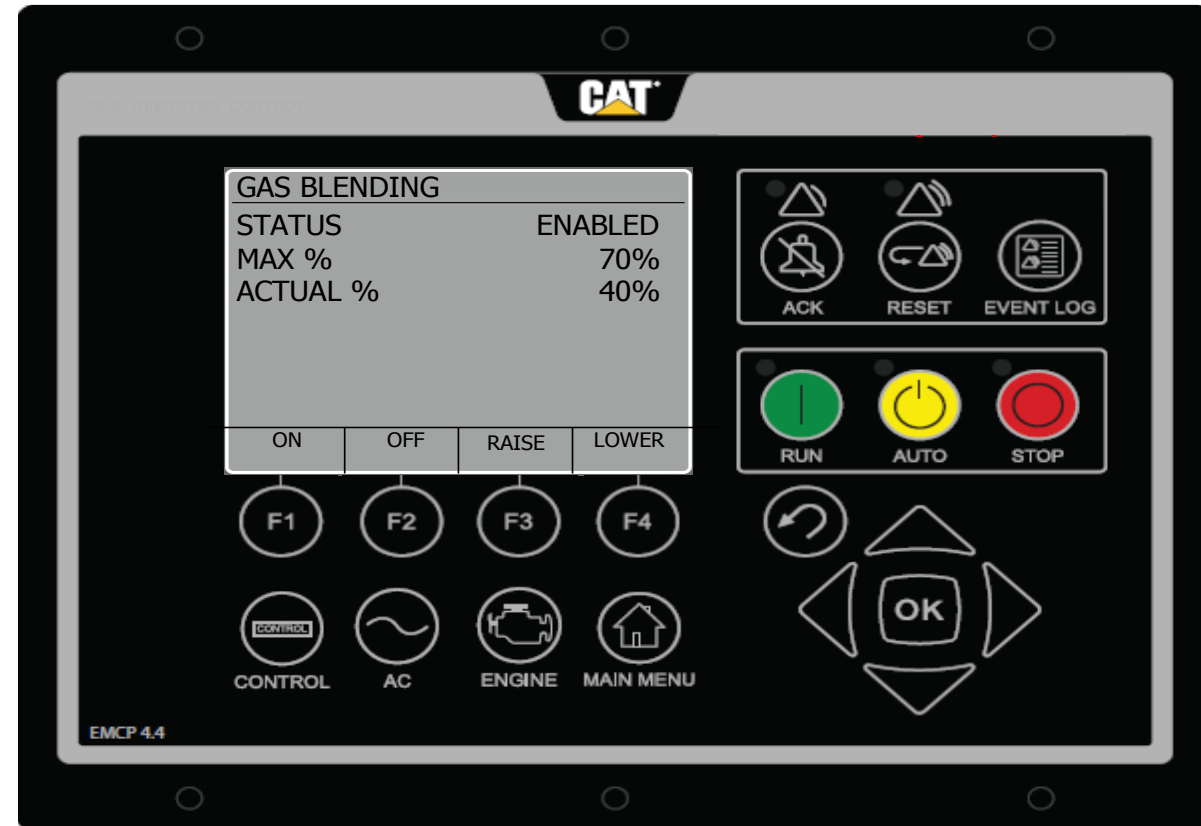
Generator Set Schematics



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Dynamic Gas Blending Controls

- Standard EMCP4.3 or 4.4 control panel
 - No additional control panels required
 - Supports remote monitoring
- DGB Parameters
 - Gas blending Status
 - Max % substitution (operator input)
 - Gas substitution reduction reason code
 - Act gas % substitution (feedback)
 - Gas pressure
 - Gas valve position status (open/closed)



System Performance

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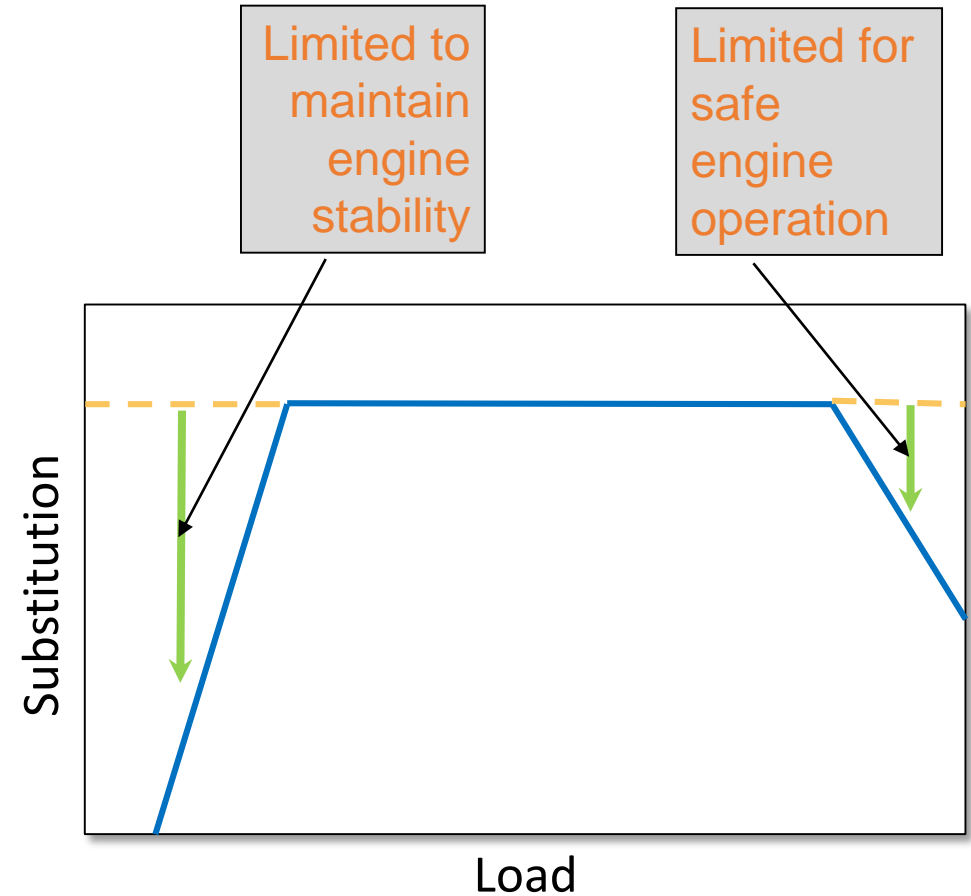
Substitution Estimates

- Factors affecting a reduction in gas substitution
 - Engine Load
 - Hot after cooler temps (SCAC temp)
 - High ambient temp and/or high altitude conditions
 - Timing adjustments on individual cylinders allows maximum substitution (Engine ECM)

Substitution is constantly being optimized within the prescribed hardware limits!

DGB – Substitution

- Primary factors affecting substitution capability
 - Engine load
 - Substitution limited/disabled at low loads to maintain stable operation, injector temperature limits (diesel cools injector tips)
 - Substitution limited at higher loads to keep engine safely under peak cylinder pressure limits
 - Ambient Conditions & SCAC temperature

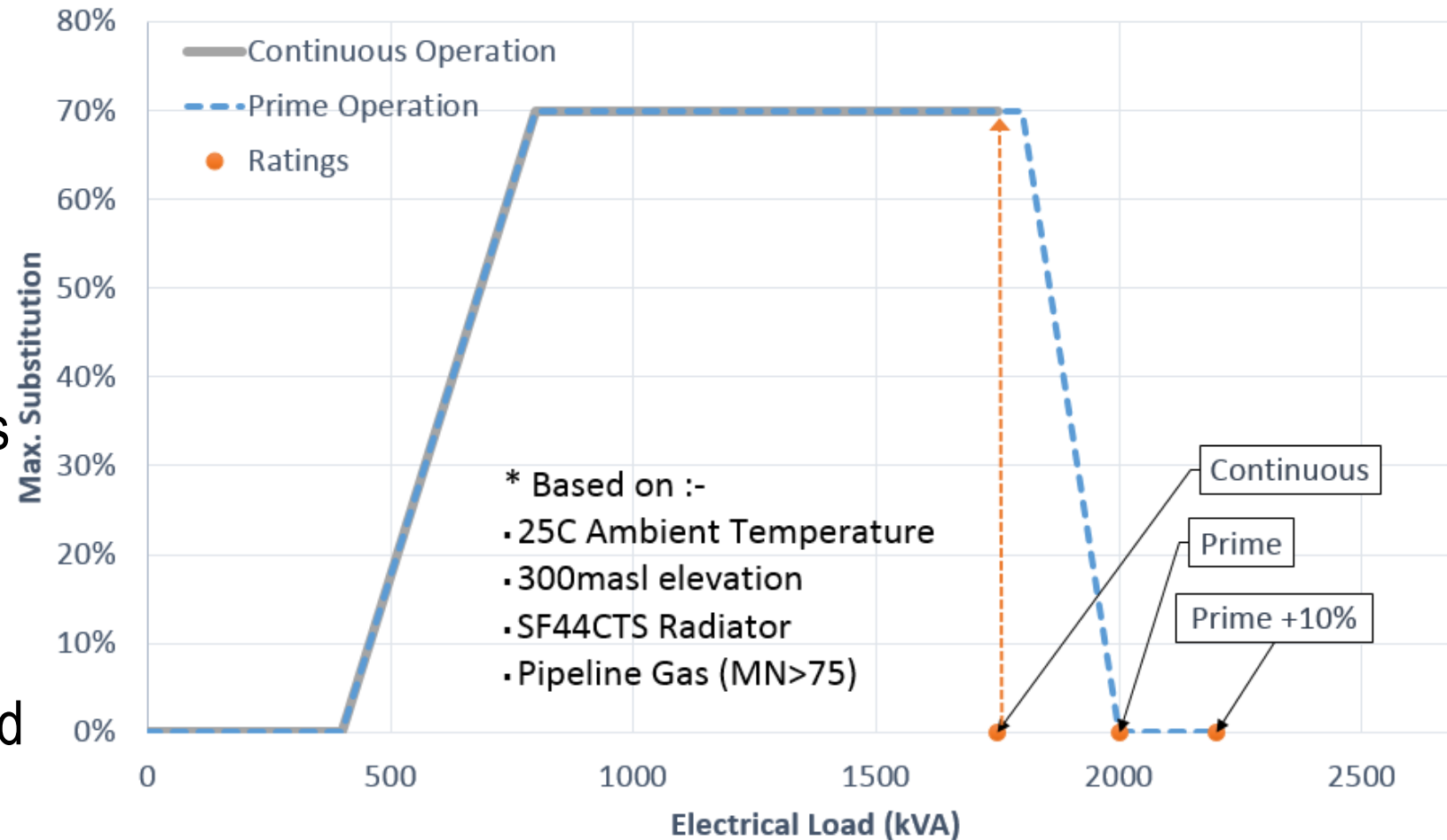


DGB – Max. Substitution vs Load

Max DGB Gas Substitution*

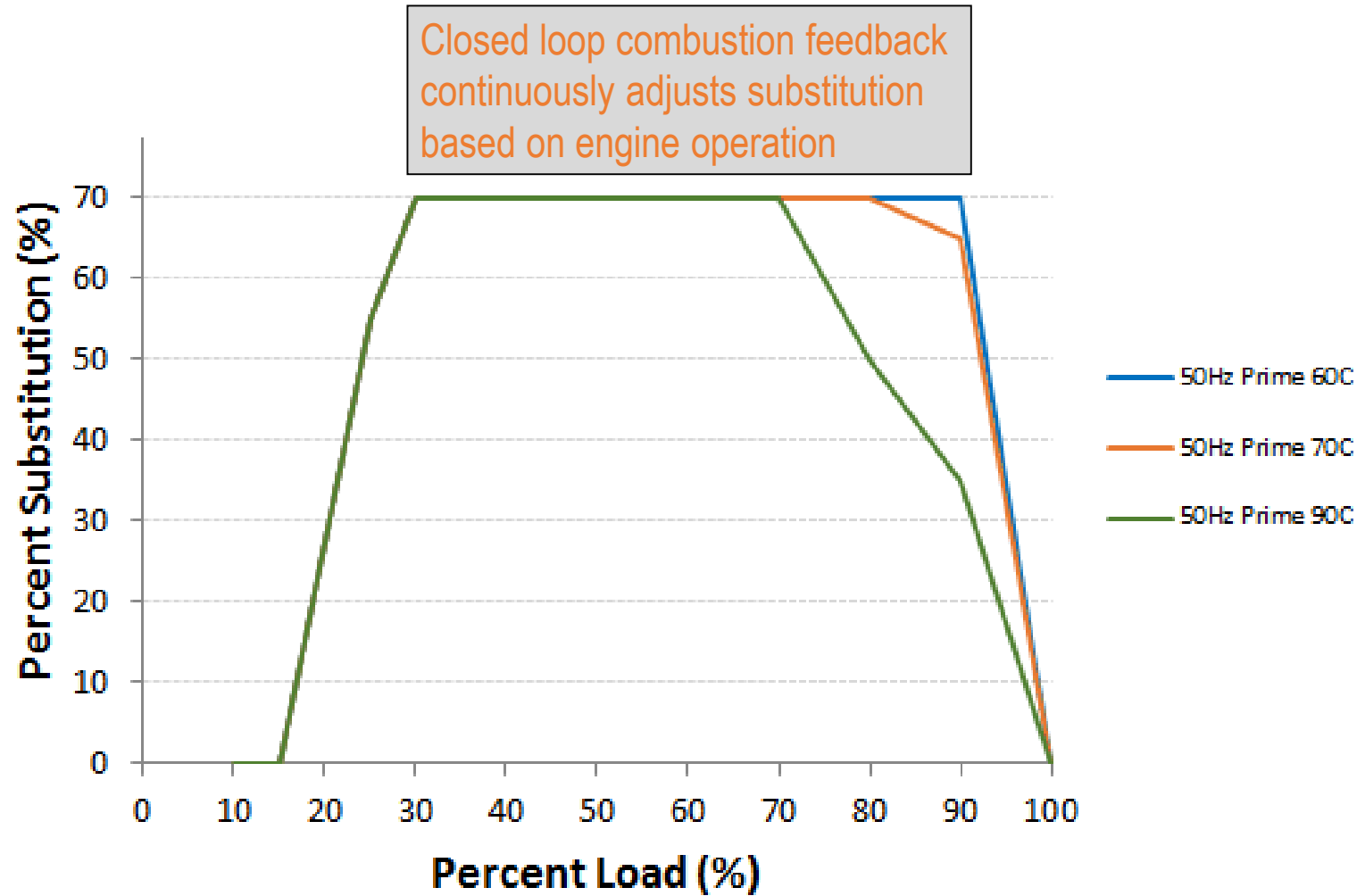
General Trends with load variation

- Maximum substitution at >40% Prime
- Close to maximum substitution at Continuous Rating
- No substitution at
 - 100% Prime
 - Prime + 10% Overload



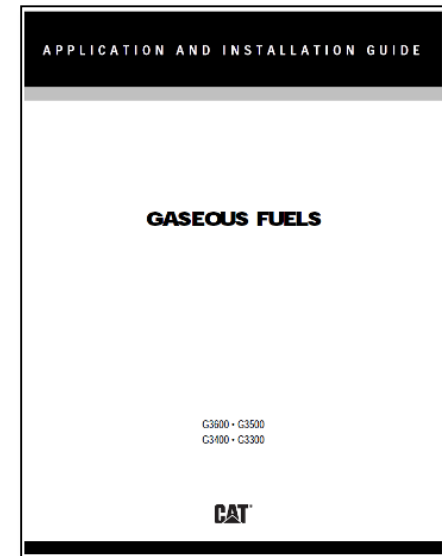
DGB – Substitution

- Primary factors affect substitution capability
 - Engine load
 - Ambient Conditions & SCAC (Separate Circuit After Cooled) temperature



Supply Gas Quality Requirements

- DGB system can accept gasified LNG, CNG & pipeline
- Recommended Lower Heating Value is between 900 and 1250 Btu/scf. (Calculate using GERP).
 - Clean, dry gas (Gaseous Fuels A&I guide LEBW4977)
- Supply gas pressure / temperature to DGB :
 - 12 to 100 PSI (0.83 to 6.89 bar)
 - -10°C to 60°C



Safety Features

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Dynamic Gas Blending Safety Features

- Complete generator set design reviewed and approved for multi-fuel operation
- Flame arrester at inlet of each cylinder head
- Durable gas pipes and hoses
- No operator adjustments: all automatic
- ECM controls gas and diesel: common monitoring, control and protection



Sales Support and Product Support

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RUN ON ALL DIESEL...

THE DYNAMIC SOLUTION

...OR SUBSTITUTE UP TO 70% DIESEL WITH
NATURAL GAS.

Visit: www.cat.com/dgb-ame

- Technical datasheets
- Animation

Installation Drawings (3516 PGFL)

See your local Dealer

Fuel Cost Estimator (available Q2 2018)



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Sales Support Material – Spec Sheets

50 HZ

Engine	Fuel Strategy	Power (kVA)	
		Prime	Continuous
3516B DGB	Low Fuel	2000	1750
3516B DGB	Low Emissions	2000	1750
3516B DGB	Low Fuel	2275	2000

60 HZ

Engine	Fuel Strategy	Power (kW)	
		Prime	Continuous
3516B DGB	Low Fuel	1825	1640

Cat® 3516B Dynamic Gas Blending™ (DGB™) Generator Sets

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Image shown may not reflect actual configuration.

Prime in kW (kW) 1825 (2497)

Continuous in kW (kW) 1640 (2207)

Standard Features

Dynamic Gas Blending™ (DGB™) System

- DGB system automatically activates when gas supply is detected.
- Reduces diesel consumption by up to 70% using gas substitution while maintaining safe engine operation.
- Control system enables maximum substitution over the widest load range in the industry.
- Maintains traditional diesel generator set power and transient response performance.
- Accepts a wide range of gas quality and automatically adjusts to fuel quality changes, eliminating the need for field calibration.
- Maintains existing diesel maintenance and overhaul intervals.

Cat® Diesel Engine

- Designed and optimized for low emissions or low fuel consumption.
- Reliable performance proven in thousands of applications worldwide.

Generator Set Package

- Accepts 100% block load in one step and meets other NFPA 110 loading requirements.
- Conforms to ISO 8528-S2 load acceptance requirements.
- Reliability verified through torsional vibration, fuel consumption, oil consumption, transient performance, and endurance testing.

Alternators

- Superior motor starting capability minimizes the need for oversizing the generator.
- Designed to match the performance and output characteristics of Cat diesel engines.

LEH1127-02

Image shown may not reflect actual configuration.

Prime in kW (kW) 2275 (3075)

Continuous in kW (kW) 2000 (2700)

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LEH1128-02

Image shown may not reflect actual configuration.

Prime in kW (kW) 2000 (2700)

Continuous in kW (kW) 1750 (2350)

Standard Features

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LEH1129-02

Bore – mm (in)	170 (6.69)
Stroke – mm (in)	160 (7.48)
Displacement – L (in³)	89 (4210.64)
Compression Ratio	14.0:1
Aspiration	Td
Fuel System	EUH
Governor Type	ADEM™ A4

Image shown may not reflect actual configuration.

Prime in kW (kW)	Continuous in kW (kW)	Emissions Performance
2000 (1600)	1750 (1430)	Optimized for Low Fuel Consumption or Low Emissions

Standard Features

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Cooling System

- Cooling systems available to operate in ambient temperatures up to 92°C (122°F).
- Tested to ensure proper generator set cooling.

EMCP 4 Control Panels

- EMCP 4, 3/4 control panel is the single-point interface for the engine, generator, and DGB functions.
- User-friendly interface and navigation.
- Scalable system to meet a wide range of installation requirements.
- Expansion modules and site specific programming for specific customer requirements.

Warranty

- 24 months/1000-hour warranty for standby and mission critical ratings.
- 12 months/unlimited four warranty for prime and continuous ratings.
- Extended service protection is available to provide extended coverage options.

Worldwide Product Support

- Cat dealers have over 1,800 dealer branch stores operating in 200 countries.
- Your local Cat dealer provides extensive post-sale support, including maintenance and repair agreements.

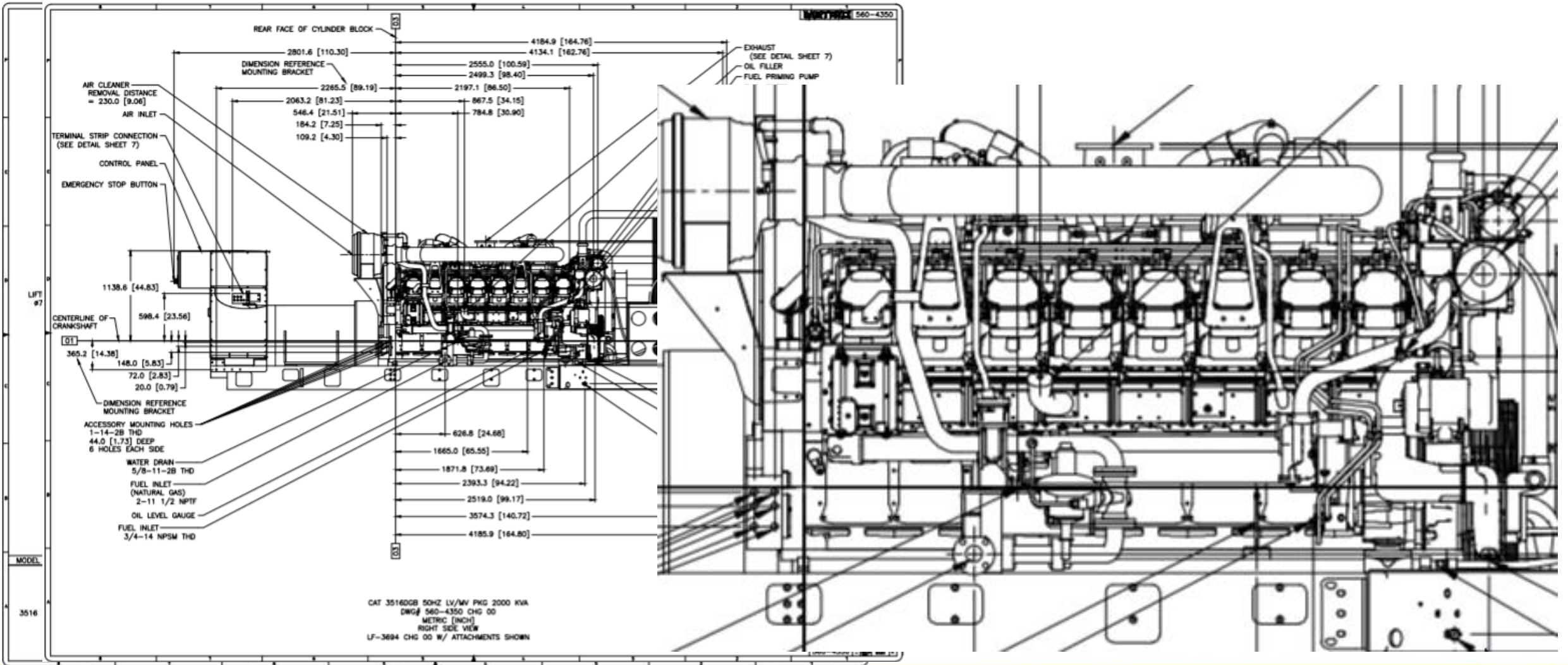
Financing

- Caterpillar offers an array of financial products to help you succeed through financial service excellence.
- Options include loans, finance lease, operating lease, working capital, and revolving line of credit.
- Contact your local Cat dealer for availability in your region.

Page 1 of 4

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Sales Support – Installation Drawings



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Product Support

- Product Prefix
- Parts Manuals
- Operation & Maintenance Manuals
- Electrical Schematics
- Parts Stocking
- Serviceability Audits

FF2, F4H

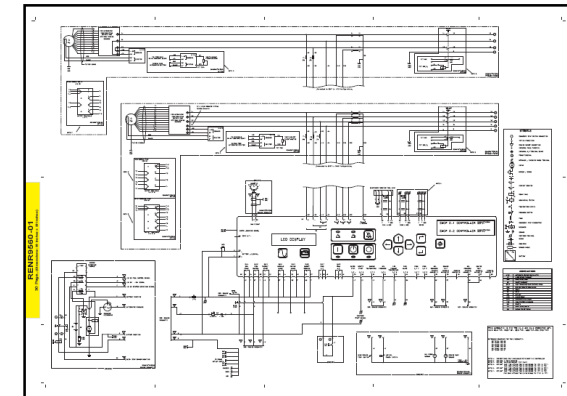
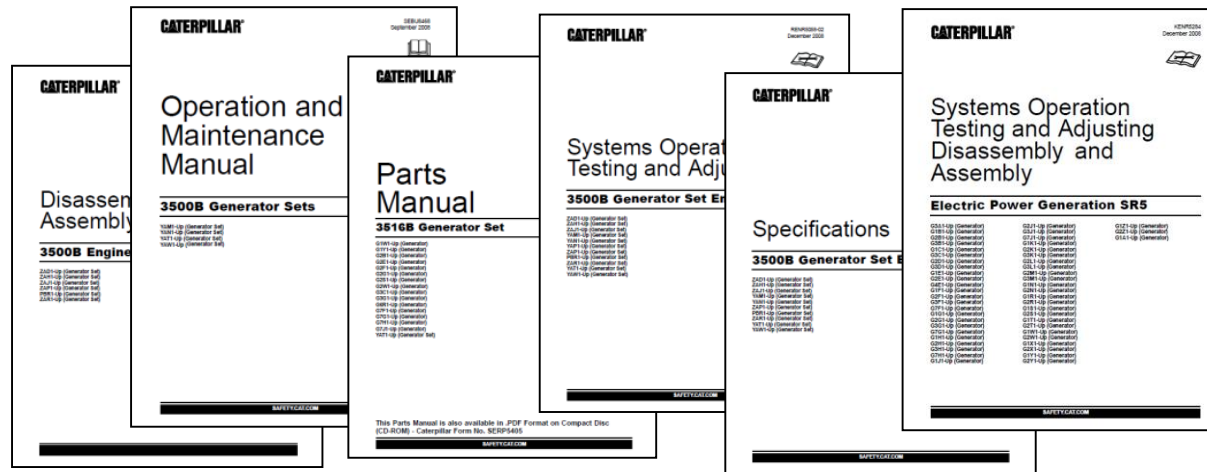
FF2 – M0085293, F4H – M0085395

SEBU9019

UENR8307

In Process

Completed



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Retrofit Kits Overview

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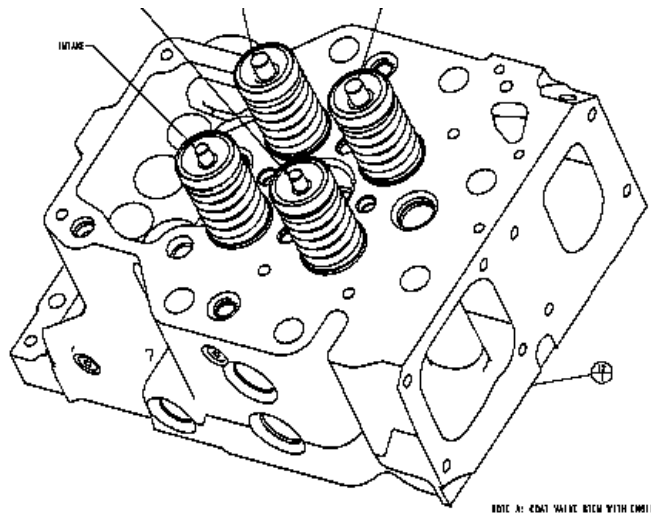
Retrofit Kits

Availability as per “Product Support Marketing Bulletin” (Media No.: PELJ2243)

For Non-Certified Engines in Service Outside of US Only (S/N : YAT , YBT , ZAP , ZBP , YAP , JCH , LY3 , LNW , 1HZ , DD8 , DD9 , YAW , YBW , ZAR , ZBR , YAR , JCN , LY4 , LNZ)

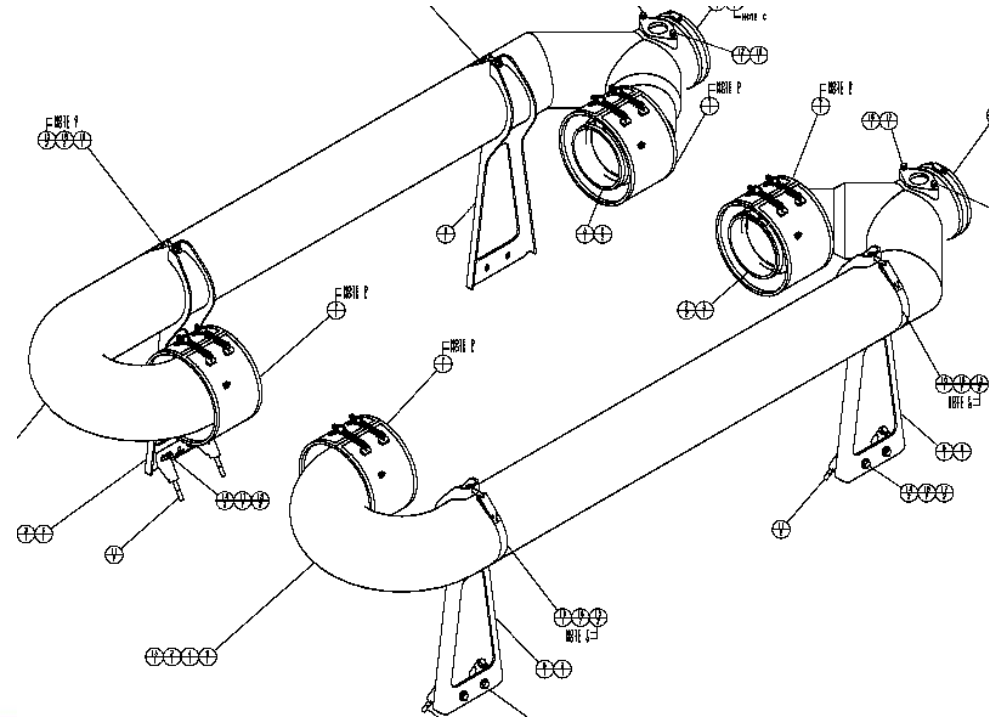
Replacement Head Assembly (463-0919) x 16

+ Head Gasket kit (355-0776) x 16



Main Kit Components (540-3893):

Air Cleaner Mounting Group (547-8143)

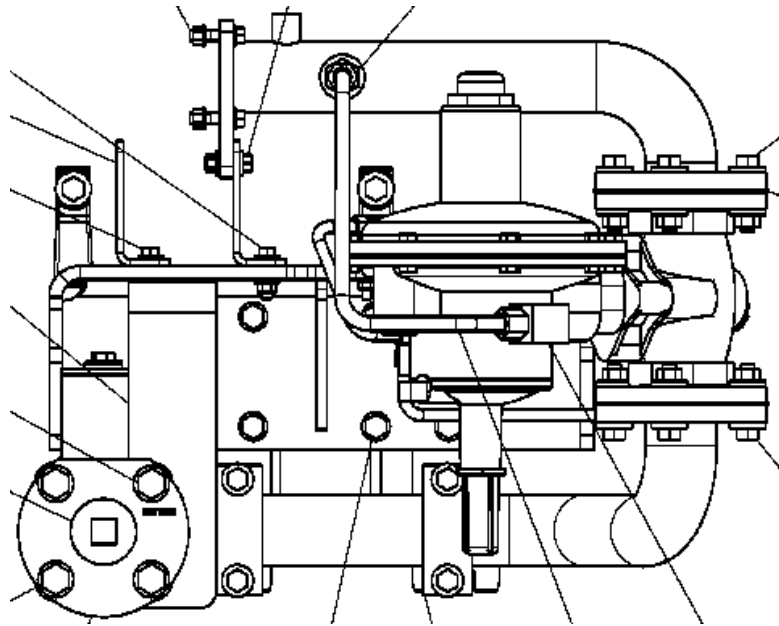


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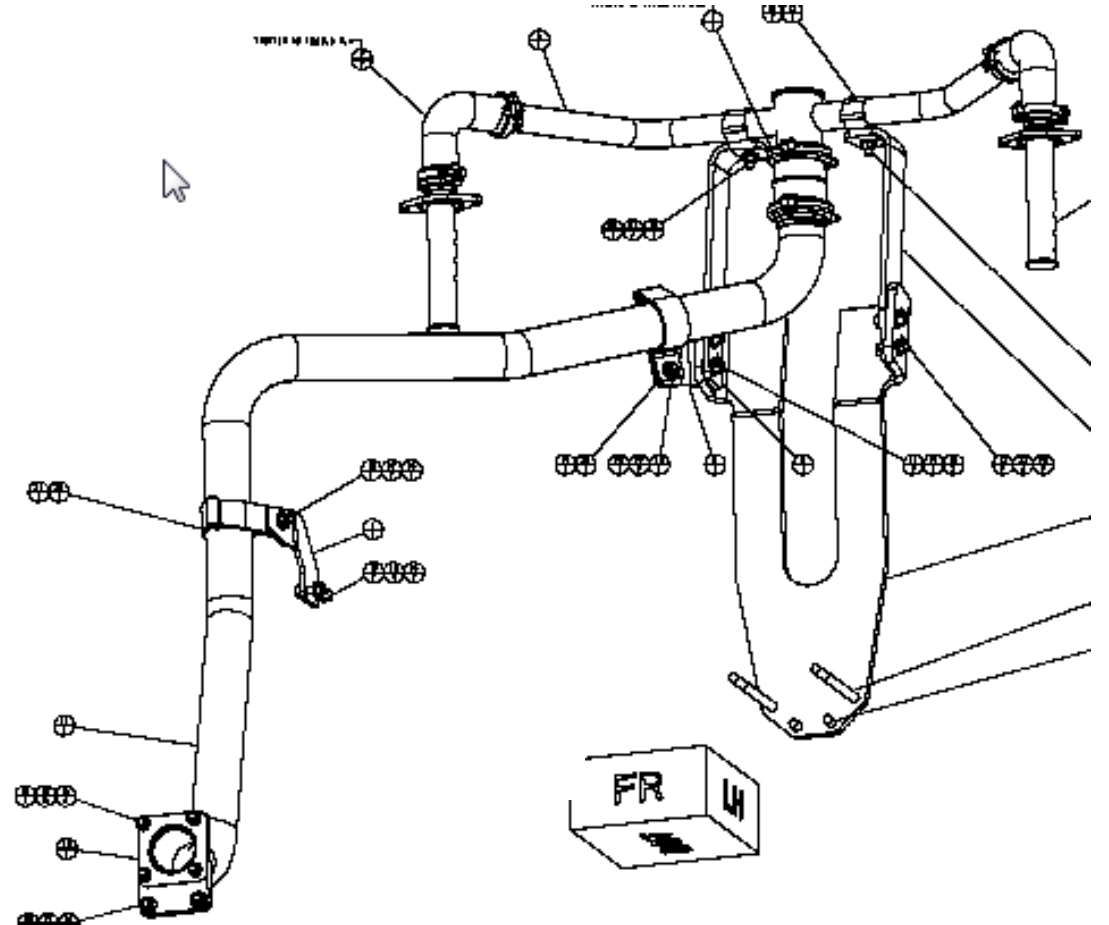
Retrofit Kits

Main Kit Components (540-3893):

Regulator Valve and mounting group



Gas Fuel Lines group

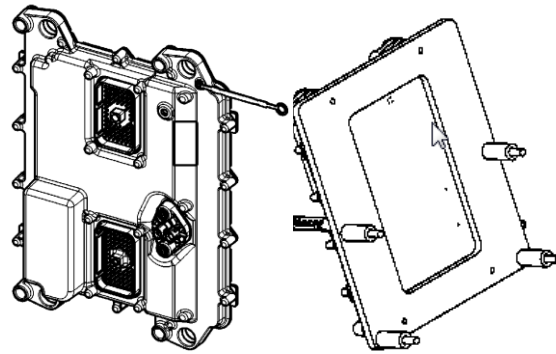


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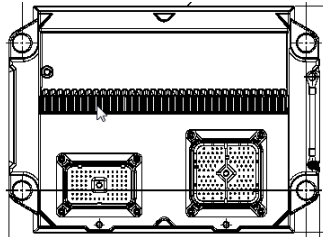
Retrofit Kits

Main Kit Components (540-3893):

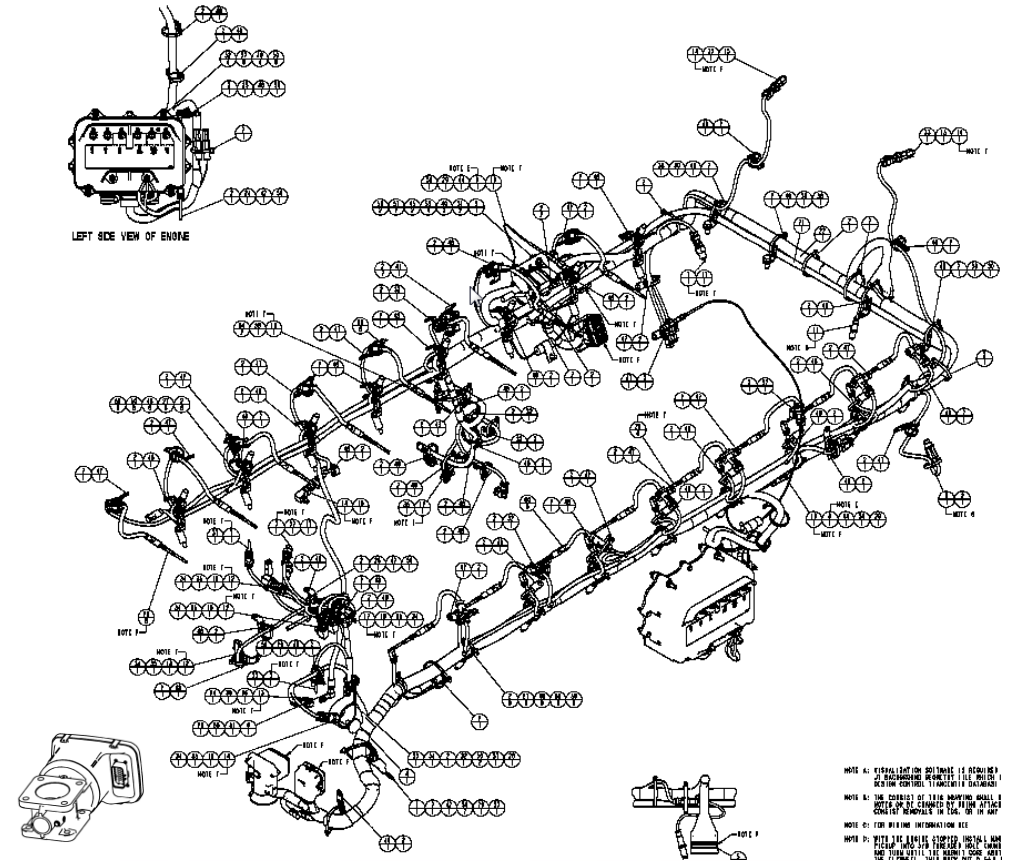
DGB Sensor Module and mounting group



ECM (ADEM™ A4) Module + Software



Engine wiring group and components



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Questions?

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