AVEC

WATCH THE FUTURE UNFOLD

AXIAL VECTOR ENGINE CORPORATION

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The creation of the crank shaft internal combustion engine shaped the 20th century. Axial Vector Engine Corporation (AVEC) has created and refined sinusoidal-cam drive engine technology that will move energy efficiency forward on many fronts and applications into the 21st century. Watch the future unfold with the advent of the Axial Vector sinusoidal-cam engine and its improvements over crank shaft technologies.

The AVEC GENSET Advantage

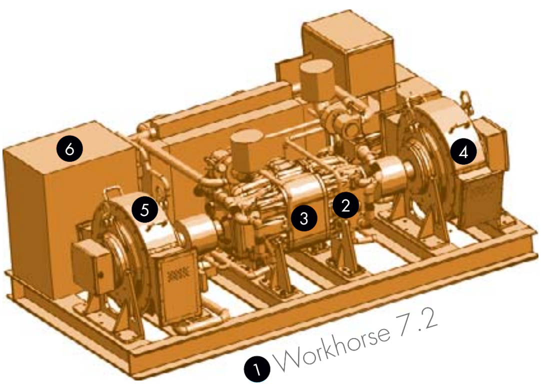
The Axial Vector prototypical engine and generator technologies have been developed, built and integrated into our early version prototype GENSET, which in itself is a breakthrough in efficiency of fuel conversion to electrical power. More features in development will be incorporated and further improve the GENSET's efficiency and weight reduction, especially as we gain increased experience and maturity.

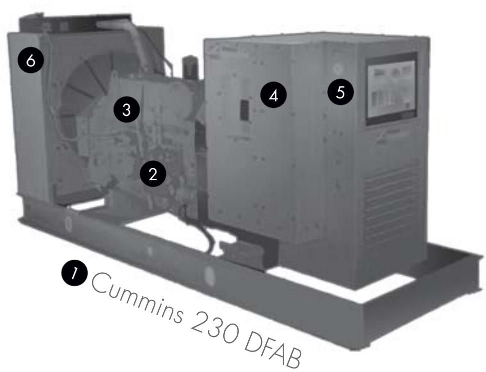
Comparing the AVEC GENSET with Some of the Best

A comparison of the AVEC Workhorse 7.2 with the Cummins 230 DFAB provided in the illustration below shows the amount of fuel consumed (48.7 vs. 54.0 liters per hour, respectively) to produce 210 kWh of electric power. The Cummins consumes 9.8% more fuel than does the Workhorse for the same 210 kWh of electric power produced. The Workhorse and Cummins engines respectively were 45.1% and 42.6% efficient in converting the fuel to work, respectively producing the equivalent of 218 kW and 228 kW of mechanical energy. The AVEC Generator was 96% efficient in converting mechanical to electric power, while the Cummins showed 92% efficiency. Thermal losses were equivalent to 82 kW for the AVEC GENSET, compared with 96 kW for the Cummins.

AVEC Workhorse 7.2 vs. Cummins 230 DFAB

(These two engines produce comparable torque to drive 210kW generators)





1	Fuel Consumption 48.7 liters/hr	Fuel Consumption 54.0 liters/hr
2	45.1% efficiency Fuel to Work	42.6% efficiency Fuel to Work
3	218 kW Mechanical Energy	228 kW Mechanical Energy
4	96% efficiency Mechanical to Electrical Power	92% efficiency Mechanical to Electrical Power
5	210 kW Electrical Power	210 kW Electrical Power
6	82 kW Thermal Loss	96 kW Thermal Loss

Engine as Contributing Factor to AVEC GENSET Superior Performance

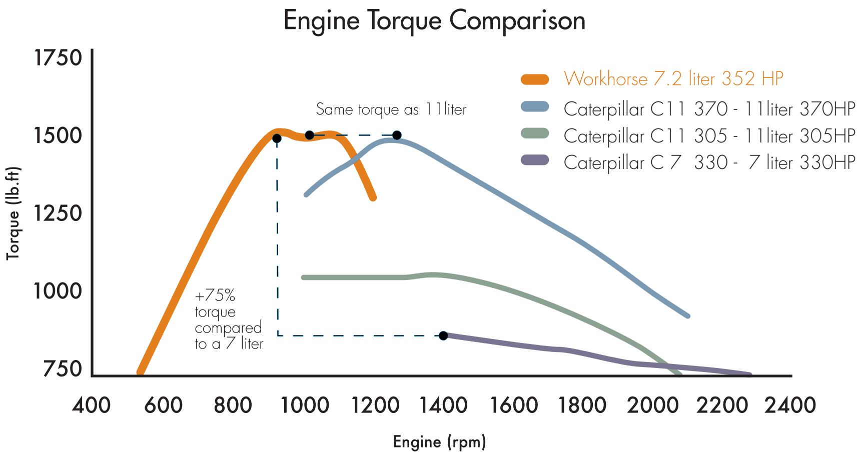
AVEC is poised for the top edge of 21st century innovation with the Axial Vector and the two or four-lobe (axially opposed piston set) sinusoidal-cam designed engine and its digital control architecture. The Workhorse 7.2 liter engine was built to be the best in its class at squeezing out efficiencies never before achieved with an internal combustion engine.

The engine is a high-horsepower/high-torque engine. The engine runs on diesel, bio-diesels and certain jet fuels, and has the ability to be modified to run on a variety of other fuels, creating a true multi-fuel technology. With 352 horsepower, it is a digitally controlled, linearly reciprocating engine with reduced side-load on the cylinder walls for friction reduction. As a prime mover in a GENSET application, the engine is designed to run at a constant optimal speed for greater combustion efficiency and longevity. The key factor in the engine design is its 0.26 pounds of diesel fuel at density of 0.88 kg/l) per horsepower per hour with an excellent torque-to-horsepower ratio. Its ideal speed is about 1100 RPM.

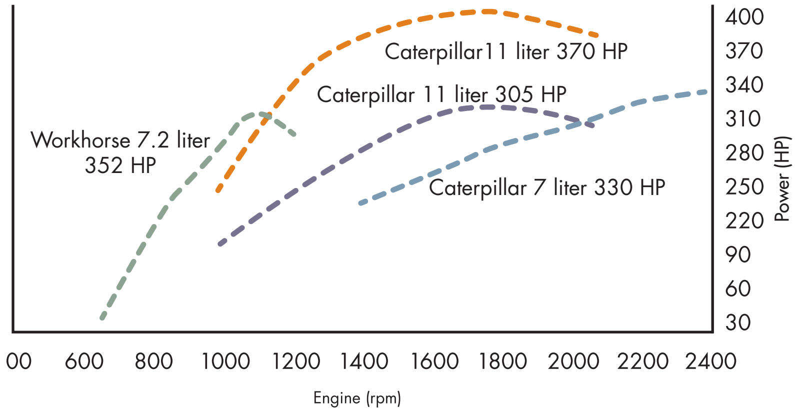
The engine is designed to run up to 40,000 hours between major overhauls. At a first reading that may not sound impressive, but consider that the engine might be running at an equivalent of 50 miles per hour, which represents 2,000,000 miles and the equivalent of about 4.6 years of continuous operation between major overhauls.

Some Engine Performance Data

- The 7.2 liter Workhorse engine has a maximum torque that is 75% greater than a 7.2 liter 6 cylinder in line crank shaft engine (Caterpillar C7 330) for the same rated power
- The 7.2 liter Workhorse engine has the same torque as the 11 liter 6 cylinder in line crank shaft engine (Caterpillar C11 370)



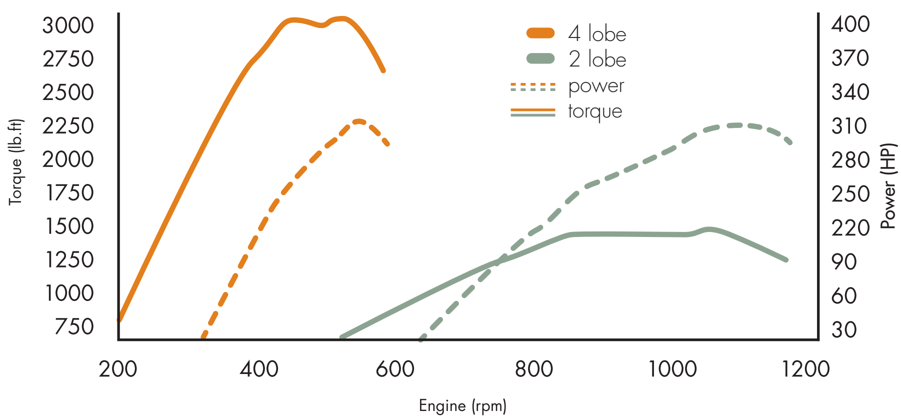
Engine Power Comparison



Importance and Flexibility of Cam Lobes

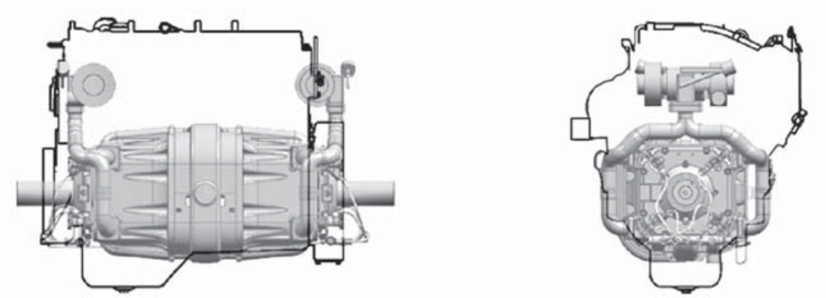
Our design provides the potential to change the torque curve by increasing the number of lobes to reduce speed and increase torque.

Torque and HP Curves for 2 & 4 lobe Workhorse 7.2



Size Comparison

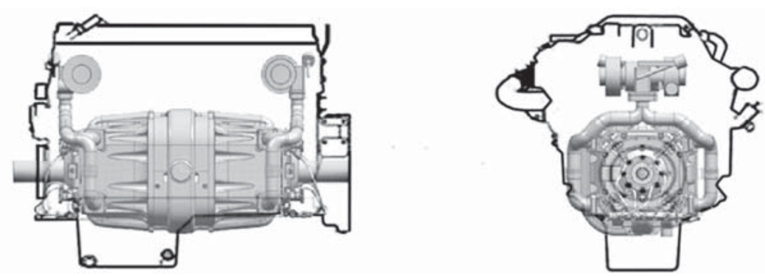
Workhorse 7.2 Prototype Engine vs. Caterpillar C7 – 7.2 liter



Engine Dimensions

Dimensions	AVEC Workhorse	Caterpillar C7
Length	47.0 in.	42.2 in.
Width	24.3 in.	33.4 in.
Height	21.0 in. (w/o opt. turbo)	38.4 in.
Weight	1223.0 lbs.	1711.0 lbs.

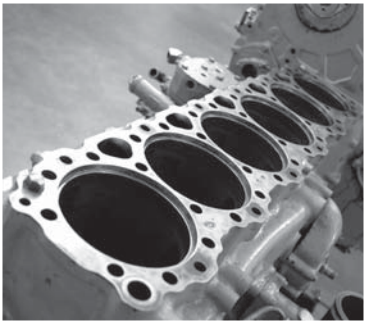
Workhorse 7.2 Prototype Engine vs. Caterpillar C11 – 11 liter

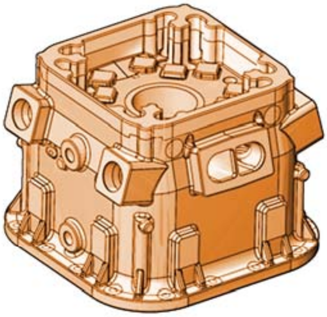


Engine Dimensions

Dimensions	AVEC Workhorse	Caterpillar C11
Length	47.0 in.	51.0 in.
Width	24.3 in.	43.3 in.
Height	21.0 in. (w/o opt. turbo)	41.4 in.
Weight	1223.0 lbs.	2270.0 lbs.

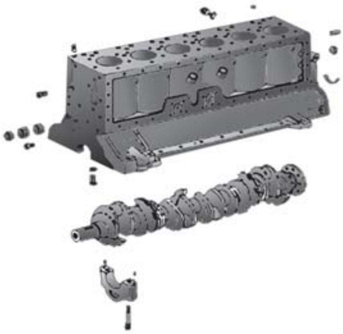
Advantage of Workhorse 7.2 Structural Assembly

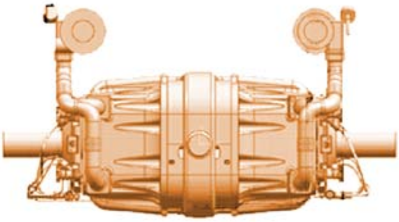




Typical 6 Cylinder in Line Diesel	Workhorse Assembly
38 Cylinder Head Fasteners	Integral head and cylinder block No cylinder head fasteners
Gasketed Joint	No head gaskets

Advantage of Workhorse 7.2 Rotational Assembly





Typical 6 Cylinder In Line Diesel	Workhorse Assembly
7 sets of main bearings	4 roller type main bearings
7 main caps	16 case studs
14 main cap fasteners	75% fewer primary fasteners
Complicated crankshaft machining	Dual end power output

Generator As Contributing Element To AVEC Superior Performance

The current AVEC GENSET is designed to produce 200 kW of continuous power (240 kW peak) from two 100 kW AVEC coreless permanent magnet flux generators, one generator spinning at each end of the AVEC 352 HP, Workhorse 7.2 engine drive shaft. Efficiency of the axial flux permanent magnet coreless generator design is very high at ~98%. Until now, these high efficiencies have only been available in major utility sized multi-mega-Watt generators.

Each generator feeds into a rectifier to establish a DC link, which is then re-inverted to AC at a selected frequency and voltage. Both rectifiers and inverters are based on modern, solid-state switches with efficient Pulse Width Modulation (PWM) switching technology controlled by the sophisticated engine/generator digital control system with overall conversion efficiency of 0.96. With the programmable capability of the inverter, there will be access to AC voltage at frequencies of 50Hz, 60Hz or 400Hz. A typical output feed to the utility generating bus is 480V at 60Hz. The output voltage could range from 120V to a maximum of 600V.

The GENSET has a built-in auxiliary power generating system for 42VDC or 24VDC to supply auxiliary power to auxiliary electrical systems such as batteries for startup of the engine or for the operation of system auxiliaries such as fuel and lube-oil pumps.

With its high torque, high horsepower and low optimal speed of only 1100 RPM, the GENSET with Axial Vector technology provides a superior power generation source.

Digital Control System

Auxiliaries that operate only when required and commanded by the Digital Control System further enhance the GENSET operating efficiency. This control system is an advanced FADEC (Full Authority Digital Engine Control) that fully monitors, optimizes and integrates engine, generator, rectifier, inverter and auxiliary systems to maximize the kWh generated per BTU of fuel.

GENSET Opens a Multitude of Market Opportunities

Grid Augmentation

The AVEC GENSET is ideal for grid augmentation in regions where surplus power can be sold back to the commercial grid. Producing low-cost power in times of high grid cost or high consumer usage allows the end-user to assist the grid in power production and to recoup expenses through sell-back arrangements. The AVEC engine digitally monitors these capabilities.

Autonomous Power Source

The GENSET allows end-users to minimize or avoid reliance on costly or unreliable grid power sources by providing multiple power options to farmers, small industry, resort operators, residential users and entire remote regions. The AVEC engine operates in conjunction with the AVEC coreless generator, designed to integrate power from two or more GENSETs. An example is the portable production of a megawatt of power by "ganging" five 200 kW GENSETs.

Generator High Efficiency Design Applied in Electric Motor

Our high-efficiency axial flux permanent magnet coreless generator can readily operate as an electric motor by reversing the current feed. This provides us with a high energy efficiency electric motor that is considerably smaller than most motors presently on the market and eliminates the startup current inrush typical of induction motors. On a worldwide scale, the power savings using high-efficiency electric motors are immense. The number of electric motors worldwide is extremely large, consuming about 50% of the worldwide production of electricity. Many of the existing motors remain highly inefficient, wasting large amounts of energy.

As part of its commitment to reducing energy wastage, the U.S. government has promulgated regulations to substantially increase energy efficiencies of appliances including compressors found in air conditioners and refrigerators. Our electric motors are ideal to meet the challenge of improving global efficiency of poor-performing motors from small refrigerator compressors to industrial-scale motors.

Our Engines

AVEC has two major engine types: a gasoline mechanical and a multi-fuel digital that will soon be introduced to multiple market outlets upon the completion of Beta site trials of the prototypes. These two engines, with greater fuel efficiencies, improved HP and torque-to-weight ratios, and smaller size will allow AVEC to enter into a multitude of market sectors presently occupied by the conventional, outdated internal combustion engine.

The gasoline engine, Gas-Cam, has many attractive features for applications where the use of gasoline is not a disadvantage and an engine of advanced digital sophistication is not required. The low weight and high torque make it particularly attractive for high-performance marine applications and light aircraft.

The adaptability of the recently modified and improved AVEC engines allows custom-made production to fit a wide range of industrial and commercial needs.

Beta Site Trials

Giving birth to a modern high-efficiency GENSET is no small feat. There are many interlocking and interdependent components and sub-systems whose operations must be perfectly orchestrated to produce the lowest-priced electrical power from a 40,000 hour-mean-time-to-major-overhaul internal combustion engine technology. Testing and performance-monitoring of the prototypical engine, the generator and the GENSET, and the sophisticated electronic systems for commercial applications is an important phase without shortcuts and cannot be rushed.

Part of the final quality validation and reliability is field testing (Beta site trials). In this phase a few initial production-grade GENSETs, which incorporate improvements and modifications that emerged during the independent lab testing and evaluation phase, are sent to Beta sites. These are "real world" application sites, where performance is closely monitored according to well-defined protocols. These initial production-run engines provide valuable feedback information and allow us to track performance over time and allow for improved precision in durability analyses. Regular production runs and sales of GENSETs can proceed while the Beta trials are underway.

Beta sites will be located in the United States, Panama and New Zealand. The Panama site is at Termica del Noreste, an existing power generating company that provides power to offshore islands and remote regions in a tropical environment. The New Zealand site will be used to augment the electric power capacity of dairy and sheep farmers to help them meet the strong demand for dairy and protein products in China. Other Beta sites are under review at the request of potential major clients.

Highlights of AVEC Prototype Systems

- The 7.2 liter Workhorse engine has the same torque as the 11 liter 370 HP Caterpillar in line crank shaft 6 cylinder engine (C11 370)
- The 7.2 liter Workhorse engine has a maximum torque that is 75% greater than the 7.2 liter Caterpillar C7 crank shaft engine for the same rated power
- The Cummins DFAB 230 consumes 9.8% more fuel than the 7.2 liter AVEC GENSET to produce an equivalent amount of electric power, i.e. 210 kW
- The AVEC Generator reaches 96% efficient in converting mechanical to electrical energy while a compatible Cummins unit is quoted at 92% efficient
- The AVEC engine obtained a Brake Specific Fuel Consumption (BSFC) of 0.26 lb/HP/hr which is considered to be amongst the very best engine fuel efficiency rates
- Excellent torque to speed ratio in the 7.2 liter Workhorse – maximum 3000 Ft-Lb @ 350 RPM – compared to the maximum 2250 Ft-Lb @550 RPM in the 11 liter Caterpillar C11 370 crank shaft engine
- The Caterpillar C7 (7.2 liter) and Caterpillar C11 (11 liter) are approximately twice the size (volume) and 40% and 85% respectively heavier than the Workhorse 7.2. Our prototypes are compared to mature production engines of very reputable companies. As the AVEC product matures, we are confident numerous opportunities will emerge to further reduce weight and make the envelope more sophisticated.
- Design features of the Workhorse engines result in substantially lower part count than essentially all of the crank shaft internal combustion engines
- The AVEC Generator has an overall conversion efficiency of 0.98

Summary of Main Distinctions and Features of the Two AVEC Engine Types

Axial Vector Digital Engine	Gas-Cam Mechanical Engine
Multi-fuel: Diesel, JP5, JP8, kerosene, bio-diesel. With appropriate modifications: alcohol, propane and natural gas can be used	Gasoline Fueled
Compression ignition	Spark plugs
Fuel injection	Carburetor
Intake and exhaust valves open and close by rotating cam and trunions – patent pending	Intake and exhaust valves open and close by overhead valve cam drive
Turbocharged	Naturally aspirated
No ignition system	Dual ignition system with coil, distributor and rotor
Either air or water cooled	Water cooled
Extensive electronic control systems, including: Full Authority Digital Control (FADEC); Engine Control Unit (ECU); Satellite communication (SatCom) system; Remote monitoring and diagnostics	No electronic control
Burn efficiency 43.5%	Burn efficiency 33%
Brake Specific Fuel Consumption (BSFC): 0.26 lbs of fuel/HP/hr	Brake Specific Fuel Consumption (BSFC): 0.43 lbs of fuel/HP/hr
Two piece crank shaft	Single piece crank shaft
Trombone oiling system for piston roller lubrication – patent pending	No special lubrication system
8 cylinders, 4 double-ended pistons	12 cylinders, 6 double ended pistons
352 HP; 7.2 liter	200 HP; 6.1 liter

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