Renewable Liquid Fuels Cat[®] 3500 and C175 Series Generator Sets

Frequently Asked Questions

SCOPE

This document covers Cat[®] diesel generator sets burning renewable liquid fuels with emphasis on Hydrotreated Vegetable Oil (HVO) and biodiesel. Reference is made to experience gained with 3500 and C175 Series engines operating at 1500 RPM (50 Hz) or 1800 RPM (60 Hz).



General HVO Questions

- 1. What is HVO?
 - a. HVO Stands for Hydrotreated Vegetable Oil.
 - b. HVO is a drop-in replacement for diesel fuel.
 - c. HVO is sometimes referred to as "Renewable Diesel"
- 2. Is HVO the same as biodiesel?
 - a. No, HVO and biodiesel are chemically different. HVO is more like diesel in chemistry than biodiesel because HVO is made up primarily of paraffinic hydrocarbon (HC) chains, while biodiesel contains fatty acid methyl esters (FAME).
 - b. Significant differences between HVO and biodiesel are highlighted in bold and italics in the following responses. Further guidance on biodiesel can be found in Cat[®] publications SEBU6250/6251.
- 3. How is HVO made?
 - a. HVO is sourced from vegetable oils, fats or used cooking oils, and processed by hydrotreating which removes oxygen from the HC chain. *This differs from biodiesel in that biodiesel is created through a transesterification process and results in an oxygenated FAME.*
- 4. Is there a standard for HVO?
 - a. EN 15940 is the preferred standard for HVO.
- 5. Does HVO meet the existing diesel fuel standards:
 - a. ASTM D975? Yes.
 - b. EN 590? Everything except density.
- 6. Will substituting HVO for diesel lower my greenhouse gas (GHG) emissions?
 - a. While operating on HVO may not significantly reduce the amount of CO₂ exiting the tailpipe, it can reduce lifecycle CO₂ emissions. Lifecycle emissions are reduced because the source of the carbon is biogenic, meaning carbon emitted from burning the fuel today consists partly of carbon previously captured from the atmosphere by the fuel's plant source. There are many variables that go into quantifying lifecycle CO₂ reductions in HVO, but it is typically in the range of 45% to 85% lower CO₂ than diesel based on the GREET model developed by the US Department of Energy.
- 7. What is the shelf life of HVO?
 - a. Compared to diesel fuel, HVO has a similar or longer shelf life (>12 months).
 - b. Biodiesel has a much shorter shelf life to either diesel or HVO and is not recommended for electric power (EP) standby applications.

Using HVO in Cat EP Generator Sets

- 1. Can I use HVO in my Cat generator set?
 - a. Yes, HVO can be used in all Cat generator sets if it meets either EN15940 or ASTM D975 specifications.
 - b. The Cat publication "Renewable and Alternative Fuels For Use in Diesel Engines" (<u>LEXE20433</u>) provides guidelines on the use of fuels, such as HVO, that can help reduce a generator set operator's carbon footprint.
- 2. Has Caterpillar tested HVO in a generator set?
 - Yes, performance testing of 3516 and C175-20 generator sets have been completed. Cat publications
 "3,000ekW, 60Hz Generator Set: Diesel & HVO Test" (LEXE20432) and "4,000 kVA, 50 Hz Generator Set: Diesel & HVO Test" (LEXE21232) document the testing and results for the 3516 and C175-20, respectively.
- 3. Can HVO be blended with regular diesel fuel?
 - a. Yes, the generator set can be used on 100% diesel, 100% HVO or any blend of diesel and HVO. However, the blended fuel must still meet either EN15940 or ASTM D975 specifications.

- 4. Can HVO be blended with traditional biodiesel?
 - a. Biodiesel and HVO can be blended, however it is not recommended that standby generator sets use more than 5% biodiesel due to fuel oxidation stability. See Cat publication SEBU6250 for further guidance on using biodiesel blends.
- 5. How will the performance of my generator set be affected by using HVO?
 - a. Caterpillar expects that most 3500 Series generator sets in application will experience an approximate 2% power derate with HVO, but it could be as high as a 5% power derate depending on environmental and specific fuel properties. This reduction in power is due to HVO's lower energy content than traditional diesel fuel. Specifics relative to the 3516, 3000 ekW rating can be found in Cat publication "3,000ekW, 60Hz Generator Set: Diesel & HVO Test" (LEXE20432). The frequency droop of the 3500 Series generator set on application of a block load may increase by up to 2% when using 100% HVO. Other 3500 Series engines/ratings are expected to have the same directional performance impact when switching from diesel to HVO. Any performance changes will vary linearly with the HVO% in the fuel blend. Note that adjustments made to an engine in service to compensate for such a power loss may cause a user to violate regulatory requirements (for example, U.S. EPA's anti-tampering provisions).
 - b. Caterpillar expects that most C175 Series operators will not see any power derate with HVO, and no negative impacts to transient response. Specifics relative to the C175-20, 4000 kVA rating can be found in Cat publication "4,000 kVA, 50 Hz Generator Set: Diesel & HVO Test" (<u>LEXE21232</u>). Other C175 Series engines/ratings are expected to have the same directional performance impact when switching from diesel to HVO.
 - c. Start time, as defined by the time taken from start of cranking until the generator set reaches rated speed, is not expected to be longer when using HVO than when using diesel.
- 6. Can Caterpillar or the dealer increase the power of the engine, so I get the same generator output on HVO?
 - a. No, any adjustment to the engine in service to compensate for such power loss may cause a user to violate regulatory requirements (for example, U.S. EPA's anti-tampering provisions).
- 7. Will using HVO instead of diesel affect other exhaust emissions from my generator set?
 - a. NO_x emissions are not expected to be significantly different from that achieved with diesel fuel above loads of 50%. Filter Smoke Number is expected to be measurably lower with HVO at loads above 30%.
 - b. For the specific case of the 3516 Mission Critical product, details can be found in Cat publication "3,000 ekW, 60Hz Generator Set: Diesel & HVO Test" (<u>LEXE20432</u>). Other 3500 Series engines/ratings are expected to have the same directional emissions change when switching from diesel to HVO. Key observations when considering 100% HVO on a 3500 Series generator set are as follows:
 - i. NO_{x} emissions are expected to be lower at load factors below 50% and equivalent to diesel above 50% load.
 - ii. Steady state (Filter Smoke Number) is expected to be approx. 60% lower when the load factor is above 30%.Particulate matter (PM) emissions are expected to have a similar reduction.
 - c. For the specific case of C175-20, 50 Hz Mission Critical product details can be found in Cat publication "4,000 kVA, 50 Hz Generator Set: Diesel & HVO Test" (<u>LEXE21232</u>). Other C175 Series engines/ratings are expected to have the same directional emissions change when switching from diesel to HVO. Key observations from the 100% HVO gen set test include:
 - i. NO_x emissions were measured to be equivalent to diesel at loads above 35% and below 15% percent of rated power. There were small increases in NO_x at loads between 15-35%. There was no significant difference in cycle NO_x emissions when considering an ISO 1878 D2 cycle.
 - ii. Steady state (Filter Smoke Number) has measured approximately 40% lower when the load is above 30% of rated. PM emissions are expected to have a similar reduction.
- 8. Can I use HVO in my generator set if I have existing exhaust aftertreatment?
 - a. Yes, using HVO (per EN 15940) in any blend with diesel (up to 100%) should not generally adversely affect emissions levels or the aftertreatment equipment itself. Aftertreatment equipment includes diesel oxidation catalysts, SCR systems, particulatetraps, EGR systems or any combination of these technologies.

- 9. Are there any concerns about using HVO in cold weather?
 - a. No, HVO has similar cold weather properties to #2 diesel. Contact your supplier of HVO if you typically use a winter blend of diesel.
 - b. Special attention needs to be given to using traditional biodiesel in cold climates. The fuel thickens at cold temperature, which can plug filters, etc.
- 10. Will the maintenance costs be the same as for diesel?
 - a. Operation on 100% HVO is expected to result in the same maintenance intervals as operating on 100% diesel.
 - b. **Operation on 100% Biodiesel may require more frequent oil change intervals.**
- 11. Can HVO be stored in normal fuel tanks?
 - a. Yes, HVO can be stored in the regular diesel fuel tank.
 - b. Storage of Biodiesel needs careful consideration due to aging and water absorption concerns.
 - c. Volumetric fuel consumption will increase by approximately 5% with HVO due to the lower energy density. Tank sizing may need to be considered.
- 12. Can I use the same filtration/polishing system with HVO that I currently use for diesel fuel?
 - a. Refer to guidance by the fuel source.
 - b. Cat fuel filters can be used with HVO, and typically HVO can be treated the same as diesel regarding conditioning. HVO does shed water more easily than diesel, so you may need to empty your water separator more frequently depending on the fuel's exposure to moisture.
- 13. Is HVO compatible with elastomers and materials used in diesel engines?
 - a. Yes, HVO is compatible with seals, O-rings, hoses and metallic materials used in diesel engines. Cat fuel system elastomeric seals have gone through aging tests in HVO and are compatible with 100% HVO fuel and any blend of diesel and HVO.
- 14. Do I need to modify my engine in any way to utilize HVO?
 - a. No, standard diesel generator sets can utilize 100% HVO.
 - b. There are also no software updates or setting changes required for using HVO.
- 15. Is there a dedicated Cat EP product spec sheet for HVO capable products?
 - a. No, all Cat EP diesel generator sets are capable of running both HVO and diesel. Information on spec sheets refers to 100% diesel operation.

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