# Engine Power and Fueling Comparison Between Vessels with Conventional Transmissions and Controllable Speed Propeller Transmissions During Dynamic Positioning Operation

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## Introduction

A comparison of the power required to maintain Dynamic Position of two propeller driven vessels is made in this report. Vessel #1 uses conventional transmissions that engage in lockup condition, and therefore the lowest propeller speed achievable is 270 rpm, and Vessel #2 uses (similar) transmissions, but that engage with CSP slip clutch technology. The CSP technology allows the propeller to be controlled to speeds as low as 50 RPM as well as having the ability to shift between forward and reverse without delay, from the computer controlled commands of the DP system. Both vessels utilize Simrad DP systems.

## Vessel differences

Vessel #1 is a 6 engine, 185 foot crew boat, utilizing Cummins KV38 engines rated at 1350 HP each. Vessel #2 is a 5 engine, 190 foot crew boat with Cummins KV50 engines rated at 1800 HP each. Whereas each vessel has different engines and these engines are rated at different power levels, the analysis is done when using only 4 engines on both vessels during normal DP operation. In addition, the analysis looks at actual horsepower needed to maintain the vessel's position, which eliminates the concern over the engines being rated for different peak power. Therefore, the main differences of concern, is that one vessel is 5 foot longer than the other, and the differences in weather and sea conditions. Which in this case were slight.

One factor not entered into the analysis, is the power provided by the drop down, azimuthing bow thruster. Vessel #1 uses a 350 HP bow thruster and Vessel #2 uses a 400 HP bow thruster. The feeling is that this is a relatively minor difference for the purpose of this comparison, since the thrusters are essentially similar, as is the Simrad software that controls them.

## Environmental conditions.

The data was collected from the two vessels operating at different locations and under slightly different but similar weather and sea conditions. For Vessel #1, the sea conditions were 2-4 foot seas, with a 10 knot wind, with the data taken from 10 - 11 p.m. March 18th, 2003. For the Vessel #2, sea conditions were 4-6 foot ground swells, 5-10 knot winds, with the data taken from 10 – 11 a.m. March 17th, 2003.

**Collection and analysis of data.**

Data collection was done using the CSP Electronics monitoring system, which collects data from each engine at user selectable intervals. The data collected for this comparison, consisted of propeller speed, engine speed, and engine fuel rail pressure collected at 2 second intervals. Engine speed was not collected from Vessel #1 since propeller speed is a direct ratio relationship to engine speed and all the speed sensing locations on the engine flywheel were occupied by existing equipment used to control the vessel.

The data used for the horsepower comparison was propeller speed, which was inserted in the propeller torque equation, as shown here:
Propeller power = Rated Power * (Propeller speed/Rated propeller speed)$^{2.7.}$. This exponent may not necessarily be appropriate for a condition where there is zero hull-speed, but in any event, the same exponent applies to both vessels.

This instantaneous power was calculated for each 2 second interval over a one hour period of operation,. The sum of the instantaneous power calculations were then divided by 1800 to obtain the average horsepower used over that hour period.

The results of that data were then summed for all engines, showing the total amount of power needed to maintain position for that vessel. Vessel #2 produced power equivalent to 78.5 HP over that hour, and Vessel #1 produced power equivalent to 595 HP over the hour of operation.

When looking at the attached plots, the data shown is shown for a 5 minute period only, just to show what typical data looks like. As you will notice, the Horsepower scale is higher on Vessel #1 than on Vessel #2, and the power level drops to zero in many instances on Vessel #2, as a result of it shifting and taking the propeller speed to zero in those instances. Vessel #1 does not take its propeller speed below lock up conditions, so it can never drop to zero power.

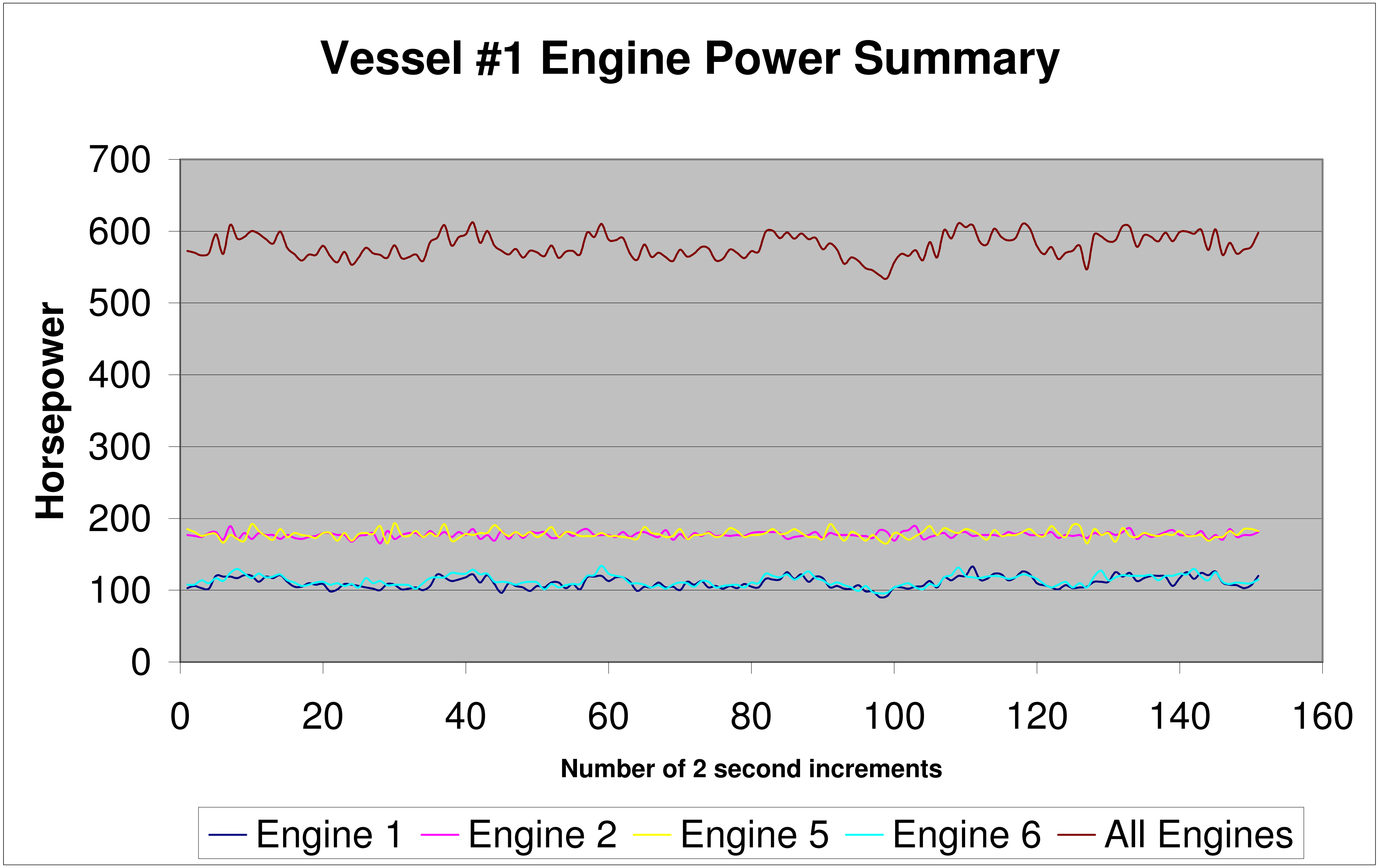
One other interesting, but possibly unrelated observation, is that the difference in power between the two sets of engines on Vessel #1, is very close to the 80 HP region, which is the amount of power needed to maintain position on Vessel #2. This is attributable to the fact that 2 of the gears are always in reverse. The fact that Vessel #1 cannot reduce its propeller speeds to zero, accounts for the higher ambient power levels needed for DP operation.

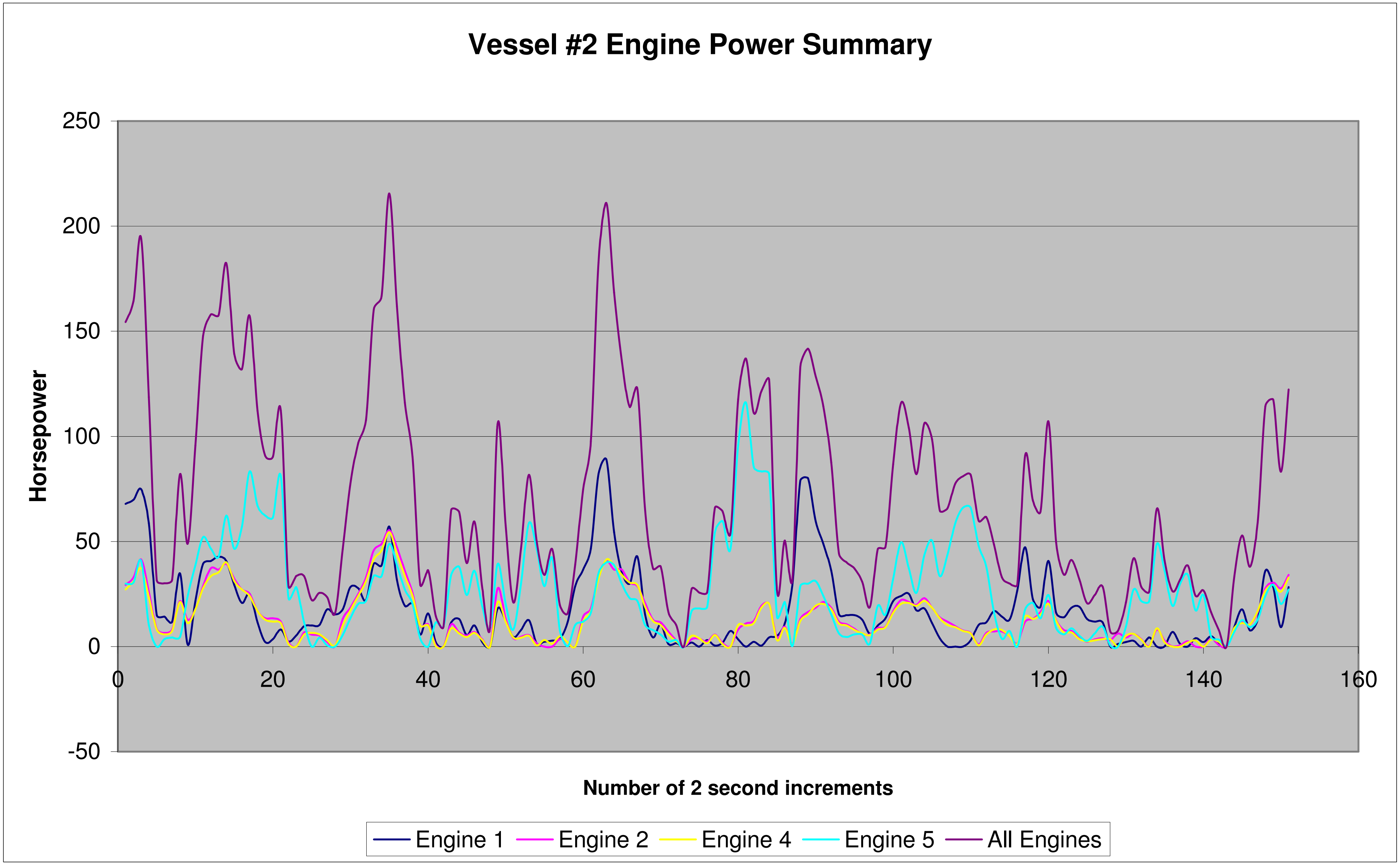
**Fuel consumption**

Fuel consumption calculations are very difficult to make for both vessels based on rail pressure data, and engine speeds. Since the Cummins fuel system uses a pressure-time formula for determining fuel delivery, the information can typically be used in determining fuel metering rates. However, in this instance, for engines at this high rated power, the fuel rail pressures were so low, especially for Vessel #2, which was operating 1800 HP engines at around 20 HP, the rail pressure numbers are so low as to be beyond any data which Cummins could realistically provide. So the attempt to calculate fuel consumption using this data was scrubbed. However, in another actual propeller power calculation, comparing fuel burn at these power levels, for a 24 hour period, revealed that approximately 1000 gallons more fuel, would be used by the Vessel #1 versus the Vessel #2. It may be more than this, but certainly will not be less.

Related Issues.

There is a further important but somewhat less quantifiable element to this comparison, which is that on Vessel #2, the high levels of engine thermal cycling normally seen on a conventional installation in the maneuver mode are completely missing, which has a measurable effect on engine life. In fact, when one listens to Vessel #2 engines in the DP mode, all one hears is a gentle variation in turbocharger speed. Engine speed per- se rarely changes except on the odd occasion when the gear actually selects lockup. But even then, at 770 rpm, given a conventional propeller curve, the engine is still a long way from the point that the turbochargers are stirring into life, which they have to have done before the fuel system will start to deliver serious thermal energy. The data on the graphical representation of the Vessel #2 appears to fluctuate far more than Vessel #1, but it should be borne in mind that the horsepower scaling is vastly different, and the Vessel #1 lacks the ability to go to zero propeller speed, or indeed to change direction.


Vessel #1 Engine Power Summary
Horsepower
700
600
500
400
300
200
100
0
0
20
40
60
80
100
120
140
160
Number of 2 second increments
Engine 1
Engine 2
Engine 5
Engine 6
All Engines


Vessel #2 Engine Power Summary
Horsepower
250
200
150
100
50
0
-50
0
20
40
60
80
100
120
140
160
Number of 2 second increments
Engine 1
Engine 2
Engine 4
Engine 5
All Engines

## Summary of Engine Horsepower delivered during DP operations

| Vessel | Engine | Rated HP | Transmission control | Avg. Pwr. Over 1 Hr |
|---|---|---|---|---|
| Vessel #1 | Cummins KV 38 | 1350 | Conventional | 595 |
| Vessel #2 | Cummins KV 50 | 1800 | CSP | 78.5 |

| Vessel | Sea state conditions | Wind | Date |
|---|---|---|---|
| Vessel #1 | 2-4 feet | 10 knots | March 18th 2003 |
| Vessel #2 | 4-6 feet | 5-10 knots | March 17th 2003 |