

0.0.1 Pure DP tests

For the pure DP tests, the vessel is simply trying to maintain position for a five minute interval. There were three tests performed in calm water (in August), and nine tests at sea, with different heading. In August these tests were performed before other maneuvers, such as the DP 4 corner maneuver of Section ???. For the pure DP maneuvers performed in at sea, the table names indicate a heading of the vessel. This heading name is the observed (by the operator) heading relative to the mean environmental forces, and it might deviate somewhat from the direction of the environmental forces reported in the table.

The tests are performed at slightly varying environmental conditions, and all the pure DP results are included. The intention of the logging of the thrust, and power usage is to perform the same maneuver after the retrofit, and compare.

For both the pure DP tests, and the DP 4 corner, the environmental condition is logged for each maneuver. That is, wind speed and direction is found from a measurement series, and the size, and direction of the waves are just manually read off just before the DP maneuver. The "DP current" is the value estimated by the DP system, and is also read off the DP screen before, during, and after a DP maneuver.

The thrust force in the tables below is T_a i.e. the delivered thrust (see Section ??). This is why two average thrust values can be different when power consumption is about the same; the propellers rotate in opposite directions, and forward is optimal.

Results - calm sea

For the test in August, the North and East measurements are sampled too low, and give a poor estimate of the standard deviation in the position error. The heading measurements on the other hand, are useful, and give a indication of DP performance.

Table 1: Pure DP, calm sea - test 1

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
2.6	0.4	—	—	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
18 .0	4.6	62.1	0.4	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
negligible	—	5.5	3.9	2.7
Current		Total average: 12.1 kN		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ]		
0.3	325 (during)-334(after)	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		2860	3500	—
		Total acc. power:: 6360 kJ (ex. tunnel thr.)		

note: the average thruster forces used are from the calculated values

Table 2: Pure DP, calm sea - test 2

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
2.2	0.4	—	—	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
3.3	9.4	130.2	0.4	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
small ripples	—	4.0	5.5	2.9
Current		Total average: 12.4 kN		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ]		
0.2	223 (before)-241 (after)	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		3100	3280	—
		Total acc. power:: 6380 kJ (ex. tunnel thr.)		

Table 3: Pure DP, calm sea - test 3

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
3.9	0.3	—	—	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
43.8	2.6	358.8	0.79	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
0.2	North	0.67	0.65	0.53
Current		Total average: 1.85 kN		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ]		
0.1	235	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		129	545	—
		Total acc. power:: 674 kJ (ex. tunnel thr.)		

Results - at sea

Table 4: Pure DP, at sea - test 1, relative heading 0 degrees

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
5.2	1.1	0.8	0.6	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
79.1	7.7	336.1	0.8	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
2.1	N-NW	1.2	1.0	—
Current (meas. by Kongsberg)		Total average: 2.2 kN		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ]		
0.4	—	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		860	413	—
		Total acc. power:: 1273 kJ (ex. tunnel thr.)		

Table 5: Pure DP, at sea - test 2, relative heading 90 degrees

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
3.3	0.5	0.6	0.9	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
72.5	13.9	65.5	0.8	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
2.3	340	4.3	3.9	—
Current (meas. by Kongsberg)		Total average: 8.2 kN (ex. tunnel thr.)		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ]		
0.3	98	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		3660	3590	—
		Total acc. power:: 7250 kJ (ex. tunnel thr.)		

Table 6: Pure DP, at sea - test 3, relative heading 0 degrees

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
4.2	0.6	0.7	0.3	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
190.8	7.5	11.0	0.78	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
1.7	14	5.0	5.6	—
Current (meas. by Kongsberg)		Total average: 10.6 kN (ex. tunnel thr.)		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ]		
0.36	336	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		3660	3590	—
		Total acc. power:: 7250 kJ (ex. tunnel thr.)		

Table 7: Pure DP, at sea - test 4, relative heading 90 degrees

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
4.3	1.0	0.5	0.5	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
204.8	5.6	101.7	0.9	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
1.7	14	1.4	2.0	—
Current		Total average: 3.4 kN (ex. tunnel thr.)		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ]		
0.2	247	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		1060	1240	—
		Total acc. power:: 2300 kJ (ex. tunnel thr.)		

Table 8: Pure DP, at sea - test 5, relative heading 45 degrees

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
4.2	0.5	0.5	0.4	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
215.3	14.0	55.3	0.7	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
1.7	14	2.8	2.4	—
Current		Total average: 5.2 kN (ex. tunnel thr.)		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ] over 5 min		
0.25	300	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		2020	1090	—
		Total acc. power:: 3110 kJ (ex. tunnel thr.)		

Table 9: Pure DP, at sea - test 6, relative heading 135 degrees

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
4.7	0.7	0.5	0.4	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
210.3	7.1	146.0	0.8	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
1.7	14	5.5	5.6	—
Current		Total average: 11.1 kN (ex. tunnel thr.)		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ]		
0.3	191	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		5480	5560	—
		Total acc. power:: 11040 kJ (ex. tunnel thr.)		

Table 10: Pure DP, at sea - test 7, relative heading 180 degrees

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
4.1	0.5	0.6	0.3	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
212.3	9.0	190.1	0.7	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
1.7	14	2.0	1.6	—
Current		Total average: 3.6 kN (ex. tunnel thr.)		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ]		
0.21	231	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		1220	810	—
		Total acc. power:: 2030 kJ (ex. tunnel thr.)		

Table 11: Pure DP, at sea - test 8, relative heading 0 degrees

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
6.9	0.6	0.7	0.8	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
166.0	8.1	241.7	0.7	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
1.9	West	1.1	1.5	—
Current		Total average: 2.5 kN (ex. tunnel thr.)		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ]		
0.5	240	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		790	590	—
		Total acc. power:: 1380 kJ (ex. tunnel thr.)		

Table 12: Pure DP, at sea - test 9, relative heading -90 degrees

<i>Environment</i>		<i>DP system performance</i>		
Wind, speed [m/s]		Position acc. (Std.) [m]		
<i>Average</i>	<i>Std.</i>	<i>North</i>	<i>East</i>	
6.9	0.7	0.8	0.9	
Wind, direction [°]		Heading		
<i>Average</i>	<i>Std.</i>	<i>Average [°]</i>	<i>Std [°]</i>	
167.6	7.3	150.4	2.8	
Waves		Average thruster force [kN]		
<i>H_s [m]</i>	<i>Direction [°]</i>	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
1.85	West	23.3	21.2	—
Current		Total average: 44.5 kN (ex. tunnel thr.)		
<i>Speed [m/s]</i>	<i>Direction [°]</i>	Accumulated power [kJ]		
0.6	200	<i>SB thruster</i>	<i>Port thruster</i>	<i>Tunnel thruster</i>
		29620	28140	—
		Total acc. power:: 57760 kJ (ex. tunnel thr.)		