Petrobalt design bureau

Technical report

Maneuvering Calculation

(FERRY for 750 passengers & 144 cars)

Saint Petersburg
2005

1 Introduction

Attached are the manoeuvring calculations showing necessary power to resist side wind. According to this analysis the power demand is as follows:

Wind speed	P-tunnel	P-stern
Normal 55 km/h	828 kW	657 kW
Max 63 km/h	920 kW	2x1825 kW

Also attached is an extract from Captains manual explaining the manoeuvring of a vessel with Steerprop units.

A vessel equipped with azimuth drives and bow thrusters is capable of turning on spot, around any specified point when stationary. The minimum radius of turning is therefore half of ship's length.

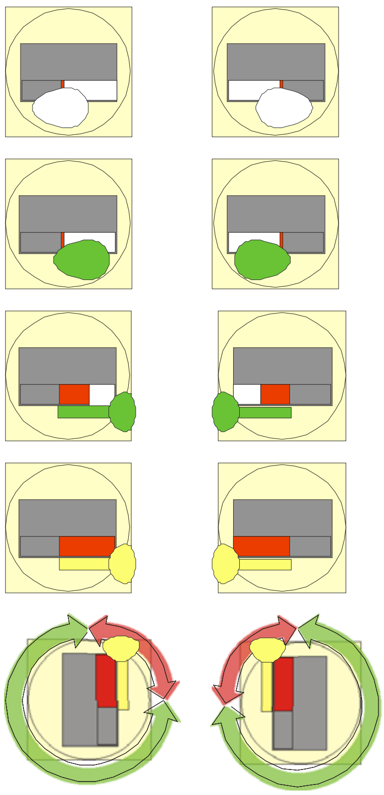
Steerprop SP45CRP Propulsor Captain's Book Operation Manual

(Extract)

1.1 Basic operation principle

This manual gives the basic advice on how to use the Steerprop propulsors to obtain a specific motion to the vessel. It should be noted that each and every vessel is different and that depending on vessel size, main dimensions, dimension ratios, hull form, engine power, propeller size etc. the effect of a specific control movement is different from vessel to vessel.

Thus the crew need to familiarize themselves with the vessel, before starting real operations.



Propeller stopped

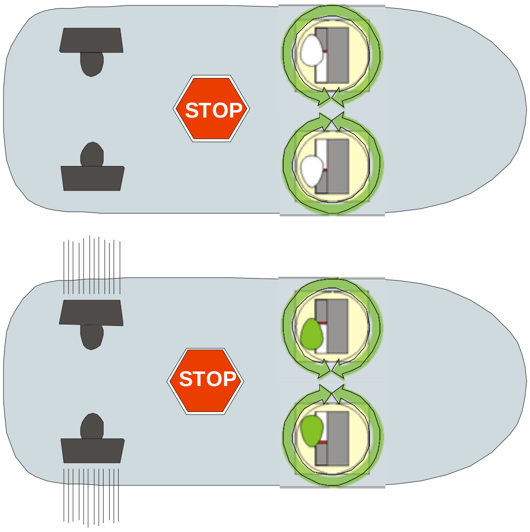
Low propeller rpm

Medium propeller rpm

Full propeller rpm

Steering angle
Full propeller rpm

1.1.1 Zero position



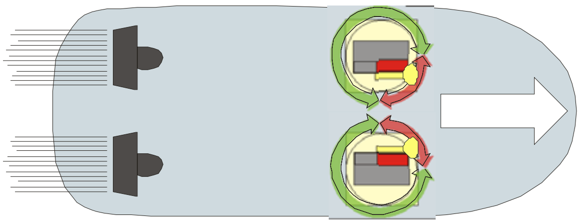
◊ BASIC STARTING CONDITION

The Steerprop propulsors should always be turned outwards before stopping and starting, to avoid propulsive forces at start-up.

◊ POSITION KEEPING

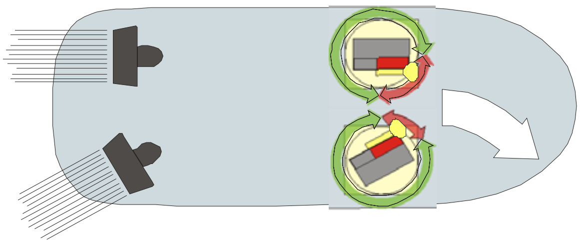
Both prime movers should run at equal power, for position keeping. Can be used at any power.
Turn on the spot possible by increasing power on one of the propulsors.
For ahead running turn both control levers slowly forward - for astern running turn both control levers slowly aft.

1.1.2 Ahead



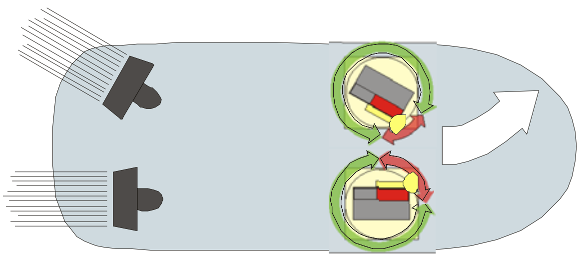
◊ STRAIGHT AHEAD

From zero position turn the control levers slowly forward until straight ahead. Both prime movers should run at equal power. Can be used at any power.
Vessels with same-handed propellers may require a small counter-angle to run a straight course.



◊ STARBOARD TURN

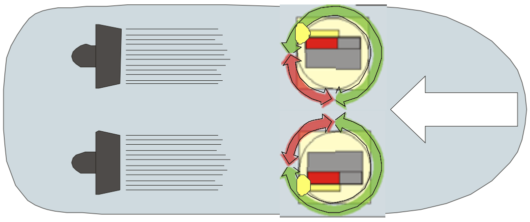
Use only one propulsor to avoid over-steering. The use of starboard (inner) propulsor is the most efficient way (port propulsor also turns the vessel to starboard).



◊ PORT TURN

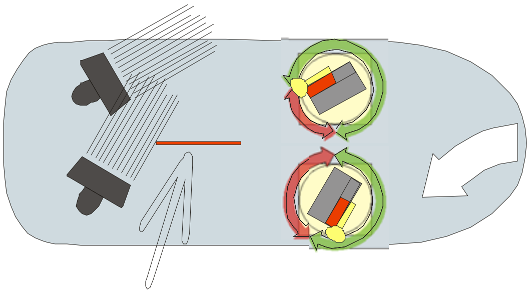
Use only one propulsor to avoid over-steering.
The use of port (inner) propulsor is the most efficient way (starboard propulsor also turns the vessel to port).

1.1.3 Astern



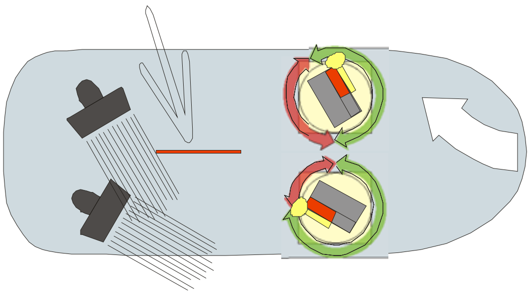
◊ STRAIGHT ASTERN

From zero position, turn the control levers slowly aft until straight astern. Both prime movers should run at equal power. Can be used at any power.
Vessels with same-handed propellers may require a counter-angle to run a straight course and may encounter course instability at high speeds.



◊ STARBOARD TURN ASTERN

Use both propulsors to improve the steering force. The starboard thruster should be turned to avoid the propeller wash to hit the skeg and cause counter-forces.

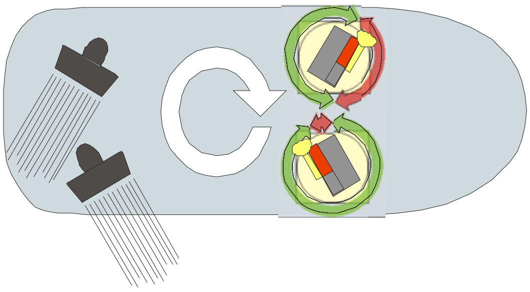


◊ PORT TURN ASTERN

Use both propulsors to improve the steering force. The port thruster should be turned to avoid the propeller wash to hit the skeg and cause counter-forces.

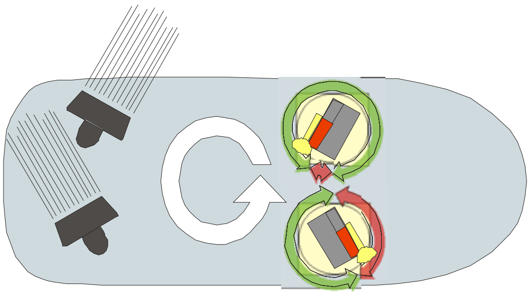
1.1.4

Turning on spot



◊ STARBOARD TURN (CLOCKWISE)

Avoid the use of straight angles on the propulsors, in order to avoid the wash from one propulsor to hit the propeller of the other.
Use propulsor angles as shown in the figure.



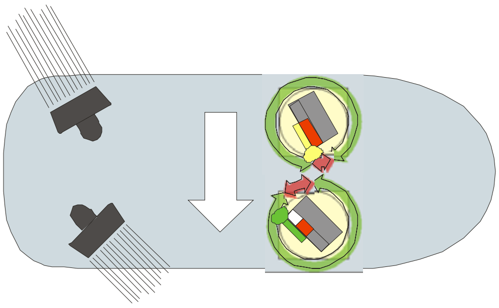
◊ PORT TURN (COUNTER-CLOCKWISE)

Avoid the use of straight angles on the propulsors, in order to avoid the wash from one propulsor to hit the propeller of the other.
Use propulsor angles as shown in the figure.

1.1.5

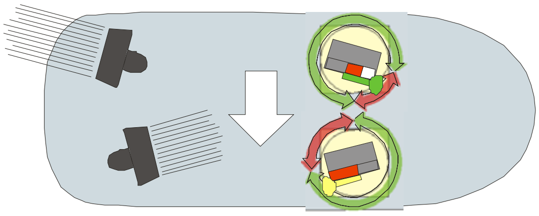
Side forces

In addition to the bow thruster the vectoring of main propulsors can also be used to create side forces on the vessel.



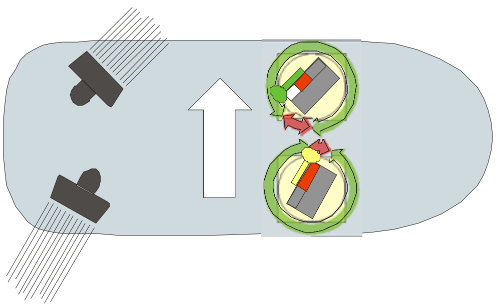
◊ HIGH SIDE FORCE TO STARBOARD

Depending on hull form and vessel length, the starboard propulsor should be set slightly astern and the port propulsor at slightly ahead. The port propulsor should be set with slightly more power.
Fore/aft motion and yaw are controlled by adjusting the power and turning angle respectively - on the port propulsor only!



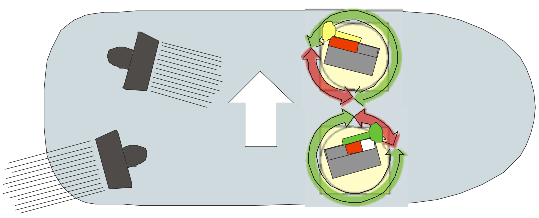
◊ LOW SIDE FORCE TO STARBOARD

Engine power should be almost equal, with only slightly more on the starboard propulsor (to avoid forward motion)



◊ HIGH SIDE FORCE TO PORT

Depending on hull form and vessel length, the port propulsor should be set at slightly astern and the starboard propulsor at slightly ahead. The starboard propulsor should be set with slightly more power.
Fore / aft motion and yaw are controlled by adjusting the power and turning angle respectively - on the starboard propulsor only!

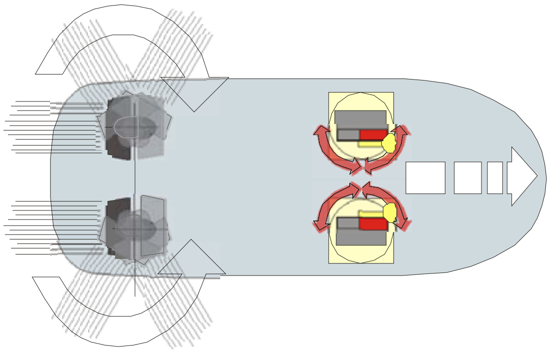


◊ LOW SIDE FORCE TO PORT

Engine power should be almost equal, with only slightly more on the port propulsor (to avoid forward motion)

1.1.6

Braking with two propulsors



◊ CRASH STOP / BRAKING

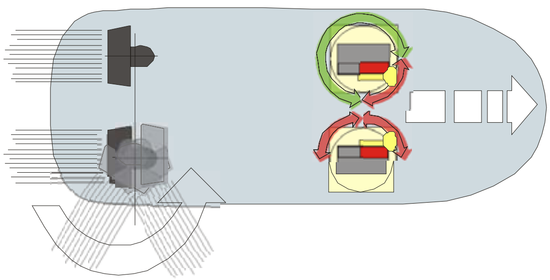
Turn the propulsors first to 90º; the starboard propulsor counter-clockwise and the port propulsor clockwise, and when the vessel speed has reduced to 8-9 knots turn the units to 180º - i.e. astern.

Note: At high vessel speeds the braking starts already at small turning angles and is most efficient at 90º; it is recommended to remain at 90º until the vessel speed has come down to approximately 8-9 knots.

Note: During crash stop, the turning speed of one of the propulsors may be slower than the other due to differences in torque. In such a case the lever turning speed on the other unit needs to be slowed down to find identical turning angles / speeds.

Recommendation: Although mechanically the propulsors allow crash stop with full power, it is recommended that the power of prime mover is reduced to approximately 25 % to minimize cavitation and vibration.

1.1.7 Braking with one propulsor



Turn the starboard or port propulsor through 180º; the starboard propulsor counter-clockwise or the port propulsor clockwise, i.e. turn the control levers from ahead to astern, via zero position.

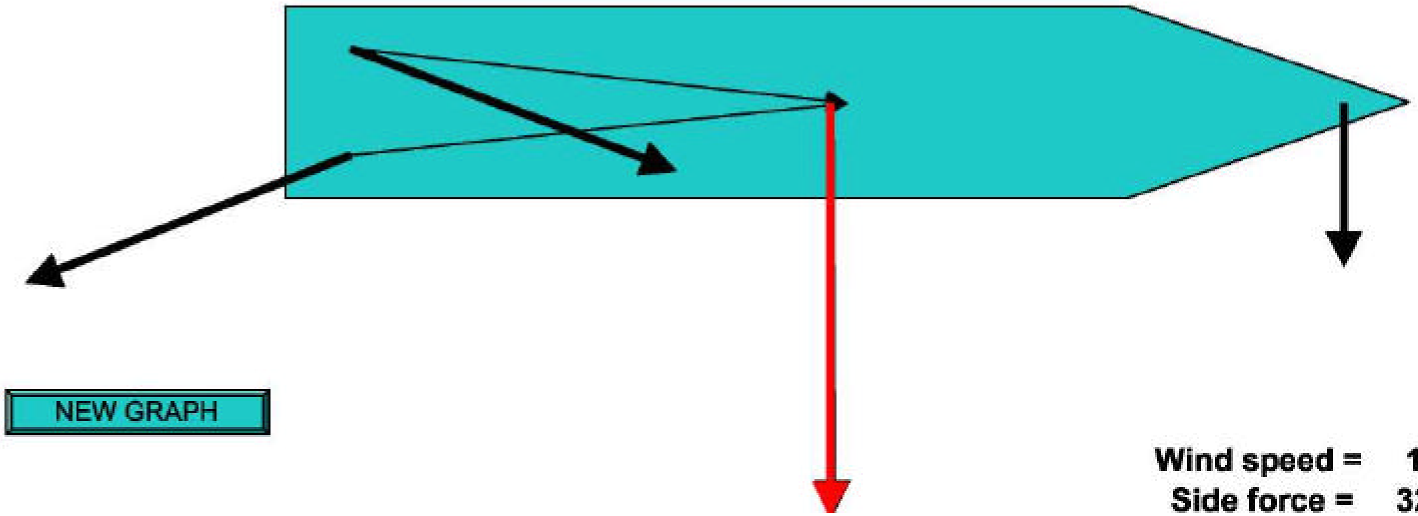
Recommendation: During the turning of the propulsors it is recommended that the power of prime mover is reduced to approximately 25 % to minimize cavitation and vibration. The braking method with two propulsors should always be primarily considered.

SIDEFORCE CALCULATION

		Power, max	Dia	Coeff	Deduction	X	Y	Thrust	Angle-0	Mom-L/2
	SP 1	1825	3.2	0.088	0.1	-43	5	251.8	173.37	-3072
	SP 2	1825	3.2	0.088	0.1	-43	-5	251.8	6.63	-2889
1	TT, á	920	1.75	0.095	0	43	0	128.0		5502
		382.5							Mom-L/2	
	Length	97	m							
	Beam	18	m							

	%	POWER	ANGLE	
SP1	100	1825	157	deg
SP2	100	1825	22	deg
TT	100	920		

	Force		ENVIRONMENT demand	
Total Flong	1.7	kN	0.0	
Total Fside	320.7	kN	321.4	
Yaw-mom	-458.6	kNm	469.2	CCW = positive
Center of effort	-1.4	m	-1.5	



NEW GRAPH

Wind speed = 17.5 m/s
Side force = 320.7 kN

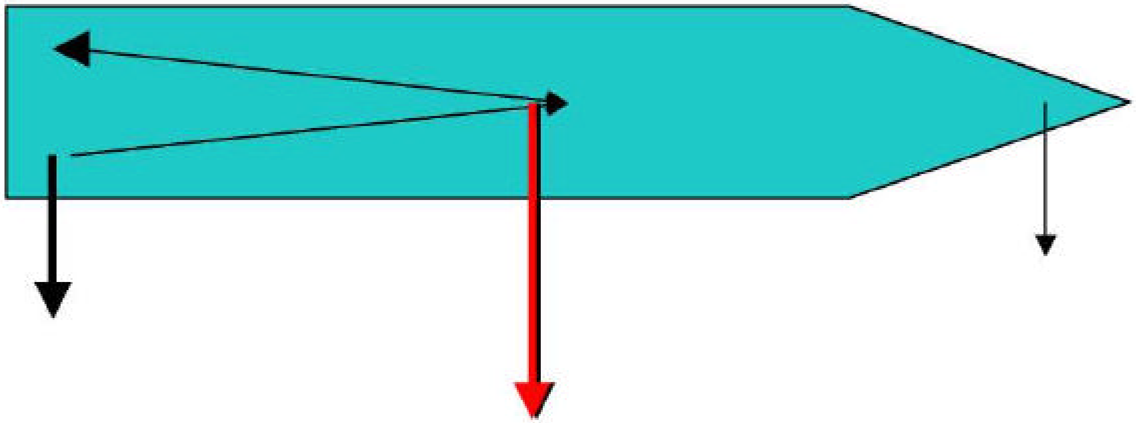
SIDEFORCE CALCULATION

		Power, max	Dia	Coeff	Deduction	X	Y	Thrust	Angle-0	Mom-L/2
	SP 1	1825	3.2	0.088	0.1	-43	5	125.1	173.37	-5378
	SP 2	1825	3.2	0.088	0.1	-43	-5	0.0	6.63	0
1	TT, á	920	1.75	0.095	0	43	0	119.3		5129
		382.5							Mom-L/2	

Length	97	m
Beam	18	m

	%	POWER	ANGLE	
SP1	35	638.75	90	deg
SP2	0	0	22	deg
TT	90	828		

	Force		ENVIRONMENT demand	
Total Flong	0.0	*kN*	0.0	
Total Fside	244.4	*kN*	244.9	
Yaw-mom	-249.1	*kNm*	357.6	*CCW = positive*
Center of effort	-1.0	*m*	-1.5	



NEW GRAPH

Wind speed =	**15.3**	**m/s**
Side force =	**244.4**	**kN**

Environmental forces

Ship	Length	91	*m*
	Beam	18	*m*
	Draft	4.6	*m*
	Displ.	3920	*cub.m.*

		Areas:	*H*	*Y*	*Cf*	*Cmom*
Areas:	Wind-X	288	8		0.6	
	Wind-Y	1468	8	-1.46	1.1	0.25
	Curr-X	82	0		0.09	
	Curr-Y	446	0	0	0.7	0.25
	Wave-X	82		0	0.24	
	Wave-Y	418.6		2.78	0.05	0.035

	Value	***Angle***	***Fx***	***Fy***	***Mom***	***Knots***	***km/h***
Wind F	*15.3*	**90**	0.0	244.9	357.6	**29.7**	55
Current-F	*0.00*	**90**	0.0	0.0	0.0	**0**	
Wave-F	**0**	**90**	0.0	0.0	0.0		
total			**0.0**	**244.9**	**357.6**	**-1.5** m	