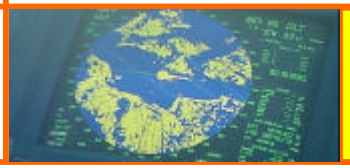
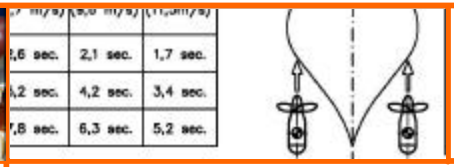
ABB Marine &
Turbocharging

T.Veikonheimo
17.05.04

Manoeuvring with Azipod





General

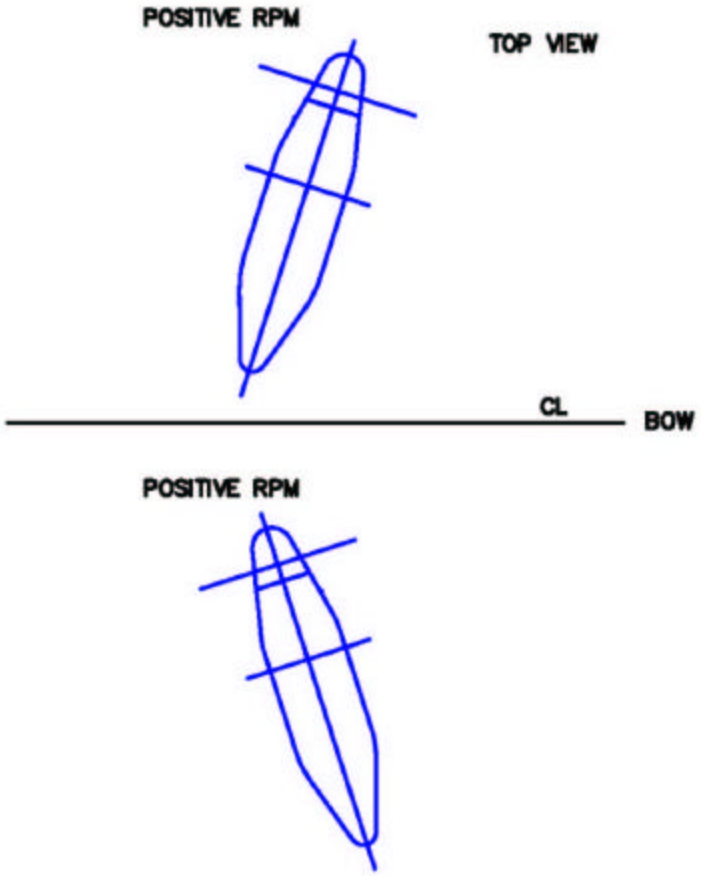
- To ensure safe and reliable operation with Azipod units, ABB recommends following for the operation of the vessel. This instruction is only for quidance and the safe navigation of the vessel is the responsibility of the master of the vessel. Unexpected and unplanned situations may require different actions.
  - These instructions are valid for 2-3 pod equipped ships
  - Bridge equipment can vary between ships
- Power limitations can vary between ships

Low speed manoeuvring A1.

Operation with 2 Azipods:

- The largest side force for the ship can be reached when both pod units are used with positive RPM.
- The range of pod angles are between 75 to 105 degrees per each pod.
- The configuration is shown in picture 1. When both pod units are blowing to the “open”, the interaction between the ship hull and pod units is minimised.

Low speed manoeuvring A2.



Picture 1.

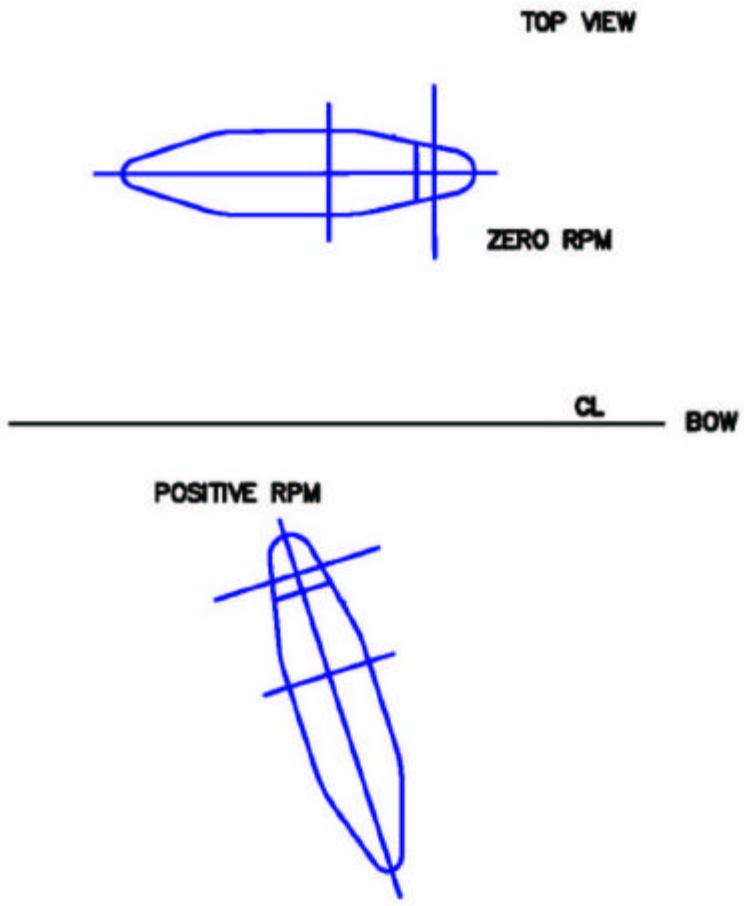
Operation with two Azipods

Low speed manoeuvring B1.

Operation with 1 Azipod:

- If the operation is done with one Azipod unit, the other is on standby. The pod thrust should be directed towards “open” sea, not towards the standby Azipod unit or ship hull, or other obstacles (for example the pier) if possible. When positive RPM is used, maximum bollard thrust can be reached.
- If the thrust of the unit is directed towards the standby Azipod or ship hull, the efficiency and thrust will be reduced up to 50% of the maximum bollard value. Also when the thrust is directed towards the ship hull, increased noise and vibrations can be expected.
- The maximum thrust and therefore maximum side force with the active pod unit can be reached when the pod angle is 50-120 degrees (propellers turned towards ship centerline) and with positive RPM (see picture 2.).

Low speed manoeuvring B2.



Picture 2.

Operation with one pulling Azipod

Astern running A.

Astern running with positive RPM:

- In this mode the pod units are first turned 180 degrees with Azimuth levers. This can be done with Azimuth levers only, and in manoeuvring mode.
- The power available is limited in this mode normally to about 50 to 60% from maximum propulsion power.
- In this mode the propellers are working in ‘’normal‘’ condition (positive RPM) thus it is the most efficient way to go astern.

Astern running B.

Astern running with negative RPM:

- The RPM is put to astern from the levers. Because the propellers are not designed for this condition (astern speed, negative RPM) the propellers are not working efficiently, and there may be noise and vibrations from cavitating propellers.
- This manoeuvre can be performed in open sea mode, where the astern torque of the propulsion motor is limited to 70 to 80% of max. torque ahead. This means that propeller performance is limited in torque instead of power (actual power available is dependent from the propeller characteristics).

Braking the speed with pod units

- The pod units themselves are generating large amounts of braking force, therefore the most efficient way to reduce ship speed (here not meant crash stop) is by turning the pod units 35-90 degrees in toe-out position (propellers outwards) and in the same time let the propellers windmill in zero power.
- This can be done even from full speed without damaging the pod units, but to minimize unnecessary vibrations, see recommendations on the table 1.
- The recommended pod angles are about 35 to 45 degr. outwards.
- This manoeuvre can be performed only in manoeuvring mode,because the azimuth levers are needed to turn the pod units in opposite directions.
- When the ship is entering restricted coastal areas with high speed the open sea mode is switched to manoeuvring mode before the braking manoeuvre described here can be executed.

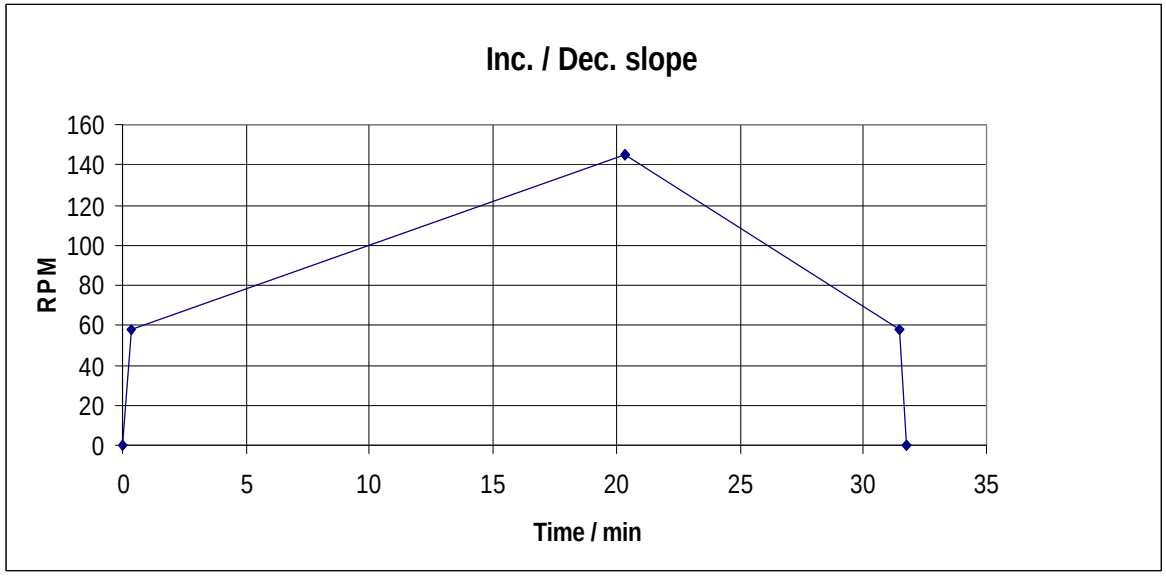
Inc./Dec. program

- The program allows operator to use ships propulsion with smooth way.
- The loads on the propulsion system are low and comfort level onboard (vibration and noise) will be improved.
- The program can be executed when preset condition is fullfilled (see next page).
- The program can be stopped at any moment necessary
- The RPM increase ramps are 10 times lower compare to lever max. RPM increase ramps.
- Decrease of the ship speed is made by avoiding any braking power in propulsion system.

Inc./Dec. program - NCL

Speed increase slope	0,0725 rpm/s = 4,35 rpm / min (58…145 rpm = 20 min)
Speed decrease slope	0,1305 rpm/s = 7,83 rpm / min (58…145 rpm = 11,1 min)
Speed reference at least	58 rpm
Speed actual at least	58 rpm
Azipod power actual	at least 0,6 MW
Bus load level at least	10% (5,9 MW)

- Bridge control selected
- Bridge back-up **not** selected
- Open sea/cruise mode on



User instruction table

Action	Daily	Rarely	Emergency
Azipod turning Inwards	Not Advised	Not Advised	Allowed at Any ship speed
Azipod turning Outwards	Recommended maximum 10 knots	Recommended maximum 16 knots	Allowed at Any ship speed
Ship slowing (start speed) by rotating both Azipods 35 to 90 degrees outwards windmilling propellers (or with low power)	Recommended maximum 10 knots	Recommended maximum 16 knots	Allowed at Any ship speed
Maximum ship speed During the use of FAST Steering Gear Mode	Recommended maximum 8 knots	Recommended maximum 8 knots	Allowed at 12 knots
Maximum allowed ship speed During the ordinary use of NFU (Non Follow Up) steering Tillers	NOT recommended	NOT recommended	Allowed at Any ship speed

Emergency steering

- In case of an emergency at high speed in open sea mode, with steering wheel operation, it is allowed to turn both units to 35 degrees pod angle (max. steering angle with steering wheel).
- The pod units (and propellers) are designed to withstand all forces and moments in this kind of manoeuvre.
- This kind of operation is done only in emergency situations.

NOTE : The vessel will heel heavily (about 12…17 degrees / ship dependent)

Two pod operation, one unit is powered

- If maximum propeller power is needed for one pod when the other is on standby for some reason, open sea mode is selected. The standby pod unit is without power and windmilling because of failure in power system or the power lever has been set to zero position on that particular pod unit.
- The steering of the vessel can be done with steering wheel normally and both units are following the helm commands, parallel from the wheel .
- The Steering gear is operating normally in both units even if one of them is not powered.

Two pod operation, one unit steering – 1

- In cases when the pod unit should be kept at zero position but the propulsion power is still needed, the particular pod unit can be hydraulically locked. Steering of the vessel is done with remaining pod unit.
- Locking of the pod unit is done locally in Azipod room. Special instructions available for this.
- This has an effect to Autopilot and thus adjustment is needed and should be done by Autopilot maker. Autopilot is adjusted for two pod operation.
- As operation mode the open sea mode can be selected. Full propulsion power can be used and the steering can be done from the wheel normally.

Two pod operation, one unit steering – 2

- But:
  - The steering capability is decreased due to one pod operation.
  - Larger steering angles are needed in order to have same steering effect as with two pods.
  - When pod unit is steered at high speed with large angles:
    - Oblique flow condition reduce propeller thrust thus operation is not economical (speed loss)
    - May cause cavitation on propellers and noise onboard
  - The loads on the pod unit are larger
    - ABB recommends in this case:
      - Reduce ship speed to approx. 75% max. speed OR
      - Limit steering angles to +/- 15 degrees.
- The emergency tillers pass the hydraulical lock on the pod unit.

Steering gear operation A.

Normal operation:

- There are three turning rates available. On open sea mode it is possible to use one or two hydraulic pumps. With two pumps, the helm rate is 100% higher than using only one pump. On both cases full steering torque will be reached.
- The Fast steering gear mode can be selected only on manoeuvring mode. Both pumps must be running before selection. The fast mode gives 200 – 300 % higher helm rate than one pump. On same time the maximum steering gear torque will go down 33 – 50 %.
- On every mode, all four hydraulic motors are on use.

Steering gear operation B.

Operation on failure situations :

- Hydraulics can be split to two separated halves: upon failure, the faulty half is separable with a valve (SV). After separation one hydraulic pump will drive only two hydraulic motors. The helm rate is 100 % higher than using all four motors, but the max. steering torque goes down by 50 %.
- In this case there is no propeller power limitation, but since the maximum torque is abt. 50%, steering angles +/- 15 degrees should not be exceeded. Ship speed reduction is recommended in this case.
- Consequently, ship speed has to be kept down below a level that will not risk the opening of safety relief valves (which would lead to loss of steering).
- If both halves are damaged at the same time, no steering torque remains. The pod will turn around. Parking brake cannot keep the pod stationary. The propulsion power (breakers will trip) will drop to zero on the damaged pod unit.

Steering gear operation C.

- Steering gear pump change procedure:
  - Active steering gear pump is to be changed in following way:
  1. Start stand-by pump without stopping the active pump
  2. Both pumps running
  3. Stop pump which was active

  - NOTE! In all conditions one of the steering pumps must be active!

Crash stop basics A.

- There are two kinds of crash stop - the conventional way and the ‘’pod way’’. Crash stop is done in conventional way by reversing the propeller RPM’s and trying to keep the ships course as straight as possible with a minimum of rudder movement.
- Because of the capability of turning the propellers around 180 degrees there is a new possibility to perform crash stop with azimuthing pod drives – the ‘’pod way’’.

Crash stop basics B.

- It is possible to turn the pod drives by 180 degrees without reversing the rotational direction of the propeller, keeping the power always ‘’positive’’.
- This way it is possible to decrease the pod drive loads and the time and distance of the crash stop.
- The crash stop will also be easier for the powerplant, because the power level does not change from full power to zero (and below). So there is no ‘’turbine-” power’, which is always difficult to the power plant.

Crash stop basics C.

- In normal operation mode - “Open sea mode”, the pod units can be steered only by 35 degrees to either side with full propulsion power available.
- In case the Azipod units would go over 35 degrees, propulsion power will be automatically reduced to zero.
- This will protect the propellers from very high loads. This way the damage to the propeller blades is prevented during the crash stop.

Procedure for Two pods

The new crash stop will be done by turning the pod drives (propellers) around their turning axes by 180 degrees (pod drives turned to opposite directions, Picture 4. Or towards each other, Picture 3.)

1. “Open sea mode” is changed to “manoeuvring mode”, then the units can be turned from azimuthing levers separately around. When the operating mode has been changed to manoeuvring mode, immediately the propulsion power is automatically decreased to 40-50% of full power (ship dependent).
2. The pod units should be turned 35 degrees outwards (propellers) simultaneously.
3. Wait until ship speed is less than15 knots. Then turn the azimuthing levers separately around to the remaining 180 degrees outwards.

NOTE! If the crash stop is executed during the ship’s turn, both or one of the Azipod units can still be used for steering purposes.

Procedure for Three pods

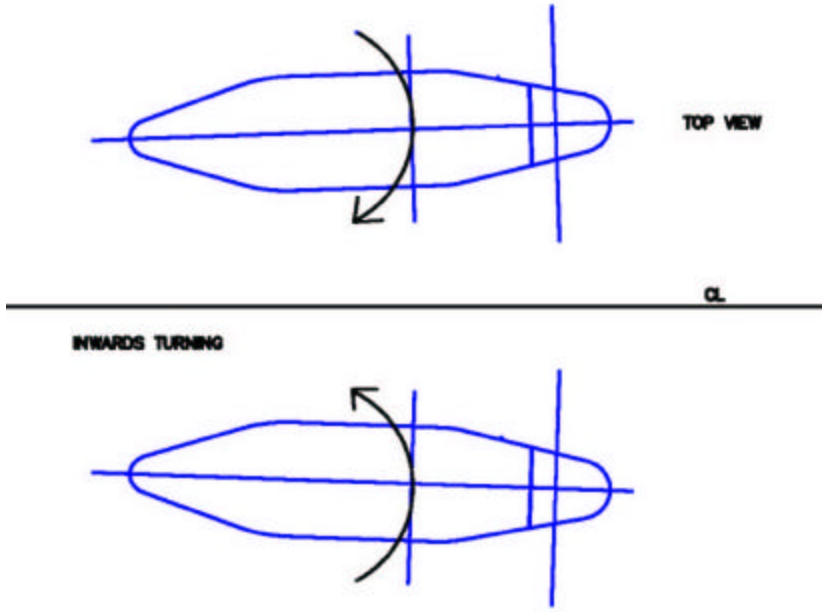
The new crash stop will be done by turning the steerable pod drives (propellers) around their turning axes by 180 degrees (Azipod drives turned to opposite directions, Picture 4. Or towards each other, Picture 3.)

1. “Cruise (or OPEN SEA) mode” is changed to ‘’manoeuvring mode’’, the system will automatically reduce propulsion power to manouevring level.
2. After this, the RPM lever for the Fixipod is set to position -1 astern. The Fixipod propeller starts to brake (separate instructions for ‘Mariner’).
3. Azipod units are turned 35 degrees outwards (propellers).
4. Wait until ship speed is less than15 knots. Then turn the Azimuthing levers separately around 180 degree outwards.
5. Move the Fixipod lever to full astern.

NOTE! If the crash stop is executed during the ship’s turn, both or one of the Azipod units can still be used for steering purposes.

Steering rotation during crash stop A.

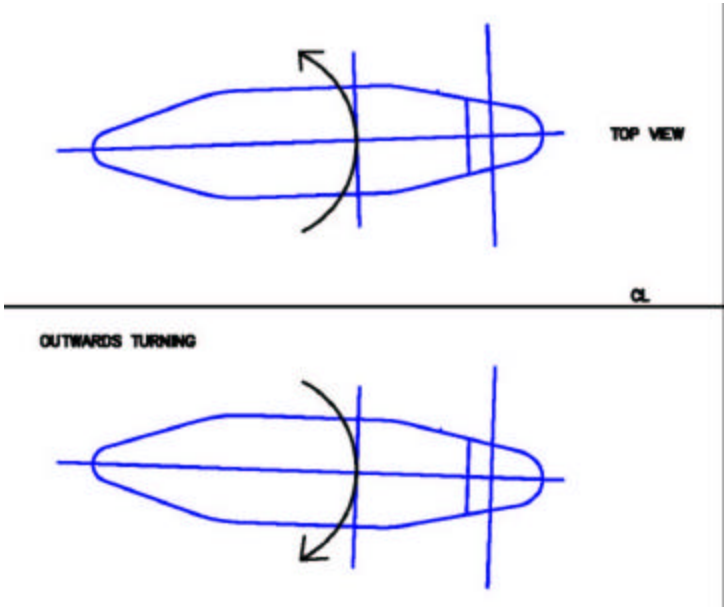
- Power limitation: propulsion power has been reduced in manoeuvering mode to about 50% of full power. This way the propulsion system is protected from high loads on extreme manoeuvres, like the crash stop.



Picture 3.

Rotating inwards

Steering rotation during crash stop B.



Picture 4. Rotating outwards

Outwards rotating is recommended

- Remark: There are clearly two items that are more favourable for new type of crash stop. First, the loads which can be harmful for the pod system and equipment will be remarkably lower. Second, crash stop length, and time will be less.

Summary

- Operation recommendations:
  - Power Inc./Dec. program should be used
  - At low speed manoeuvring positive RPM to be used
  - Propeller turning direction change to be minimised
  - In braking condition reverse power to be avoided
  - In open sea condition pod angle to be limited to +/- 10 degrees
  - Recommended way to perform crash stop is POD WAY (turning pods outwards)