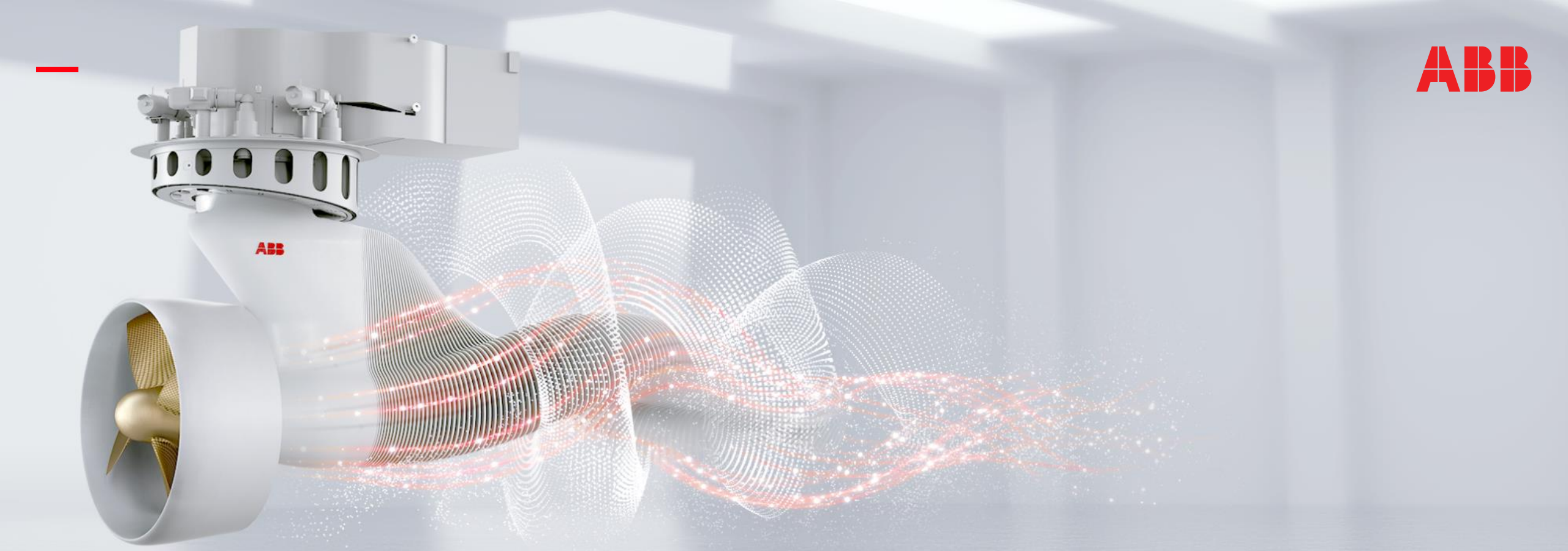
DYNAMIC POSITIONING CONFERENCE
OCTOBER 9-11, 2017

DESIGN/OPERATIONS

Unique full-scale bollard pull test of large DP vessel newbuilding with six Azipod® CZ thrusters

Ole Jacob Irgens & Kimmo Kokkila
ABB OY



DP CONFERENCE | OCTOBER 10, 2017

Azipod®Six Thruster Configuration

Accommodation / work barge – Bollard pull test analysis

Ole Jacob Irgens, VP Sales, Thruster products

Agenda

Introduction

CFD Analysis and Cavitation Tunnel Test

Bollard Pull Test in China

Bollard Pull Test Results and Reflections

Conclusions

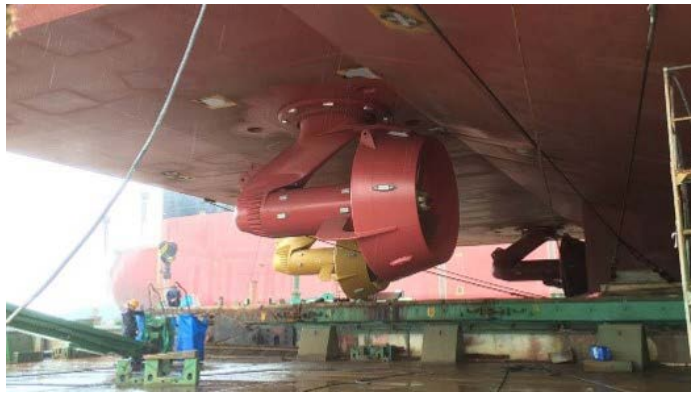
Introduction

Introduction

Subject vessel is DP3 accommodation / work barge | The propulsion system

- 115.5m in length
- Breadth of 34m and depth of 9.1m. The maximum draft is 6.1m
- The vessel was built in China and will be delivered this year
- Hull shape is basic pram type

- Three thrusters in the stern/ bow respectively
- Side thrusters positioned ahead of center thruster
- Bollard pull requirement was 30 tons per thruster



The thruster selection

Specification called for a thruster with 1.8MW capacity to achieve the 30t bollard pull

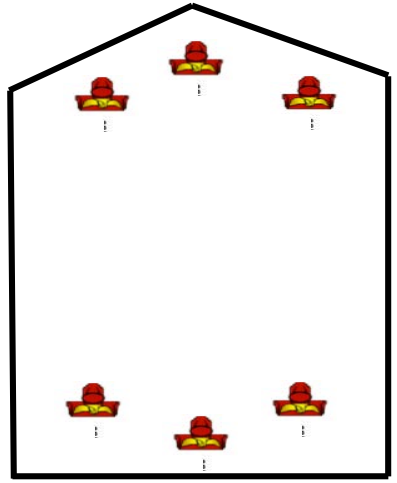
The vessels has 6 thrusters, three in the bow and three in the stern

- Side thrusters positioned ahead of center thrusters

ABB was selected based on performance predictions

Based on reference data it concluded there could be a 3-4% thrust loss for the side thrusters due to the configuration

As a result the power rating was increased to 1.9MW



AZIPOD®CZ980

- Pushing podded thruster with a ducted propeller
- PM motor
- Prop dia. 2.4m
- RPM is 301 at max power of 1.9MW

CFD Analysis and Cavitation Tunnel Test

CFD Analysis to Verify Thruster Selection

1.8MW was used for the CFD analysis

CZ980 Thrusters at 1.8 MW	Thrust (t)
BP condition pod thrust	33.4
Hull related thrust deduction at BP condition	0.96
Vessel BP w/ thrust deduction	32.5

Based on reference data

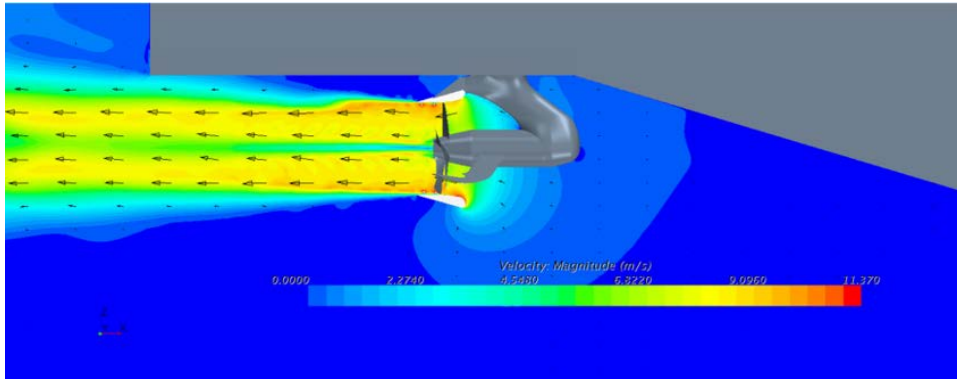
The corresponding BP thrust for side thrusters at 1.9MW would be ~ 34.5 tonnes.

With the hull related thrust deduction the thrust would then be ~ 33.4 tonnes.

CFD Analysis to Verify Thruster Selection

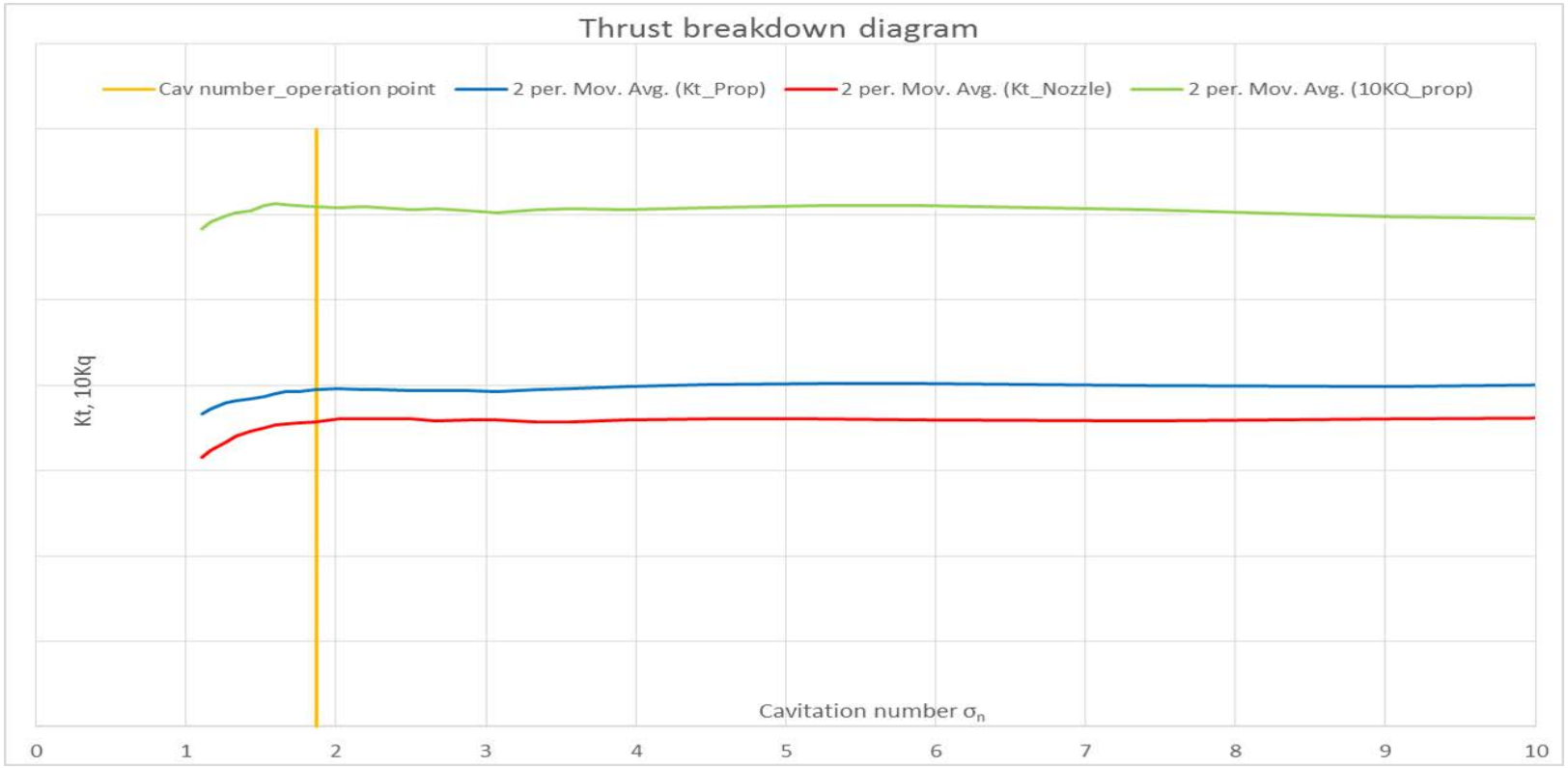
Impact of Ocean Current at 1.8MW Power

Current direction	Current velocity (m/s)	Pod open water thrust (t)
From the front	0.1	33.1
	1	30.1
From the rear	0.1	33.9
	1	37.6
Side	0.1	33.2
Opposite side	0.1	33



Cavitation Test for Nozzle Propeller

Thruster power of 1.9MW



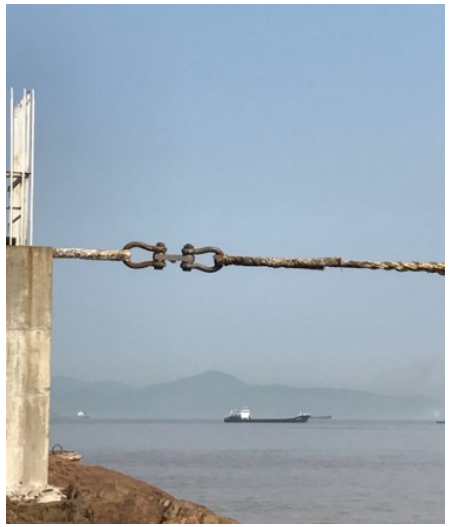
Margin before thrust breakdown at max power (yellow line)

Bollard Pull Test in China

Bollard Pull Test Preparations

ABB recommendations based on ITS2002 Bullard Pull trial code

- Current, waves, water depth, water density
- Testing protocol, time and frequency
- Load cell arrangement and calibration
- Towing length
- Orientation of the vessel



Bollard Pull Test Conditions

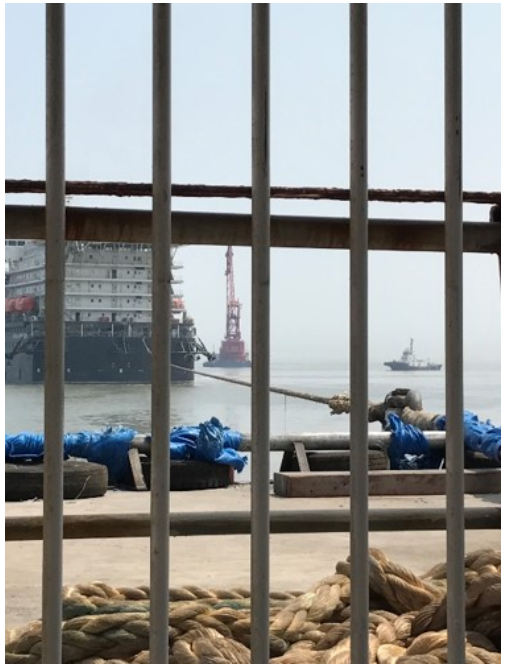
COSCO Zhoushan Shipyard July 26th 2017

Measured bollard pull over 10 minutes for each test

4 tests completed as follows,

1) Centre pod in the bow (#5)
2) Side pods in the bow (#4,6)
3) Centre pod in the stern (#2)
4) Side pods in the stern (#1,3)

Beautiful summer day in Shanghai!



Testing the thruster in the bow!

Bollard Pull Test Conditions

Ocean Currents

For Azipod®Thrusters 1-3 the towing line was attached to the stern.

For Azipod®Thrusters 4-6 the towing line was attached to the bow with the vessel backing out.

Bollard Pull Test Results and Reflections

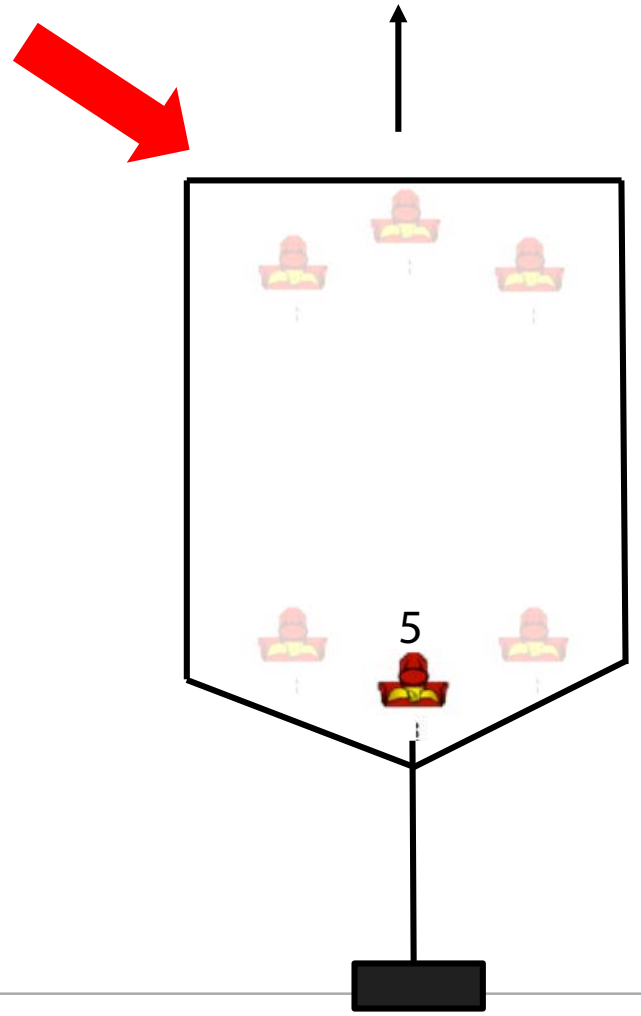
Bollard Pull Test Results

Test 1 – Centre pod in the bow

Pod	Static bollard pull (t)	Sustained bollard pull (t)	Average RPM	Current Average (kn)	Current direction
Pod # 5	34.7	31.6	305	0.6	Ahead/port side

t 1

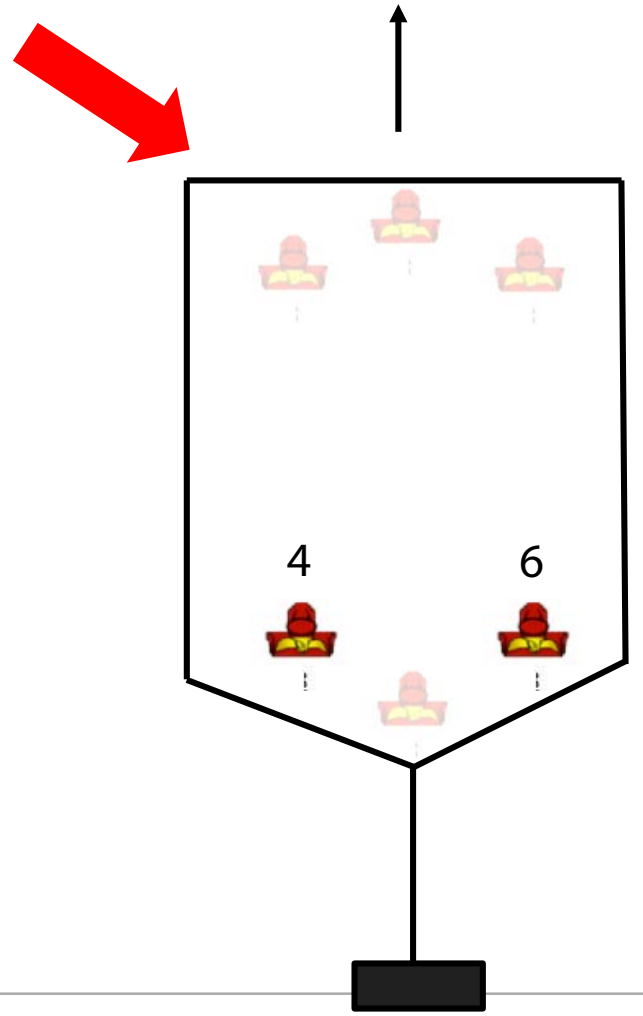
- Vessel backing out with towing line fastened in the bow.
- Sustained BP of 31.6 tons and Static BP of 34.7 tons
  - . Impact from varying head current ~ -1-1.5 tons.
- Higher RPM value due to the head current.



Bollard Pull Test Results

Test 2 – Side pods in the bow

Pod	Static bollard pull (t)	Sustained bollard pull (t)	Average RPM	Current Average (kn)	Current direction
Pod # 4/ 6	33.1	32.4	302/ 307	0.3	Ahead/port side



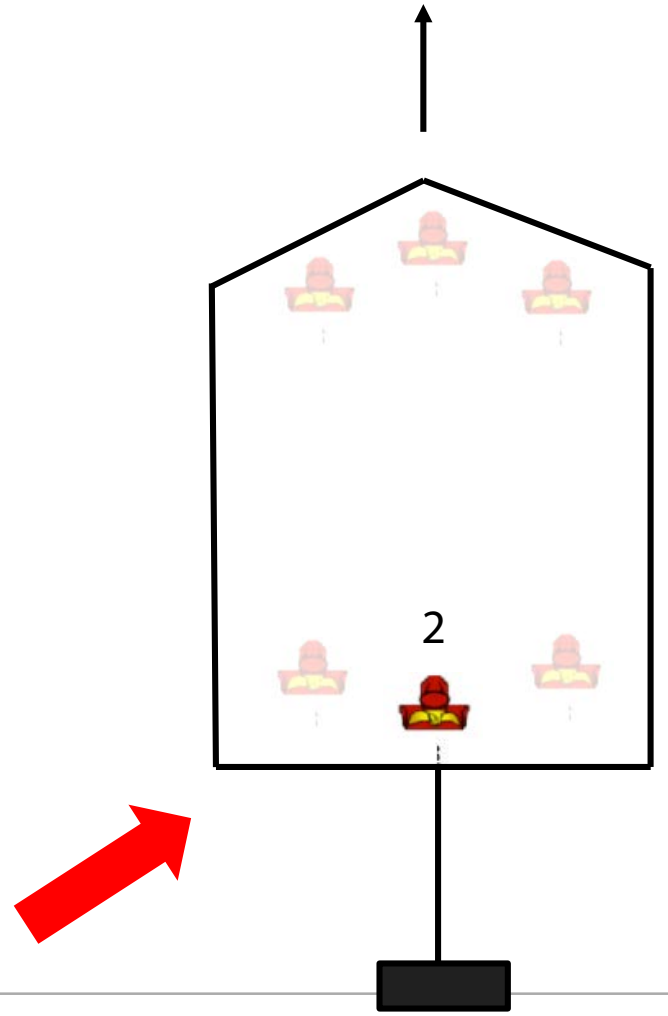
- Vessel backing out with towing line fastened in the bow.
- Sustained BP of 32.4 tons.
  - Impact from varying head current ~ -0.3-1 tons.
- Static BP of 33.1 tons.
- Higher RPM value due to head current

Bollard Pull Test Results

Test 3 – Center pod in the stern

Pod	Static bollard pull (t)	Sustained bollard pull (t)	Average RPM	Current Average (kn)	Current direction
Pod # 5	37.2	35.9	298	1.1	Stern/port side

- Vessel moving forward with towing line fastened in the stern.
- Sustained BP of 35.9 tons.
  - Impact from varying head current ~ +2-3 tons.
- Static BP of 37.2 tons
- Lower RPM value due to the current from behind.

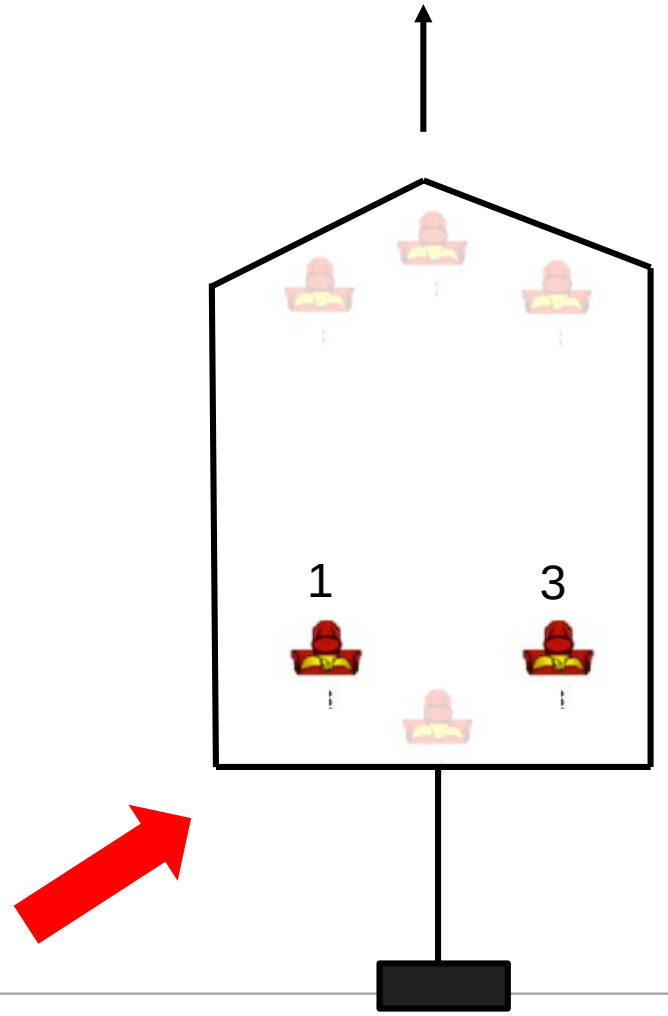


Bollard Pull Test Results

Test 4 – Side pods in the stern

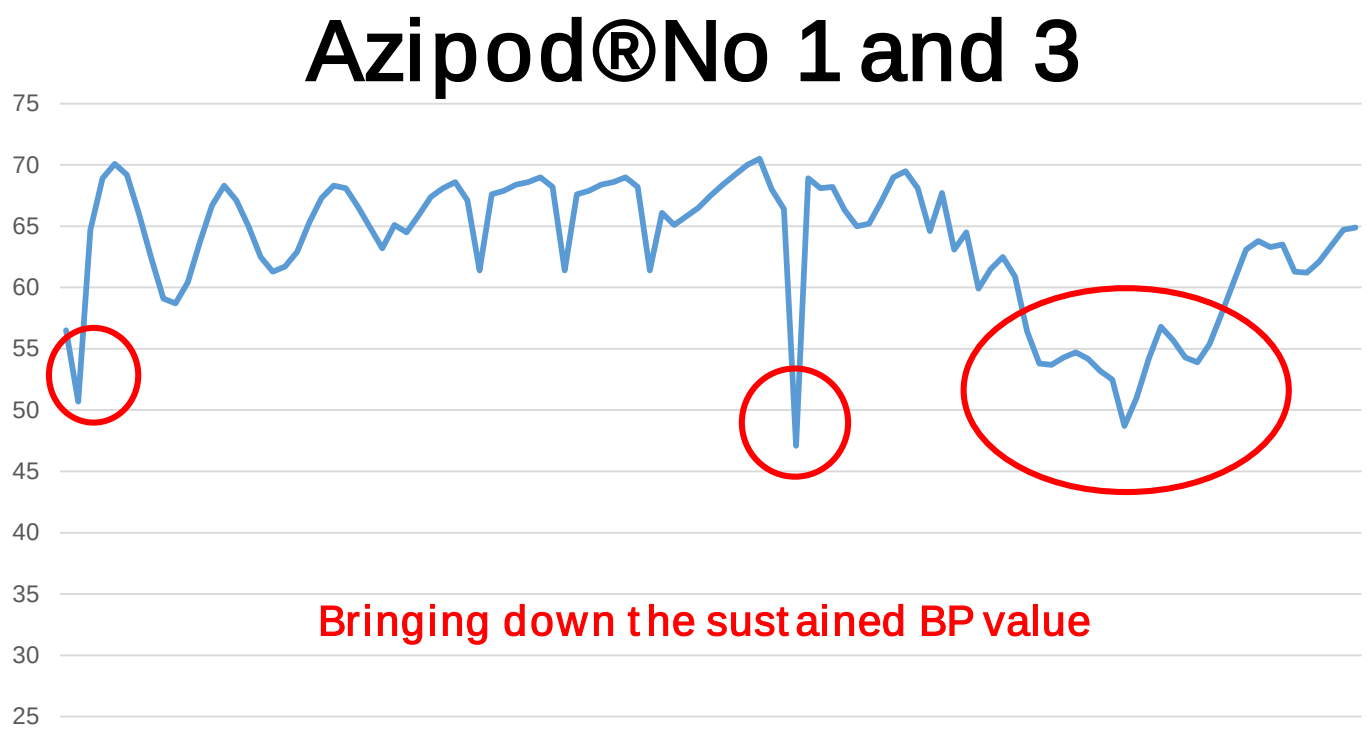
Pod	Static bollard pull (t)	Sustained bollard pull (t)	Average RPM	Current Average (kn)	Current direction
Pod # 1/ 3	34.1	31.7	302/ 299	0.9	Stern/port side

- Vessel moving forward with towing line fastened in the stern.
- Sustained BP of 31.7 tons.
  - Impact from varying head current ~ +1-1.5 tons. Misalignment of the vessel relative to the towing line led to a few low data points bringing down the average sustained BP figure.
- Static BP of 34.1 tons



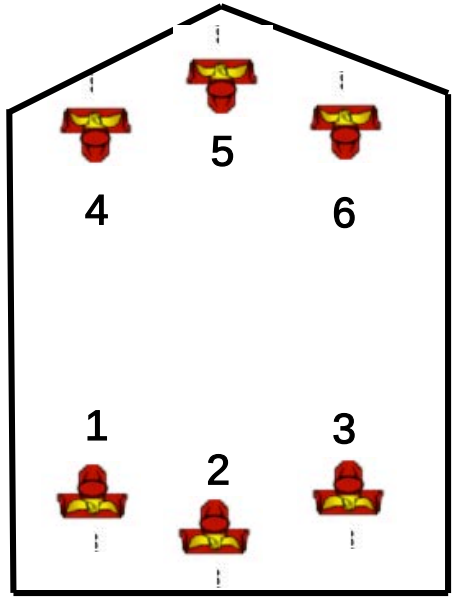
Bollard Pull Test Reflections

Alignment Issues of the Vessel Respective of the Towing Line



Summary of Results with Thrust Deductions for Current Impact

Pod #	Static bollard pull (t)	Current Impact (t)	Calibrated Static BP (t)
1	34.1	-2-2.5	**~ 32.1**
2	37.2	-2-2.5	**~ 35.0**
3	34.1	-2-2.5	**~ 32.1**
4	33.1	+0.1-0.5	**~ 33.3**
5	34.7	+0.5-1	**~ 35.5**
6	33.1	+0.1-0.5	**~ 33.3**



Conclusions

Conclusions

All thrusters met the Bollard Pull Requirement

- The current had an impact during the test
- Alignment issues of the vessel during parts of test # 4 affected the sustained bollard pull values for Pods #1/ 3
- Calibrating the Static Bollard Pull results with the thrust deductions from the current gives a consistent picture
- It seems like the side thruster position had higher than expected impact on the thrust. The reduction was more in the order of 6%.
- Measured thrust from the bow thrusters was higher than the stern thrusters due to hull shape

Azipod Thruster #	Static bollard pull (t)	Current Impact (t)	Calibrated Static BP (t)	BP Estimate from CFD
1	34.1	-2-2.5	**~ 32.1**	**33.4**
2	37.2	-2-2.5	**~ 35.0**	
3	34.1	-2-2.5	**~ 32.1**	**33.4**
4	33.1	+0.1-0.5	**~ 33.3**	**33.4**
5	34.7	+0.5-1	**~ 35.5**	
6	33.1	+0.1-0.5	**~ 33.3**	**33.4**