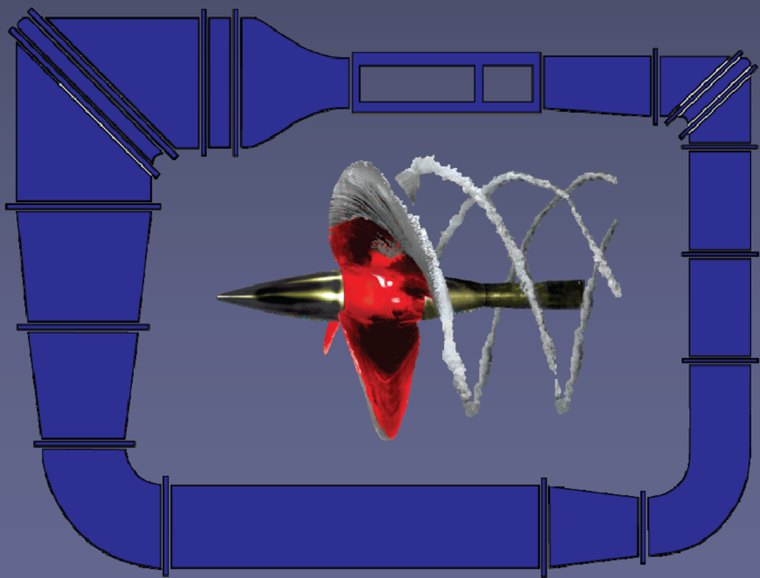
Effect of cavitation during propeller ice interaction

Rod Sampson

Emerson Cavitation Tunnel, University of Newcastle, UK



ITTC Specialist Committee on Ice

Podded Propulsor Performance in Ice

Papers published 2005 - 2008

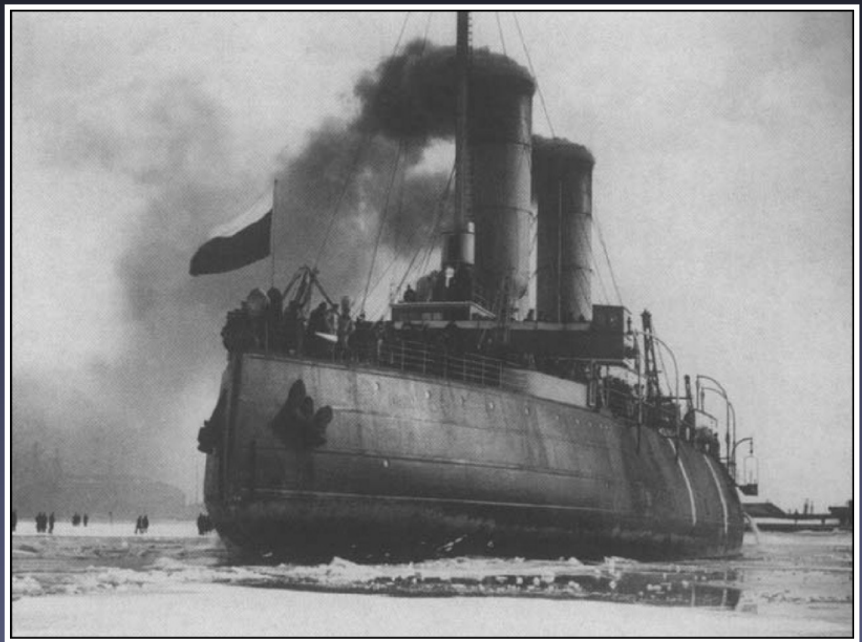
Sampson, R., Atlar, M. & Sasaki, N. (2006a). Ice blockage tests with a dat tanker podded propulsor. In Technical advances in podded propulsion T-Pod 2006 , 18, Brest, France.

Sampson, R., Atlar, M. & Sasaki, N. (2006b). Propulsor ice interaction - does cavitation matter? In Sixth international symposium on cavitation (Cav2006), Wageningen, The Netherlands.

Sampson, R., Atlar, M. & Sasaki, N. (2007a). Effect of cavitation during systematic ice block tests. In Port and Ocean Engineering under Arctic Conditions (POAC)

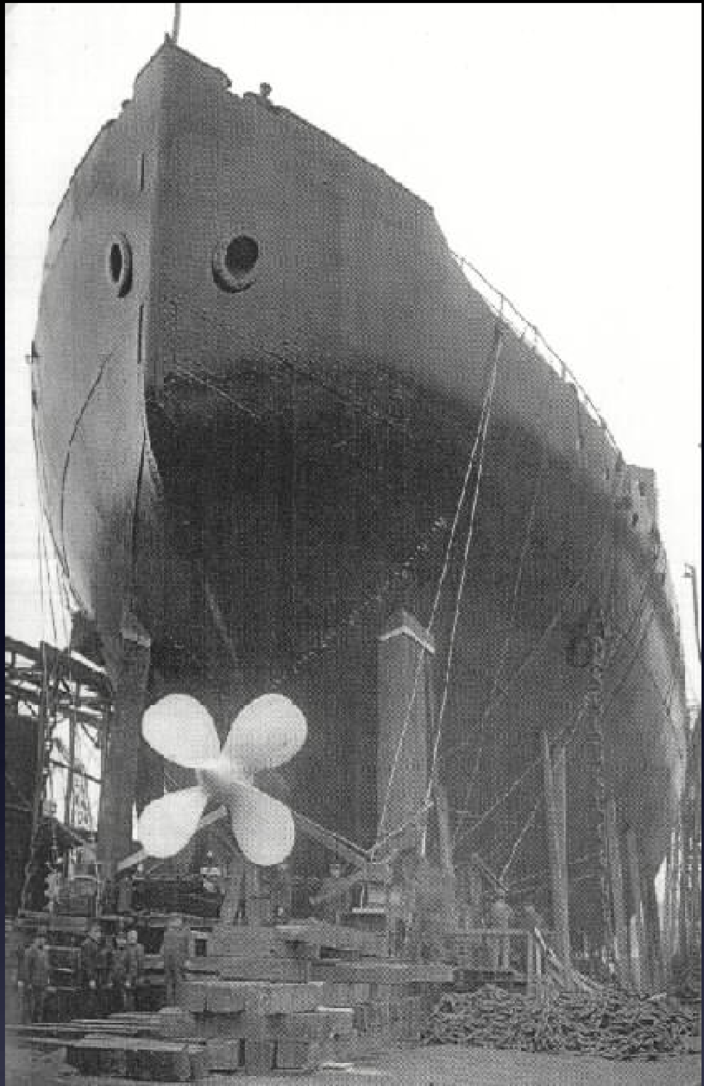
Sampson, R., Atlar, M. & Sasaki, N. (2007b). Ice blockage tests with a podded propulsor - effect of recess. In 27th Offshore Mechanics and Arctic Engineering (OMAE)

Icebreaker Designs



Yermark 1903

Tempera 2003



Then and now - the bow propeller
1933 - 2008

Development of the bow propeller

- Podded vessels perform well when reversing into ice
- Vessel remains controlable due to pod azimuth
- Development of Mastera and Tempera (2003-4)
- USCG Makinaw (2005)
- Trend for Tankers and LNG carriers is set to rise
- Deliveries from Samsung 2007-9

The ‘double acting’ tanker concept

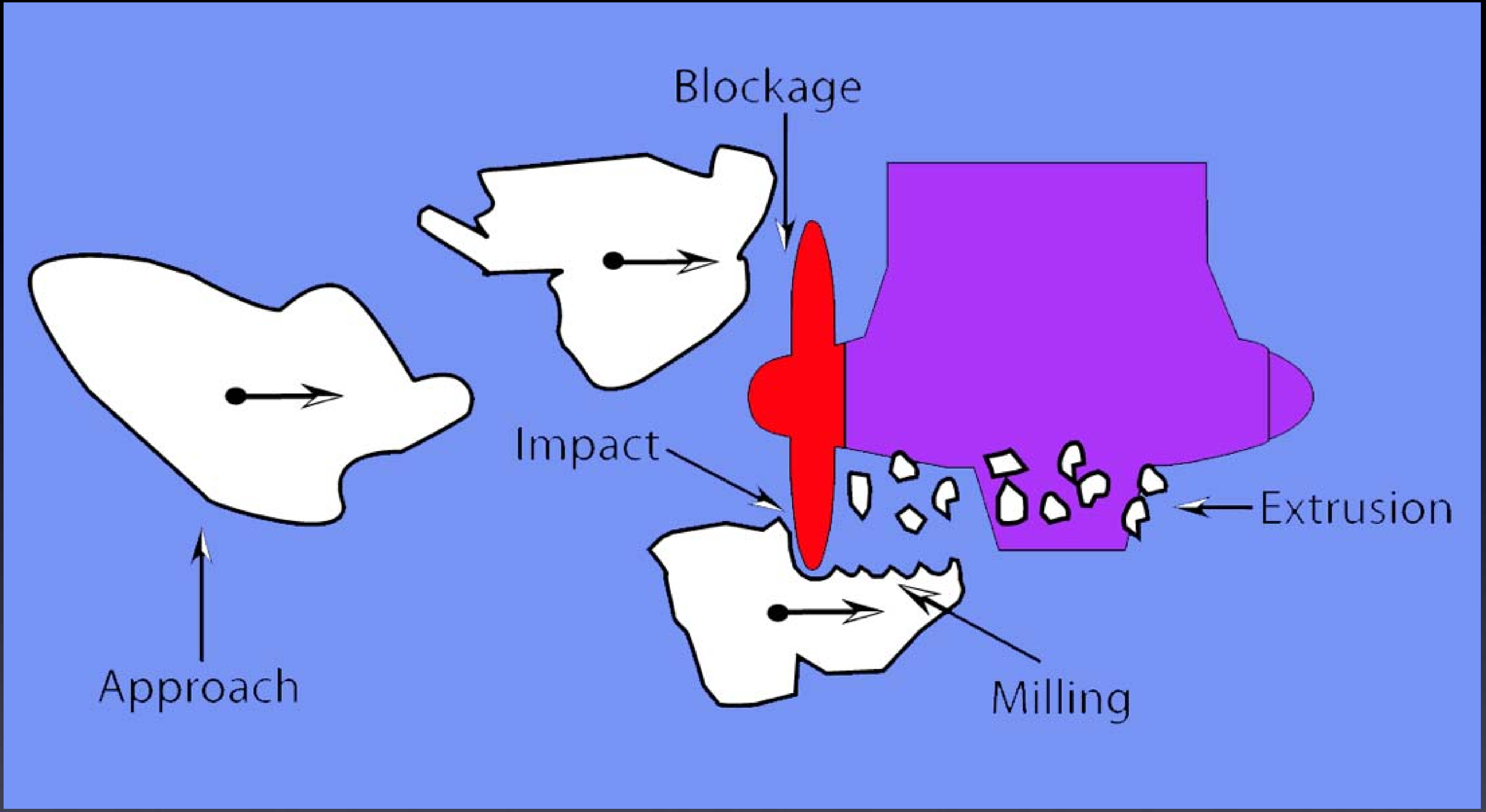
DAS vessels

- Clear benefit to DAS design
- Propulsion system exposed to less risk
- Icebreaking speed increased
- Propeller rotating continuously
- Wake is extreme posing a high risk of cavitation

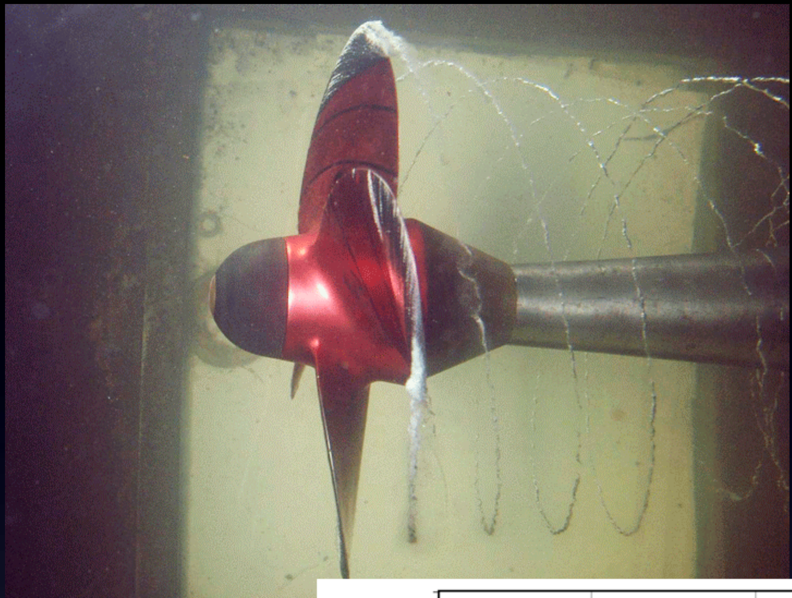
Research rationale

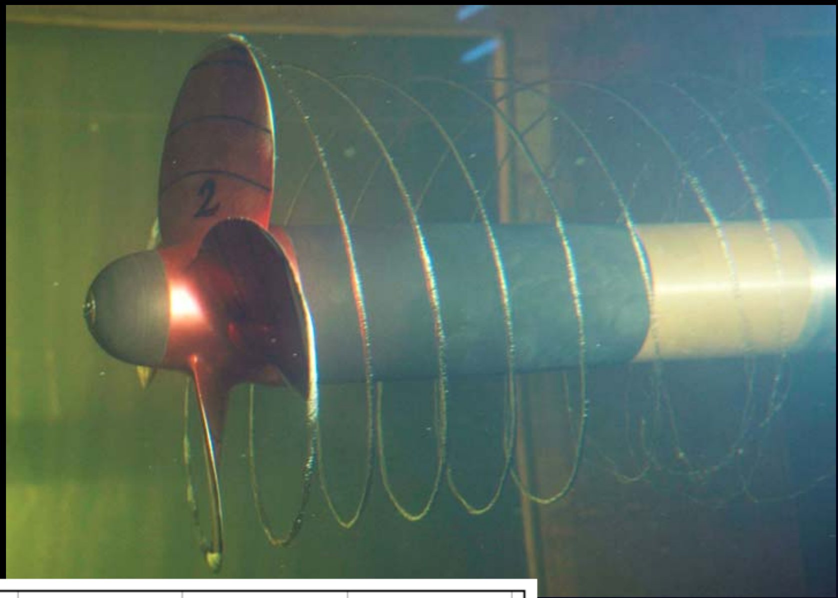
- Omission in the state-of the art
- Blockage test adopted as a quasi-static analysis
- Great insight into the process obtained
- Milling tests performed
- Tests of interest to ITTC specialist committee on ice and ITTC specialist committee on azimuthing podded propulsion

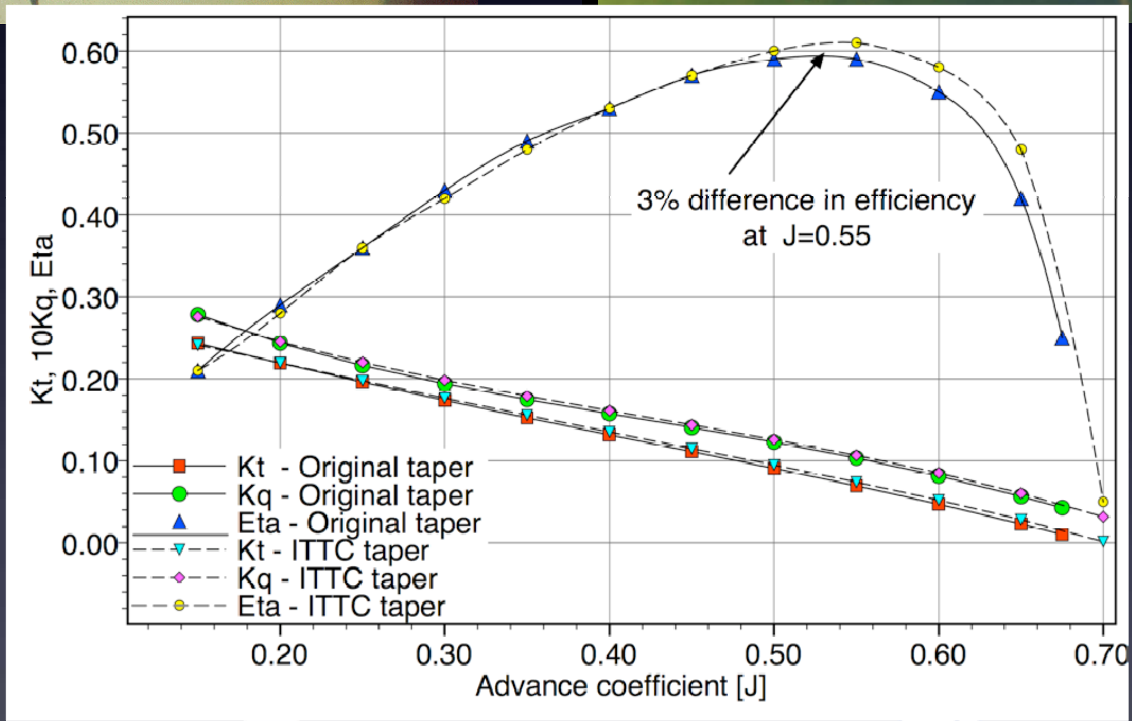
Propeller ice interaction terminology



Taper collar tests

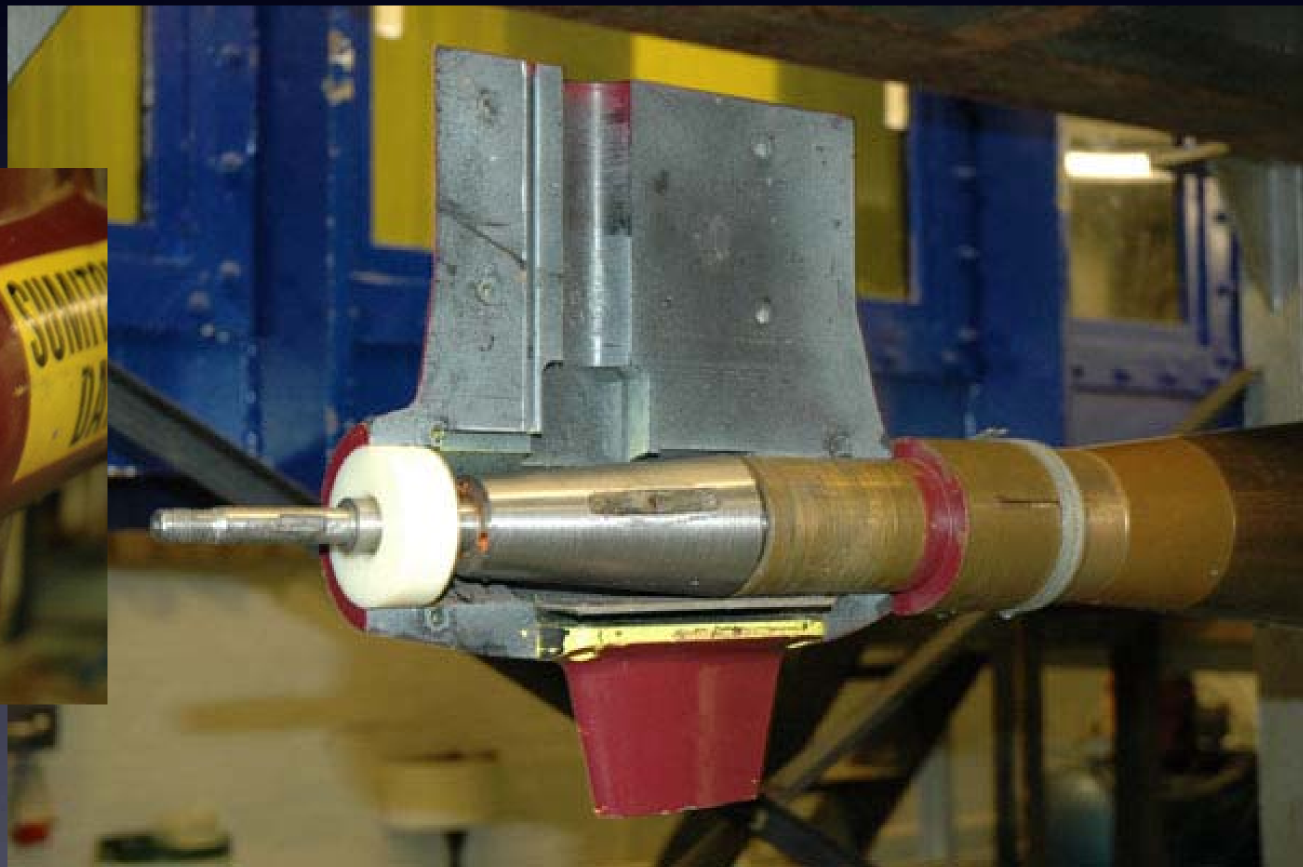




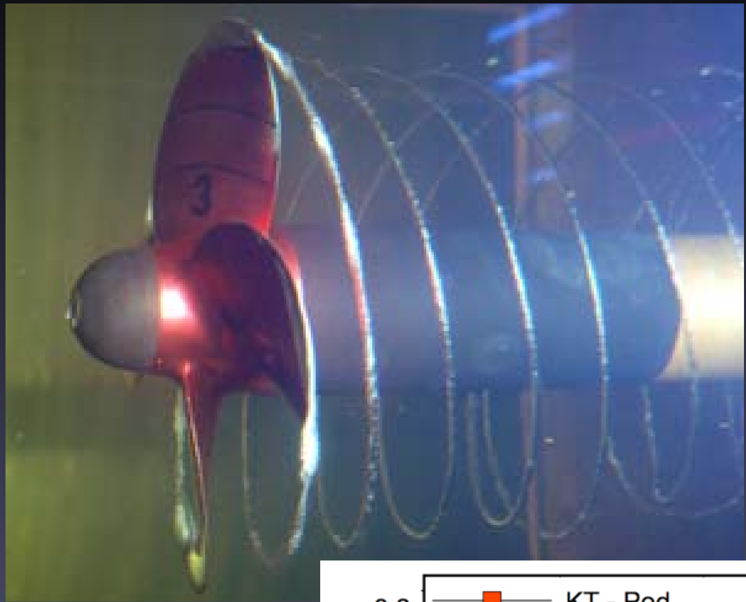


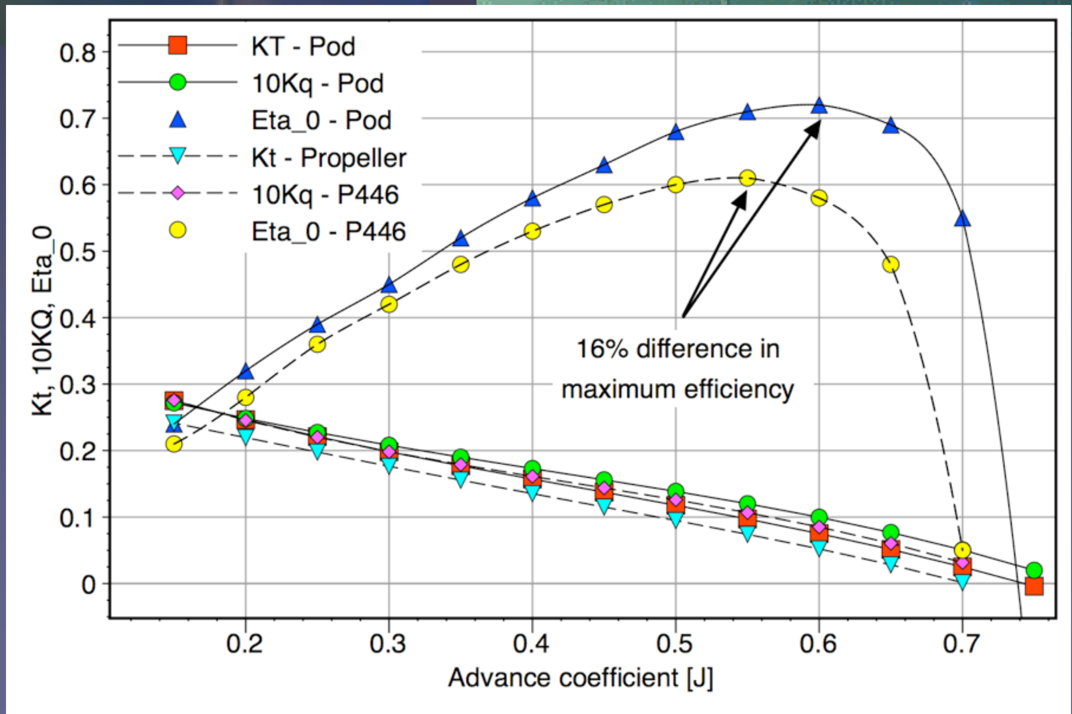
Pod mounting on the K&R H33 Dynamometer

- Pod introduced to modify the propeller wake
- Unconventionally mounted on dynamometer
- Blanking disk to limit circulation inside pod body

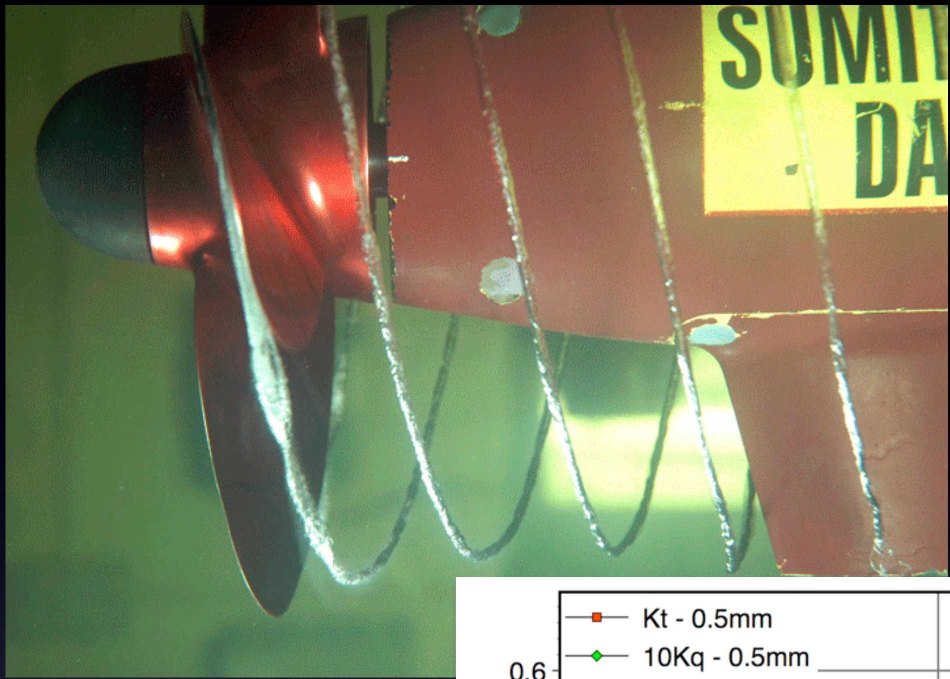


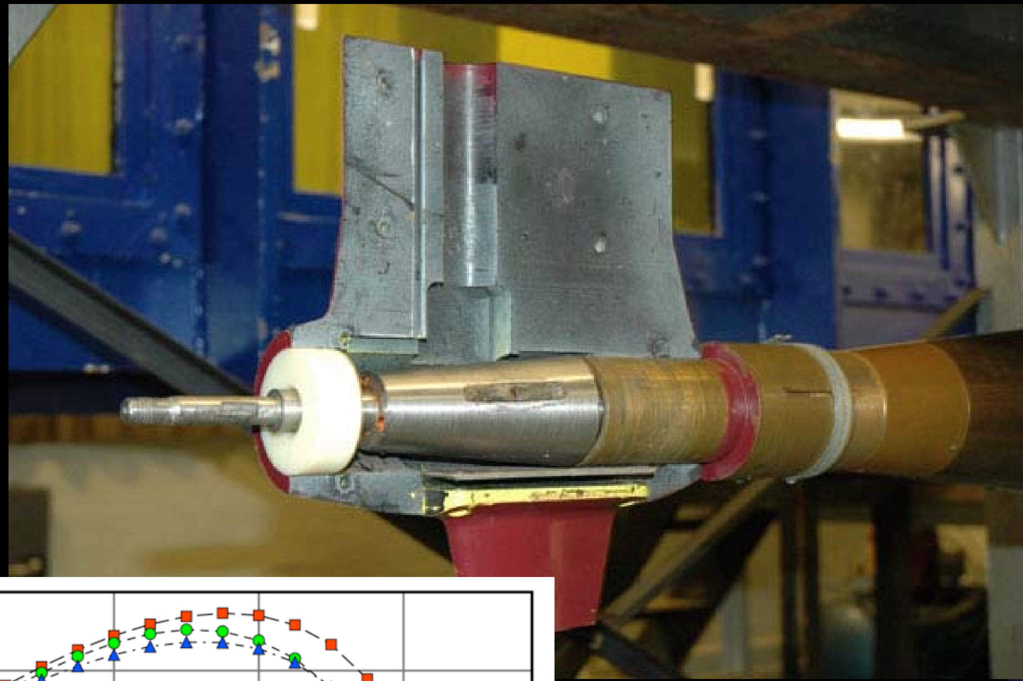
‘Open water’ performance (shaft loads only)

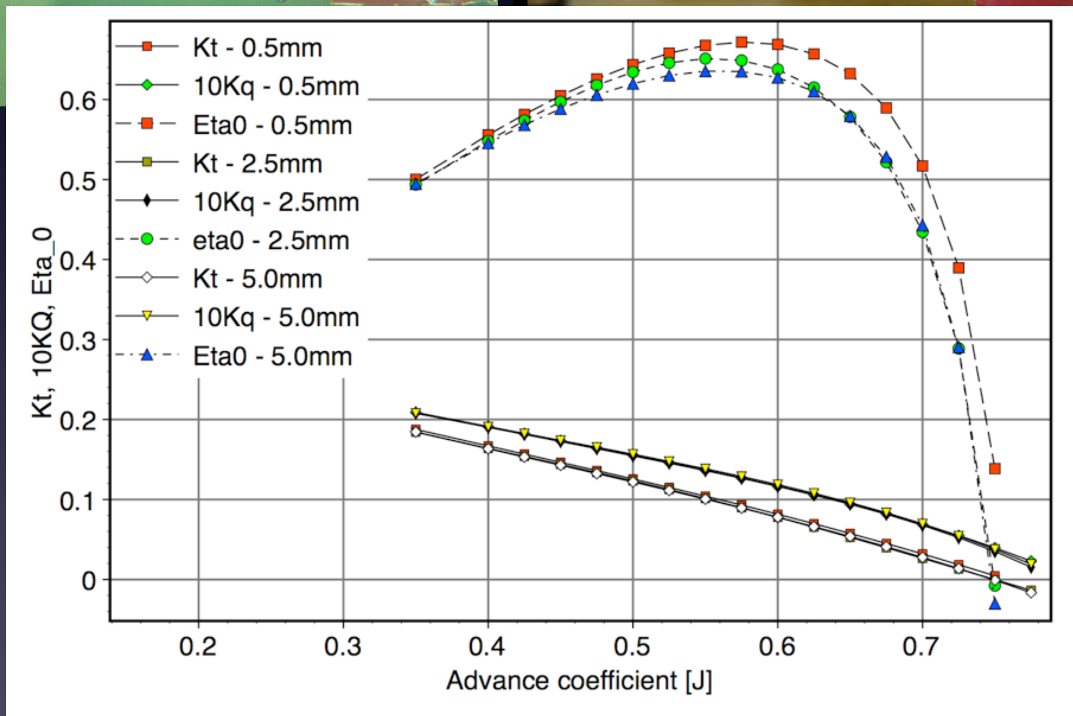




Gap test - 0.5mm, 2.5mm, 5mm

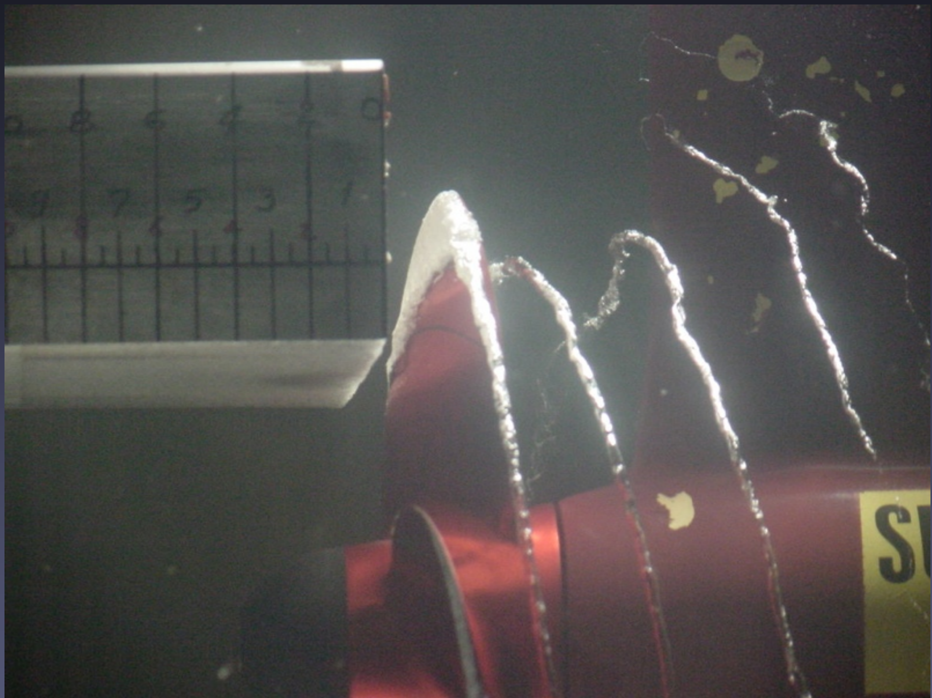







SUMITOMO
DAT

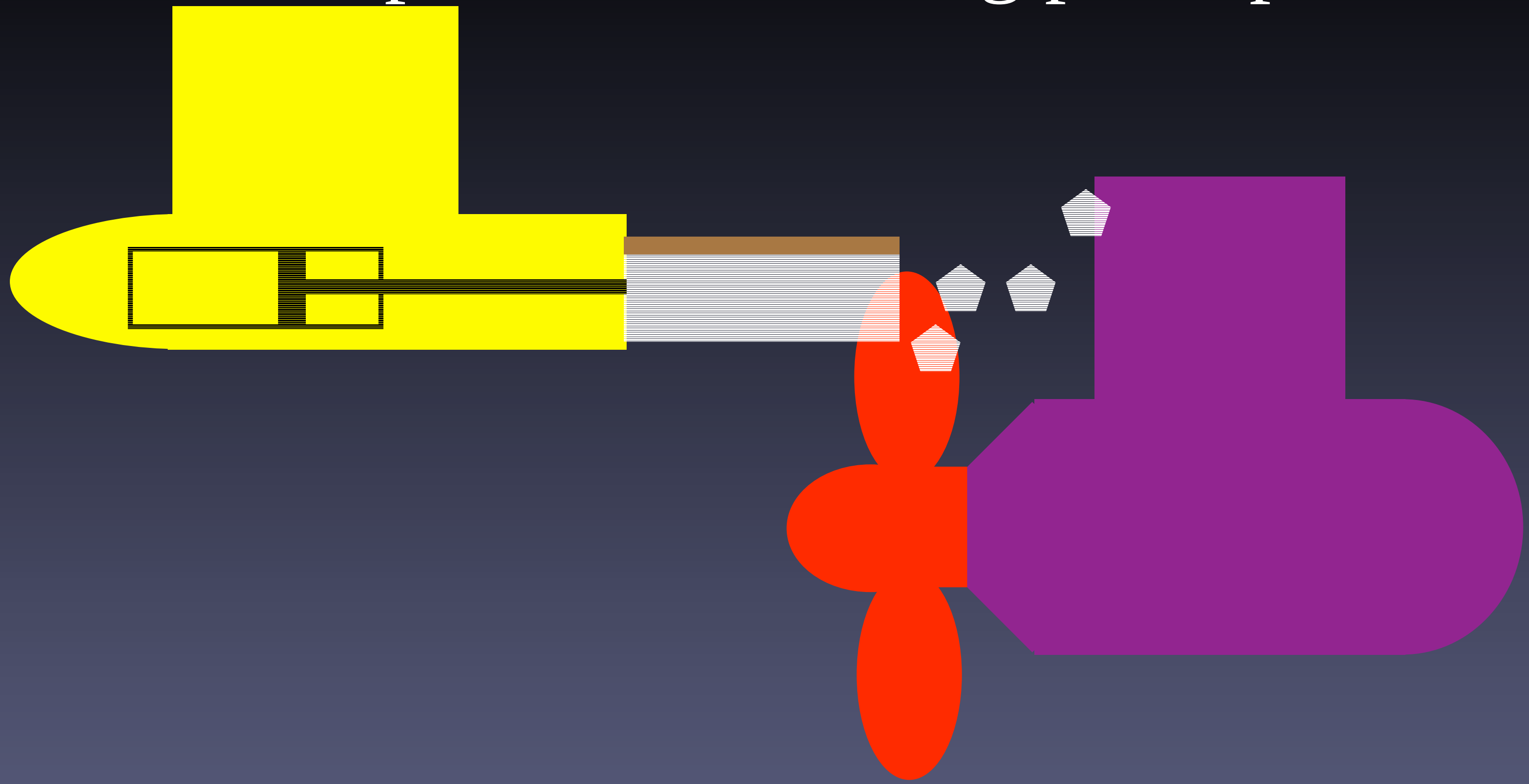
Types of propeller loading



Blockage - static
(due to obstructed flow)

Milling - dynamic
(blade contacts the ice)

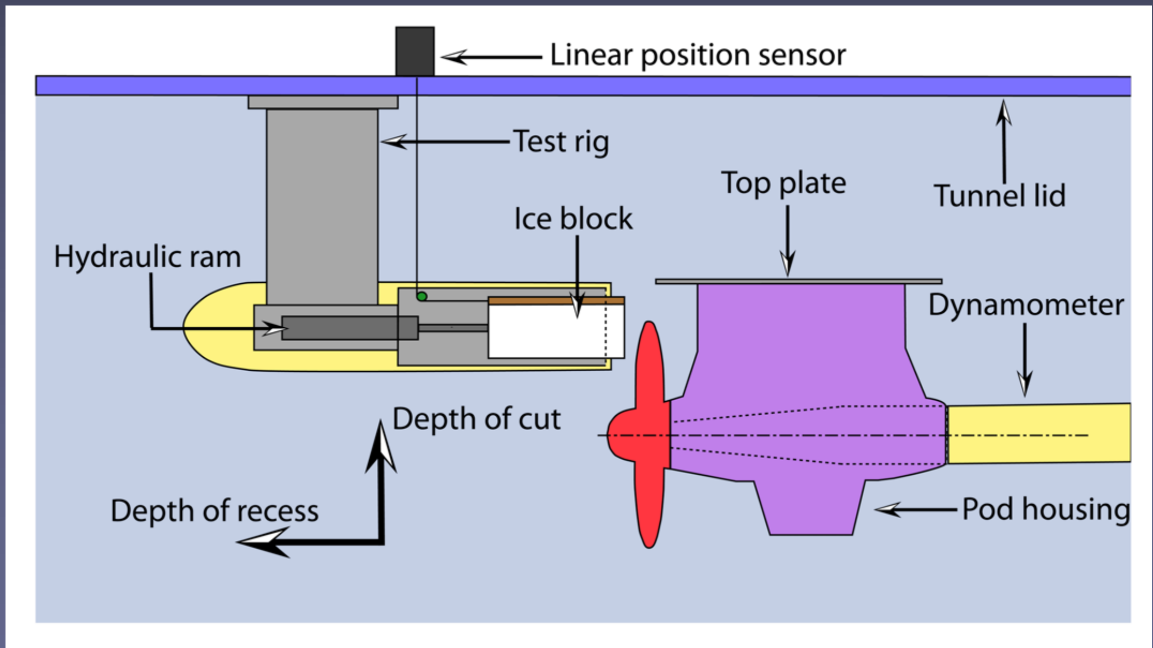
Experimental test rig principles

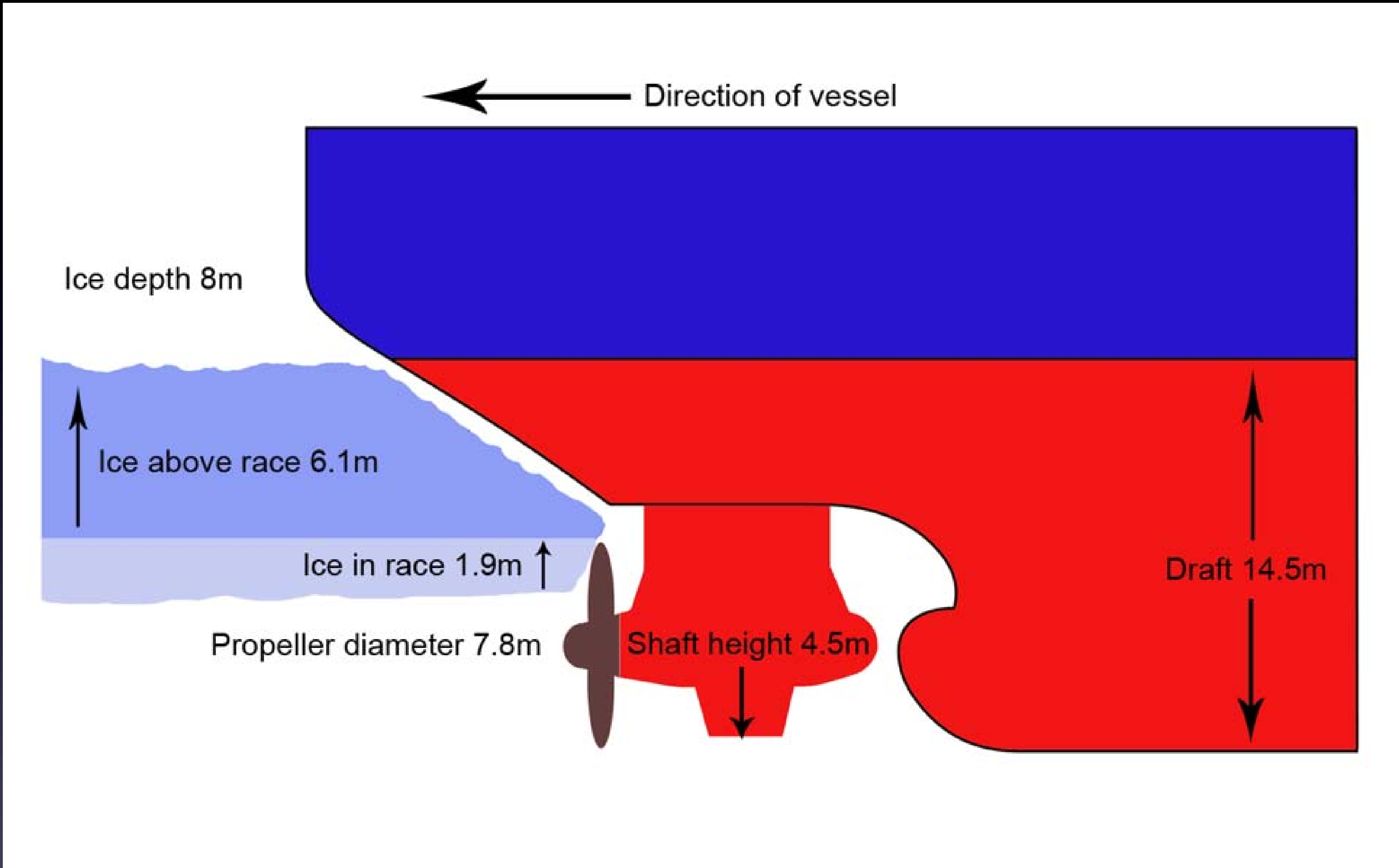


- Icebox mounted upstream of the pod unit
- Hydraulic ram forces blockage toward propeller
- Ice block modifies the inflow to the propeller
- Ice block impacts the propeller and is milled

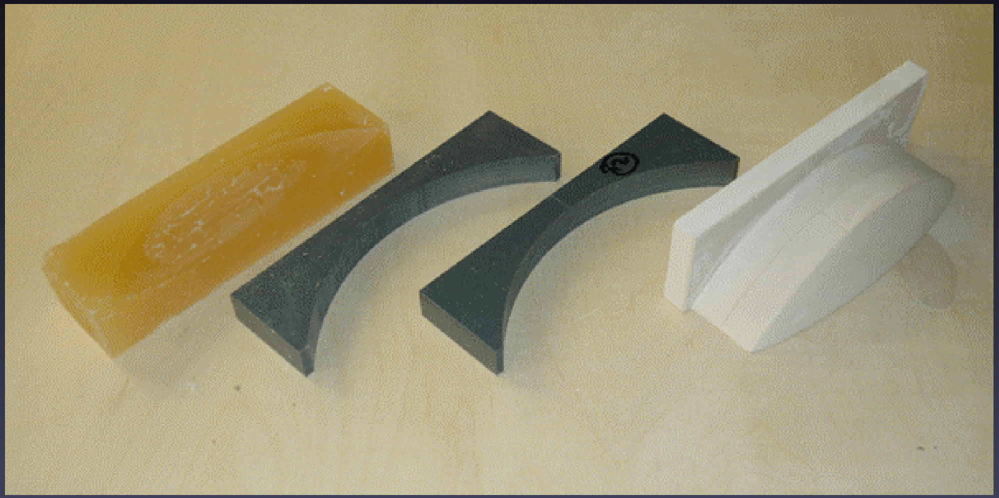
Experimental test rig

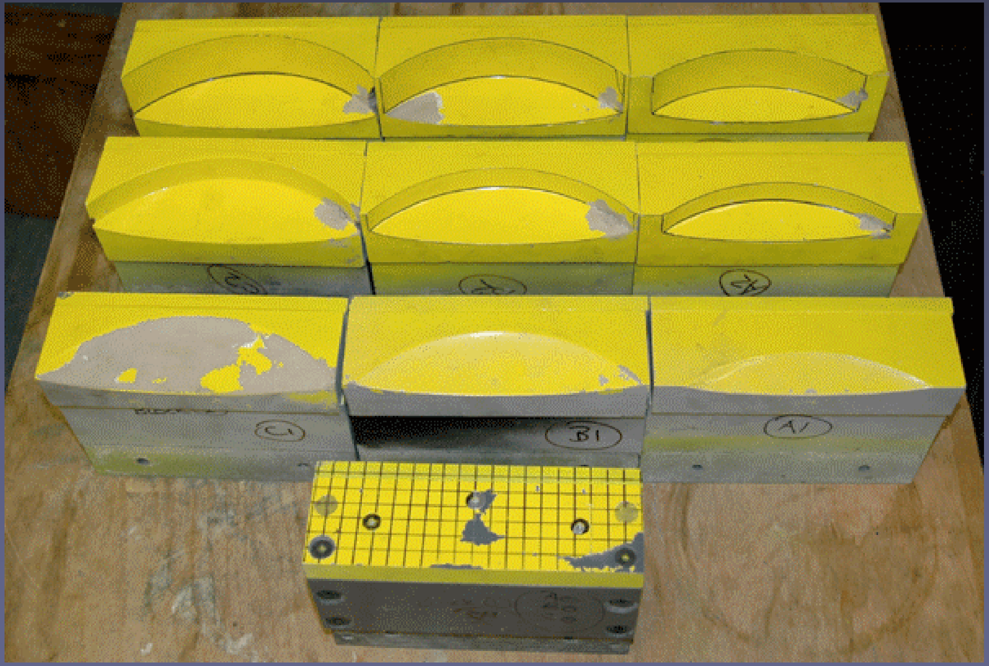
- Icebox mounted on the measuring section lid
- Pod body mounted around the dynamometer
- Blockage tests performed at fixed distances
- Milling tests used hydraulic feed




Direction of vessel
Ice depth 8m
Ice above race 6.1m
Ice in race 1.9m
Propeller diameter 7.8m
Shaft height 4.5m
Draft 14.5m

Blockage Manufacture



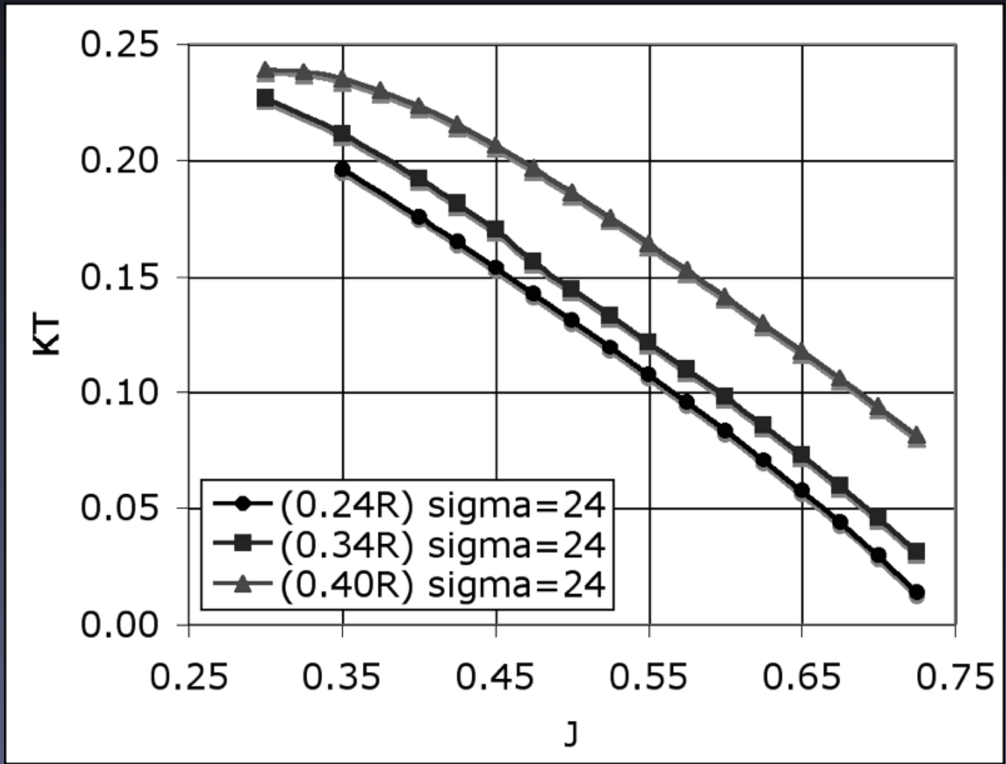


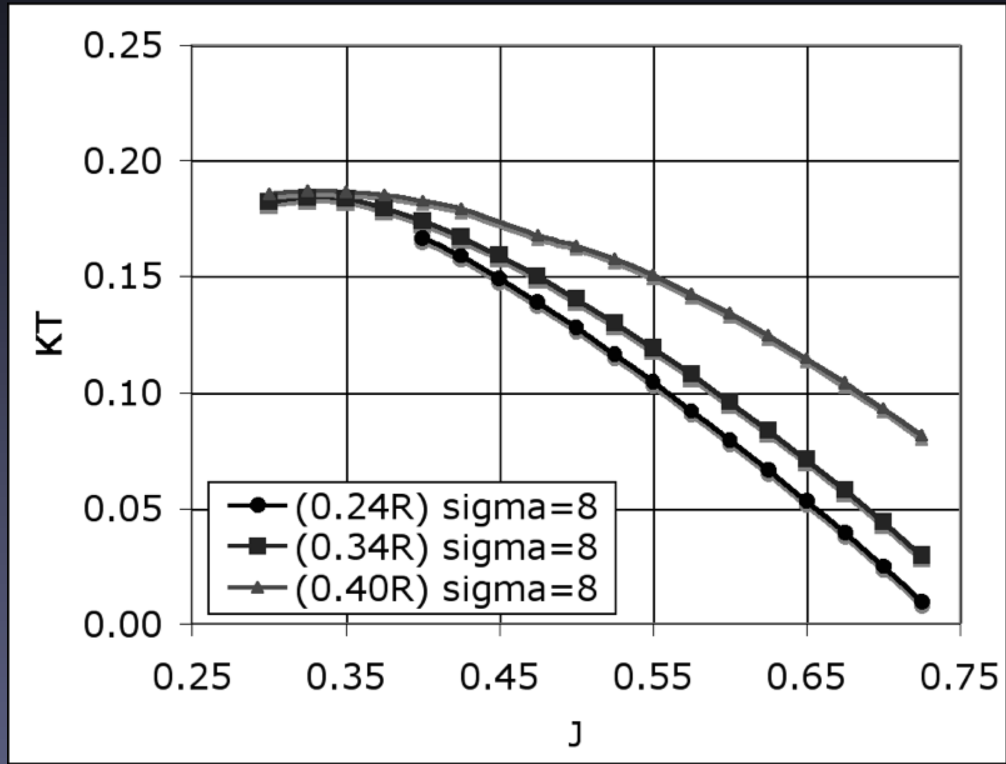
Blockage test - parameters

Depth of cut (mm)	50, 43, 20
Gap (mm)	3
Tunnel speed (m/s)	3, (1.94)
Vacuum (mm/Hg)	atmospheric, 150, 300, 450
Cavitation numbers	24, 17, 12, 8

Blockage test

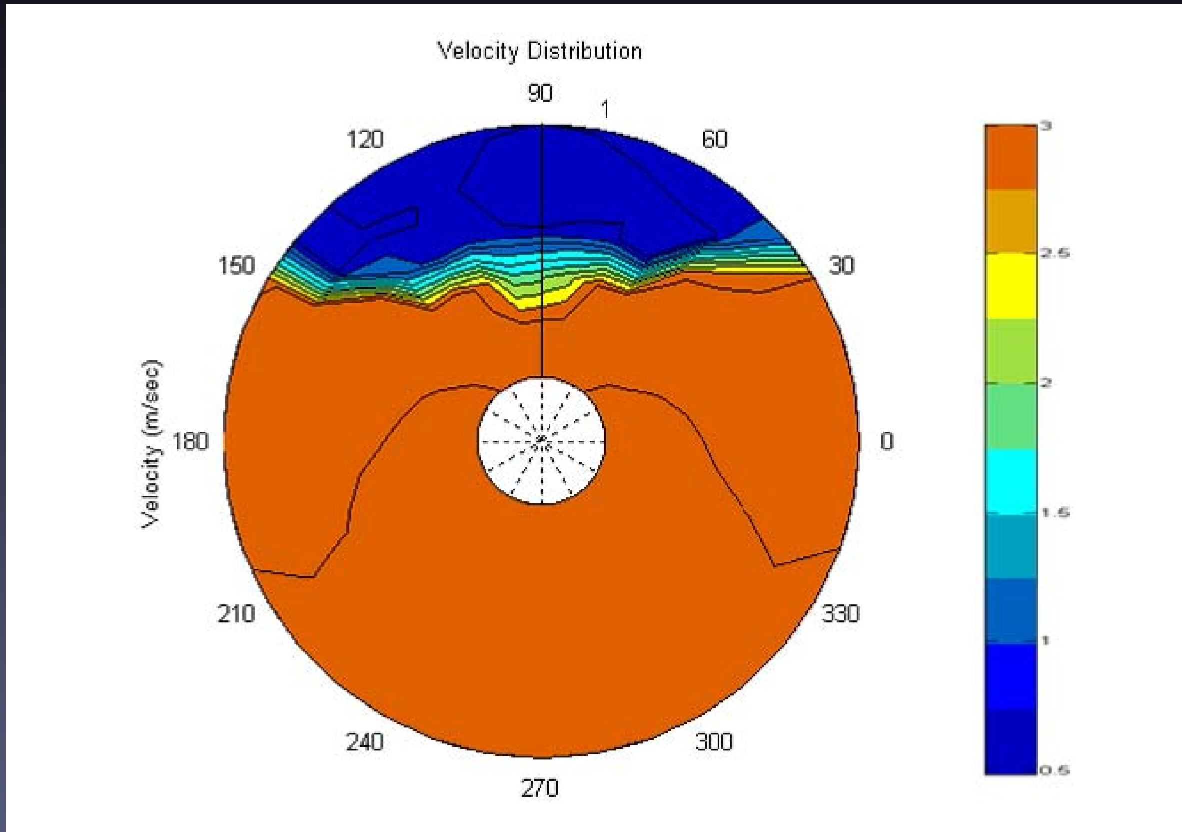
Changes in depth of cut (KT sigma = 24 & 8)





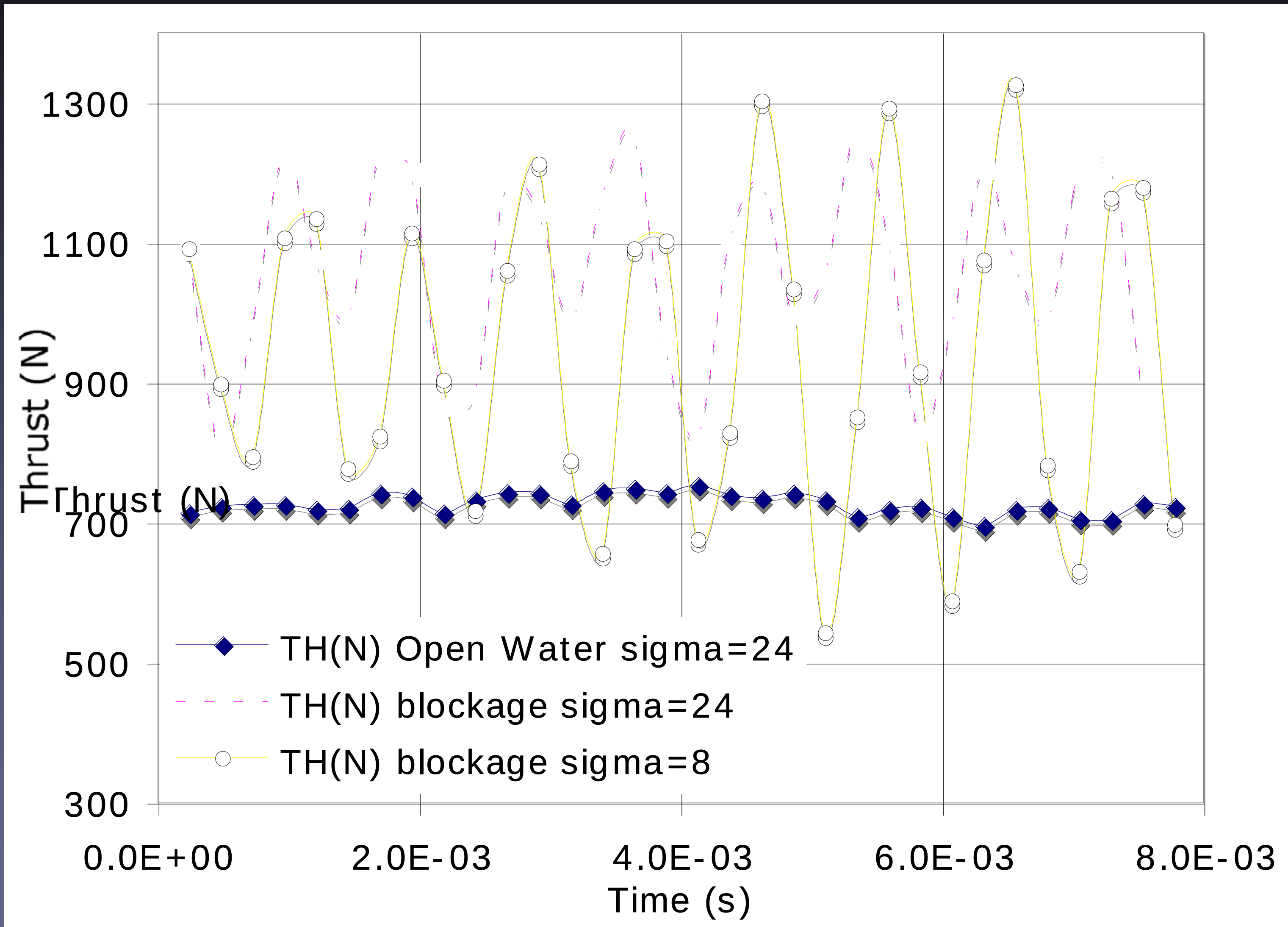
Sigma = 24, 12, 8 for DOC = 40%   J = 0.3

Wake of the blockage



- Extreme blockage wake
- 3m/s free stream
- 0.5m/s behind blockage
- Measured axial flow only

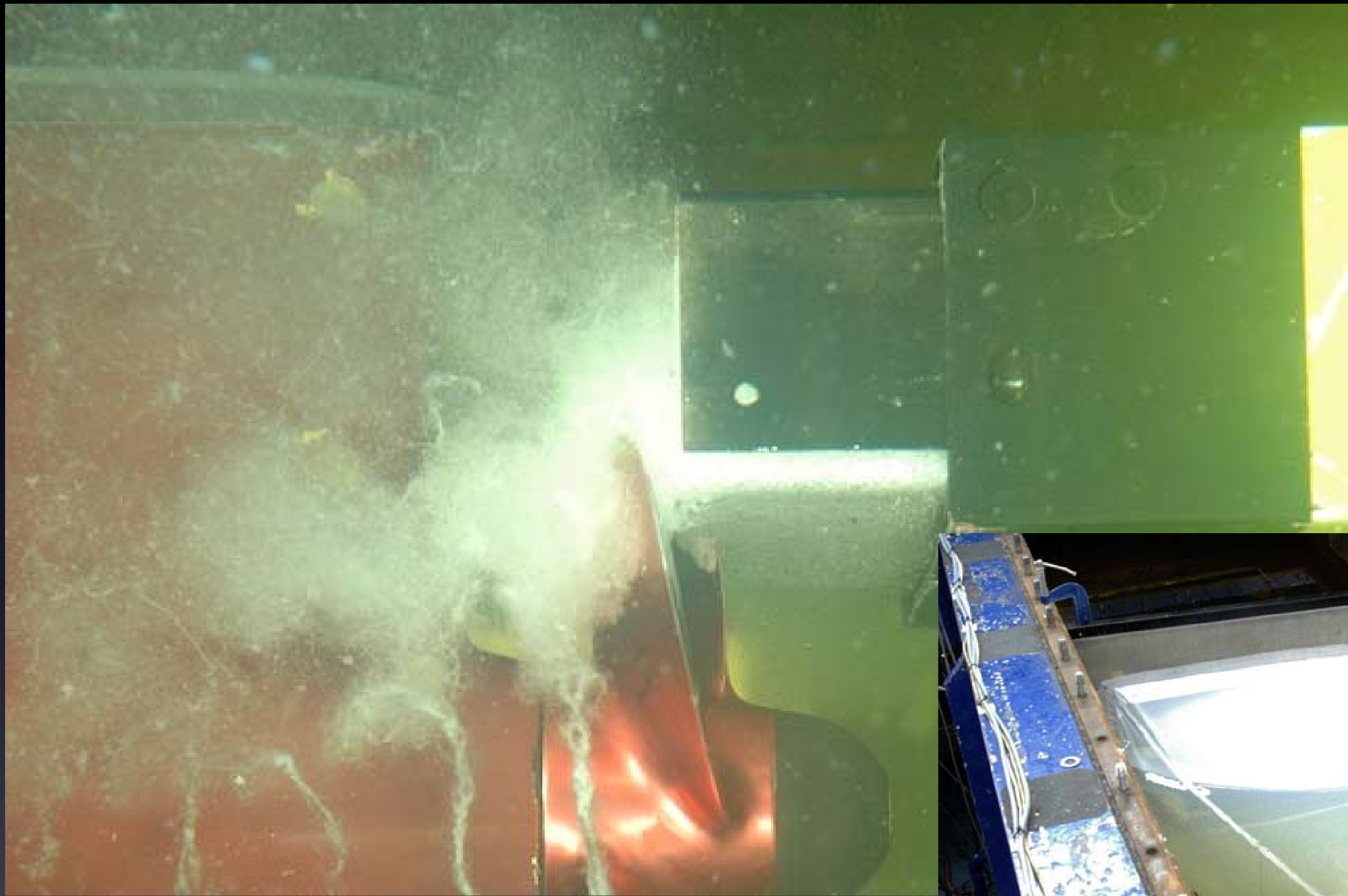
Pod / Propeller open water comparison

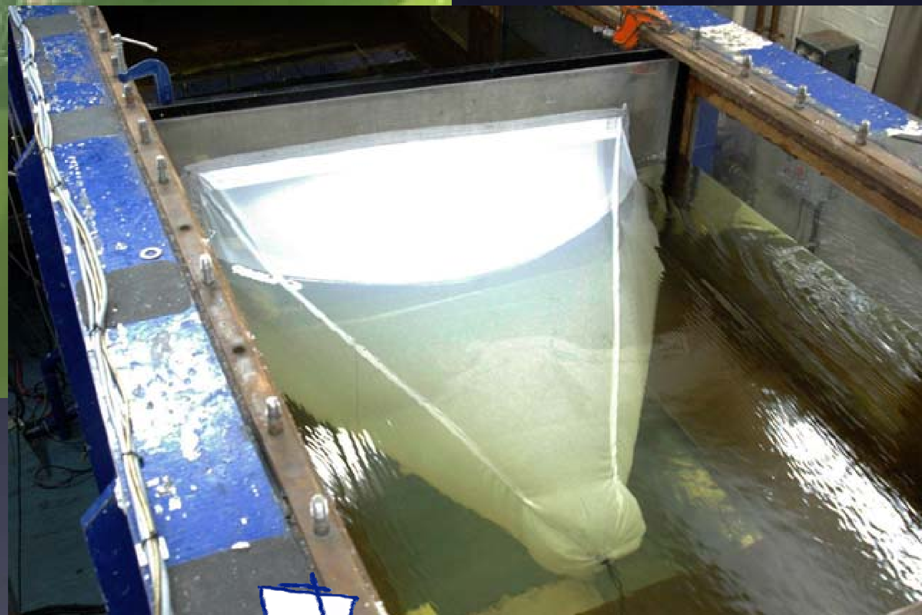


Milling Tests in Cavitation Tunnel

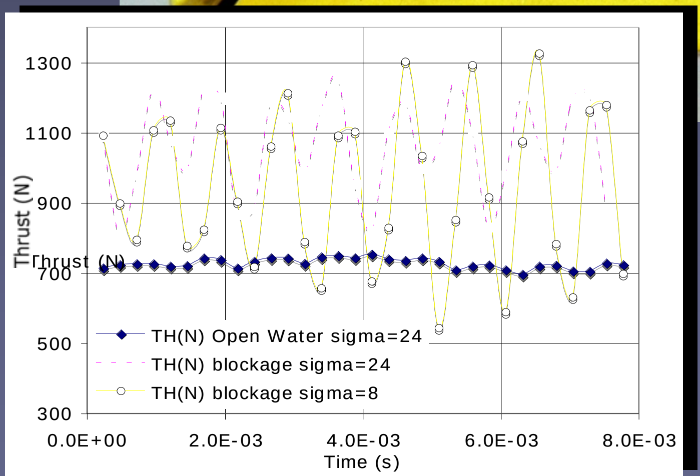
- Milling tests built on blockage results
- Styrofoam type material used
- 170Kpa strength equivalent to first year ice
- Tests covered design J conditions
- Tests expanded to study near bollard pull

Milling Tests in Cavitation Tunnel



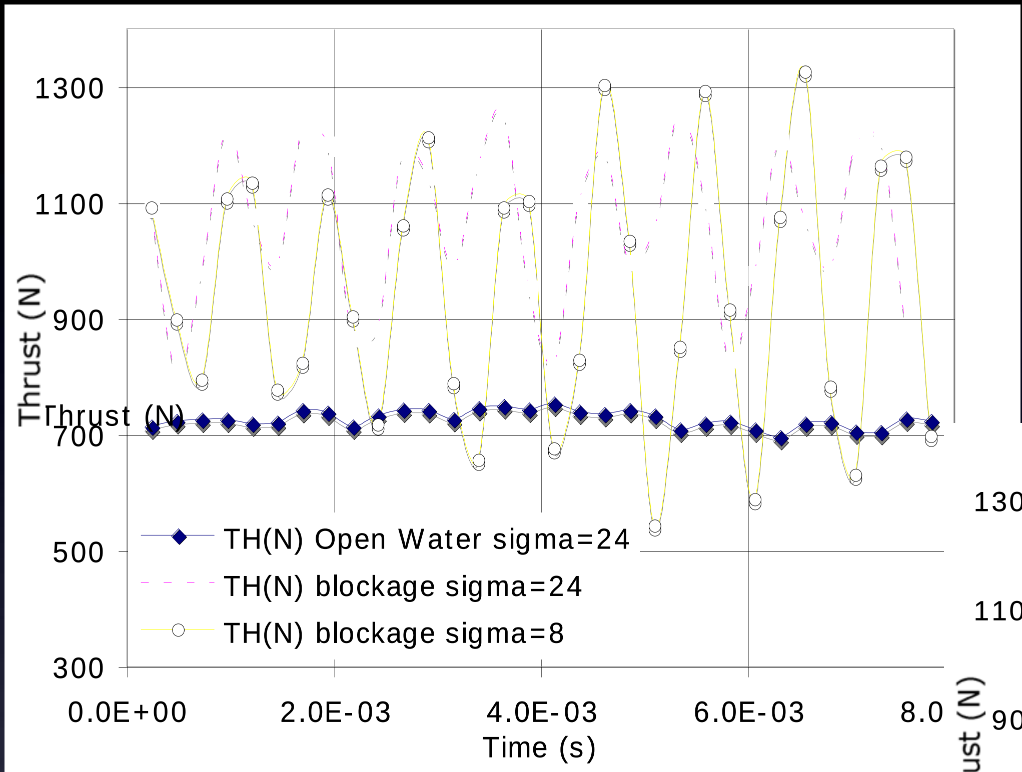


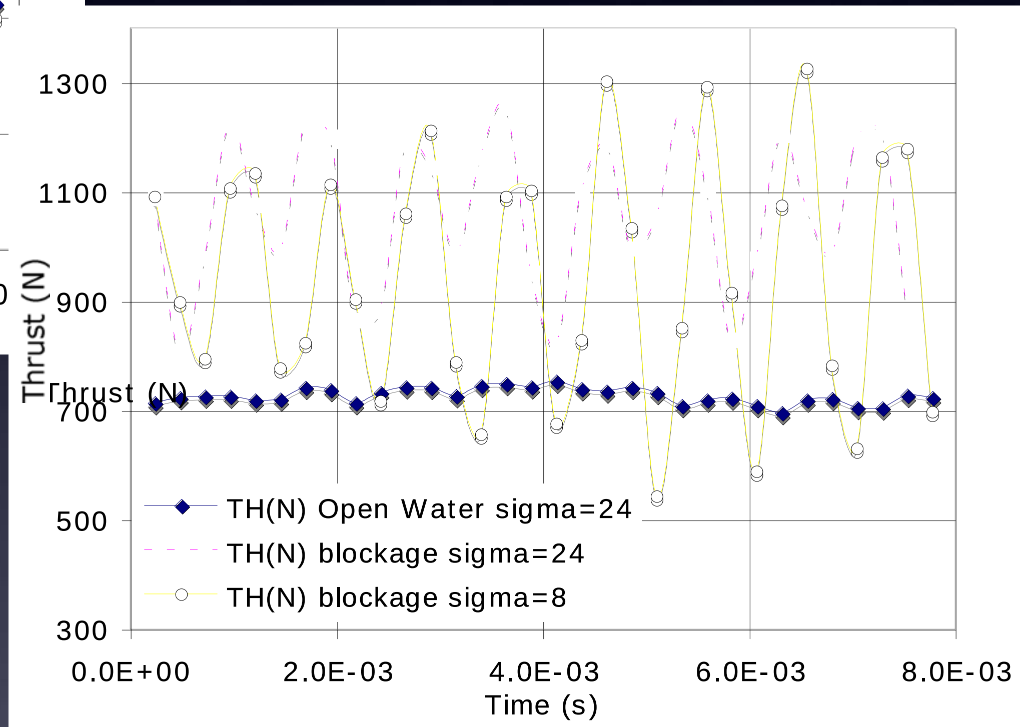
Block damage



Block damage

Propeller damage due to cavitation





Summary

The blade loads show dramatic oscillations about the mean load during blockage; this was attributed to the highly unsteady wake due to the blockage. The amplitude of the oscillations increases dramatically with reducing cavitation number

The long term implications of these loadings on podded drives is unknown. All in service vessels have performed well, however with such a short window of service further study is required.

Trials of *Norilsky Nikel* published by Wilkman (2007), the vessel (with a 9m draught) was reported to operate in continuous level ice of 0.5-1.5m.

On ice trials conducted between Murmansk to Yenisey River in March 2006, Wilkman reported trials in ridges with ice thickness of 5-10m. The vessel was able to penetrate these fields at a speed of 1 knot at 13MW, (full power) for 5 Nautical Miles, or 5 hours transit in restricted/blocked flow conditions.

It is clear therefore that blocked and restricted flow conditions capable of reaching the propeller do exist and are not always transient.