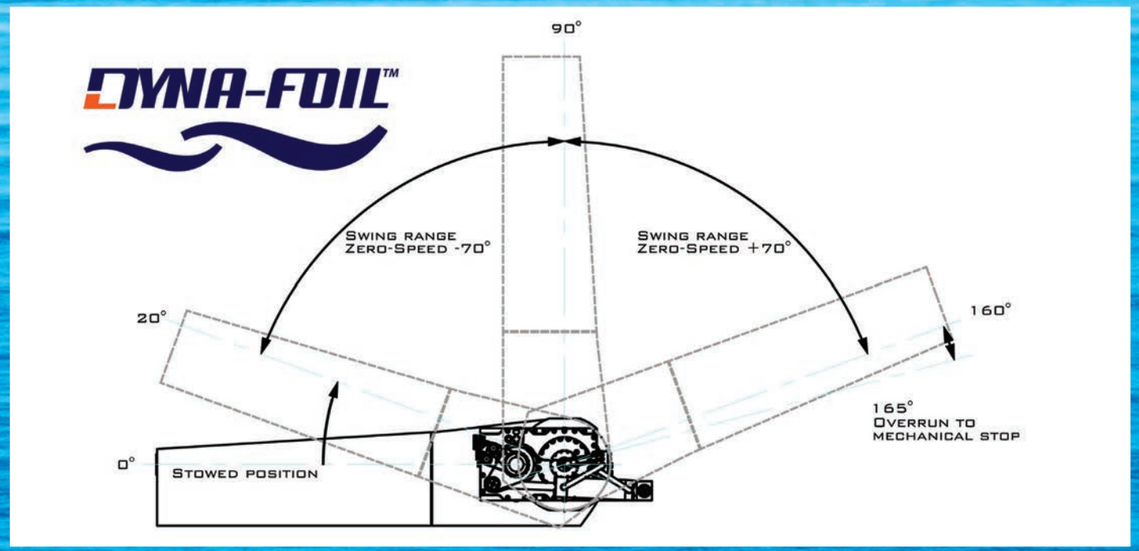
SYSTEM SPECIFICATIONS*

Foil to Hull Unit Size Specifications*					
	FOIL AREA	**SPAN (mm)**	**CHORD (mm)**	**Max. Underway Lift Force (20° @ 16 knt)**	**Minimum Design Roll-Period**
D. Foil 1.0	1.0 m^2	2000	500	43 kN	5 sec.
D. Foil 1.5	1.5 m^2	2450	610	65 kN	6 sec.
D. Foil 2.0	2.0 m^2	2830	710	88 kN	7 sec.
D. Foil 3.0	3.0 m^2	3460	870	131 kN	8 sec.
D. Foil 4.0	4.0 m^2	4000	1000	175 kN	9 sec.
D. Foil 6.0	6.0 m^2	4900	1230	264 kN	10 sec.



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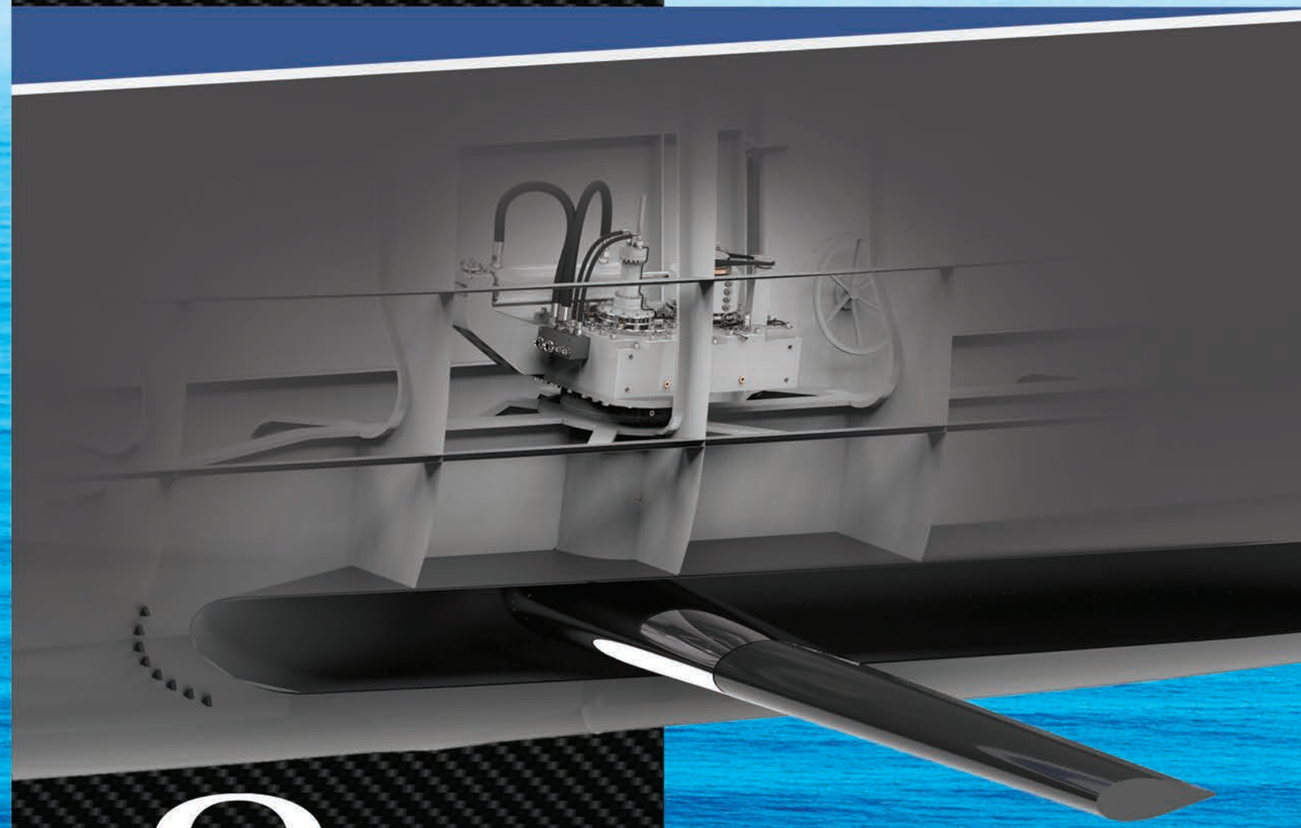
DYNA-FOIL™

THE NEW STABILIZER SYSTEM FROM QUANTUM



Quantum
The Art of Stabilization

A Dynamic Stabilizer System Designed for a Dynamic Environment

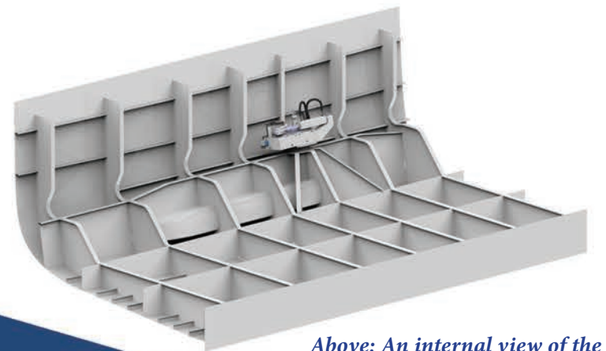
DYNA-FOIL™

"Reduced power requirement means less energy used and reduced impact on the electrical system."

THE NEW STABILIZER SYSTEM FROM QUANTUM

The DYNA-FOIL™ is a NEW dual purpose fully retractable ship stabilizer system that provides exceptional roll reduction for vessels at both Zero Speed™ and underway.

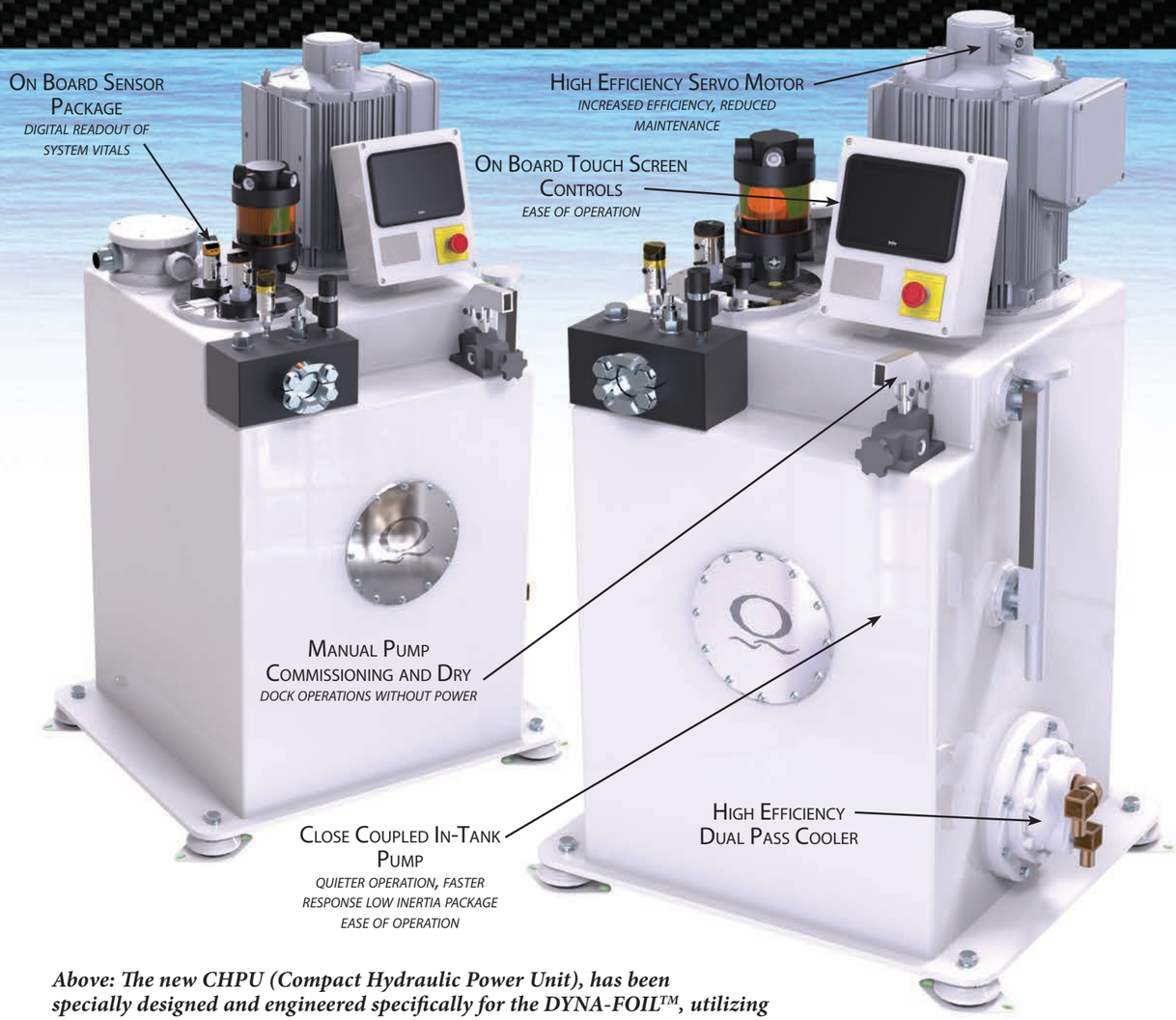
The stabilizer system utilizes a unique foil design that allows for a dynamic self-induced lift for outstanding Zero Speed™ operation. The design features a highly efficient lift to drag coefficient for superior underway operations. These desirable characteristics coupled with Quantum's unrivaled SMC4000 series control system, provides the most technologically advanced stabilizer system in the world.



Above: An internal view of the DYNA-FOIL™ with pocket shown.

Above: An external view of the DYNA-FOIL™ with pocket shown.

Above: The new dual purpose fully retractable DYNA-FOIL™ from Quantum features a dynamic foil providing the highest level of stabilizing performance in the world.



Above: The new CHPU (Compact Hydraulic Power Unit), has been specially designed and engineered specifically for the DYNA-FOIL™, utilizing the latest technology to maximize the efficiency of the system.

THE POWER BEHIND THE FORCE

At the heart of every Quantum system is the hydraulic power source. For the DYNA-FOIL™, Quantum has developed an all new CHPU (Compact Hydraulic Power Unit) that brings together tested and proven hardware with a new approach to power management and power shaving. Through the stored energy accumulators and variable motor control the CHPU can provide power to the DYNA-FOIL™ with extremely low power cycling on the ships net. By use of in-tank (submerged) pumps, airborne noise is reduced without the use of sound shields. Structural borne noise is handled with both mechanical absorption and hydraulic suppression hardware.

Each individual hull unit receives its own stand-alone CHPU complete with touch screen. The touch screen can serve as a user friendly portal for any diagnostic activities that may be required allowing for local and remote control through any Quantum interface on the ship. The system also allows for complete redundancy between hull units.

DYNA-FOIL™

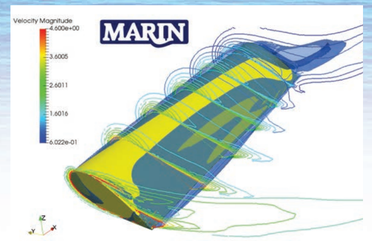
"Simply the next step in high performance stabilization for both underway and Zero Speed™."

Above: A precision built model was used for both underway and Zero Speed™ tank testing.

DESIGN AND TESTING

As with all Quantum products, extensive design, development and testing are critical benchmark in the process. The development of the DYNA-FOIL™ is no exception.

To begin, Quantum performed preliminary tests at ½ scale using an in-house test tank. Quantum then initiated an independent third party model test program at the MARIN[1] (Maritime Research Institute Netherlands)



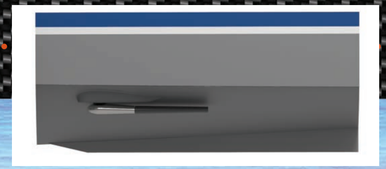
Above: Extensive CFD (Computational Fluid Dynamic) testing was also used to supplement the traditional tank testing to assess the foil performance.

testing facility located in Holland.

Further to the model tank tests, Quantum has worked closely with the MARIN[1] on an extensive CFD (Computational Fluid Dynamic) analysis for the optimum foil and appendage design.

Above: The model used in extensive testing for both Zero Speed™ and underway at the MARIN facility.

Above: Full pocketed version of the DYNA-FOIL™



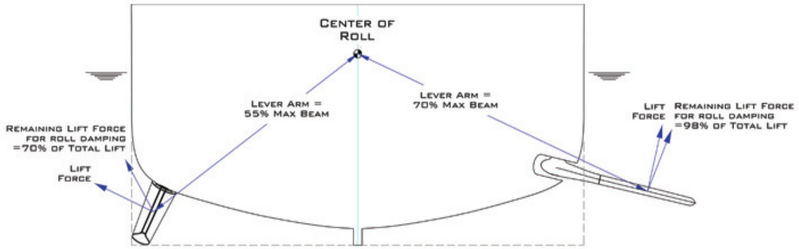
Above: Non-pocketed version of the DYNA-FOIL™

INSTALLATION FLEXIBILITY

To accommodate multiple types of hull designs and various mission profiles, the DYNA-FOIL™ is available in both a full pocketed version and also a non-pocketed version.

Pocketed Version:
For vessels that require ice class classification or have a high block coefficient where an externally mounted appendage is not desirable, Quantum offers the DYNA-FOIL™ in a full pocketed version.

Non-Pocketed Version:
For high speed hard chine vessels where space and weight in the vessel is critical the DYNA-FOIL™ can be supplied in a non-pocketed version. To make this version usable for high speed applications, Quantum has optimized the stowed profile of the unit up to 30 Knots by way of CFD testing.



Above Image: Cross section pictorial view of a hull showing the larger lever arm than that of a fixed fin (XT™ or standard fin stabilizer) along with down angle position relative to the roll center of the vessel.

PERFORMANCE AND EFFICIENCY

Performance/efficiency at Zero Speed™ can be measured by the lift force generated in kN (kilonewton) relative to the area of the foil. It can then be compared to a standard or XT™ fin for bench mark reference.

In the case of the DYNA-FOIL™ there are a number of factors that contribute to the performance and efficiency of the system. Some of the key advantage of the system relative to that of a fixed fin system are noted below:

1. The lever arm is much larger than that of a fixed fin.

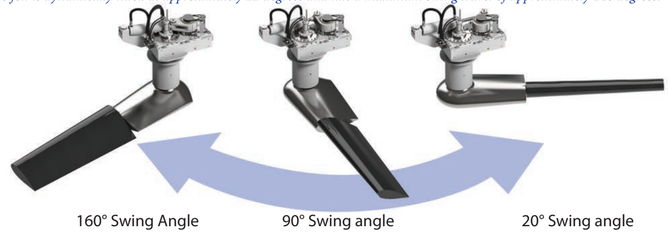
2. The down angle positioning of the hull unit is not governed by the hull profile; therefore attaining the most efficient down angle is generally possible with the DYNA-FOIL™ when it is not with a fixed fin.

3. Higher lift coefficient of the foil compared to that of low aspect fixed fin.

When comparin the DYNA-FOIL™ in terms of foil area to that of a standard fixed fin at Zero Speed™, one needs to include the mechanical advantages the DYNA-FOIL™ has over the fixed fin system in terms of *lever-arm* and *optimized down angle*. While the lift force to foil area of the DYNA-FOIL™ is greater than that of the fixed fin the net result as a stabilizing force can be greater still when all factors are considered.

ZERO SPEED™ MODE

The foil is dynamically tilted at approximately 22 degrees and has a maximum swing travel of approximately 140 degrees.



THE PRINCIPLE OF OPERATION

Zero Speed™:
For Zero Speed™ stabilization, the fundamental operating principles of the DYNA-FOIL™ departs from that of traditional Zero Speed™ stabilizer systems.

A typical low aspect, fixed fin system uses the fin in a paddling action, effectively pushing water to create drag, which when applied at the correct time will provide a counter force to the roll motion of the vessel.

Working outside of this paradigm and counter to that of the fixed fin system Quantum's DYNA-FOIL™ uses the hydrodynamic lift generated by water flow over the profile of the fin to generate force at Zero Speed™.

The foil is positioned at a (dynamically adjustable) angle of attack, then it is swept back and forth through a 140° arc. The swinging action creates water flow over the surface of the foil thus generating a very highly efficient lift force. The direction of swing determines the direction of lift force generated. Both the angle of attack and the swing speed are controlled variables that are adjusted to provide the optimum stabilization. While the concept is relatively simple and very similar to the principles of the MAGlift™ system, the implementation and possibilities for optimization of the system are infinite.

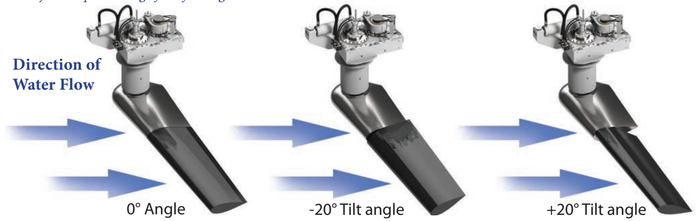
Underway:
With the foil deployed at 90 degrees to the hull center-line, lift is generated much like a traditional fin system, by articulating the foil thus changing it's angle of attack through the water flow and generating lift. Where the DYNA-FOIL™ departs from the norm is twofold:

1. The unique profile of the foil allows a substantial lift force to be generated at low angles of attack where the drag developed is at its minimum; hence maximum lift with minimal drag. This advantage coupled with the mechanical properties of the actuation mechanism, provide for an almost instantaneous positioning of the foil, thus improving lift force timing. This timing in itself, is critical to maximizing the roll reduction with minimal effort.

2. The advanced control algorithms unique to the Quantum SMC4000 series controller lie at the heart of all Quantum's stabilizing systems. In the case of the DYNA-FOIL™ these control functions are front and center in commanding the most precise foil movements critical to handing the lift force requirements with real time feedback.

UNDERWAY MODE

Shows the dynamic positioning of the foil angle.



DYNA-FOIL™

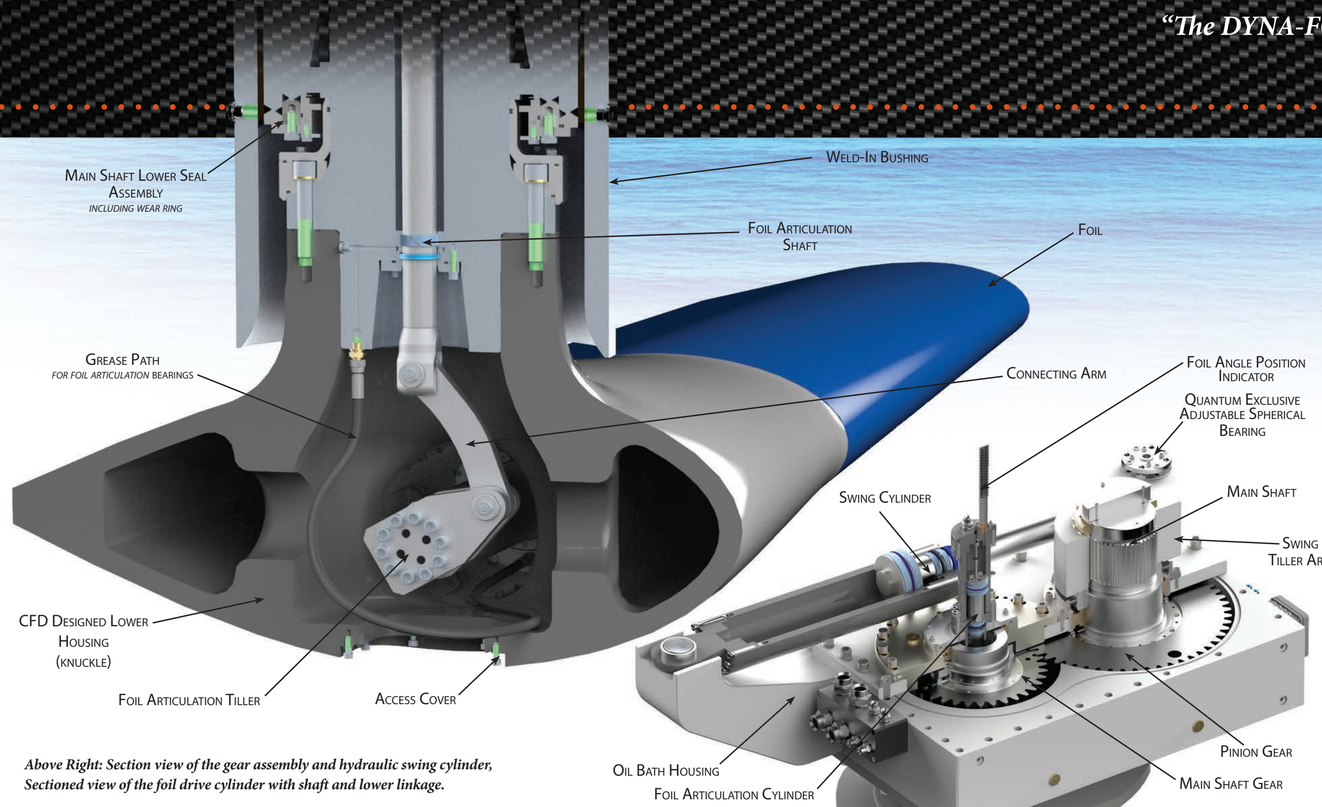
"The DYNA-FOIL™ from Quantum can produce the equivalent of three times the lifting force of a traditional fixed fin and while using less power!"

CUTTING EDGE CONTROL TECHNOLOGY

The DYNA-FOIL™ hull units each have a dedicated compact hydraulic power unit (CHPU). The control system has the ability to start, deploy and activate each hull unit independently, so if a unit is shut down for maintenance or repair the other unit is free to operate allowing for more flexibility. The touchscreen HMI (Human Machine Interface) indicates both the status of each hull unit as well as the standard monitoring conditions of each CHPU.

Zero Speed Image: Shown above is the operator control screen set for action in the Zero Speed mode. In this screen both the foil position and the swing angle are highlighted in blue to indicate that both functions are active. The Zero Speed active mode is highlighted as is the vessels roll angle and speed through the water.

Underway Image: Shown above is the operator control screen set for action in the underway mode. The primary screen shows foil position at 20 degrees +/-. This function is highlighted in blue which means the foil position is currently active. The outer scale shows the foil angle. This is set at 90 degrees when the system is in the underway modes and therefore the scale remains in the inactive grey color but the indicator is highlighted.
This screen also displays the active mode in use as well as the vessels roll angle and speed through the water.



Above Right: Section view of the gear assembly and hydraulic swing cylinder, Sectioned view of the foil drive cylinder with shaft and lower linkage.

PRECISION ENGINEERING

In order for the DYNA-FOIL™ to be fully retractable and yet have the capability to deploy and swing through 140 degrees, the mechanical system must have 165 degrees of swing range. To attain this range of mechanical travel Quantum employs a dual gear system with a single drive cylinder. Simplicity of design with rugged construction being the selection criteria. It should be noted that Quantum employs their specialty expandable spherical bearings at both connections points to the cylinder to increase bearing life and wear properties.

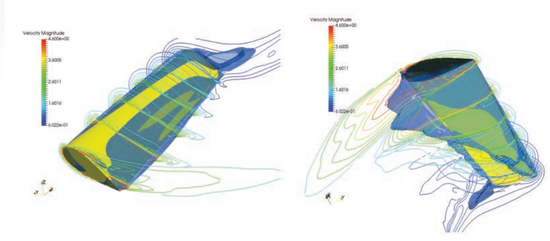
With a backup mechanical locking system, the main cylinder can be removed with the unit retracted while the vessel is either underway or docked. The drive gears are submerged in an oil bath chamber for longevity and quiet operation.

Actuation for the foil is yet another Quantum innovation where serviceability and efficiency are paramount in the design criteria. Unlike the more traditional retractable stabilizers that employ low efficiency rotary actuators with limited serviceability while the vessel is in the water, Quantum has created a unique design that positions a single hydraulic cylinder into the center of the main shaft. Connection to the foil pivot shaft is via a linkage and tiller arm. The cylinder can be completely disassembled with the vessel in the water. The built in LVDT (Linear Variable Differential Transducer) system along with the high efficiency of the cylinder provides for instantaneous and extremely accurate positioning of the foil.

APPENDAGE AND POCKET DESIGNING CRITERIA

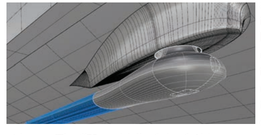
As with any underwater appendage, minimizing drag and reducing cavitation is of paramount concern. With the Dyna-Foil™ there are four distinct regions that have been addressed by way of CFD (Computational Fluid Dynamics) calculations:

- DYNA-FOIL™ deployed: when the unit is deployed the fixed part of the appendage known as the 'knuckle' has to provide the minimum drag profile while at the same time meet the mechanical requirements for loading as well as have suitable volume to house the internal components. To this end the profile optimization can be seen in the image below.



Above Left: Foil showing forward motion. Above Right: Foil showing reverse motion.

- DYNA-FOIL™ retracted: To compound the design requirements for the knuckle, the profile has to be streamlined when in the stowed position. This is critical to avoid harmful cavitation and maintain undisturbed water flow to the propellers. In accomplishing this, Quantum has ensured minimum drag to satisfy ship requirements for maximum design speeds.



Above: The "Knuckle" of the foil has been extensively tested to minimize the possibilities of cavitation and resistance during normal operation.

- The unique profile shown here is known internally to Quantum as the 'pancake' design. The flat shape provides the strength necessary to support the forces and the internal space for the mechanics, but also provides a near perfect profile while either deployed or retracted.

- The Pocket: This is also a vital component in the hydrodynamic design of the system. Although overlooked in the past by many of the established retractable stabilizer manufacturers, the pocket design for Quantum has been front and center from the inception of the product. Show in the attached graphics the inflow and outflow shape is specifically designed to reduce any pressure deviation both when the DYNA-FOIL™ is deployed or retracted. On the leading edge of the pocket vortex generators are carefully positioned to create turbulent flow which will minimize separation of the water from the shell plate in the pocket thus reducing drag and possible cavitation.

While each application can be unique Quantum has developed specific proven design elements that remain the same for each individual application.

- Non-Pocketed Installation: For systems fitted to vessels that do not have a hull pocket (which would be typical for a hard chine hull with a low dead rise angle), it is necessary to create an external fairing around the exposed part of the welding bushing such that a stream line flow path is created around the bushing. As with the pocket, the actual design will change from one hull form to another. However, the fundamental elements of the fairing will remain the same.

[1] *MARIN, the Maritime Research Institute Netherlands, is an independent research and testing facility. QUANTUM is not affiliated with or sponsored by MARIN and QUANTUM makes no express or implied representation whatsoever regarding any endorsement by MARIN to QUANTUM's stabilizer systems, DYNA-FOIL™ or any of the equipment used in connection therewith..*