

DIGITAL SOLUTIONS

# NAUTICUS™ MACHINERY

For marine propulsion design and analysis

DNV GL has a strong tradition of involvement in the development of design-verification methodology and acceptance criteria for shafting systems for ship propulsion. This activity is a consequence of DNV GL's main objectives: to assure safe and reliable operation at sea. DNV GL has done extensive research bridging the gap between shaft design theory and reality.

The Nauticus Machinery software is a set of calculation tools intended for strength assessment of rotating machinery components and systems. The Nauticus Machinery software package includes Shaft Alignment, Torsional Vibration, Gear Faceload, Gear Rating, Shaft Fatigue, Crankshaft Fatigue, Propeller Blade and Controllable Pitch Mechanism. The first two are Class-free for design and troubleshooting; the others are DNV GL Rule or other common rules based.

#### **Technical expertise makes better software**

Nauticus Machinery is developed in close cooperation with DNV GL technical experts and with other major users with extensive knowledge of marine propulsion systems. The software package benefits from continuous improvements based on the latest results from R&D projects and damage experience.

#### **Technical tendency during recent years**

Shaft alignment has in recent years become more of a challenge due to increased power, lower shaft speeds and heavier propellers in combination with a shorter propulsion shaft and more flexible hull structures. Consequently, these effects should be carefully considered when designing an optimal shaft line in order to avoid problems in operation.

The decline of sea ice is creating opportunities, challenges and risk for those looking to access previously unobtainable resources and trade routes. While ice class vessels are becoming more popular, the relevant ice class rules are being significantly updated, especially regarding propulsion machinery. The challenges are evident when designing propulsion machinery for handling ice impact on the propeller. DNV GL's extensive knowledge and experience in this domain is brought into the tailored modules in Nauticus Machinery.

#### **Shaft alignment challenges**

Proper shaft alignment analyses during the design phase help to avoid both delays in delivery and alignment problems in operation, thereby reducing expensive off-hire. Most of the shaft alignment damage cases seem to be related either to fatigue or wiping due to poor lubrication in the stern tube. DNV GL has updated the shaft alignment rules basing on extensive research and measurements carried out in the "FLEX" Joint Industry Project of 2002-2012 and the modification of the rules is intended to insure sufficient lubrication in stern tube bearing. DNV GL has in-house multidisciplinary technical knowledge and experience and is therefore a preferred active partner for



finding the underlying reason for damage caused by shaft alignment and for providing assistance in shaft design.

#### **Nauticus Machinery - Shaft Alignment**

Shaft Alignment provides efficient methods to build a shaft model and analyze bearing loads, bending moments, deflections and more. It also provides customised verification results such as hydraulic jacking curves and gap/sag values in flanged connections. Whirling and axial vibration analysis is also covered. It provides the after-stern tube bearing lubrication analysis from two aspects: calculating the required minimum shaft rotational speed to insure the sufficient lubrication; calculating the oil film pressure and thickness distribution inside the after stern tube bearing to find the maximum pressure and minimum thickness.

#### **Nauticus Machinery - Torsional Vibration**

Torsional Vibration is a state-of-the-art tool for analysis of vibratory levels in marine propulsion systems (diesel, electric, gas or steam powered). It contains a powerful mass-elastic modeller, scripting functions and advanced charting and reporting. It calculates the free vibration and forced vibration. Both frequency domain calculation and time domain calculation can be performed for the same model. Frequency domain calculation is for analysis of steady-state vibration while the time domain calculation is tailored to handle shaft line transient dynamic analysis regarding the propeller ice torque excitation.





### **Nauticus Machinery - Shaft Fatigue**

Shaft Fatigue is a rule-based calculation tool for validation of fatigue life and safety factors in steel shafts according to DNV GL Rules, Class Guidelines 0038 and IACS UR M68. The tool calculates the maximum stress limits for high-, low- and transient cycle fatigue which can be applied as acceptance criteria check in Nauticus Machinery - Torsional Vibration. It also has support for ice-class calculations and corresponding parts of DNV GL Ice Class Rules (which is equivalent to the IACS Polar Ice Class Rules and Finnish-Swedish Ice Class Rules) and Class Guidelines 0041 (Ice strengthening of propulsion machinery).

### **Nauticus Machinery - Gear Faceload and Gear Rating**

Gear Face load evaluates the face load factor for parallel axis spur and helical gears based on the graphical method (iterative analytical method) outlined in DNV GL Class Guidelines 0036. The face load factor takes into account the effects of the non-uniform load distribution across the gear face width on the surface stress.

Gear Rating is intended for cylindrical and bevel gears. The calculation procedures cover gear rating as limited by contact stresses, subsurface fatigue, tooth root stresses and scuffing resistance. The tool also support fatigue strength analysis due to ice impact loads for ships with ice-class. The calculation methods are according to DNV GL Ice Class Rules (which is equivalent to the IACS Polar Ice Class Rules and Finnish-Swedish Ice Class Rules) and Class Guidelines 0041 (Ice Strengthening of propulsion machinery).

### **Nauticus Machinery - Propeller Blade**

Propeller Blade is developed in close cooperation with DNV GL Approval Center and the calculation methodologies are based on the latest DNV GL rules. It helps you improve propeller design by calculating lifecycle and safety against fatigue damage in propeller blades and tunnel thrusters. The ice class strength requirements according to the latest common ice class rules (IACS Polar Ice Class Rules and Finnish-Swedish Ice Class Rules) have also been taken into consideration.

### **Nauticus Machinery - Crankshaft Fatigue**

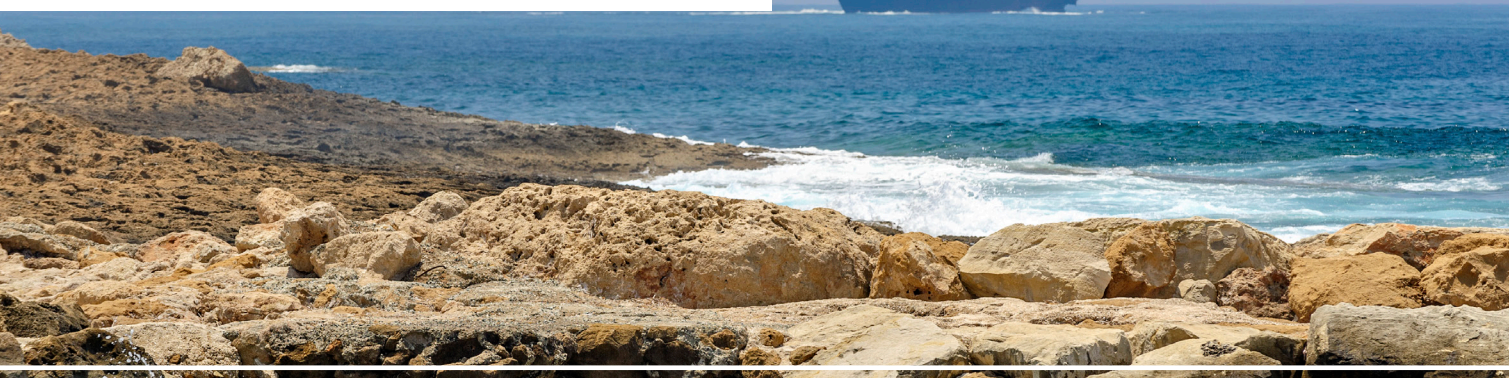
Crankshaft Fatigue is a rule-based calculation tool for calculation of safety against fatigue failure in pin and journal fillets and in oil bores, as well as safety against slippage for semi built crankshafts. The calculations methods are according to IACS and DNV GL Rules.

**“Nauticus Machinery is a very easy and convenient tool. The result of shaft alignment calculation by Nauticus Machinery is reliable. These characteristics help us calculate many operating conditions very easily.”**

**Senior Engineer K.M. Hwang at Hyundai Heavy Industries**

"As the number of Nauticus Machinery users is increasing in China, DNV GL have earned a good reputation in the industry. DNV GL is a trustworthy partner."

Sun Xun, Senior Engineer, Hudong Heavy Machinery



### Nauticus Machinery - Controllable Pitch Mechanism

Controllable Pitch Mechanism is developed in close cooperation with DNV GL Approval Center and the calculation methodologies are based on the latest DNV GL rules. It calculates the strength capacity for the components in pitch control mechanism and propeller hub. Both basic strength capacity and ice class (Finnish-Swedish ice class and IACS Polar ice class) strength capacity are analyzed.

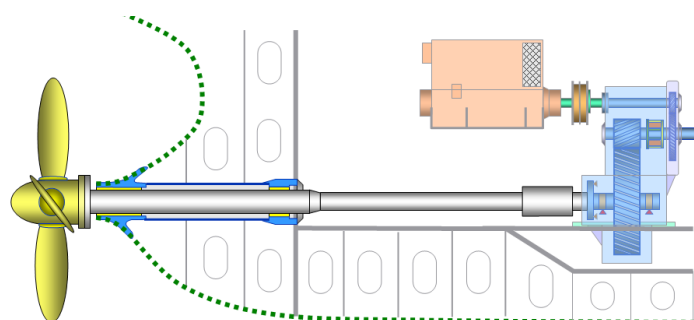
### Project Manager and collaboration

Project Manager acts as the common entry point to all available calculation tools in Nauticus Machinery. It provides a scalable deployment model where users can install the calculation tools and database on the same physical computer, or work towards a central/remote database. With the Project Manager, it is easy to organise calculations, notes, spreadsheets and attachments in one common user interface. In-house spreadsheets and tools can easily be integrated in the Tool Library which provides a simple role-authentication and revision control for your calculation tools.

### Training, conferences, seminars and workshops

DNV GL - Digital Solutions organises user conferences, seminars and workshops worldwide, providing a unique opportunity to communicate with our users and receive valuable feedback.

Our training catalogue includes open courses in all regions, and customers can request customised training. Many of the courses are held jointly by our own software support team and by engineers from DNV GL who bring essential domain expertise.



### NAUTICUS MACHINERY CONFIGURATION

Nauticus Machinery is a market-driven modular software system enabling users to configure the package based upon their needs. Some manufacturers are involved in all the components in a propulsion system, i.e. propeller, shafting, gears, couplings, dampers and engines, while others are specializing on single components.