

## NORSEPOWER ROTOR SAIL SOLUTION

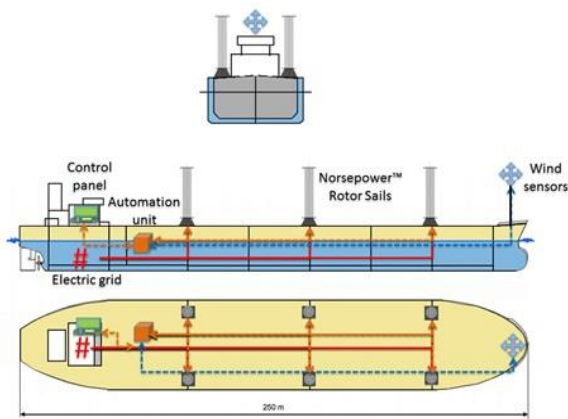
### Overview

Norsepower's Rotor Sail Solution technology harnesses wind to maximise cargo ship fuel efficiency. When wind conditions are favourable, the Rotor Sails allow the main engines to be throttled back, saving fuel and reducing emissions while providing the power needed to maintain speed and voyage time. Rotor sails can be used with new vessels or retrofitted to existing ships. The Norsepower Rotor Sail Solution is particularly suited to the tanker, Ro-Ro, general cargo and bulk carrier markets, as well as cruise, ferries, and RoPax.

The Norsepower Rotor Sail Solution technology is based on the concept of a Flettner rotor, which has been completely modernised by using composite materials and advanced control systems.

The Norsepower Rotor Sail Solution is best suited to vessels where:

- The required installation space is available on deck
- Cranes and cargo handling equipment do not prevent the installation of Rotor Sails
- There is a high proportion of time-at-sea, and the prevailing wind conditions are favourable.



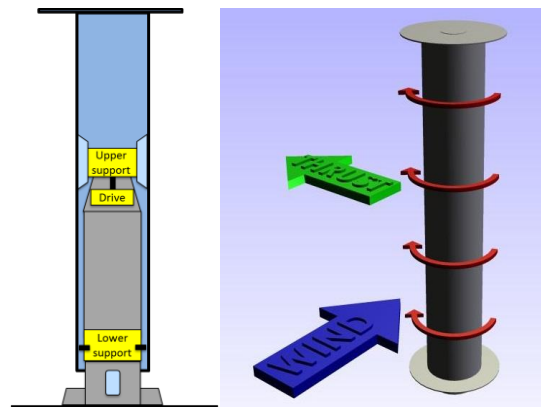
The essential parts of the Rotor Sail Solution are:

- Norsepower Rotor Sails, which deliver the forward thrust
- A control panel, which gives the captain full control of the operation and performance of the Norsepower Rotor Sail Solution
- A fully automatic control system, which optimises the forward thrust of the Rotor Sails
- A low-voltage electrical power supply to each Rotor Sail.

The required number and size of Rotor Sails is based on the size, speed, and operating profile of each vessel.

### Configuration

Norsepower Rotor Sails are available in three sizes with different Rotor Sail heights of 18, 24 or 30 meters. The operating principle of the Norsepower Rotor Sail is shown in the following pictures.



### Installation

The Norsepower Rotor Sails are installed on the deck of the vessel with vessel-tailored foundations, which are installed during a yard stay. The rotors are installed on the foundations with a bolt connection. When the installation of the foundations has been completed, the rotors can be lifted on the vessel and attached to the foundations during a normal harbour stay.

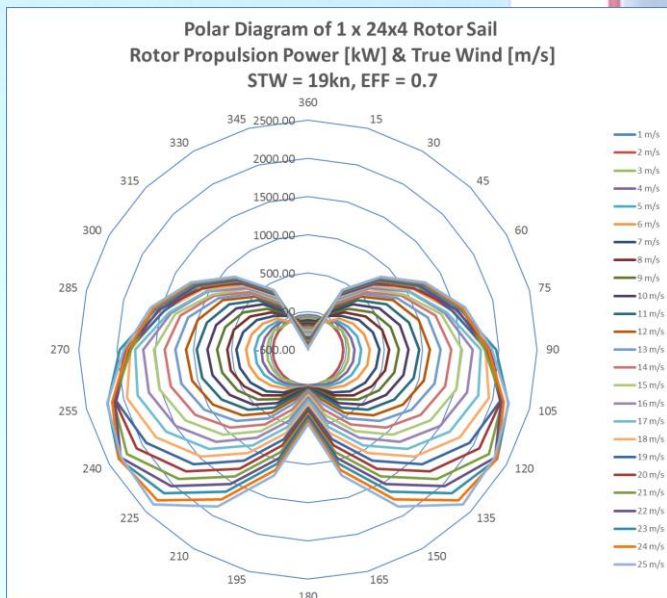
### Operation

The crew is able to control the solution from the bridge through the Norsepower Control Panel. After initiating with a push button start, the solution is fully automated and senses whenever the wind is strong enough to deliver fuel savings, at which point the Rotors start automatically, minimising crew time and resource.



## Norsepower Rotor Sail Technical specifications

Model	18 x 3	24 x 4	30 x 5
<b>Rotor</b>			
Rotor height x diameter [m]	18 x 3	24 x 4	30 x 5
Material	GFRP/CFRP sandwich	GFRP/CFRP sandwich	GFRP/CFRP sandwich
Rotor speed [rpm]	0-250, variable	0-225, variable	0-180, variable
Lightning conductor / Ice prevention	Yes / Optional	Yes / Optional	Yes / Optional
<b>Support structure</b>			
Tower	Cylindrical/conical steel structure,	Cylindrical/conical steel structure,	Cylindrical/conical steel structure,
Foundation height (typical) [m]	2	2.5	3
Weight incl. typical foundation [tons]	27	34	49
<b>Drive</b>			
Electric motor	55 kW, 50/60 Hz IE4, IP55	90 kW, 50/60 Hz IE4, IP55	110 kW, 50/60 Hz IE4, IP55
Variable speed drive	ABB, Siemens or similar (400/440V)	ABB, Siemens or similar (400/440V)	ABB, Siemens or similar (400/440V)
Brake resistor / Mechanical lock	Yes / Optional	Yes / Optional	Yes / Optional
<b>Control system software</b>			
Hardware	Beckhoff/Siemens/similar automation, distributed system	Beckhoff/Siemens/similar automation, distributed system	Beckhoff/Siemens/similar automation, distributed system
Condition Monitoring System	Yes	Yes	Yes
Hydraulic Tilting mechanism	Optional	Optional	Optional
ATEX compliant design	Optional	Optional	Optional
<b>Ambient conditions</b>			
Operational temperature	+50 - -30C	+50 - -30C	+50 - -30C
Operational wind speed range	0-25 m/s	0-25 m/s	0-25 m/s
Survival wind speed	70 m/s	70 m/s	70 m/s
<b>Thrust (max. continuous)</b>	100 kN (limited)	175 kN (limited)	270 kN (limited)



The Polar diagram displays the thrust produced by the Rotor Sail in propulsion power equivalent kW's for different true wind angles and speeds for a ship sailing at 19 knots. In this example, a thrust force equivalent of approximately 2000 kW or more of propulsion power is produced when the true wind speed is more than 22 m/s and the true wind angle is 105 – 135 or 225 – 255 degrees from the bow. Correspondingly, more than 500 kW of propulsion power is produced with 10 m/s and 60 – 130 or 230 – 300 degrees from the bow.

### TYPICAL SCOPE OF SUPPLY

#### Rotor Sail delivery (one ship set) includes:

- Rotor Sail units assembled ready for installation
- Norsecontrol automation system
- Supervision of installation and commissioning
- Project management

#### Rotor Sail delivery excludes:

- Manufacturing and installation of foundations
- Ship cabling and connection of cables from ship to Rotor Sail
- Mechanical installation work and crange
- Transportation of components to the installation location

#### Remote service support agreement includes:

- Spare parts (excluding rotor and support steel tower)
- Remote monitoring with monthly reports
- Remote expert support for possible troubleshooting and corrective maintenance work
- One day of training for ship's crew and technical superintendents during the Rotor Sail installation and commissioning phase

#### Remote service support agreement excludes:

- Transportation costs for spare parts to the vessel or warehouse
- Installation or service work onboard the vessel
- Travel costs