



MARINE SHAFT POWER METERS

The Ultimate Guide

INTRODUCTION

In an effort to optimize their operations, vessel owners and managers in the marine industry are moving more towards a “Smart” fleet, with various sensors providing the data needed to save fuel, reduce emissions, and extend maintenance intervals. One key piece of technology that helps do this are marine shaft power meters.

Shaft power meters help reveal the true mechanical horsepower, torque, speed, and thrust on a propulsion shaft. Their use spans decades in the marine industry with the technology on thousands of vessels.

With so many options for shaft power meters available in the market, the task of finding and selecting the right one can be daunting. In this guide, we help simplify the process by answering some common questions, including the different types of meters, the benefits you can expect once installed, selection considerations, and more.

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Frequently Asked Questions

How does a marine shaft power (torsion) meter work?

A marine shaft power (torsion) meter measures the real time torque (torsion), speed, and power output on a propellar shaft. When torque is applied to a shaft, a small amount of strain or “twist” occurs on the shaft surface. A shaft power meter measures this strain on the shaft with a sensor and wirelessly transmits the signal to a stationary receiver, which processes and calculates a torque value based on the mechanical properties of the shaft. The torque measurement is then combined with a speed measurement (usually measured with a built-in tachometer) to calculate power. Power is nothing more than a simple multiplication of torque, speed, and a factor depending on the desired units:

Power (HP) = Torque (ft-lbs) x RPM / 5252

Power (kW) = Torque (Nm) x RPM / 9550

Because of the close relation between power and torque, the name “shaft power meter” is often used interchangeably with “shaft torque meter” or “shaft torsion meter”. Both torque and power can be important values depending on the application.

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What are the different components of a marine shaft power (torsion) meter system?

There are three primary components of a marine shaft power meter system: 1) A sensor 2) A transmitter, 3) A receiver. The sensors have the sole purpose of converting the twist on the shaft to an electrical signal. The transmitter energizes the sensor and wirelessly transfers the signal from the sensor off the shaft. Usually the transmitter (and sometimes the sensor) is embedded into a structure that is mechanically fastened to the shaft. The receiver is stationary (non-rotating) and within close proximity to the transmitter. The primary job of the receiver is to receive the signal from the transmitter, process the signal and output it in a data output format that is acceptable to the end user. In systems designed for long-term monitoring, the receiver also energizes the transmitter via an inductive link. By placing the hard-wired stationary receiver a close distance to the rotating transmitter, a magnetic field “induces” current into the circuitry that powers the rotating transmitter.

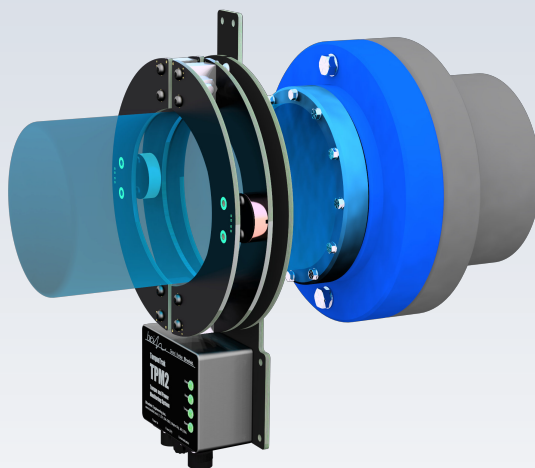


Figure 1. *The TorqueTrak TPM2 shaft power meter from Binsfeld Engineering.*

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Marine shaft power meters are commonly used in conjunction with other accessory items as well. These include displays of the data for the engine control room or bridge, fuel flow meters, and/or cloud-based software to remotely access and monitor the data. Combining all of these elements together helps provide a full monitoring solution that enables real-time tracking of engine efficiency and other Key Performance Indicators over time.



Figure 2. A fuel flow meter (left) and an engine control room display (right), commonly used in conjunction with a shaft power meter.

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What are the different types of marine shaft power (torsion) meters?

Marine shaft power meters generally come in two different categories – portable meters meant for short-term measurements during sea trials and permanently installed meters meant for continuous monitoring of torque and power. Portable meters are usually battery-powered and capable of being installed quickly on variety of different shaft sizes. Permanent marine shaft power meters are typically inductively-powered, allowing for continuous operation without the need to switch out batteries. They are usually specifically manufactured to the diameter of the shaft, although some manufacturers are starting to introduce modular systems that are attached to the shaft by chain links, allowing for easy interchangeability between shaft sizes. Due to the benefits they offer in terms of accuracy and fuel savings, the most popular shaft power meters in the marine industry are permanently installed systems.

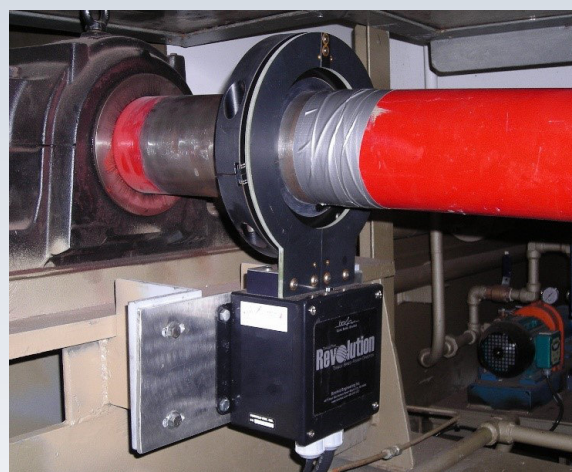


Figure 3. A portable battery-powered system (left) and a permanently installed inductive system (right).

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The primary difference between the various types of permanently installed shaft power meters is the method they use to sense strain (torque or “twist”) on the shaft. The most common methods include: optical, magnetic, and strain gages.

Optical

Optical systems rely on 2 bars that are bolted onto the shaft and aligned at a close distance from each other. A light is modulated between the two bars. As the shaft twists, the strength of the light changes which can be directly related to the amount of torque on the shaft. The advantage of these systems is that they are usually capable of detecting strain in multiple directions, meaning they can inherently measure torque and thrust with relative ease. However, this comes at the expense of decreased accuracy since the point of measurement is at a point removed from the actual shaft surface. The systems are also prone to picking up unwanted measurements (such as vibrations) and can be expensive.

Magnetic

In these systems, a magnetic band is strapped along the surface of the shaft. When torque is applied, the magnetic moments inside the shaft are reoriented, causing a magnetic flux to develop around the circumference of the shaft. The strength of the magnetic flux field is linearly proportional to the stress — and therefore, the torque — on the shaft, and the polarity of the magnetic field indicates the direction of torque. Magnetic field sensors positioned around the shaft determine the amount and direction of torque based on this flux. Systems that utilize this method tend to be relatively inexpensive and easy to setup. Getting bands to adhere perfectly to the shaft is virtually impossible, however, which induces a level of uncertainty into the measurements and decreases the overall accuracy.

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Strain Gage

Strain gage- based sensors rely on a grid of metal foil bonded directly to the shaft. The instrumentation, i.e. transmitter, is connected to the gage and applies a voltage through the grids. As the shaft twists under load the grids or elements are stretched or compressed and change resistance which changes the voltage measured by the transmitter.

Strain gages are very precise, although more care needs to be taken during the installation process to ensure the gage is adhered and environmentally protected. Due to their accuracy, strain gages are typically considered the golden standard for propulsion shaft torque measurement, commonly referenced in a variety of international standards.

Sensing Method	Strain Gage	Optical	Magnetic
Advantages	Very accurate Industry standard Fits small spaces (<152mm/6")	Bolt-on system No chemicals required	Bolt-on system No chemicals required
Disadvantages	Installation process can be tedious Requires chemicals that expire	Expensive Susceptible to unwanted measurements (vibration, etc) Requires >305mm/12" of available shaft space	Not capable of thrust measurement Requires >6" of available shaft space
Ease of Install	Med	High	Med
Accuracy	High	Med	Low
Cost	\$\$	\$\$\$	\$
Required Shaft Space	Low	High	High

Figure 4. Comparison of the three most common types of shaft power meters.

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How much do marine shaft power (torsion) meters cost?

The cost of a marine shaft power meter depends on a variety of factors including shaft size, required accessories and whether or not installation and commissioning support is needed. The table below includes ranges for the most common expenses of a marine shaft power meter installation:

Item	Cost Range	Notes
Shaft Power Meter	\$9,000-\$12,000 per shaft	Usually depends on diameter
Install & Commissioning	\$800-\$1500 per day	1-2 days typical for most installs
Engine Control Room Display	\$1000-\$3000	One usually accommodates multiple power meters
Fuel Flow Meter	\$1000-\$4000	Depends on class certification requirements. Two needed per engine.

Figure 5. *Most common expenses to a marine shaft power meter installation (Prices in USD, as of January 1, 2020).*

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What are the benefits of using a marine shaft power (torsion) meter?



The key value proposition for any shaft power meter is that it provides an accurate, real-time, method for monitoring the shaft power on a vessel via a direct measurement of torsion on the propulsion shafting. Direct measurements of power can be 10-20% more accurate than engine estimations.

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Fuel and power measurements provided by diesel engines originate from a theoretical “baseline” propulsion efficiency curve developed by the engine manufacturer. The baseline curve is theoretical and indirect, meaning the values are extrapolated from other measurements (such as electrical current). While the measurements may be somewhat accurate initially, their accuracy decreases over time. They do not take into consideration degradation of engine components over time, varying sea conditions, or the presence of inefficiencies such as hull fouling. To quantify this accurately, you need direct measurement. (More on this in our blog post [Theoretical vs True Mechanical Torque](#)).

Making vessel efficiency decisions based on inaccurate data leaves efficiency gains on the table. Implementing direct power measurements eliminates the guess work and helps vessel owners and managers make decisions that maximize efficiency.

More accurate measurements of vessel horsepower and torque have been shown to:

1. Increase maintenance intervals by up to 50%. Through accurate measurements of real-time horsepower and/or other KPI's such as Specific Fuel Oil Consumption, owners can delay maintenance on an engine until truly necessary.
2. Reduce fuel costs by 5%, or more. This can be accomplished in several ways. Shaft torque/thrust measurements can help identify hull and/or propeller fouling at the on-set. Un-checked fouling has been shown to increase fuel burn by 5%. Additionally, monitoring shaft horsepower compared to a theoretical baseline efficiency curve established by the manufacture can help determine when inefficiencies are present.

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What are common applications where marine shaft power (torsion) meters are used?



There are a variety of applications where marine shaft power meters provide significant value in the marine industry. First of all, marine shaft power meters can be used to help troubleshoot propulsion problems. In these situations, specialized consultants with portable meters are brought in to characterize the performance of a propulsion system. A common problem involves a new build or retrofit vessel not achieving rated performance and it is suspected that either the propeller is designed incorrectly or the engine is not generating the horsepower it should. A power meter is used due to its high accuracy in obtaining the actual horsepower at the shaft to help determine whether the problem is with the engine or with the propeller. Another problem that occurs is the presence of excessive vibration on the driveline. In this situation, a torsion meter with a high sampling rate will be used to quantify the presence of torsional vibrations, which are a common cause of premature failures on rotating equipment.

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Another common application for shaft torsion and power meters is demonstrating compliance to various regulatory and/or class certification requirements. A few of the most prevalent are as follows:

- 1. EU Common Fisheries Policy.** Under European Commission Regulations fishing vessels are obliged to verify the declared engine power of fishing vessels to ensure compliance with the rules of the Common Fisheries Policy. The engine power of a fishing vessel (usually in kW) is recorded for the Maritime Coastguard Agency (MCA) Registry and fishing vessel licensing. It is prohibited to fish with a vessel that is equipped with an engine whose power exceeds the one specified on the fishing license. Horsepower is commonly measured during a Bollard Pull Test.
- 2. MARPOL ANNEX VI - Measuring Emissions Standards.** The Annex is a directive from the International Maritime Organization (IMO) that regulates the emissions of diesel engines and engine efficiency is a key performance measurement. The EEDI (Energy Efficiency Design Index) is a key measure that demonstrates compliance to this requirement. It measures the theoretical CO₂ emission performance of new ships over 400 gross tonnes and is calculated from ship design and engine performance data. The Engine Efficiency (or Specific Fuel Oil Consumption) is commonly measured using a shaft power meter along with fuel flow meters, to demonstrate compliance to this requirement.
- 3. ABS Class Certification.** Ships that are built to ABS standards are required to have torsional vibrations on the propulsion system analyzed. A shaft torsion meter is typically used to measure these torsional vibrations on the propeller shaft to ensure that there does not exist vibration modes that can cause premature failures.

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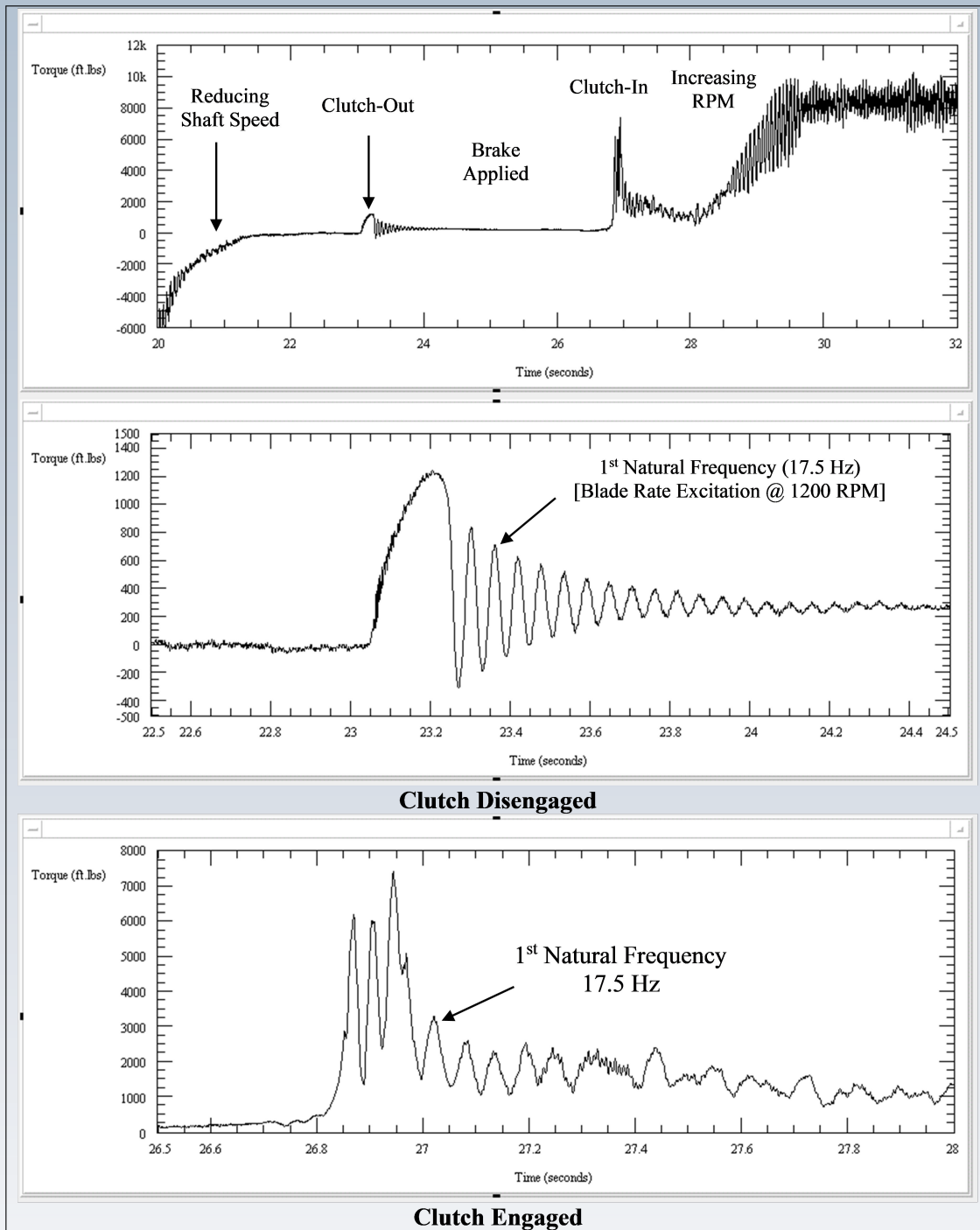


Figure 6. A plot of torsional vibration testing during a sea trial of an ABS class-certified vessel.

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How accurate are marine shaft power (torsion) meters?

We have already established that the primary benefit of marine shaft power meters is that they provide an inherently more accurate way of determining torque and horsepower than engine estimations but just how accurate are they? The short answer – usually 3%-5% (or better). The longer answer requires an explanation of the three primary sources of error: Instrumentation accuracy, calibration uncertainty, and assembly uncertainty:

Instrumentation Accuracy

The instrumentation accuracy between shaft power meters tends to be relatively consistent and quite precise (within .1-.3%). This is because the main source of this error are the electronics of the meters, which tend to be similar between meters. Of this error range, the most significant contributors have to do with the impact of temperature and non-linearity.

Calibration Uncertainty

Uncertainty in the calibration is the largest contributor to error in any shaft power meter. Shaft power meter calibration is the process of correlating an electrical measurement of a sensor to a physical torque or power value. The “Full Scale” output of the power meter (usually quantified in bits or volts), corresponds to a given torque and/or power value. This value is established by using an equation that relates the sensor to the shaft parameters (see figure 7 on next page for an example). Error is introduced due to uncertainties in the inputs to the calculation (such as exact shaft diameter, gage factor, Poisson’s ratio, and modulus). Aside from physically testing the shaft material in a laboratory, there’s no way of knowing exactly what this will be for a given installation and it is possible the parameters are exact. This is why it’s

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referred to as uncertainty, as opposed to accuracy. Generally speaking, one can expect a 3%-5% error if these parameters are not known to a high degree of confidence.

$$\frac{(S_{\text{Trans}})(\pi)(E)(4)(D_o^4 - D_i^4)}{(GF)(N)(16,000)(1+\nu)(D_o)(12)} = T_{\text{Full Scale}} \text{ (ft-lb)}$$

Legend of Terms	
D_i	Shaft Inner Diameter (in) (zero for solid shafts)
D_o	Shaft Outer Diameter (in)
E	Modulus of Elasticity (30×10^6 PSI for steel)
GF	Gage Factor (specified on strain gage package)
S_{Trans}	Transmitter sensitivity (mV/V) (not user configurable); Typical is 1 mV/V for ± 500 microstrain range
N	Number of Active Gages (4 for torque)
$T_{\text{FullScale}}$	Full Scale Torque (ft-lb)
ν	Poisson's Ratio (0.30 for steel)

Figure 7. A typical equation for calibration of a strain gage based shaft power meter.

Assembly Uncertainty

Assembly uncertainty is error introduced by how far removed the shaft sensor is from the shaft surface. When a sensor is bonded to the shaft (such as with a strain gage), the amount of twist/strain on the shaft is sensed directly and the assembly uncertainty is essentially zero. When sensors are further removed from the shaft surface through a series of mechanical connections (such as with a bolt-on optical system), this error increases.

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What needs to be considered when selecting a marine shaft power (torsion) meter?

Selection of the appropriate marine shaft power depends on the specifics of the application. Below is a list of common considerations:

1. *Measurement Duration.* If the measurements are for short-term testing (days), a battery-powered portable system should be selected. If measurements are needed long-term (months-years), inductively powered permanent systems should be explored. Some manufacturers also provide portable units with the option for inductive power, which is ideal for mid-term (weeks) testing.
2. *Desired Measurements.* Most shaft power meters include shaft torque, speed, and power as default outputs. Thrust measurements can be included as an option for many systems, at an increased cost.
3. *Sensor Type.* Although this was covered in a previous section, it is still worth noting that this is the main differentiator between shaft torsion meters. The selection requires carefully weighing the tradeoffs between cost, ease of install, and accuracy.
4. *Shaft Diameter.* Marine shaft power meters have a minimum shaft diameter they can accommodate (usually no less than 152mm/6"). This becomes an important consideration for vessels with smaller shafts. If a diameter less than this is needed, the options become limited.
5. *Desired Data Output.* Shaft power meters come in a wide variety of data outputs, the most common being RS-485/MODBUS. Standard Analog Outputs are also available including 4-20 mA and +/- 10VDC. Digital signals tend to be more robust, less susceptible to noise, and more stable over time (reducing the need for re-calibration).

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6. *Available Shaft Space.* The amount of shaft available is an important consideration. The rotating sensor/transmitter assembly needs to physically fit on the shaft, while at the same time, allow for a robust signal path to the stationary receiving unit. Clamp-on optical systems usually require significantly more shaft space (>305mm/12") than surface-mounted strain gage telemetry systems (152mm/6" or less).

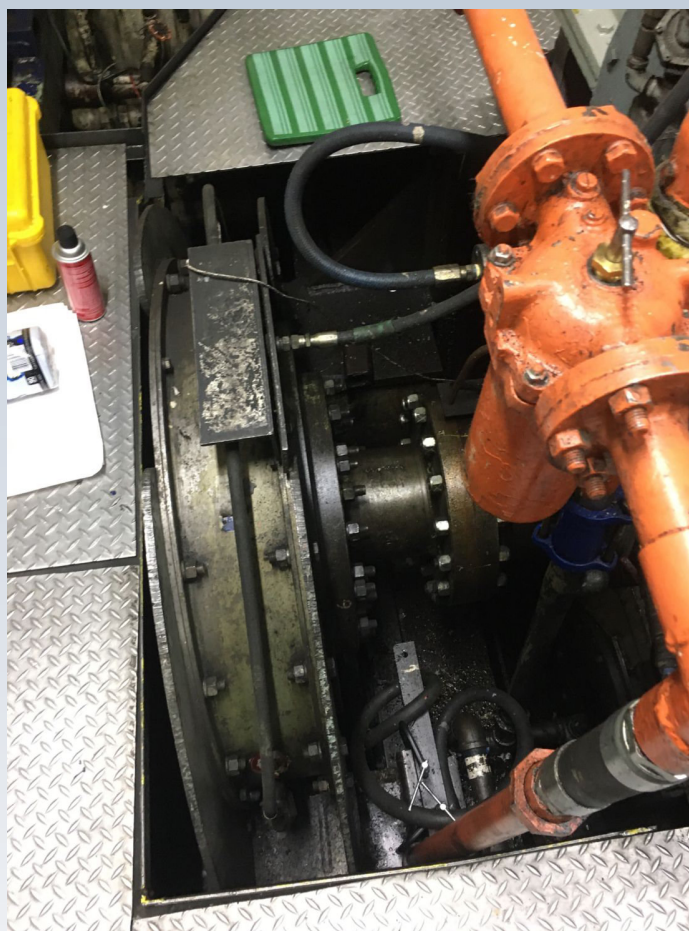


Figure 8. *Smaller vessels, like this tug, have limited available shaft space. This makes it difficult for many shaft power meters to physically fit onto the shaft.*

Binsfeld Shaft Power Meters

TorqueTrak Solutions In The Marine Industry

Binsfeld shaft power meters include the TorqueTrak 10K, TorqueTrak Revolution, and TorqueTrak TPM2. The TorqueTrak 10K is a robust battery-powered, portable unit that has been used by consultants for over 10 years to provide reliable torque data from a shaft. It is compatible with the OPDAQ Field Test 2 Data Acquisition system. The TorqueTrak Revolution and TorqueTrak TPM2 are inductively-powered systems designed for continuous measurement of torque, speed, shaft direction, and power. All products are made in the USA - designed to be robust, easy-to-install, and highly accurate.

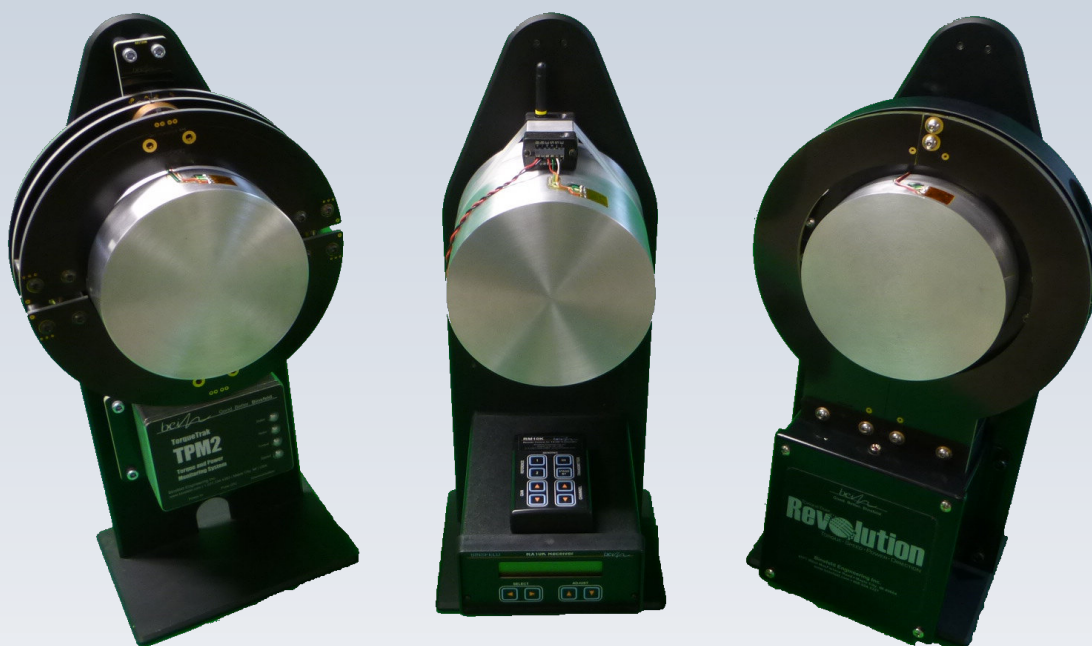


Figure 9. Binsfeld Engineering's line of marine shaft power meters (left to right): TorqueTrak TPM2, TorqueTrak 10K, and TorqueTrak Revolution.



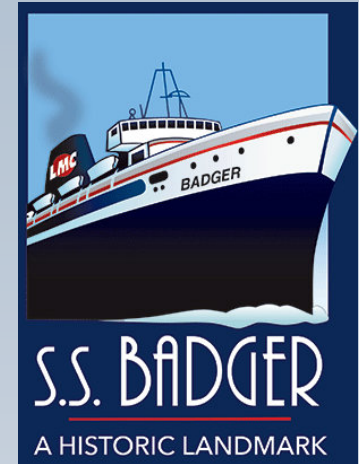
CASE STUDY

ENGINE HORSEPOWER VERIFICATION
ON A STEAM-POWERED VESSEL

The Client

SS BADGER

The S.S. Badger is a passenger and vehicle ferry that has been in service since 1953. Currently, she shuttles across Lake Michigan between Manitowoc, Wisconsin and Ludington, Michigan. What makes her unique is this: she is the very last coal-burning steamship in service in North America.



The Challenge

ENVIRONMENTAL REGULATIONS



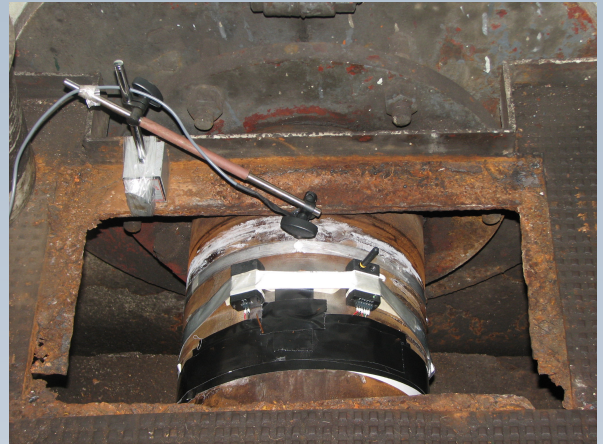
Due mostly to environmental regulations, burning coal on the Great Lakes has become prohibitively expensive. The owners, Lake Michigan Carferry Service were considering replacing the steam engines with modern engines, and needed to know what size engine they needed. The old

steam engines were rated (60 years ago) at 3500 Hp each, 7000 Hp total for the vessel. Does the ship need all that Power? How much Power does she use now during normal operation and the routine crossing of Lake Michigan? The ramifications of the engine size are significant, with more horsepower costing significant money.

The Solution

THE TORQUETRAK 10K

The **TorqueTrak 10K** and **OPDAQ Field Test 2** were selected to provide high-accuracy torque and power measurements on each of the propeller shafts during normal operation. Each TorqueTrak system utilized a torque-pattern strain gage sensor from **Vishay Micro Measurements**.



The Impact

REDUCED OPERATIONS COST



The results were quite interesting and exactly what the Chief Engineer had expected. Normal Operating Power for the steam engines was about 1700 Hp per shaft, 3400 Hp total. Max Power output of the engines was about 2500 Hp per shaft, 5000 Hp total.

With the power data in-hand, the ship owners were empowered to make a cost-effective decision for their ship. Instead of purchasing a pair of 3500 horsepower engines, the owners could purchase a pair of 2500 horsepower engines, and still get the job done. The data quite literally saved the ship owner **thousands of dollars**, helping **reduce operation costs** of their vessel.



CASE STUDY

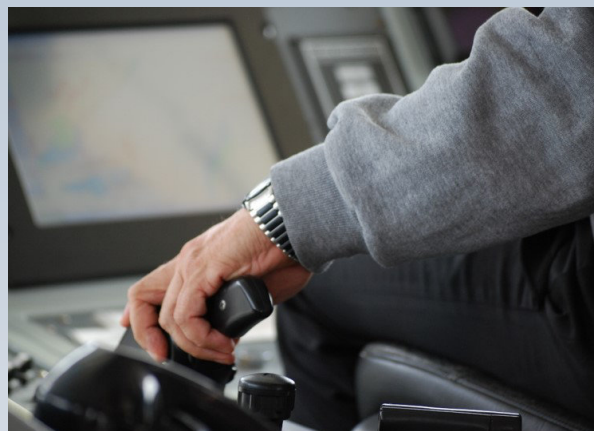
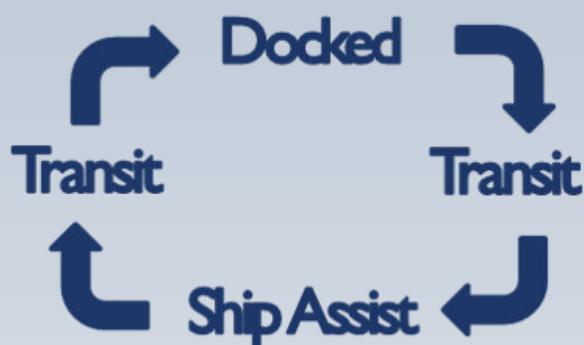
Harbor Towing Optimization

Background

Increasing Efficiency During Transit

With increased emissions regulations and rising fuel costs, vessel owners are constantly looking for ways to reduce fuel consumption of their fleet and tugboats are no exception.

In a typical tug operation, there are 2 basic modes of operation: in-transit and ship assist. The only valuable work is during the ship assisting. Transit is an unfortunate necessity.



Tugboats are not designed to be efficient at high speeds. When in transit between the dock and the vessel to be assisted, there is no advantage for the tugboat to sail at high speed but they are often operated too fast, leading to a higher fuel consumption than is necessary. Some shipowners try to set speed limits, but without monitoring it is unsuccessful. Operating crews reduce their speed but after a couple weeks, old habits come back and they are back to the starting point. To monitor effectively, it is critical to measure the fuel consumption in transit. This is where the Binsfeld Vessel Performance Monitoring system comes in - allowing for seamless measurement of the most important parameters.

A tug company in Canada decided to use a performance monitoring system to determine whether implementing the technology would provide an adequate ROI and help them reduce operating costs.

The Solution

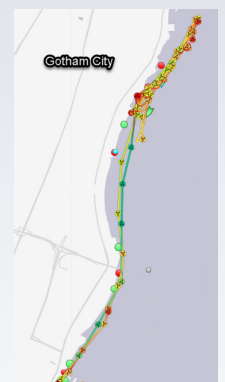
Vessel Performance Monitoring System

One vessel was selected for a trial of the system. To determine fuel consumption and vessel speed, an embedded solution was installed including Binsfeld Shaft Power Meters, KRAL Flow Meters, and an OPDAQ OP-HMI ECR Display. The display then connected to the OPDAQ Op-Fleet Online Platform via the internet.

The Shaft Power Meter provided accurate horsepower data and the Flow Meters provided accurate fuel consumption data. They were used over standard engine readings due to their higher accuracy, which provided more opportunity for efficiency gains.

The Op-HMI uses an innovative algorithm to detect whether the tug is in transit or assisting another boat. The system also integrates the signals from the shaft power and fuel sensors to provide the operational status of the tug to the captain. The data helped instruct the captain to respect the speed limits while in transit. The innovative algorithm detects the operational state with great reliability without the captain having to enter data manually.

The Op-Fleet Online Dashboard allowed administrators to see the consumption statistics of the tug and to see if the limits were respected. This dashboard was also used to provide the operating crew with real-time feedback on how well they were doing.



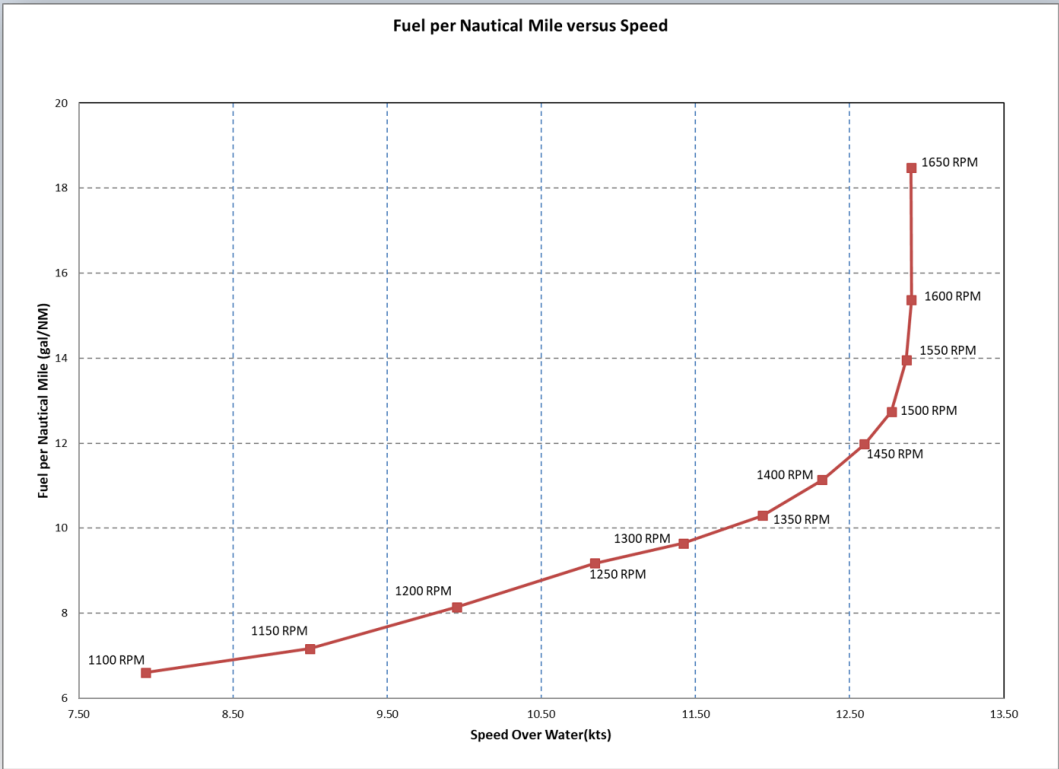
The Impact

Reduced Fuel Costs & Delayed Maintenance Intervals

The system was trialed on the tug over a period of a year, and provided the data needed to make significant financial impacts to the ship’s operations.

By monitoring vessel speed, fuel consumption, engine RPM, and operational mode, the shipowner was able to determine that a decrease in just 2.8 knots during the daily 5NM transit would save **23 gallons per day**, while only delaying transit time by 4 minutes. Additional reductions in speed allowed the crew to eventually increase this to **31 gallons per day** totaling a savings of **11,315 gallons per year (~\$30,000)**.

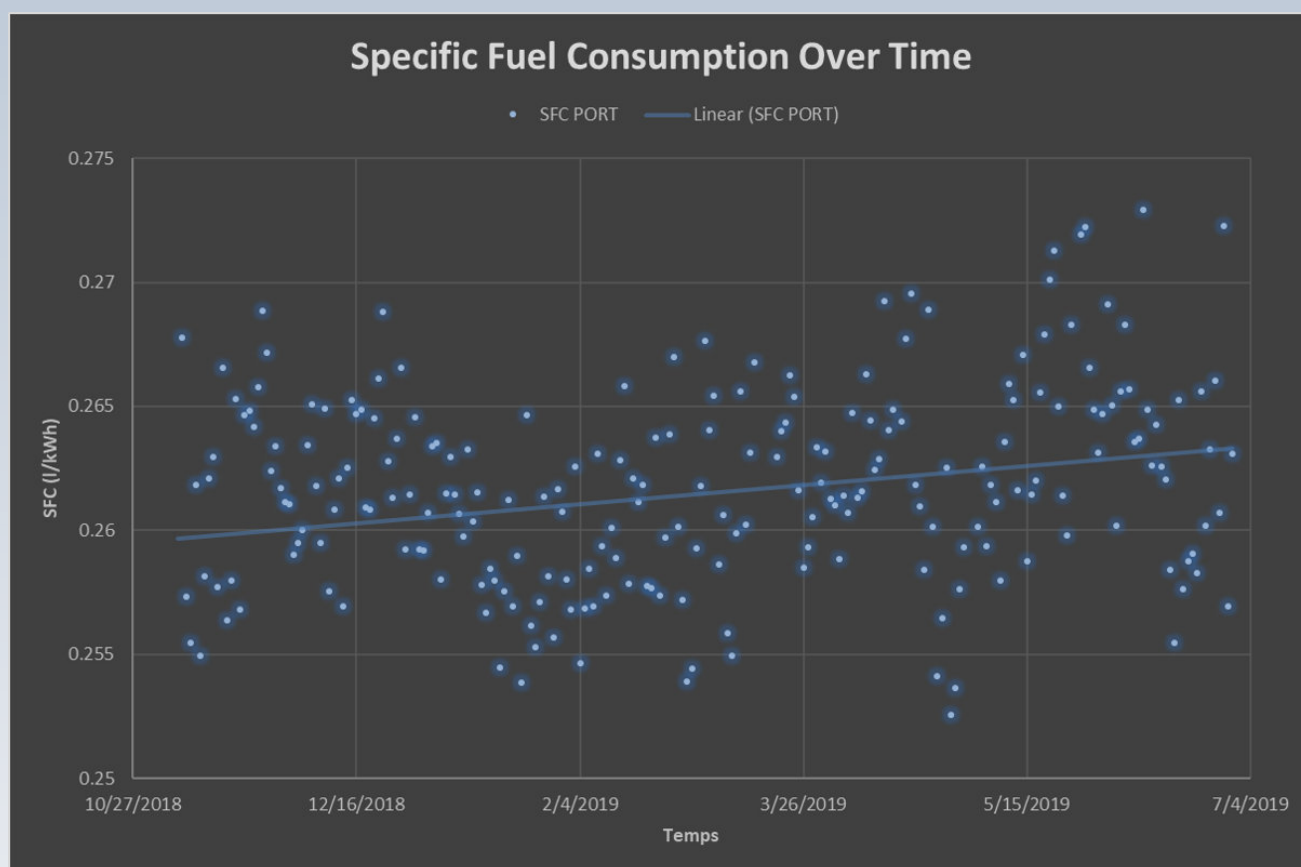
RPM	Speed (kts)	Fuel Cons. (gallons)	Time for 5NM transit (minutes)
1200	10.0	41	30
1500	12.8	64	26



The Impact

Reduced Fuel Costs & Delayed Maintenance Intervals

Maintenance managers were also able to monitor the engine performance and help delay maintenance intervals. By monitoring specific fuel oil consumption with fuel and shaft power meters, the engine performance trend was determined and used to determine when the engine is will be in need of an overhaul. The maintenance teams expects to **delay major engine overhauls by 50%** (from every 12,000 to every 18,000 hours).



By implementing the vessel performance monitoring system, the shipowner was able to significantly reduce operating costs for this vessel and stands poised to implement this across their entire fleet. By reducing fuel costs, the technology has enabled them to receive a fast ROI and a competitive advantage over other tug operators.

Sample Vessel List

Installation Date	Vessel Name	Vessel Type
2002	NDS Progress	Freighter (Cargo)
2003	Gotland Spirit	Freighter (Tanker)
2003	Kanata Spirit	Freighter (Tanker)
2004	Histria Onyx	Freighter (Cargo)
2005	Seasong	Freighter (Tanker)
2005	Seacrown	Freighter (Tanker)
2005	Matilda	Freighter (Tanker)
2005	Seavoyager	Freighter (Tanker)
2005	SEAOATH	Freighter (Tanker)
2006	Spitfire III	Tugboat
2006	Goviken	Freighter (Bulk)
2006	STAR	Freighter (Tanker)
2007	Camille Marcoux	Passenger
2007	Dorothy Ann	Tugboat
2008	Henry Bain	Tugboat
2008	Superstar Libra	Cruise Ship
2009	USNS Kanawha	Naval
2009	USNS Big Horn	Naval
2010	Redhook	Freighter (Tanker)
2010	Frontier Discovery	Freighter (Bulk)
2010	CSL Niagara	Freighter (Bulk)
2010	CSL Assiniboine	Freighter (Bulk)
2010	Fionia Swan	Freighter (Tanker)
2010	John W Johnson	Ferry
2010	RTM TWARRA	Freighter (Bulk)
2010	RTM PIRAMU	Freighter (Bulk)
2010	Hafnia Crux	Freighter (Tanker)
2011	Jerry Jones	Tugboat
2011	Miss Kris	Tugboat
2012	American Phoenix	Freighter (Tanker)
2012	Seminole Princess	Freighter (Cargo)
2012	TH Kelly	Tugboat
2013	American Mariner	Freighter (Bulk)
2013	American Integrity	Freighter (Bulk)
2013	Piiramu	Freighter (Bulk)
2013	Twarra	Freighter (Bulk)
2014	Algoma Transport	Freighter (Bulk)
2015	Clementine Maersk	Freighter (Container)
2017	Abundance	Tugboat
2017	H.A Sklenar	Freighter (Bulk)
2017	USNS Tippecanoe	Naval
2017	Norsul Abrolhos	Tugboat
2017	Island Enterprise	Fishing Vessel
2017	Sir Wilfrid Laurier	Icebreaker

Sample Customer List

Customer Name
American Steamship Company
Bollinger Shipyards, Inc
Bombardier Recreational Products Inc. (BRP)
Canadian Coast Guard
Canadian Steamship Lines
Cascade Engine Center LLC
Caterpillar Inc.
Caterpillar Marine Asia Pacific Pte Ltd
Cummins Cumberland, Inc.
Cummins MerCruiser Diesel
Cummins Middle East, FZE
Cummins Recreational & Light Duty Commercial Marine
Det Norske Veritas
Detroit Diesel Corp.
Electro-Motive Diesel
GE Transportation Systems
General Dynamics - Electric Boat Corp
Interlake Steamship Co
John Deere Power Systems
Kirby Corporation
Maersk
MAN B&W Diesel A/S
MAN Diesel & Turbo
Marinette Marine
MerCruiser / Mercury Marine
Mercury Marine
Military Sealift Command
NAMJet LLC
Nichols Bros Boat Builders
Rolls-Royce Marine AS
Roymar Shipmanagement
Texas State Ferry
Textron Marine & Land Systems
Thenamaris
Trinity Yachts
Uni-Tankers
US Coast Guard
US Navy
VOLVO PENTA
Wärtsilä Danmark A/S
Wärtsilä Finland Oy
Wärtsilä Italia SpA
Wärtsilä Nederland B.V.
Wärtsilä Switzerland Ltd
Washington State Ferry
Yanmar Marine USA



bein

BINSFELD ENGINEERING INC.

4571 W. MacFarlane Road, Maple City, MI 49664 USA

binsfeld.com | 231-334-4383 | sales@binsfeld.com