Shaft Power Meter (SPM)
Shaft Power Limitation (SHaPoLi)

Fuel Performance System (FPS)

Enhanced Process Efficiency and Data Management to Reduce your Carbon Footprint

Our Competence

For enhanced process efficiency to reduce your carbon footprint

AQUAMETRO OIL & MARINE

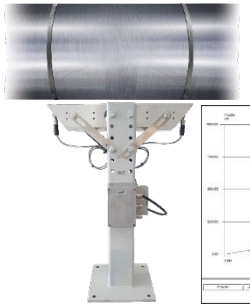
✓ Fuel Measurement

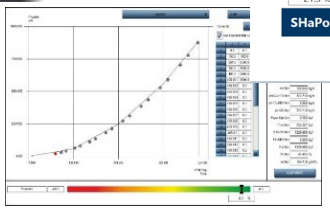
CONTOIL®, Viscomaster™

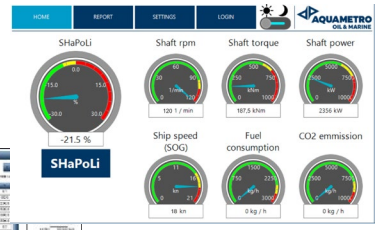
✓ Fuel Performance & Reporting

FPS 2.0, RMS, SPM

SHaPoLi



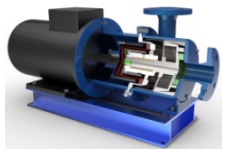




✓ Fuel Management & Treatment

NEW Diesel Switch / Fuel Blending

Homogenizer / WFE



Dedication and History of Aquametro Oil & Marine

» 1928 - Aquametro AG was founded

Our worldwide agencies provide you with local service and support

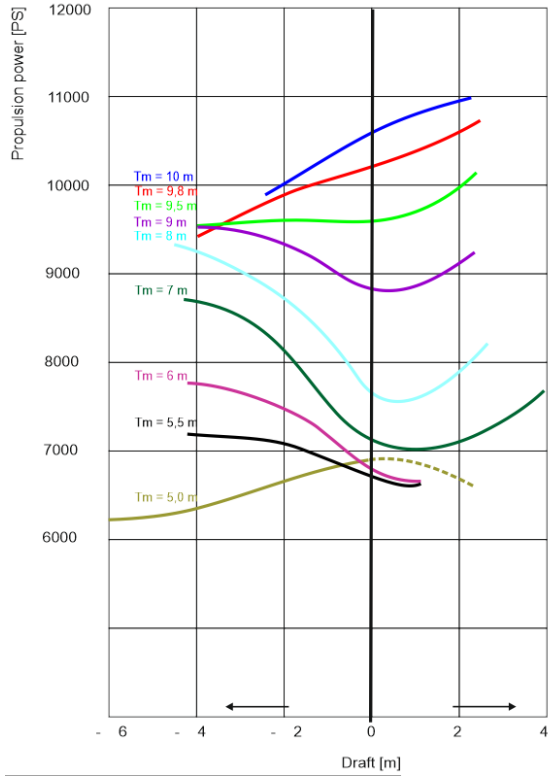
- Aquametro AG Headquarter
- Aquametro local offices
- Aquametro Distributors

Our Competence

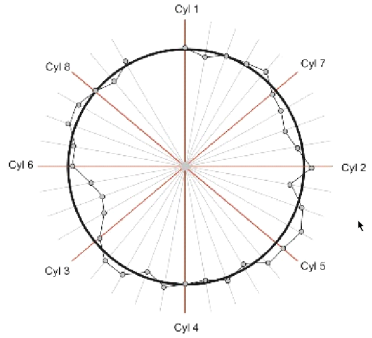
Process understanding

» Safe, efficient & environmentally friendly ship operation

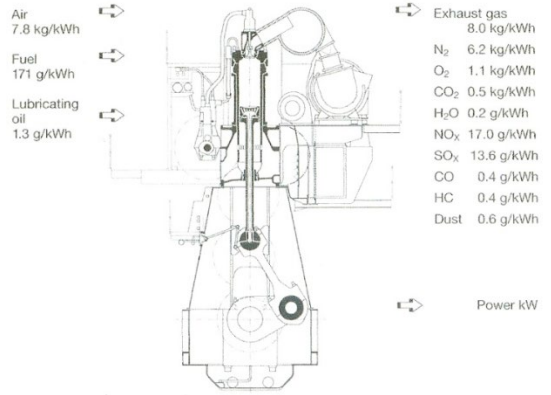
Hull performance / Trim optimizing



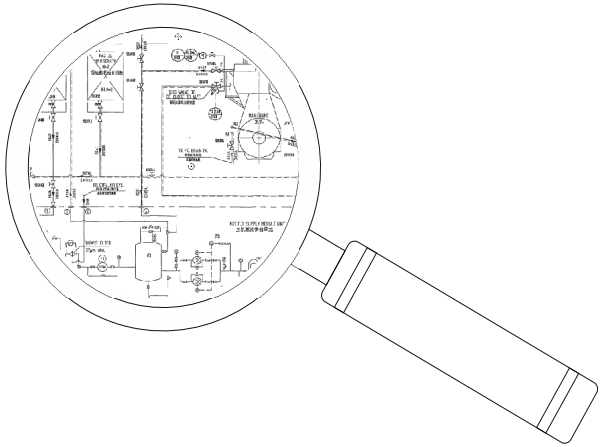
Engine performance

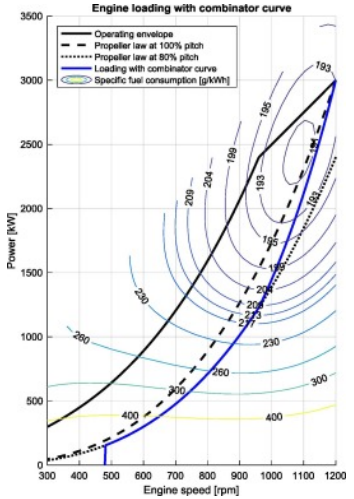


Engine exhaust gas emission

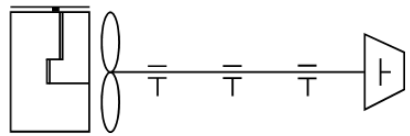


Experience in ship operation





Basics mathematics ship propulsion

	Propeller Rudder	Shaft power Shaft generator	Main engine Auxiliary systems	
				
Power	▪ Propeller power $P_D = Q \cdot 2\pi up$ ▪ Trust T $P_T = T \cdot V_A (V_A < V_S)$		▪ injected power P_i ▪ mechanical power HM $P_e = M \cdot 2\pi n_M$ $= P_i \cdot \eta m_M$	▪ power $P_E = R_T \cdot V_S$
Efficiency	▪ Propeller efficiency $\eta_0 = P_T / P_D$ ▪ Propulsion efficiency $\eta_D = \eta_O \cdot \eta_R \cdot \eta_H$ ▪ η_O - ▪ η_R – ▪ η_H – ship hull $= \frac{(1-t)}{(1-w)}$ $t = \frac{T - R_T}{T}$ $w = \frac{V_S - V_A}{V_S}$	▪ Transmission efficiency $h_ü = P_D / P_e$	▪ Effective engine efficiency $\eta_e = 3600 / (g_e \cdot H_U)$ $= \eta_i \cdot \eta_{mM}$ ▪ Mechanic efficiency $\eta_{mM} = P_e / P_i$ ▪ η_i -	
measurement	▪ Trust – T ▪ Propeller torque –Q ▪ Propeller revolution - np		▪ Engine torque – M ▪ Motor revolution – n_M ▪ Cylinder pressure ▪ Fuel consumption - G_e ▪ g_e – g/kWh ▪ fuel quality	

FUEL PERFORMANCE SYSTEM FPS

Challenges ENERGY EFFICIENCY REGULATIONS

Design

» **E**nergy **E**fficiency **D**esign **I**ndex **EEDI**
CONSTRUCTION INDEX for **NEW SHIPS**

» **E**nergy **E**fficiency E**x**isting Ship **I**ndex **EEXI** **NEW**
CONSTRUCTION INDEX for **EXISTING SHIPS**

Plan

Operate

» **S**hip **E**nergy **E**fficiency **M**anagement **P**lan **SEEMP**
Energy Efficiency Management Plan (SEEMP) for **ALL SHIPS**

Operate

» **E**nergy **E**fficiency **O**perational **I**ndex **EEOI**
OPERATION INDEX for **ALL SHIPS**

Monitor

» **C**arbon **I**ntensity **I**ndicator **CII** **NEW**
OPERATION INDICATOR for **ALL SHIPS**

» **CO_2 - M**onitoring – **R**eport – **V**erify **MRV** (EU) or **DCS** (IMO) **/ MSA** (CHINA)
OPERATION REPORT for **ALL SHIPS**

Design

Design the energy efficient ships
CONSTRUCTION INDEX
- New building vessels **EEDI**
- Operating vessels **EEXI**

Plan

Plan to operate & improve the energy efficiency of the ship
- **SEEMP**

Operate

Operate the ship in energy efficient way
- **SEEMP**

Monitor

Monitor energy efficiency & collect data for further improvements
OPERATION INDEX
- Ship in operation **EEOI**
- Ship in operation **CII**
- CO_2 reporting **MRV / DCS / MSA**

FUEL PERFORMANCE SYSTEM FPS

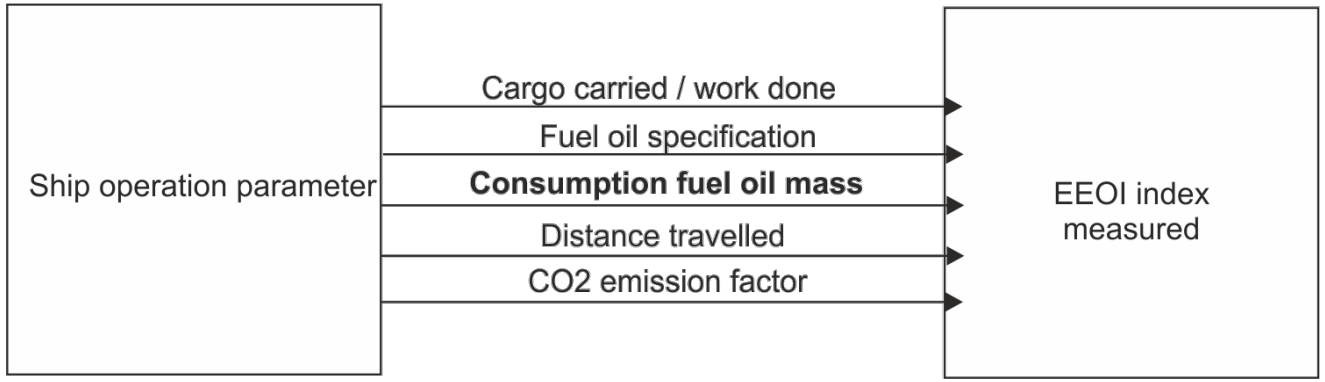
Challenges OPERATION Classification of all ships

Monitor Operate

EEOI

Energy **E**fficiency **O**perational **I**ndex

OPERATION INDEX for **ALL SHIPS**

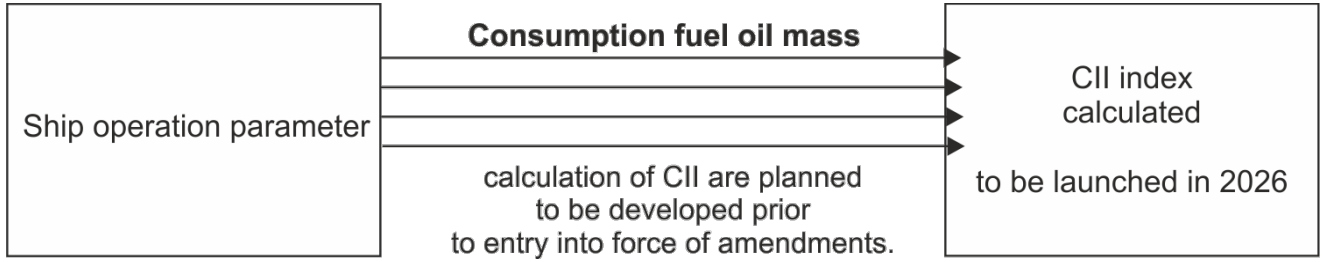


Monitor Operate

CII

Carbon **I**ntensity **I**ndicator

OPERATION INDICATOR for **ALL SHIPS**

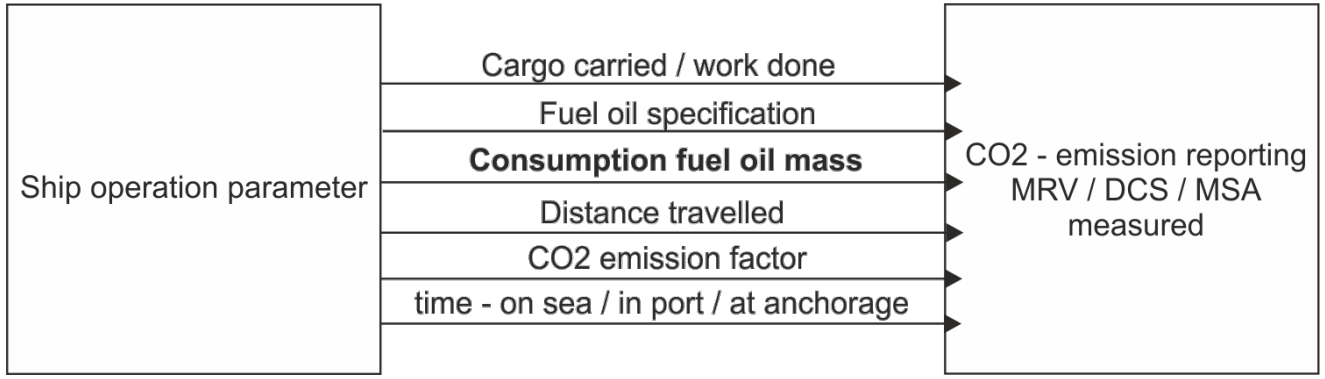


Monitor Operate

MRV / DCS / MSA

CO_2 - Monitoring – **R**eport – **V**erify

OPERATION REPORT for **ALL SHIPS**



Shaft Power System / SHaPoLI

Challenges OPERATION Classification of all ships

Carbon Intensity Indicator CII

Monitor Operate

NEW

OPERATION INDEX for **ALL SHIPS**

Operation index calculated based on real measurement of:

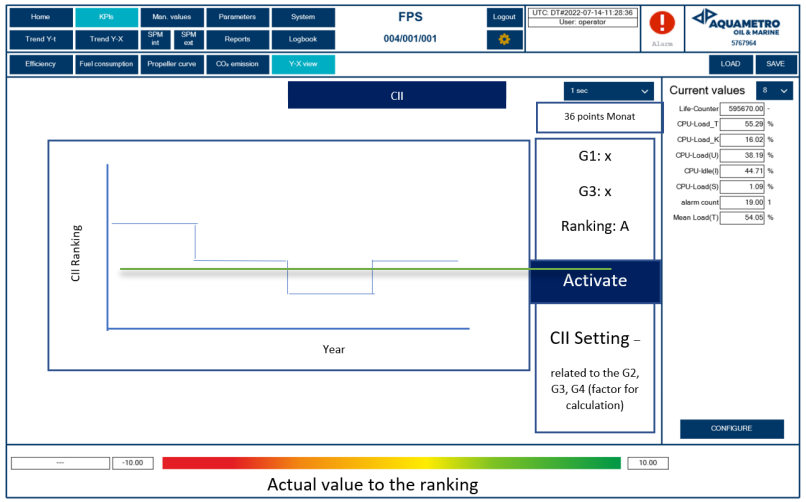
- Ship fuel oil consumption measurement
- Ship CO2 emission calculation based on:
  fuel oil consumption & fuel oil CO_2 factor
- Transport work based on:
  Distance traveled & cargo carried (DWT & GT)

In Result Ship Rating acc. MEPC guidelines.

All the ships which more than 5000 GT must have their first SEEMP Part III and verified by the beginning of January 2023.

The aim in carbon emission reduction from ships by an average 40% by 2030 and 70% by 2050 compared with 2008.

Ship Rating
G1 - CII Attained
G2 - CII reference line
G3 - Required CII (factor calculated)
G4 - Rating CII (A,B,C,D,E) according to IMO/IACS



CII - KPI Ship Rating – configuration, reporting – in FPS PLC - ECR

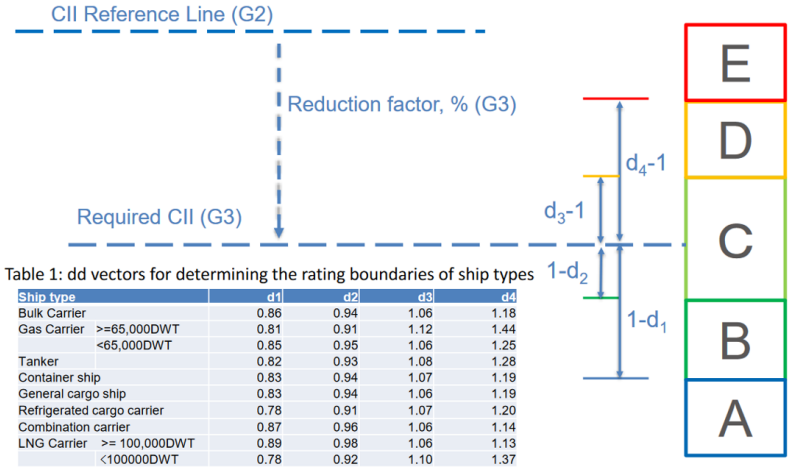


Table 1: dd vectors for determining the rating boundaries of ship types

Ship type		d1	d2	d3	d4
Bulk Carrier		0.86	0.94	1.06	1.18
Gas Carrier	>=65,000DWT	0.81	0.91	1.12	1.44
	<65,000DWT	0.85	0.95	1.06	1.25
Tanker		0.82	0.93	1.08	1.28
Container ship		0.83	0.94	1.07	1.19
General cargo ship		0.83	0.94	1.06	1.19
Refrigerated cargo carrier		0.78	0.91	1.07	1.20
Combination carrier		0.87	0.96	1.06	1.14
LNG Carrier	>= 100,000DWT	0.89	0.98	1.06	1.13
	<100000DWT	0.78	0.92	1.10	1.37
Ro-ro cargo ship (VC)		0.86	0.94	1.06	1.16
Ro-ro cargo ship		0.66	0.9	1.11	1.37
Ro-ro passenger ship		0.72	0.90	1.12	1.41
Cruise passenger ship		0.87	0.95	1.06	1.16

Shaft Power System / SHaPoLI

Challenges DESIGN Classification of all ships

Shaft Power Limitation ShaPoLi

Design

» **E**nergy **E**fficiency E**x**isting Ship **I**ndex **EEXI**
NEW
CONSTRUCTION INDEX for **EXISTING SHIPS**

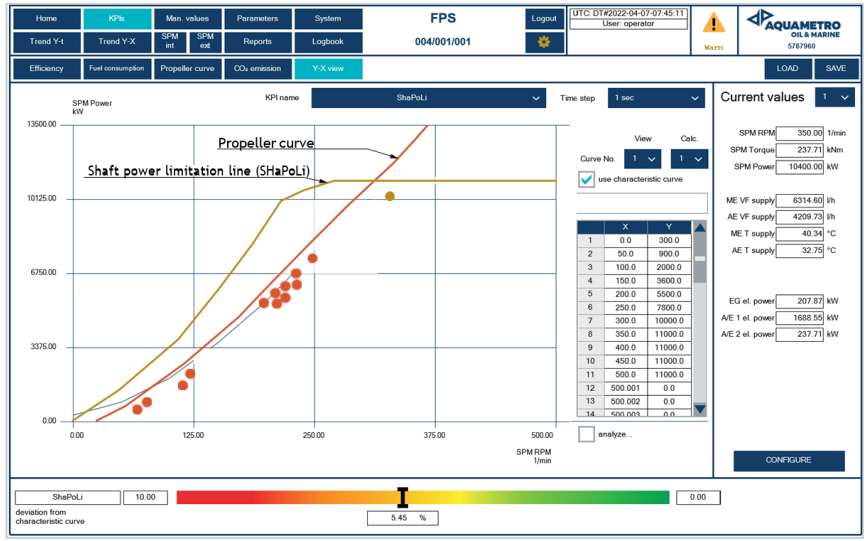
Construction index calculated based of existing ship design

Have to optimize **if EEXI index out of limit** with technical solutions to reduce CO2 emission:

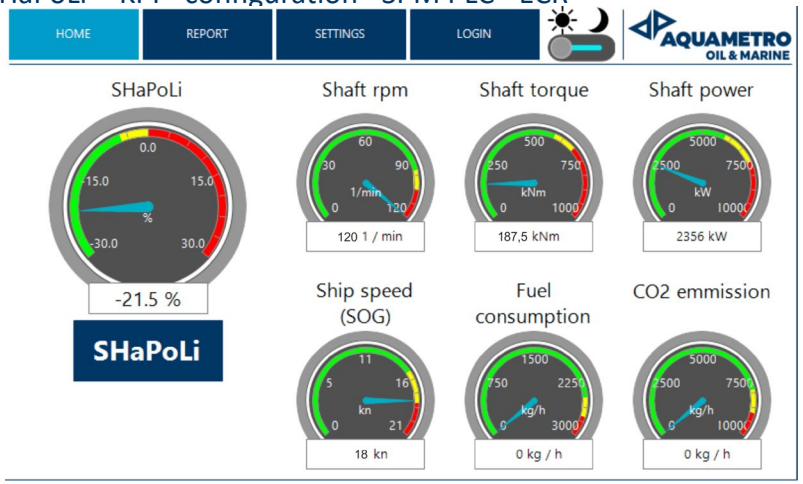
- **Shaft** / engine **power limitation - SHaPoLI**
- Fuel changes
- Energy saving devices
- Other veritable options

SHaPoLI - Shaft power limitation have to documented by (SHaPoLi shaft power measurement)

» SHaPoLi monitors whether the operating point approaches the characteristic curve (Shaft Limitation)
» Warning and Alarm (Limit) and whether the characteristic curve is exceeded – Digital output of alarm created
» The characteristic curve can be generated manually with support points by authorized engineer only
» Overriding SHaPoLi function – activation by ship's master or OICNW only – digital output created for external limit control device

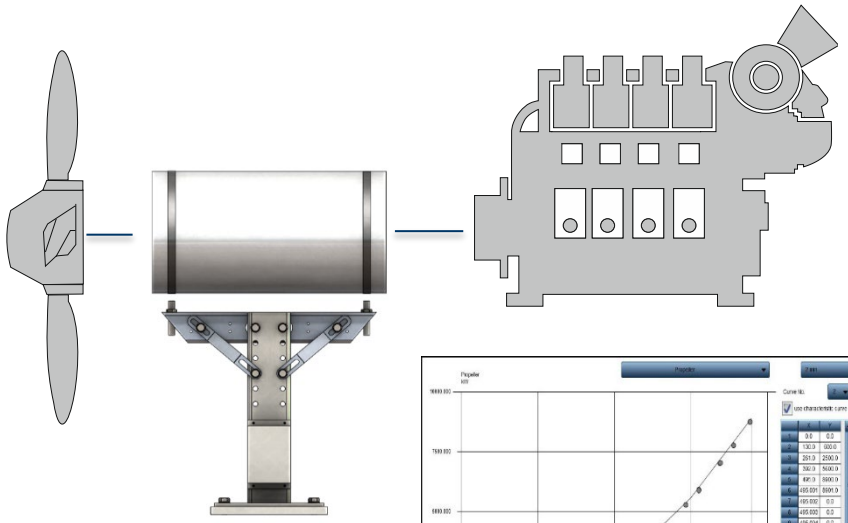


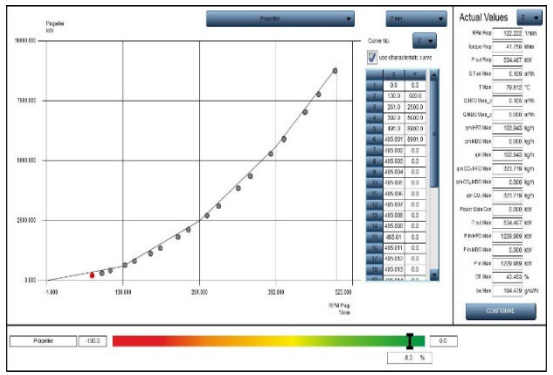
SHaPoLi - KPI - configuration - SPM PLC - ECR

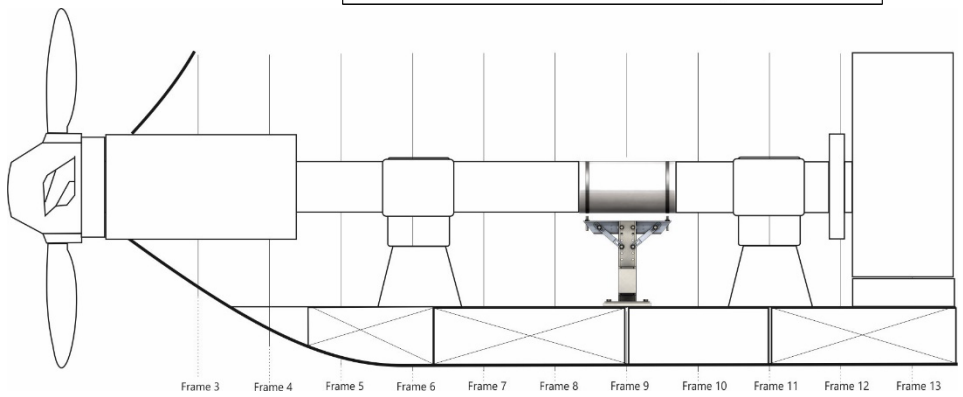


SHaPoLi - Reporting / signal output - Monitoring Display - wheel house

Shaft Power Measurement

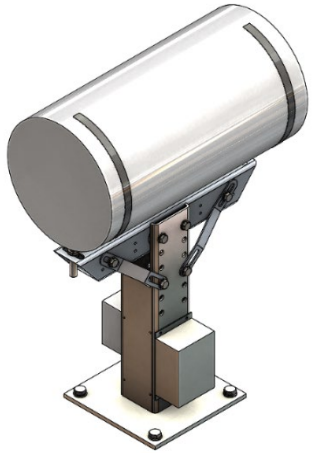


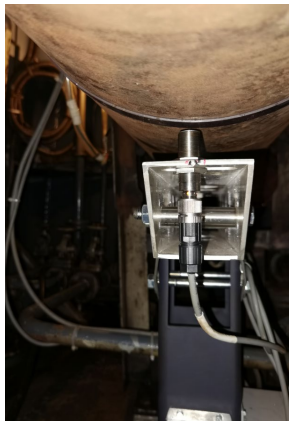


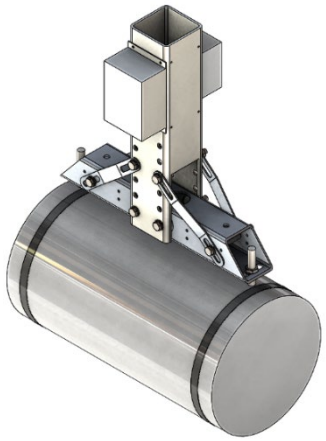


SPM FEATURES

- Easy installation
- RPM, Torque and Power signals
- Reliable data
- Fuel / propulsion efficiency
- Key component for fuel performance system **FPS 2.0**
- PLC based system
- Data storage on SD card





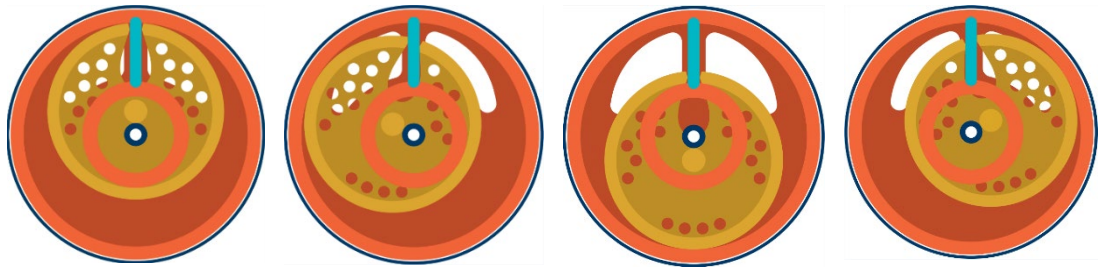


CONTOIL® - Fuel Measurement

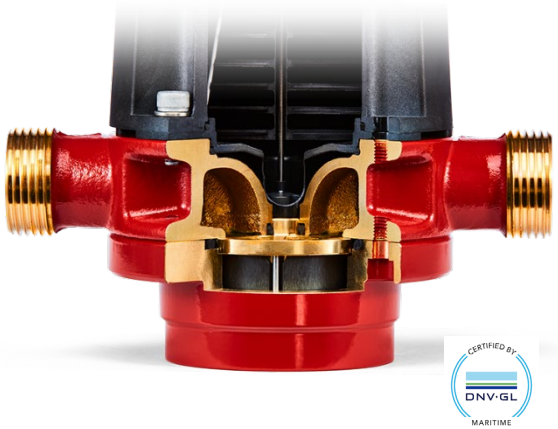
Volume/Mass flow meter

DN 4 - 8 (12)
Flow range: 1 l/h to 400 l/h
Accuracy: 1 %
Pressure: 25 (32) bar

DN 15 - 50
Flow range: 20 l/h to 30.000 l/h
Accuracy: 0.1 % to 1 %
Pressure: threaded ends = 16 bar, flanges = 25 / 40 bar
Flange (DIN, ANSI, JIS), threaded ends



Working principal



CONTOIL ® FEATURES

- Volume flow measurement
- **Mass flow calculation**
- **Integrated temperature sensor**
- Temperature compensated norm volume
- Simple consumption monitoring
- Space-saving installation, PLUG & PLAY
- No straight inlet/outlet sections are required
- Flexible mounting of the meter in horizontal, vertical or inclined positions
- Accurate measurement
- Multiple signal outputs
- Type Certificate by DNV GL , LR, CCS, …

AOM-CM - Fuel Measurement

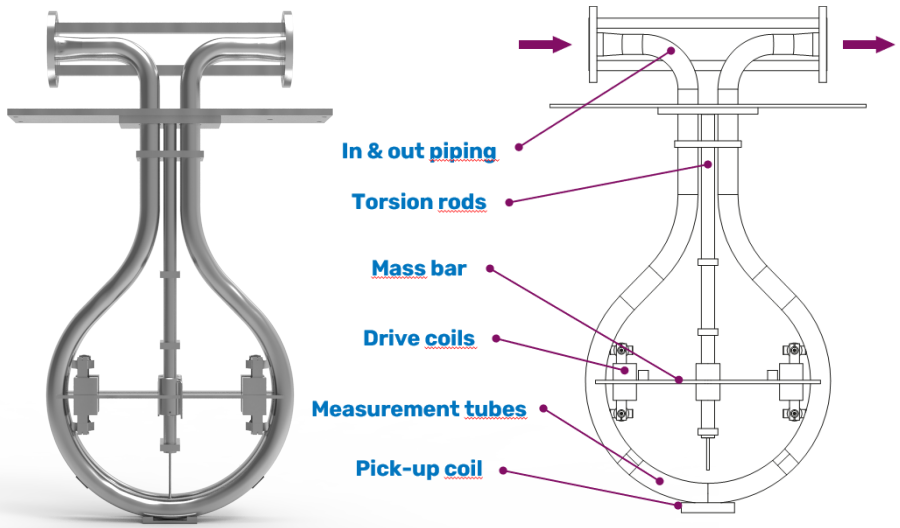
Mass flow meter

DN 015 - 100
Flow range: 2 kg/h to 540.000 kg/h
Flange DN15 up to DN200
Accuracy: 0.2 %
Pressure: 40 bar
Flange (DIN, ANSI, JIS), threaded ends

AMO-CM® FEATURES

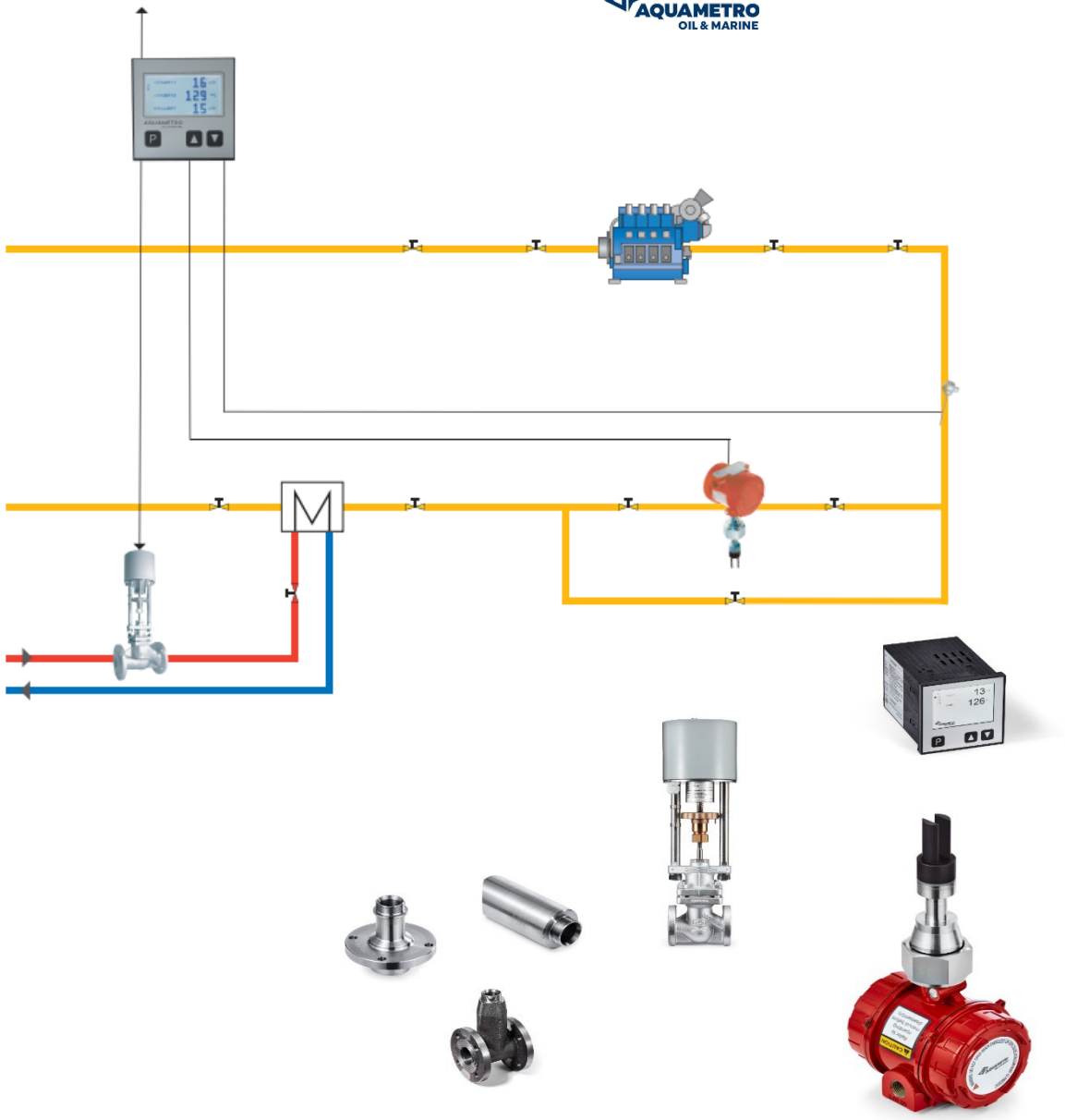
- Torsion oscillator design assures a stable and drift free measurement with excellent signal to noise ratio
- Resilient to external noise and vibration
- Insensitive to pipe pressure changes
- Robust tube wall thickness provides increased operational safety in abrasive applications
- Long life guaranteed due to low mechanical stresses in the sensor mechanism
- No moving parts to wear or fail
- Accurate measurement
- Multiple signal outputs
- Type Certificate by DNV GL , LR, CCS, …

Working principal



VISCOSITY CONTROL SYSTEM VCS

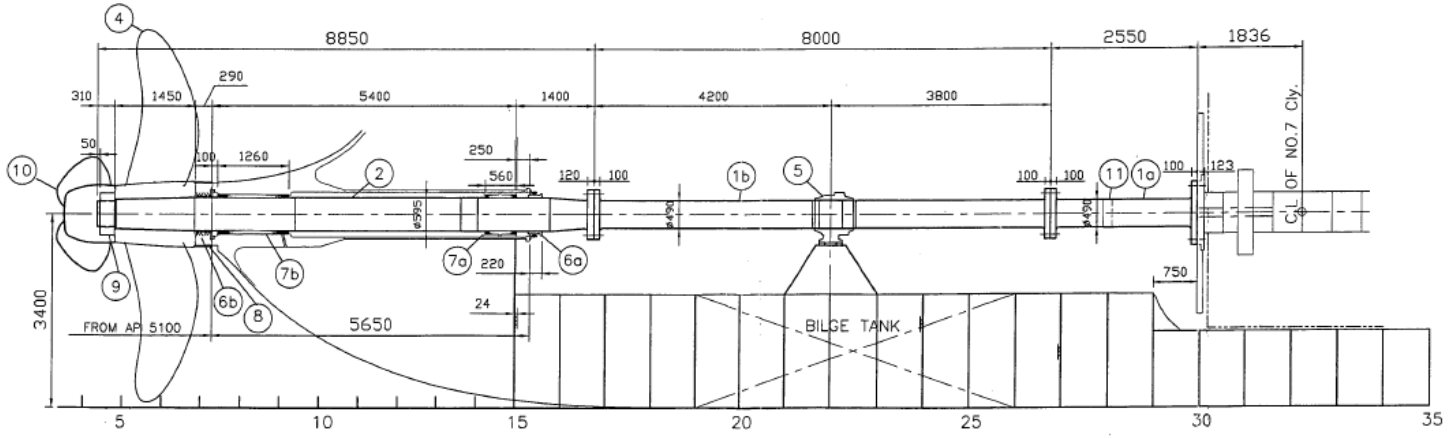
- Measurement
  - Viscomaster Measures Viscosity / Temperature (Density)
  - Vibration of the forks
- Controller/Comparison
  - Controller check Viscosity set Point (Temperature Setpoint) with actual Value
  - Actuates the Heating
- Steam Valve
  - Opens or closes the steam line to reduce or raise viscosity



Fuel Efficiency for Fuel Monitoring

FUEL Performance System FPS configuration Example

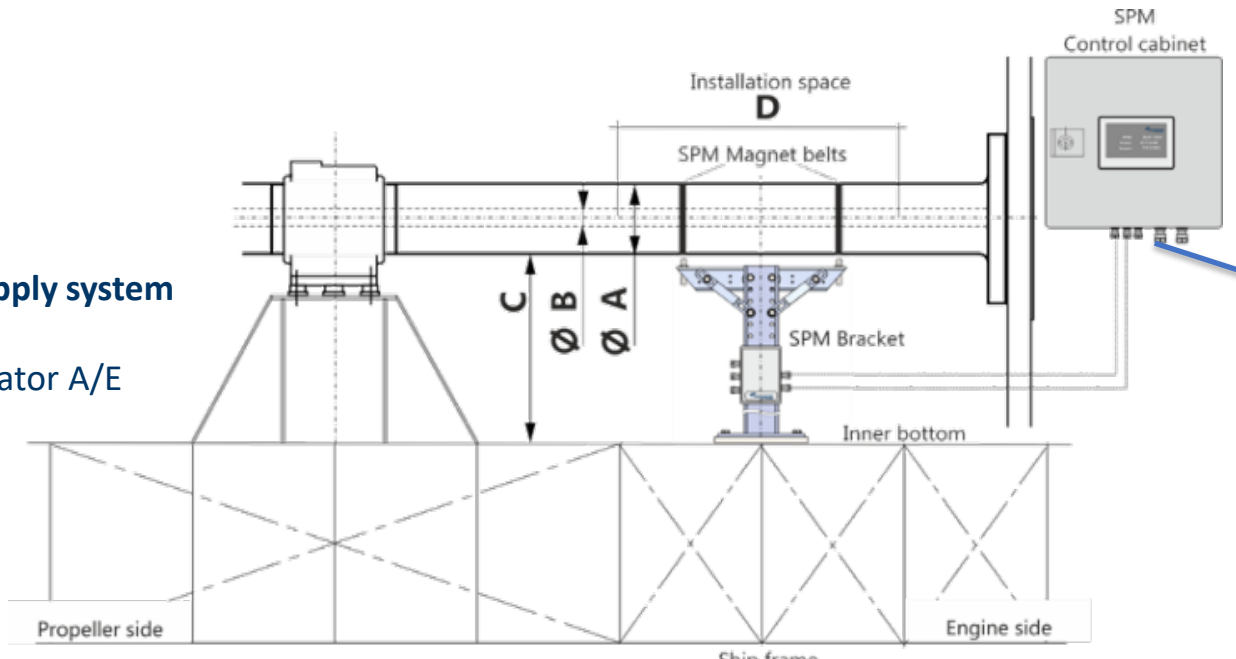
Shafting arrangement

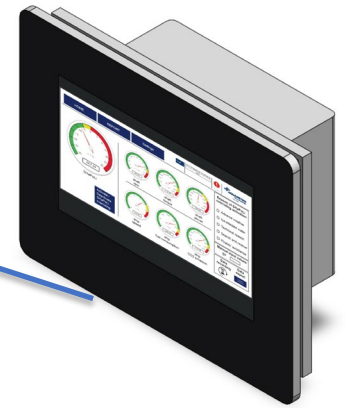


Measurement in Propulsion / power supply system

1 SPM shaft power measurement

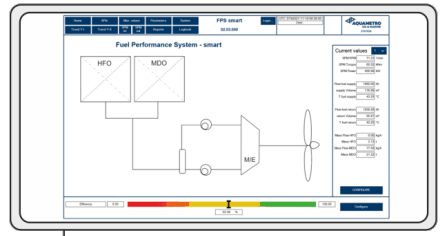
3 signal (4-20mA) electrical power generator A/E



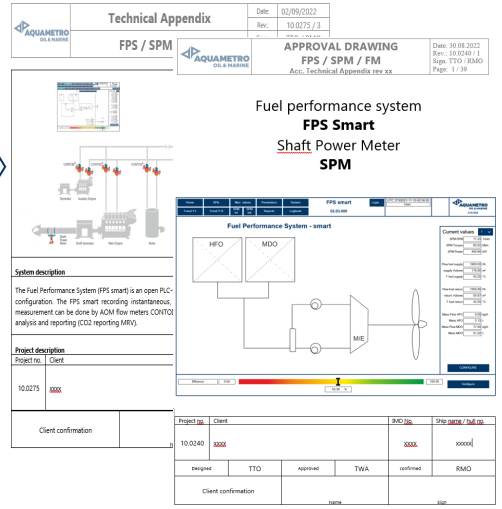


Fuel Efficiency for Fuel Monitoring

FUEL Performance System FPS configuration Example



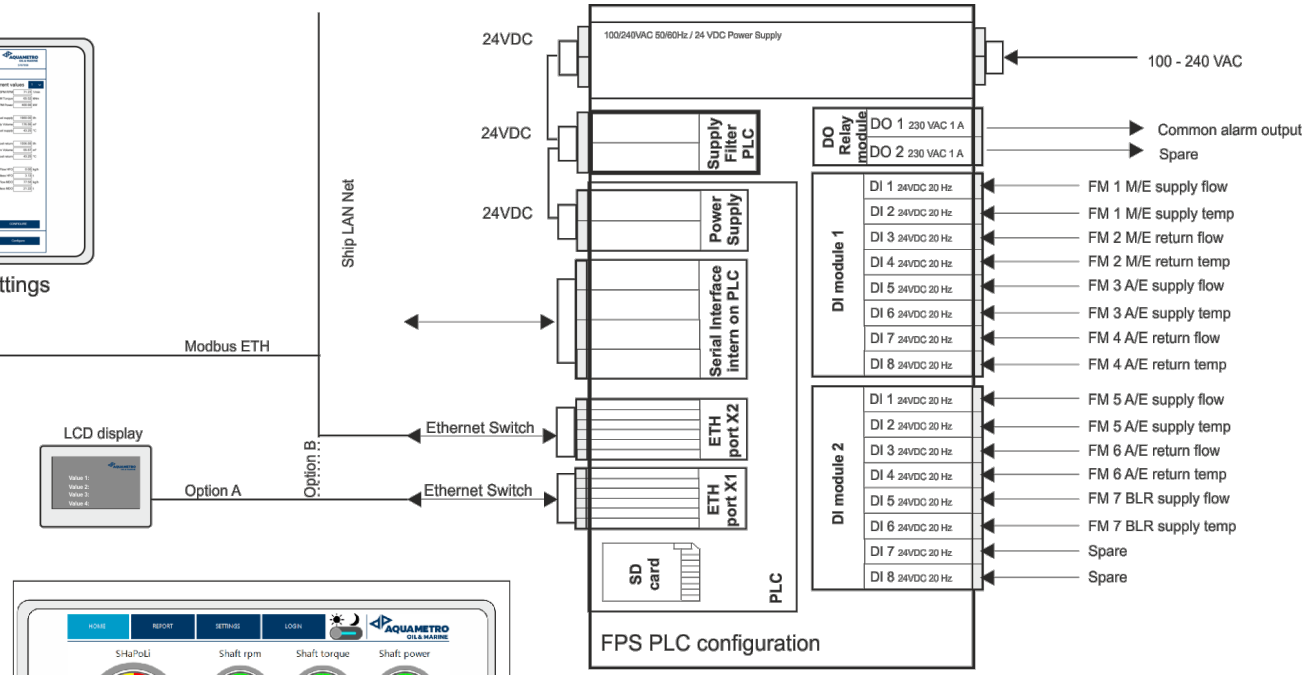
FPS configuration and settings

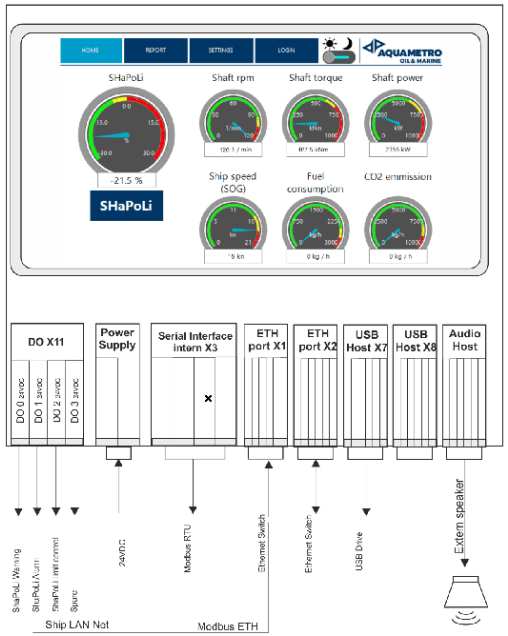


Fuel performance system
FPS Smart
Shaft Power Meter
SPM

Engineering Support
to design a Monitoring concept decribed in

TA Technical Appendix
AD Approval Drawing





Our Solution for Fuel Efficiency

FUEL Performance System FPS GENERAL DESCRIPTION

» Fuel Performance Monitoring

- ✓ Fuel oil flow/consumption - M/E, A/E and Boiler (A/B)
- ✓ Propulsion system SPM - shaft power / torque / rpm
- ✓ CO_2 Emission - calculated
- ✓ Specific fuel consumption (SFOC) - characteristic curves
- ✓ Trim / heeling
- ✓ …

» KPI calculation

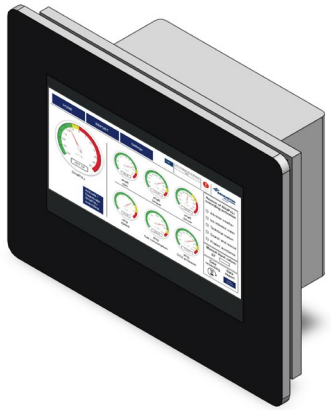
- ✓ Fuel efficiency
- ✓ EEOI Energy Efficiency Operation Index
- ✓ Transport work / effectivity
- ✓ CII
- ✓ **SHaPoLI**
- ✓ …

» Condition Monitoring

- ✓ Engine performance
- ✓ Hull performance
- ✓ …

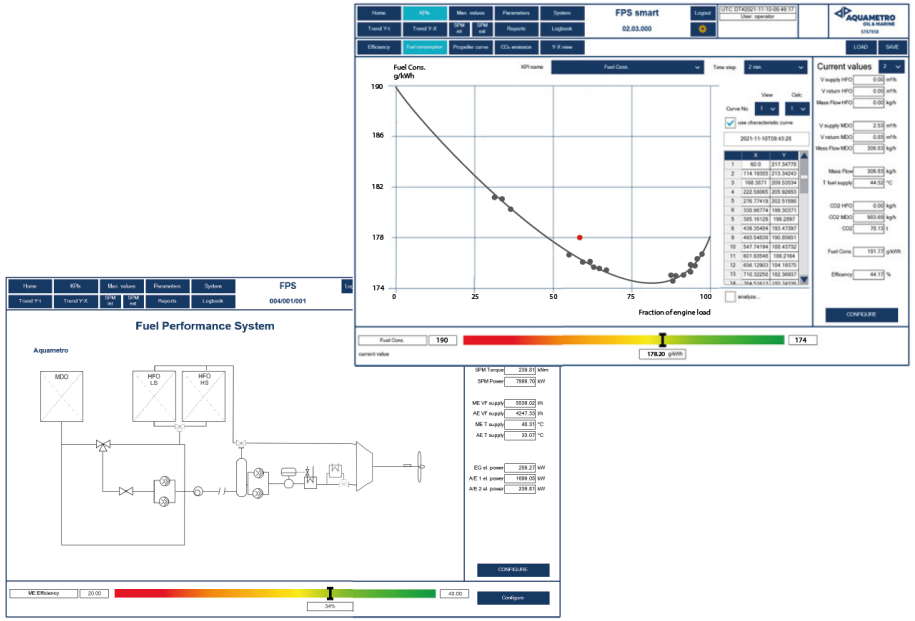
» Technical Support / Reporting

- ✓ Web based open configuration
- ✓ Data ONBOARD & Data ONSHORE
- ✓ …



SHaPoLi Monitoring Display

WAGO - certified open modular design



FPS fuel monitoring WEB portal visualisation on standard PC

» Fuel Performance Monitoring Hardware concept

- ✓ Simple standard PLC system with class type approval certificate
- ✓ Modular design to configure acc. client request
- ✓ Synergy effects to use same hardware of different processes
- ✓ Standard data interface (open structure) to communicate with other systems (NMEA / MODBUS Master, Slave)

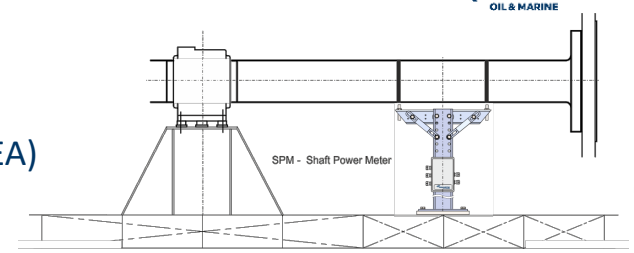
Our Competence

FUEL Performance System FPS concept onboard / onshore

Onboard

CONTOIL® FM AQUAMETRO OIL & MARINE

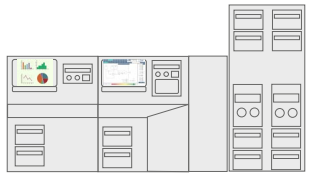
Other signals or protocols (Modbus / NMEA)



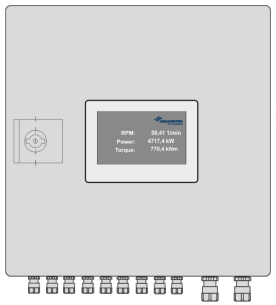
Shaft Power Meter SPM AQUAMETRO OIL & MARINE

VSAT

SHaPoLi



Ship Automation System/ AMS



FPS 2.0 PLC HW

FPS 2.0 Onboard Dashboard

FPS 2.0 Cloud Server

Onshore

FPS 2.0 AQUAMETRO OIL & MARINE

FPS 2.0 Onshore GUI will be available on Desktop Web Portal & Mobile App

AQUAMETRO OIL & MARINE

FPS 2.0 Technical Support Reporting

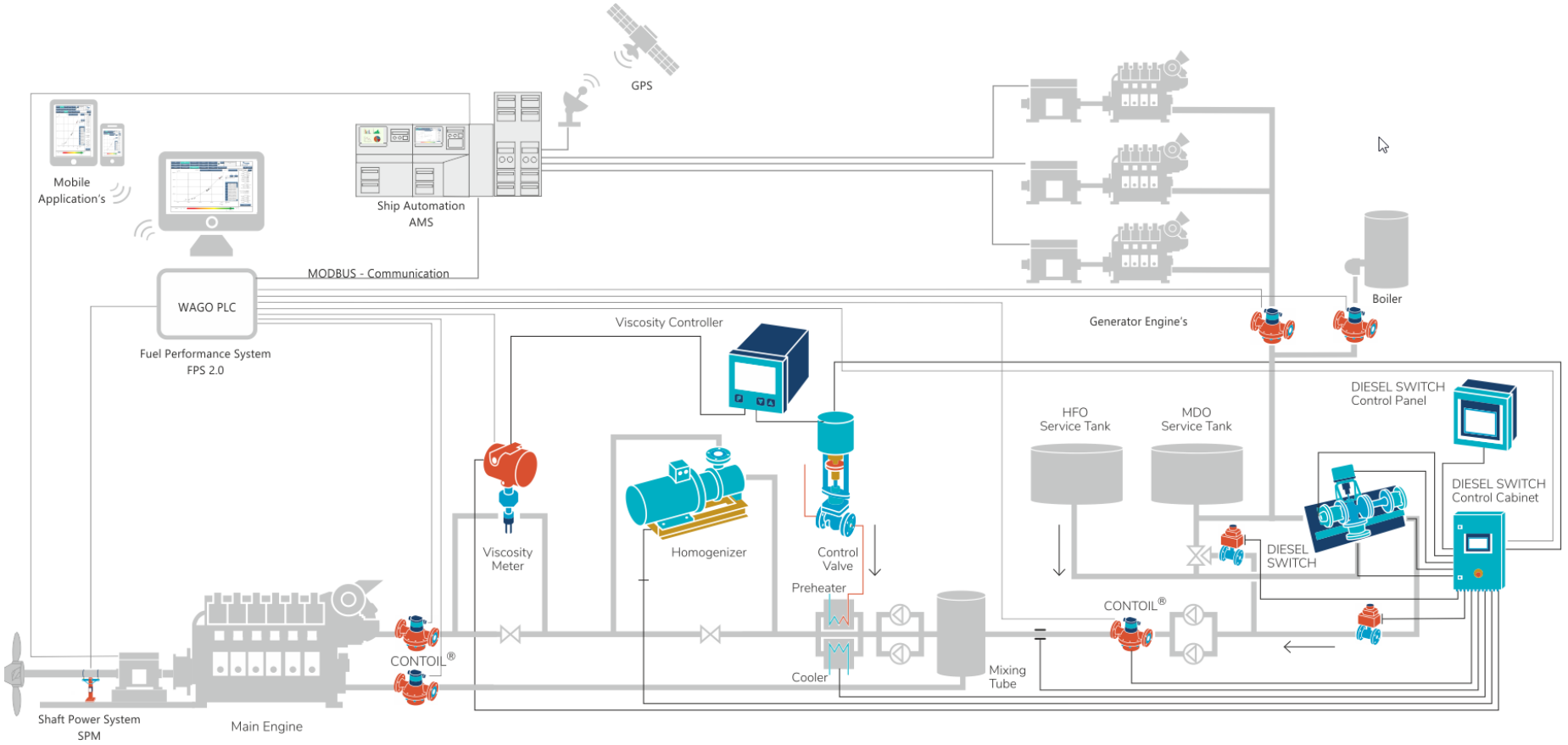
FPS 2.0 Onshore Dashboard

End Customer Existing System

Allow 3rd Party access server to achieve data extraction and transfer to their own system

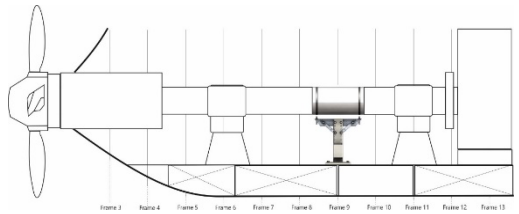
Our Competence

For enhanced process efficiency to reduce your carbon footprint



Fuel oil consumption

Fuel oil viscosity control



Propulsion - Shaft Power

Thank you for your attention!