Voith Group

One of the large family-owned companies in Europe:

- 43,000 employees
- 290 locations
- Euro 5.1 billion in sales
Voith Turbo SteamTrac Marine

Voith Turbo SteamTrac Marine is the company (product group) within the Voith Turbo Marine Division worldwide responsible for the product Voith SteamTrac.
Position in the Voith Group

Voith Group

- Voith Paper
  - Market Area Industry
    - PG Schneider propulsion

- Voith Siemens Hydro
  - Market Area Road
    - PG Radial propeller

- Voith Turbo
  - Market Area Rail
    - PG Adv. propeller technologies

- Voith Industrial Services
  - Market Area Marine
    - PG Marine engineering

- Market Area Trading
  - PG SteamTrac
  - PG Linear Jet
Voith Turbo Marine product range

- Voith Schneider Propeller
- Voith Turbo Fin
- Voith Linear Jet
- Voith Contur Propeller
- Voith Radial Propeller
- Voith Inline Thruster
- Voith Vector Propeller
- Voith Water Tractor
- Voith SteamTrac
Market areas for SteamTrac

Voith SteamTrac Marine
- Waste heat recovery system for combustion engines in marine applications

Further application areas:
- Road
- Rail
- Industry
Marine applications for Voith SteamTrac

- Tug boat
- Ferries
- Navy / Marine
- Passenger ships
- Special vessels
- Offshore supply vessels
- Yacht
- Inland ships
- Drilling platforms
- FPSO
- Cruise ships
- Drilling vessels
SteamTrac - Balance of a combustion engine

\[
\dot{Q}_{\text{Fuel}} \rightarrow 100\% \rightarrow \dot{Q}_{\text{SteamTrac}} \rightarrow \dot{P}_{\text{Combustion engine}} \rightarrow \dot{Q}_{\text{Exhaust gas}} \rightarrow 31\% \rightarrow \dot{Q}_{\text{Radiation}} \rightarrow 3\% \rightarrow \dot{Q}_{\text{Cooling}} \rightarrow 28\% \rightarrow \dot{Q}_{\text{Fuel}}
\]
SteamTrac - Working principle

- Exhaus gas
- Integration into Control unit
- Media tank
- Feed pump
- Heat exchanger
- Control unit
- Expander
- Control
- Condenser
- Integration into cooling system
SteamTrac - Working principle

- Combustion engine
  - Main propulsion engine
  - Auxiliary engines
  - PTI Gearbox
SteamTrac - Benefits

- Expected reduction of fuel by SteamTrac up to 12%
- Optimization of working point combustion engine, generating additional fuel savings
- Reduction Carbon dioxide (CO2)
- Nitrogen oxides (NOx)
- Sulphur oxides (SOx)
- Particulate Matter (PM)
- Hydrocarbons (HC)
- LCC Combustion engine
- Downsizing combustion engine

Reduction of Fuel

Reduction of Emissions

Reduction of other Cost
## Voith SteamTrac - fuel & emissions saving example

### Basic calculation information

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>ISO-DMX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunker fuel price</td>
<td>€650.00 per metric ton</td>
</tr>
<tr>
<td>Reference:</td>
<td>Bunker world Prices - Latest Prices</td>
</tr>
<tr>
<td>Time vessel operational</td>
<td>3,500 hours per year</td>
</tr>
<tr>
<td>Engine type</td>
<td>Cummins QSK60M</td>
</tr>
<tr>
<td>Applied SteamTrac model</td>
<td>R6/3000</td>
</tr>
</tbody>
</table>
Voith SteamTrac - fuel & emissions saving example

**Operation profile**

<table>
<thead>
<tr>
<th>y % MCR</th>
<th>10,0%</th>
<th>25,0%</th>
<th>50,0%</th>
<th>75,0%</th>
<th>85,0%</th>
<th>100,0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(x % of T)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power set point 1</td>
<td>10,0%</td>
<td>1,0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power set point 2</td>
<td>10,0%</td>
<td></td>
<td></td>
<td>8,5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power set point 3</td>
<td>30,0%</td>
<td></td>
<td></td>
<td></td>
<td>30,0%</td>
<td></td>
</tr>
<tr>
<td>Power set point 4</td>
<td>50,0%</td>
<td></td>
<td>25,0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Σ(X % of T)</td>
<td>100,0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Σ (X% of T) * (y % MCR)</td>
<td>1,0%</td>
<td>0,0%</td>
<td>25,0%</td>
<td>0,0%</td>
<td>8,5%</td>
<td>30,0%</td>
</tr>
<tr>
<td>Average MCR power set point in 100 % T</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>64,50%</td>
</tr>
</tbody>
</table>

(MCR=Maximum Continuous Rating)
### Voith SteamTrac - fuel & emissions saving example

**Engine type** | Cummins QSK60M
---|---

**Engine information** | **Unit** | **Amount**
---|---|---
MCR | kW | 1,491
rated speed | rev/min | 1,800
φ exhaust gas | l/sec | 5,474
Exhaust gas temp (turbine out) | deg C | 373
Fuel consumption@rated speed | l/hr | 376.9
Spec fuel gravity | gr/liter | 0.8389
Spec fuel consumption | gr/kWh | 212.1
NOx (Oxide of Nitrogen) emission (ISO 8178 E3 test cycle) | gr/kWh | 6.25
PM (Particulate Matter) emission (ISO 8178 E3 test cycle) | gr/kWh | 0.08

**Annual fuel cost per engine** | Euro | 463,957
Voith SteamTrac - fuel & emissions saving example

<table>
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<th>Unit</th>
<th>Amount</th>
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<td>Cummins QSK60M</td>
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<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual generated energy engine @ flywheel</td>
<td>MWh</td>
<td>3.366</td>
</tr>
<tr>
<td>Annual CO2 emission engine</td>
<td>kg/year</td>
<td>2.246.249</td>
</tr>
<tr>
<td>Annual NOx emission engine</td>
<td>kg/year</td>
<td>21.037</td>
</tr>
<tr>
<td>Annual PM (Particulate Matter) emission engine</td>
<td>kg/year</td>
<td>269.3</td>
</tr>
<tr>
<td>Effective energy feedback@flywheel SteamTrac Expander</td>
<td>kWh</td>
<td>269.275</td>
</tr>
<tr>
<td>Annual fuel savings by Voith SteamTrac</td>
<td>€/year</td>
<td>37.117</td>
</tr>
<tr>
<td>Annual savings CO2 emission</td>
<td>kg/year</td>
<td>179.700</td>
</tr>
<tr>
<td>Annual savings NOx emission</td>
<td>kg/year</td>
<td>168</td>
</tr>
<tr>
<td>Annual savings PM (Particulate Matter) emission engine</td>
<td>kg/year</td>
<td>21.54</td>
</tr>
</tbody>
</table>
Voith SteamTrac - additional savings / benefits

- Due to lower average engine load:
  - reduced brake mean effective pressure – increased bearing life
  - lower combustion chamber temperature (thermal load) - increased 
    exhaust valve/piston/turbo life

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the combustion engine repair cost will improve!
Voith SteamTrac - additional savings / benefits

- Engine working point optimization:
  - Cummins QSK 60@ 1800 rpm → engine load from 100 % to 80%

Specific fuel consumption improves with ~ 3 %!
SteamTrac - additional savings / benefits

- Engine exhaust emissions reduction **improves**:
  - Carbon dioxide CO₂ → favourable environmental tax regime
    → less toxicity
    → climate change
  - Sulfur dioxide and nitrogen oxides → acid rain
  - Particulate matter (PM) → asthma, lung cancer, cardiovascular issues
# Voith SteamTrac - Expander portfolio

<table>
<thead>
<tr>
<th>Type</th>
<th>R2/800</th>
<th>R4/2000</th>
<th>R6/3000</th>
<th>R4/8000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinders</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Volume</td>
<td>800 ccm</td>
<td>2000 ccm</td>
<td>3000 ccm</td>
<td>8000 ccm</td>
</tr>
<tr>
<td>Power output</td>
<td>40 kW</td>
<td>95 kW</td>
<td>145 kW</td>
<td>360 kW</td>
</tr>
<tr>
<td>RPM-Range</td>
<td>600 – 3500</td>
<td>600 – 2300</td>
<td>600 – 2300</td>
<td>300 - 1900</td>
</tr>
<tr>
<td>Max. Pressure</td>
<td>60 bar</td>
<td>60 bar</td>
<td>60 bar</td>
<td>60 bar</td>
</tr>
<tr>
<td>Max. Temp.</td>
<td>400 °C</td>
<td>400 °C</td>
<td>400 °C</td>
<td>380 °C</td>
</tr>
<tr>
<td>Suitable for engine</td>
<td>300 – 500 kW</td>
<td>400 – 1200 kW</td>
<td>800 – 2000 kW</td>
<td>1800 – 3600 kW</td>
</tr>
</tbody>
</table>
SteamTrac - Project ThyssenKrupp Veerhaven X

Testing SteamTrac on inland ship for 6 months.
- SteamTrac system R2/800
- Testing period from April 2011 till October 2011
Voith SteamTrac - Project ThyssenKrupp Veerhaven X
SteamTrac - Project ThyssenKrupp Veerhaven X

- steam expander
- engine connection
- condenser
- medium tank
- feed pump
SteamTrac – Test facility