

Acce/eron

Turbocharger cleaning in operation & Engine performance analysis – Tekomar XPERT™ marine

NTIK – Hamburg, 16.11.2022

AGENDA

- Welcome
- Introduction to Accelleron
- Turbocharger cleaning in operation
- Engine performance analysis – Tekomar XPERT™ marine

01

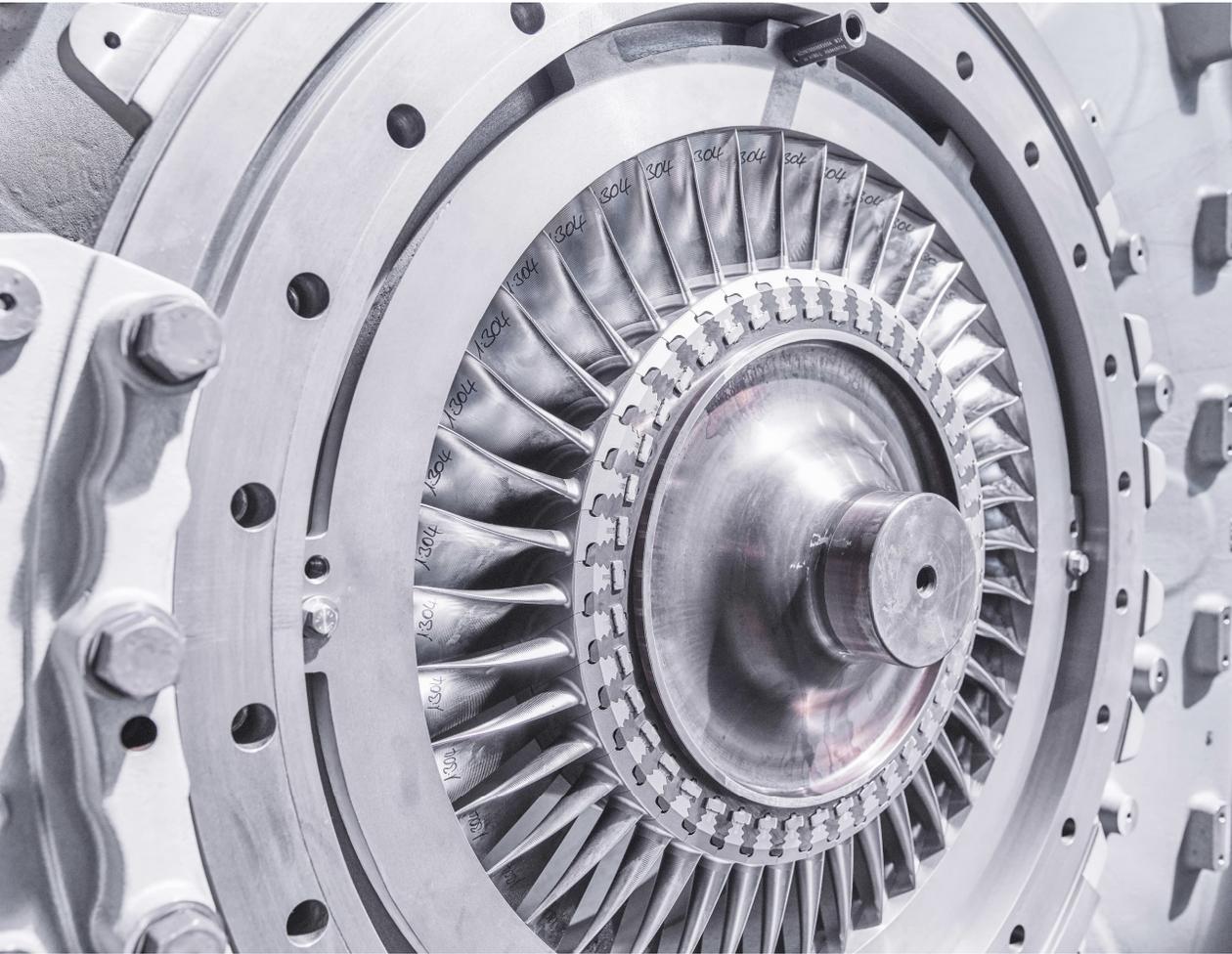
Introduction to Accelleron

Accelleron – the new face of ABB Turbocharging

- Together we inspire, innovate & exceed expectations – setting industry benchmarks for the benefit of all



- **Accelleron is a strong name inspired by acceleration**
- The name is based on the **accelerated** development of technologies for energy transformation and with this the **accelerated growth** we deliver to customers, to us and to investors
- Accelleron stands for **global access** and **impact** as well, be it with the global service network, with our dedicated professional service engineers or with leading industry solutions
- Finally, Accelleron is inspired by our **commitment to excel**, no matter what the challenge may be
- Building on a **heritage of over 100 years in turbocharging**, our business will continue its development as the **global market-leader in its sector**



• Accelleron

117 years of customer care

- A global leader in the manufacture and maintenance of turbochargers for 500 kW to 80+ MW diesel and gas engines
- Leading-edge technology and innovation enables our customers to perform better and produce fewer emissions, even in the toughest terrains
- Approximately 200,000 Accelleron turbochargers in operation globally on ships, power stations, gen-sets, diesel locomotives and large off-highway vehicles
- Over 100 Service Stations in 50+ countries and a wide service portfolio providing tailored solutions with Original Parts and Original Service anytime, anywhere

Industries and applications we provide to

Mining

Off-highway trucks, excavators

Rail

Locomotives

• **Power**

- Peak and base load electrical power generation (EPG), back up power plants, nuclear power plants (NPP)

• **Oil & Gas**

- Onshore drilling, production and pipelines, offshore drilling, FPSO, transportation and supply & support vessels

• **Marine**

- Container ships, tankers, bulkers, LNG carriers, dredgers, yachts, cruise & ferries, tugs, coastal & river shipping

Service Offering

At a glance

- **Standard Offering**

- Original Parts & Services
- Service Network
- Service of non-ABB turbochargers

- **Service by exchange & repairs**

- Exchange Units
- Customer Parts Exchange Program (CPEX)
- Laser cladding repair

- **Upgrades**

- Upgrades / Retrofits

Service Agreements

- Maintenance Management Agreement
- Fixed Rate Service Agreement
- Turbo LifecycleCare
- Turbo UptimeCare
- Turbo MarineCare

Digital Customer Solutions

- Tekomar XPERT marine
- Tekomar XPERT for power plant
- Digital lifecycle solutions

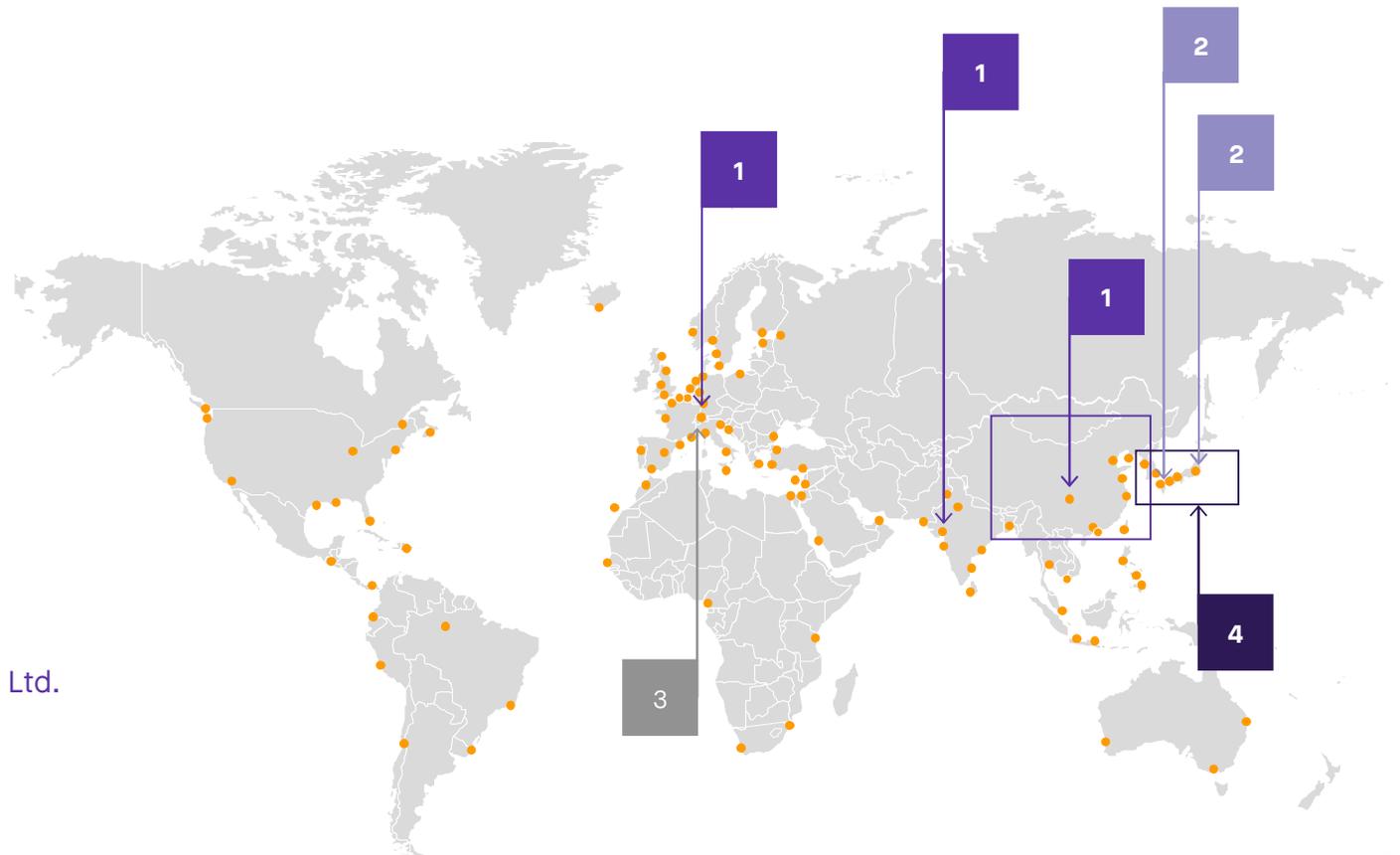
Training & Consulting

- CIAC / Condition Assessment

The world of Accelleron

> 100 sales and service stations

- **1. Production and assembly**
Switzerland, China, India
- **2. Licence production**
Korea, Japan
- **3. Global HQ**
Engineering and R&D
- **4. Joint Ventures**
JP: Turbo Systems United Co. Ltd.
CN: ABB Jiangjin Turbo Systems Co. Ltd.



02

Turbocharger cleaning in operation

Turbocharger cleaning in operation

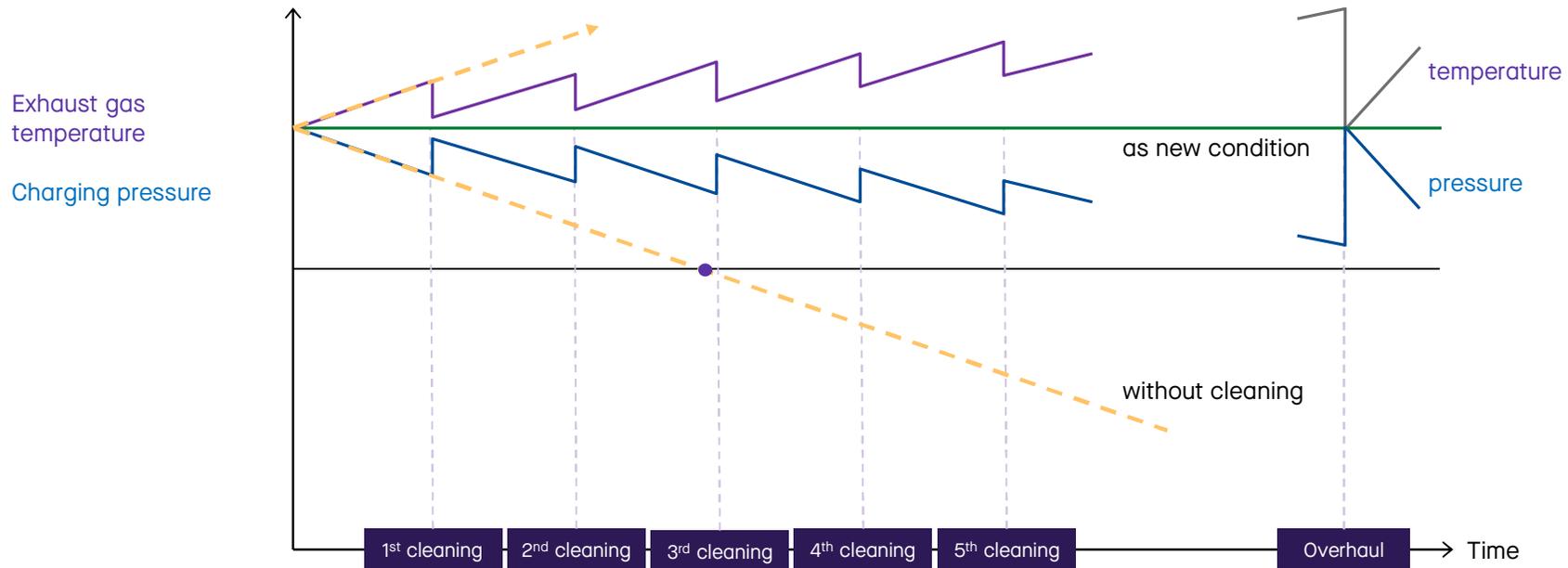
Overview

Engine type	Fuel		
	Heavy fuel Oil HFO	Marine diesel oil MDO	GAS
Four-stroke engines	!	✓	✓
Two-stroke engines	✓	✓	✓

Turbocharger cleaning in operation

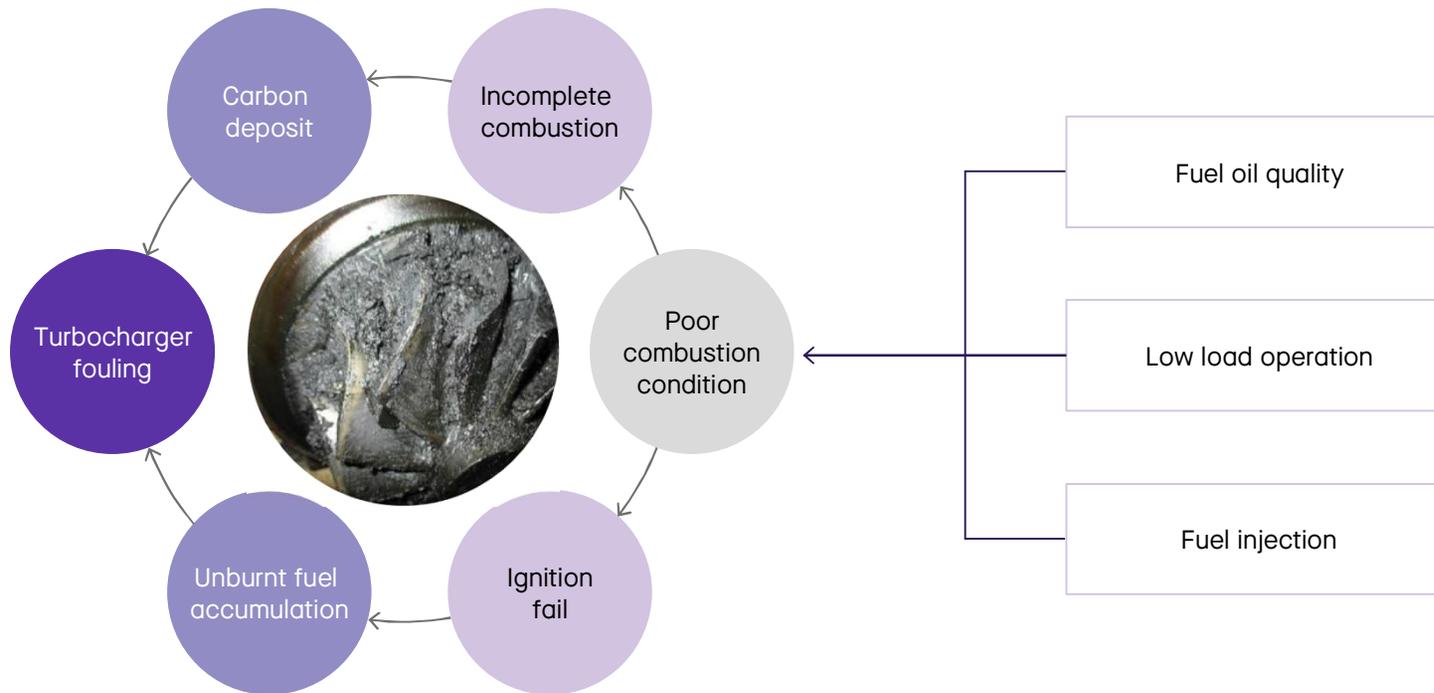
Benefits of cleaning

Regular cleaning improves the performance between overhauls



Turbocharger cleaning in operation

Four-stroke engines and HFO operation



Turbocharger cleaning in operation

Turbine and compressor cleaning



General turbine and compressor cleaning in operation

Turbine cleaning

- wet on four-stroke engines
- dry on two-stroke engines

Compressor cleaning

- wet on four- and two-stroke engines

Turbocharger cleaning in operation

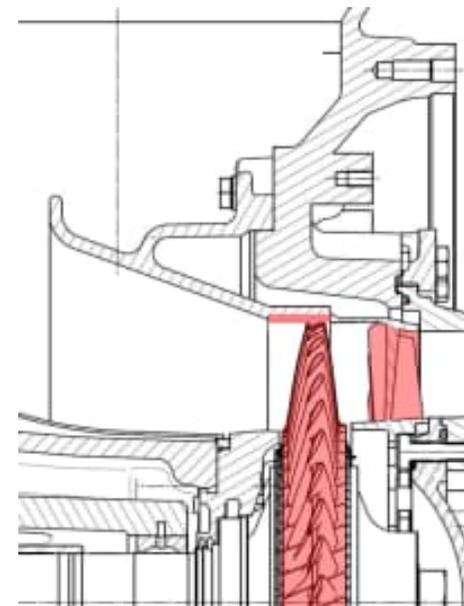
Components in exhaust gas and their impact

Ash	Hard residues, erosion and wear
Alumina + Silica	Hard residues, erosion and wear $\text{Al}_2\text{O}_3 + \text{SiO}_2$
Sodium	Corrosion in combination with other metals Na
Sulphur	Corrosion in combination with other metals S
Vanadium	High-temperature corrosion in combination with sodium V
Water	Corrosion effects H_2O
Carbon residue	Contamination of turbine surfaces

Turbocharger cleaning in operation

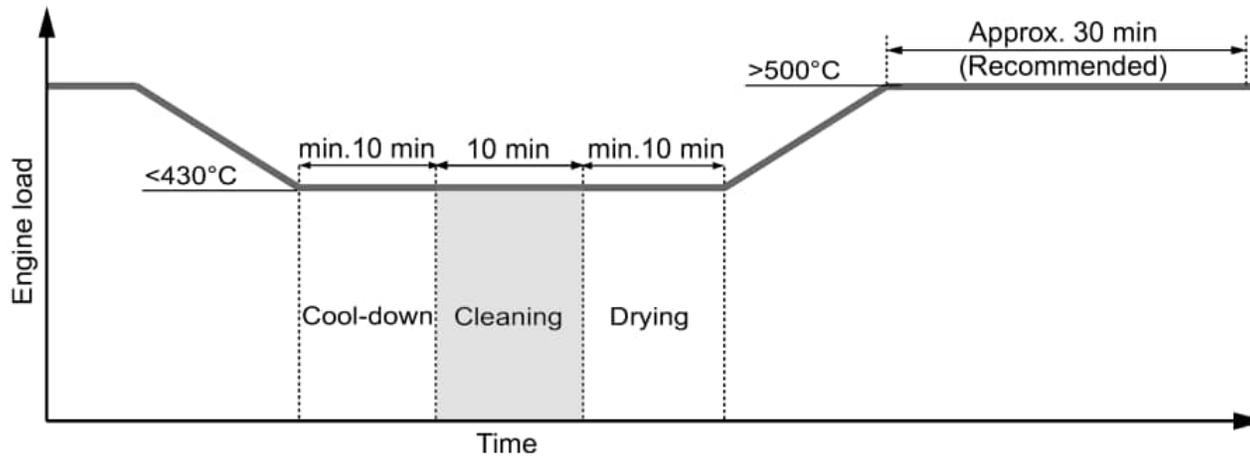
Turbine contamination & cleaning issues

- The **contamination builds up** in a time-frame between **50-100 hrs** and deteriorates the aerodynamic and thermodynamic properties of the turbine stage.
- The most contaminated parts are the **nozzle ring**, the **turbine blades** and the **turbine diffuser (cover ring area)**.
- Other parts e.g., **gas inlet casing** are contaminated as well, but usually the impact is less and therefore there is less necessity for a cleaning.



Turbocharger cleaning in operation

Cleaning process



Interval

Every 50 ... 200 hrs

Principle / Effects

Erosion

impacting droplets

Solubility

water solubility of
contamination in water

Thermal shock

spalling of contamination

Engine load

$\approx 10 \dots 15\%$

Turbocharger cleaning in operation

Turbine contamination - Examples



Gas inlet casing

- reduced η_{TC}
- higher fuel consumption



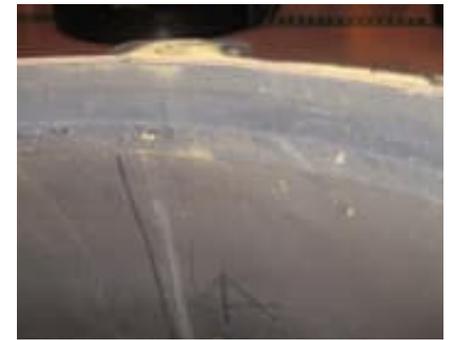
Nozzle-ring

- lower engine scavenging
- Increase of exh. gas temp. and thermal load



Turbine blades

- Deterioration of aero- and thermodynamic properties
- reduced η_{TC}

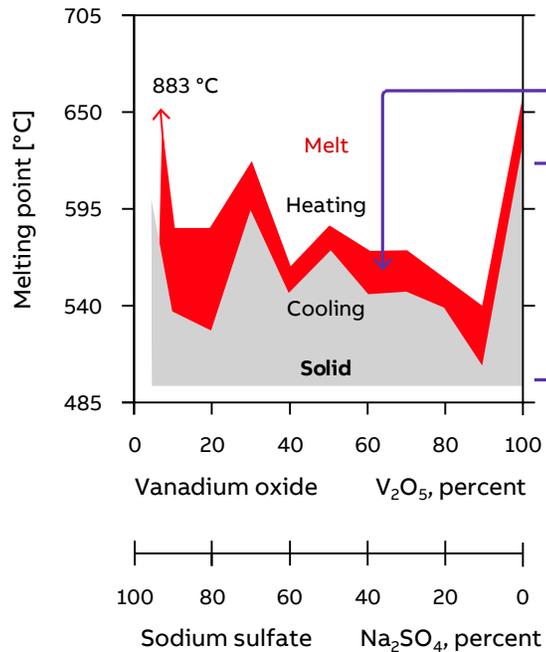


Turbine-diffuser

- Rubbing of turbine blades

Turbocharger cleaning in operation

HFO Background



Melting point in the system

Vanadium oxide V₂O₅ – Sodium sulfate Na₂SO₄

Area where the consistency of the particle's changes from solid to liquid/ melt

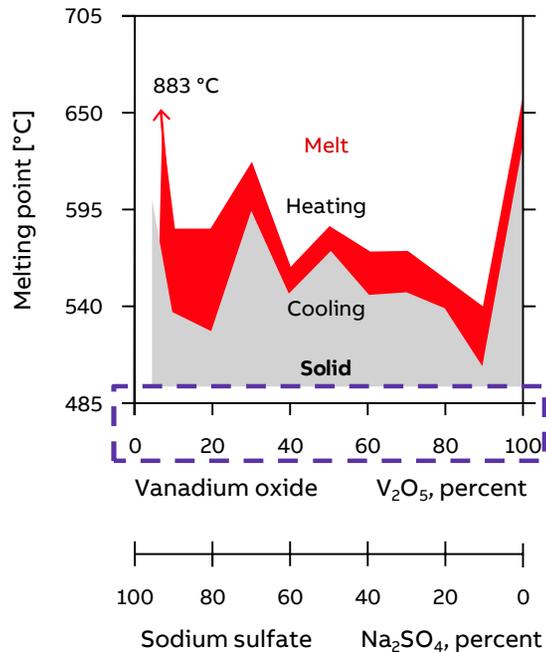
Temperature range of four-stroke engines

Critical parameters

- V₂O₅/ Na₂SO₄ ratio
- Exhaust gas temperature level
- Certain content of Vanadium (V) and Sodium (Na)
- Temperature level influences consistency of particles

Turbocharger cleaning in operation

HFO Experiences in different temperature ranges I



Solid range (≤ 500 °C)

Hardly any contamination

Erosion impact possible

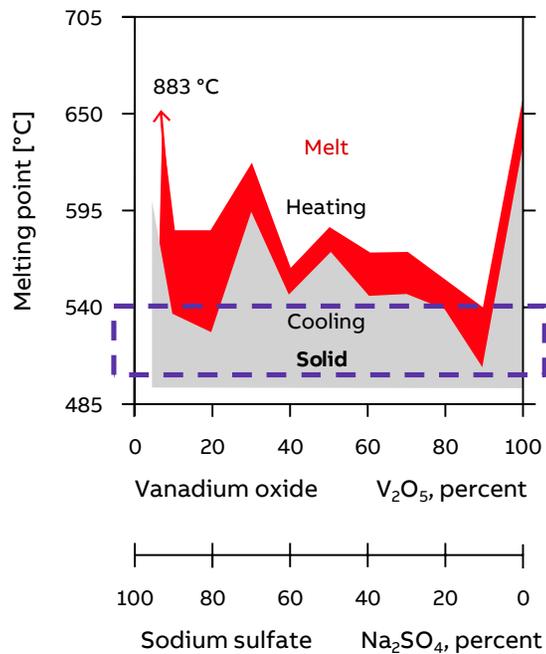
Dry cleaning at normal or even extended intervals is sufficient

Mechanical cleaning during regular inspection intervals is sufficient

Only little performance deterioration due to fouling, wear and tear

Turbocharger cleaning in operation

HFO Experiences in different temperature ranges II



Range with mainly solid/ partly melt particles
(500 – 540 °C)

Contamination build up is likely in the exhaust duct
and on turbocharger components

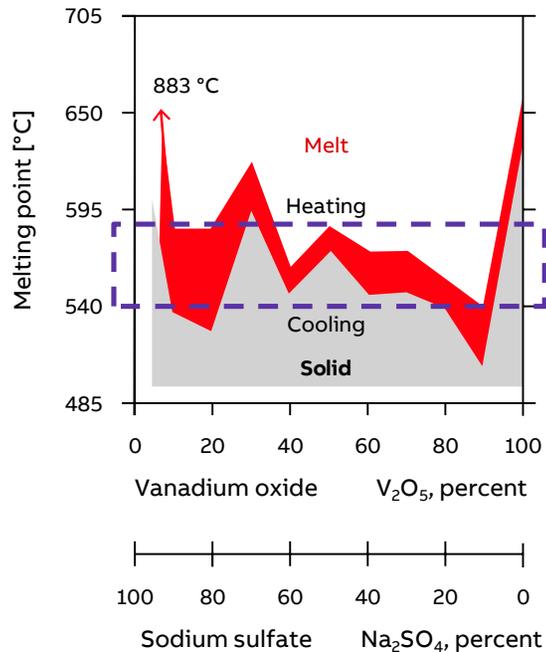
Wet cleaning at normal – or maybe reduced
intervals needed

Mechanical cleaning during regular or in certain
cases reduced intervals needed

Performance deterioration due to contamination
build-up to be expected

Turbocharger cleaning in operation

HFO Experiences in different temperature ranges III



Range with mainly melt/partly solid particles
(540 – 580 °C)

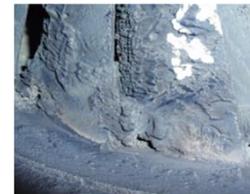
Strong contamination build up in exhaust duct
and on turbocharger components

Well developed wet cleaning required

Cleaning at reduced intervals

Mechanical cleaning in reduced intervals likely

Performance deterioration to be controlled
by optimized cleaning, proper installation
and professional operation



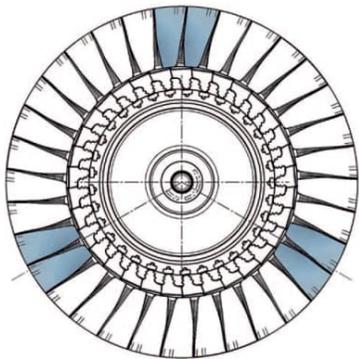
Turbocharger cleaning in operation

Coated turbine blades combat accelerated tip wear



Deposits on turbine diffuser

- rubbing of turbine blades
- wear, loss of turbine diameter
- exh. gas bypassing the turbine
- reduction of η_{TC}



Coated blade tips

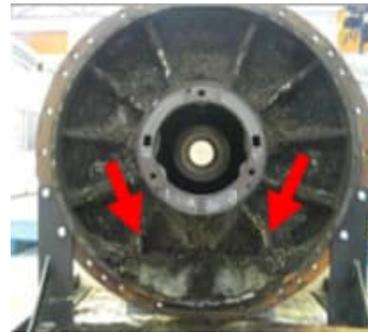
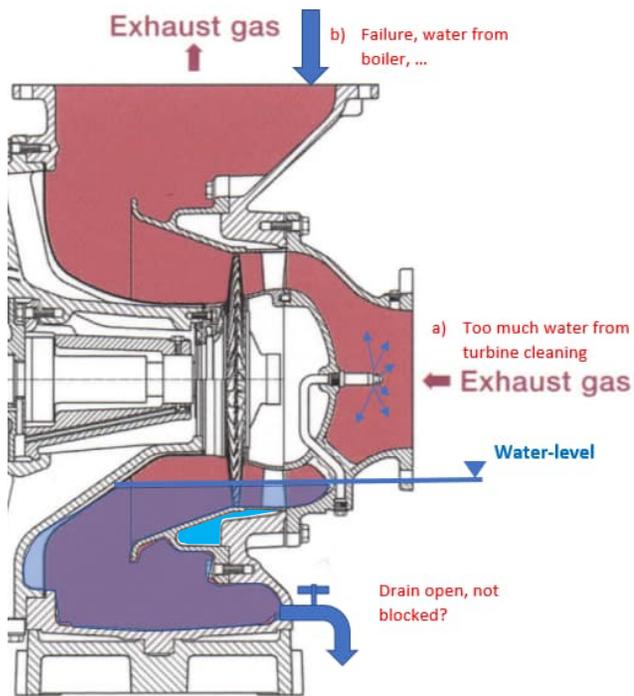
- 3x 2 hard tipped blades
- 120° intervals around the turbine wheel
- 4-stroke applications, only
- DF engines as well



After 12.000 hrs in operation

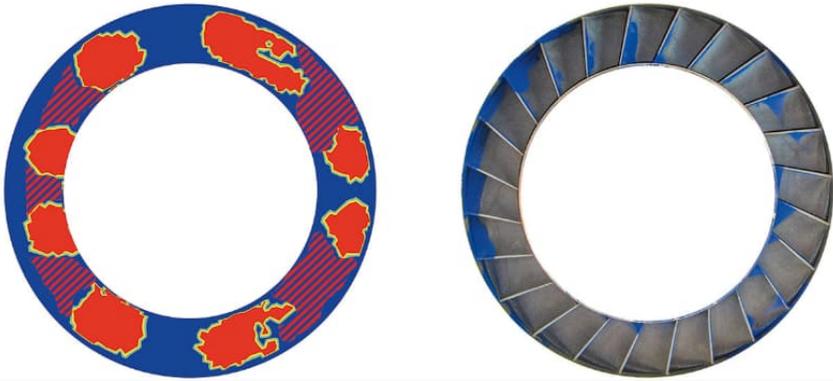
Turbocharger cleaning in operation

Too much water ingress in turbine



Turbocharger cleaning in operation

Development of effective turbine cleaning systems



Water distribution on a nozzle ring

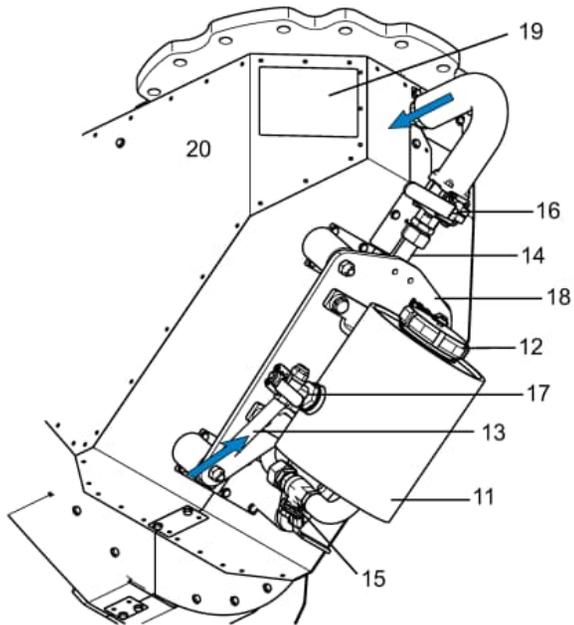
- Left: result of a computer simulation (in red/hatched: cleaned area)
- Right: experimental results. The blue paint denotes the non-washed regions. The results correspond with the cleaning effects in the field.

Targets

- **Homogeneous water distribution**
numerous possible designs of cleaning nozzles and water injection conditions are simulated
- **Impact of water on surfaces**
Cleaning system considers thermal shock due to wetted areas and avoids any damage to parts

Turbocharger cleaning in operation

Turbine dry cleaning - Two stroke engines



- | | | | |
|----|--------------------------------------|----|---|
| 11 | Granulate container (51702) | 16 | Protection valve [closed] (51713) |
| 12 | Cover cap (51703) | 17 | Pressurised air valve [venting] (51704) |
| 13 | Pressurised air supply [4 ... 7 bar] | 18 | Plate |
| 14 | Piping | 19 | Cleaning instructions (51717) |
| 15 | On-Off valve [closed] (51705) | 20 | Gas inlet casing, insulated |

Product Quantity [dm ³]	
A165-L	1.0
A170-L	1.5
A175-L	2.0
A180-L	2.5
A185-L	3.0
A190-L	3.5

Interval

HFO: every 50 hrs

Gas/HFO: increase to max. 150 hrs

Principle

Dirt removed by the mechanical action of impacting solids (granulate).

Material

Natural core granulates

Soft-blast media

Activated carbon particles

Size: 1,2 ... 2,0 mm

Specific weight: $\leq 1,2 \text{ kg/dm}^3$

Operating state

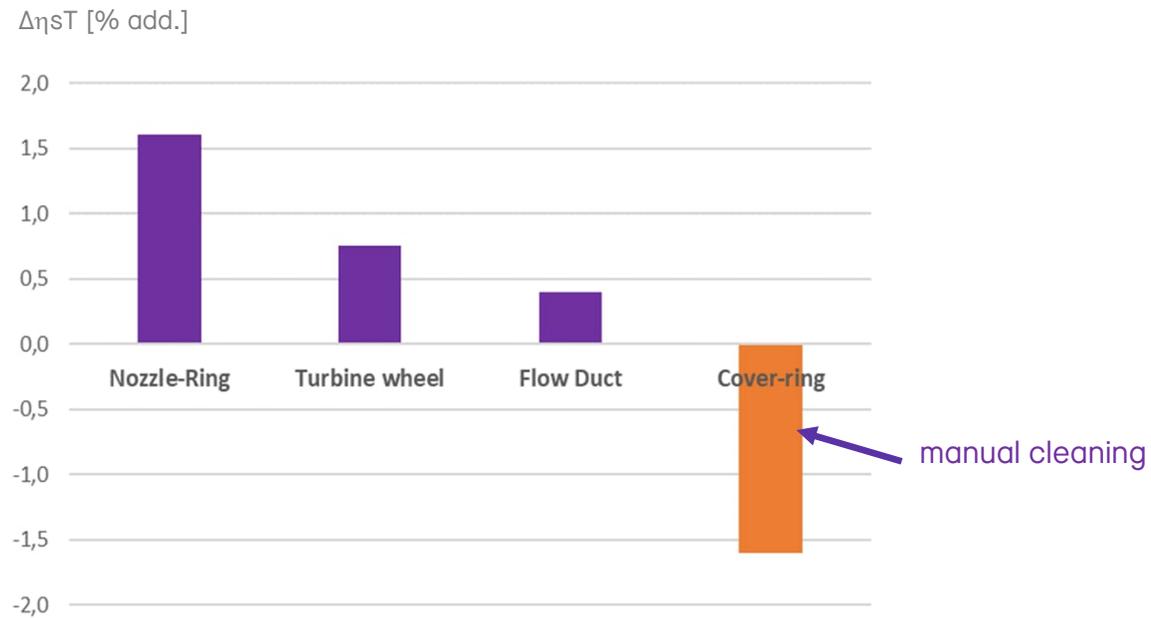
Engine load 5 ... 85%

Repeating cleaning

max. 3 processes

Turbocharger cleaning in operation

Magnitude of efficiency gain after turbine cleaning



Source: Test lab/Different HFO-contaminated TC's

Turbocharger cleaning in operation

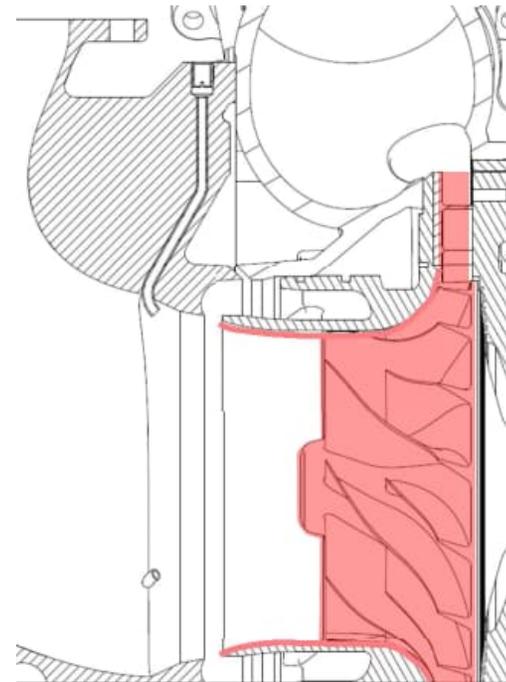
Compressor contamination – Examples



Turbocharger cleaning in operation

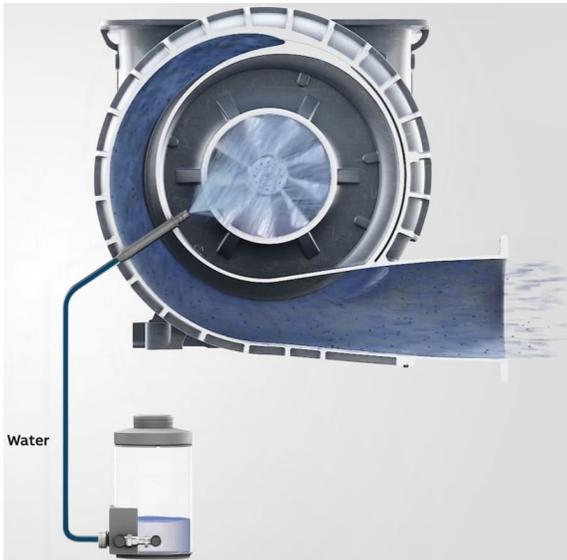
Compressor cleaning issues

- The sensitive parts regarding contamination are the **insert wall**, the **compressor wheel** and the **diffuser**.
- The **thermodynamic loss** in compressor efficiency is in the range of **2...3%**.
- Beside the thermodynamic degradation of the compressor stage there are also **corrosion effects**, which cannot be neglected.
- The cleaning mechanism is a combination of water droplets impact and dissolving the contamination layer.
- Washing effect is influenced by the flow field of the compressor. – **Poor water, only.**



Turbocharger cleaning in operation

Compressor cleaning wet on four- and two-stroke engines



Product	Contents of cleaning medium vessel [dm ³]
TPL69-A	0.4
TPL73-A	1.0
TPL77-A	1.0

Product	Quantity [dm ³]
A165-L	2.0
A170-L	2.0
A175-L	3.0
A180-L	3.0
A185-L	3.0
A190-L	3.0

Interval

Every 25 ... 100 hrs

Principle / Effects

- Impact of droplets
- Only clean fresh water

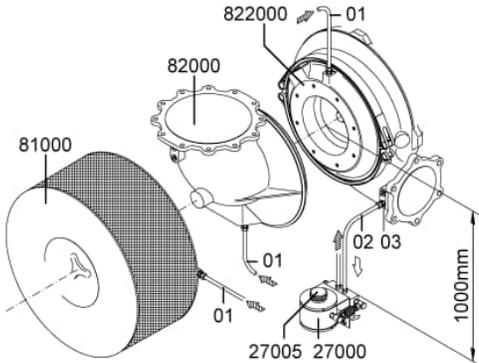
Engine load

50 ... 85%

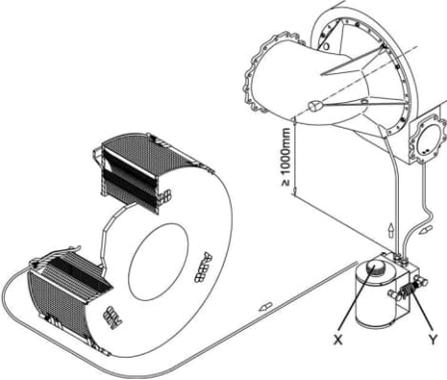
Turbocharger cleaning in operation

Wet cleaning equipment - Compressor

TPS / A100-M



TPL-A/C



(TPL-B) / A100-L / A200-L

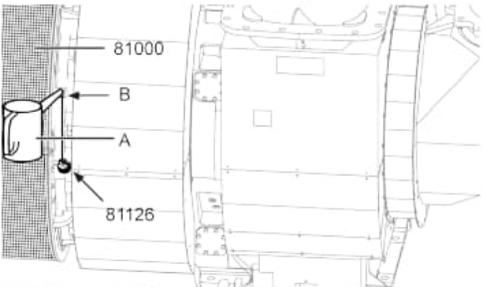


Fig. 17: Overview of wet cleaning of compressor

- | | | | |
|-------|-----------------|---|----------------|
| 81000 | Filter silencer | A | Can |
| 81126 | Lock | B | Filler opening |

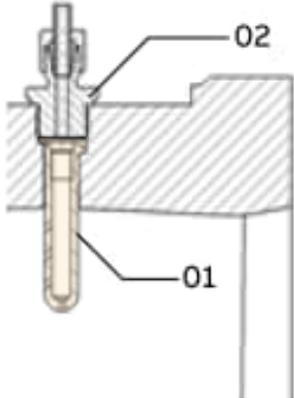
4-Stroke

2-Stroke

Turbocharger cleaning in operation

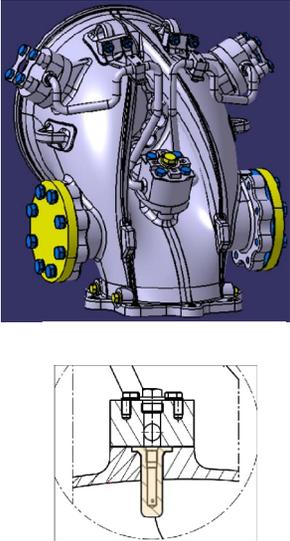
Cleaning equipment - Turbine

TPS / A100-M



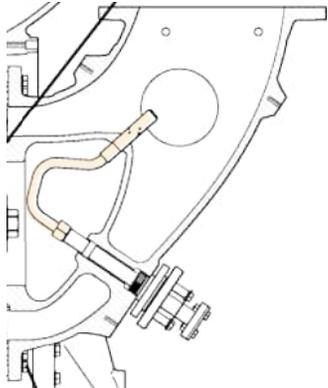
Wet-cleaning

TPL-A/C

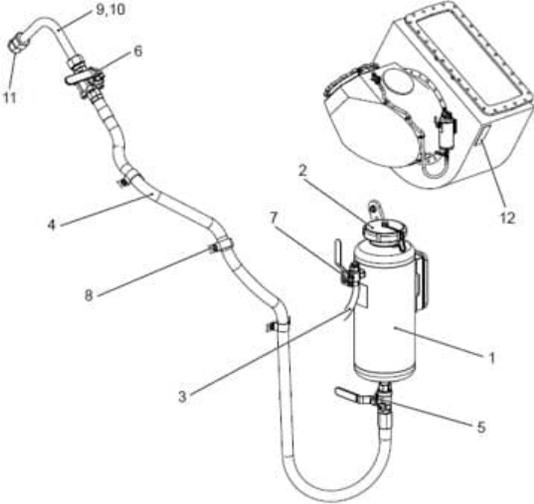


Wet-cleaning

A100-M



TPL-B / A100-L



Dry-cleaning

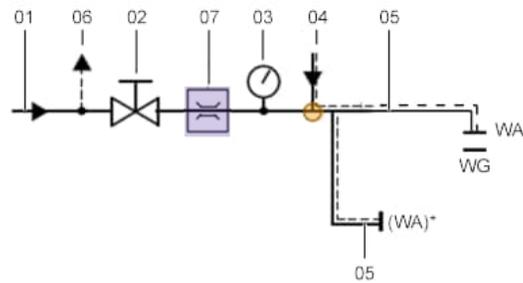
4-Stroke

2-Stroke

Turbocharger cleaning in operation

Operation Manual: Layout & parameter for wet cleaning of turbine

Even with the water pressure being observed, the volume of water may be too low due to a blockage. Accelleron recommends installing a water flowmeter.



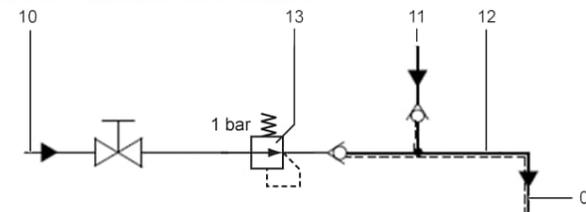
- 01 Water supply
- 02 Regulating valve
- 03 Manometer
- 04 Scavenging air supply with 3-way valve
- 05 Water pipe made of stainless steel
- 06 Additional engine
- 07 Flowmeter (recommended)
- WA Connection provided by the customer (option)
- (WA)* Connection for additional turbochargers (V-engine)
- WG Connection at turbocharger end

Product	Temperature before turbine before cleaning [°C]	Maximum temperature before turbine during cleaning [°C]	Water volume flow V_w [dm ³ /min] ¹⁾	Injection time [min]
A130	350 ... 430	530	4.0	10
A135	350 ... 430	530	5.5	10
A140	350 ... 430	530	8.5	10
A145	350 ... 430	530	12.0	10

Table 16: Wet cleaning of turbine, parameters

¹⁾ Corresponds to a water pressure p_{WT} of 1.5 bar (overpressure compared to atmosphere)

Layout of the scavenging air supply



- 04 Scavenging air supply to 3-way valve
- 10 External compressed air (optional)
- 11 Charge air after cooler
- 12 Scavenging air pipe
- 13 Pressure relief valve

Turbocharger cleaning in operation

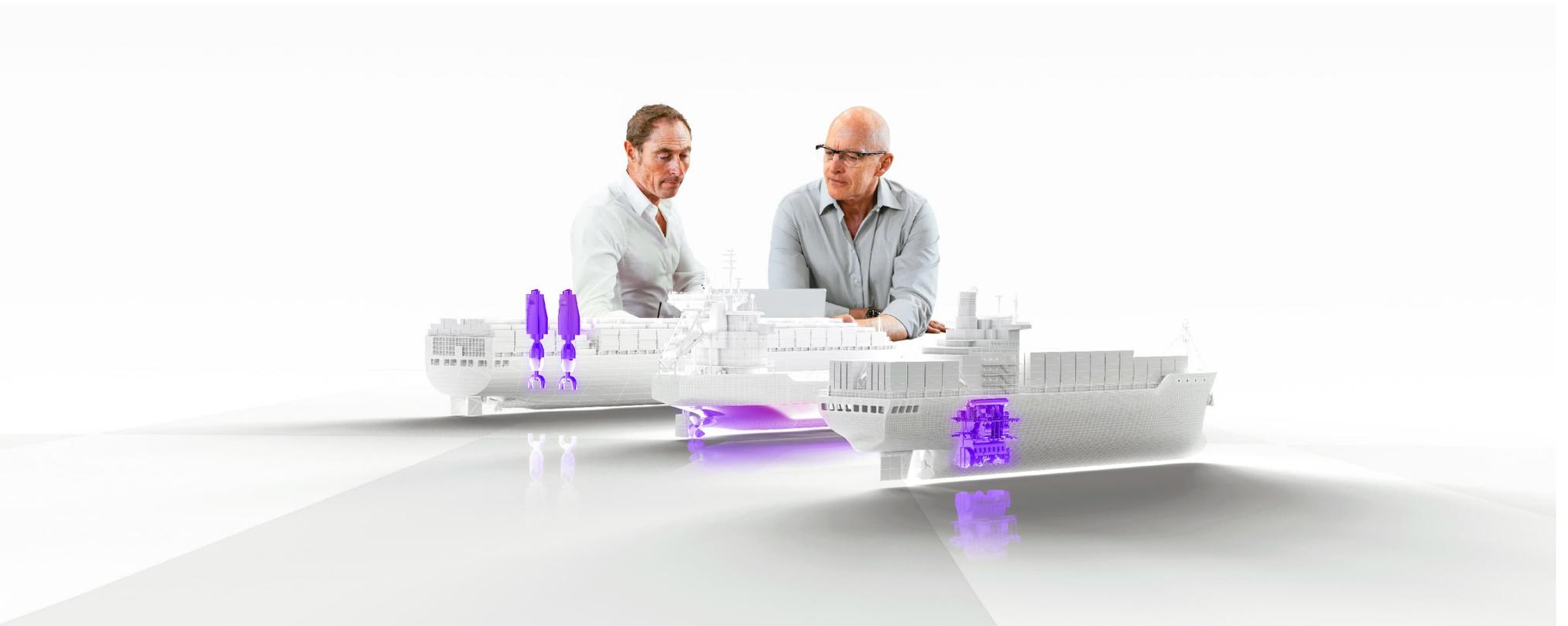
Summary

Engine type	Fuel		
	Heavy fuel oil HFO	Marine diesel oil MDO	GAS
Four-stroke engines	Regular wet cleaning	Occasionally wet cleaning	Usually not required ¹
Two-stroke engines	Regular dry cleaning	Occasionally dry cleaning	Usually not required ¹

¹ Depending on gas – and lube oil composition

03

Engine performance analysis – Tekomar XPERT™ marine



Tekomar XPERT™ marine

Extended product presentation

We developed Tekomar XPERT™ marine: A complete suite for sustainability, efficiency and compliance

Tekomar XPERT™ marine



Engine

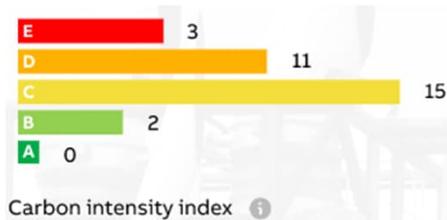
- Engine Performance Diagnostic
- Automatic and specific advisory



Emissions

New launch

- EU-MRV and IMO-DCS reporting
- CII trending & forecasting



Hull & Propeller

New launch

- Hull resistance determination
- Fuel consumption compared to charter party or sea-trial
- Hull cleaning advisory



Connect package: Continuous data evaluation, based on cloud-to-cloud connection



The Engine module assesses engine performance and delivers advisory

What is it?

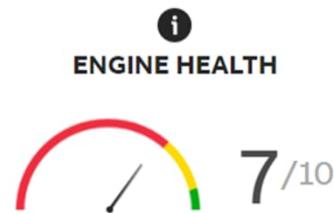
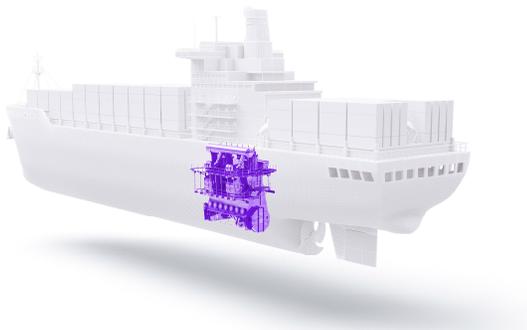
- Software that **diagnoses engines performance** and **delivers advisory on how to optimize** them across your fleet

How does it work?

- Applies to **any engine** make, type, fuel and age, **main and auxiliaries**
- **Automated** or manual data input
- Compares engine performance to shop test (ISO corrected)

What does it deliver?

- Engine performance **diagnostic**
- Instant optimization **advisory**
- **Benchmarking** for the fleet





What is our Desktop App?

Data input/import

Evaluation of engine performance

Diagnostics with advisory and savings

Comparison of readings and vessels

- **Manual data input** by crew or **data import** from third party devices or monitoring systems
- **Actual engine performance is compared to shop test reference values (baseline performance)**
- **Instant quantification of fuel oil saving potentials and advice on how to improve performance** including specific measures
- **Comparison of readings** for equipment across the entire fleet
- **Data trending** regardless of engine power

The screenshot shows the Tekomar XPERT desktop application. The main window displays a table with engine performance data. A menu is open over the 'Import' button, listing various data sources for import. The table data is as follows:

Category	Value	Unit/Label			
Sea water	8.15	00 : 00			
Outside air					
Engine room air					
Barom. press. Engine room					
CALCULATED		MEAS			
XPERT	TORSIOM.	by Ft*rpm			
17798	18025	19229			
70.4 %					
ENGINE					
95.7 %	99.5				
70.4 %	17798				
CORRECTED					
CALC.	AVG.	CYL 1	CYL 2		
95.2	93.1	92.3	94.1		
	4.0	4.0			
CORRECTED					
QUALITY:	REF.	CALC.	AVG.	CYL 1	CYL 2
Imported					
Firing press. pmax	barG	121.5	112.6	114.6	111.5
pmax deviation	bar			-3.1	

Tekomar XPERT™ marine - Emissions module

Tekomar XPERT™ marine

Engine

- Engine Performance Diagnostic
- Automatic and specific advisory

≈ 1.8 t/d
Fuel saving potential ⓘ

Emissions

New launch

- EU-MRV and IMO-DCS reporting
- CII trending & forecasting

Category	Count
E	3
D	11
C	15
B	2
A	0

Carbon intensity index ⓘ

Hull & Propeller

New launch

- Hull resistance determination
- Fuel consumption compared to charter party or sea-trial
- Hull cleaning advisory

10 %
Hull Resistance ⓘ

Connect package: Continuous data evaluation, based on cloud-to-cloud connection



The Emissions module supports shipping companies in the path to sustainability

What is it?

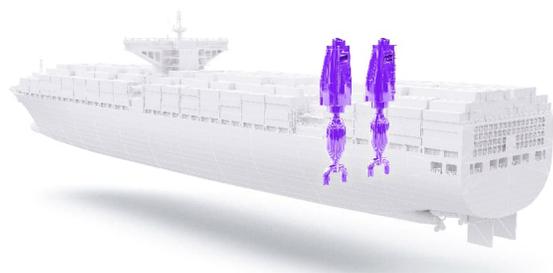
- The Emissions module **calculates and forecasts your CII** and generates automatic, pre-validated **MRV and IMO-DCS reports** per voyage

How does it work?

- **Reports are automatically generated** using continuous data⁽¹⁾
- Reports are **pre-validated**, using methodologies in line with IMO, EU
- **Future CII rating is simulated**, based on adjustable key parameters and historic operational data

What does it deliver?

- Automated, pre-validated **emissions reporting**
- Interactive **CII trend and forecast**





Tekomar XPERT™ marine – Emissions module

Emissions Dashboard

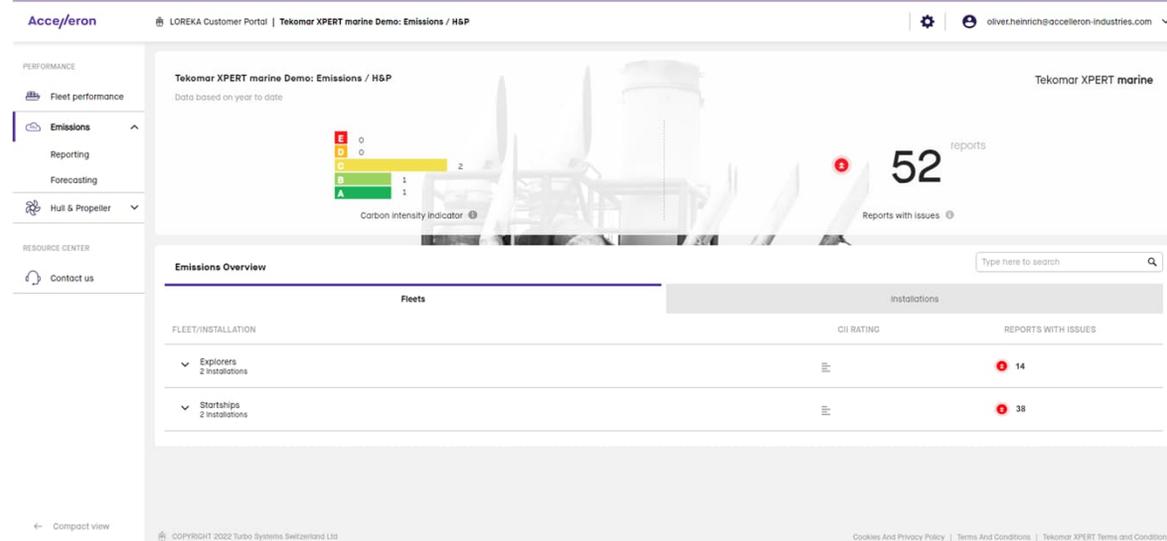
- KPIs for CII and Reporting Issues
- KPIs available at vessels, fleets and company level

Emission reporting (MRV, DCS)

- Listing of automatically detected voyages per vessel with associated CII rating
- In case of problematic report status editable by crew

CII Forecasting

- Prediction of future CII rating (end of year and future years) based on operation pattern and adjustable key parameters



Tekomar XPERT™ marine - Hull & Propeller module

Tekomar XPERT™ marine

Engine

- Engine Performance Diagnostic
- Automatic and specific advisory

≈ 1.8 t/d
Fuel saving potential ⓘ

Emissions

New launch

- EU-MRV and IMO-DCS reporting
- CII trending & forecasting

Category	Value
E	3
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A	0

Carbon intensity index ⓘ

Hull & Propeller

New launch

- Hull resistance determination
- Fuel consumption compared to charter party or sea-trial
- Hull cleaning advisory

10 %
Hull Resistance ⓘ

Connect package: Continuous data evaluation, based on cloud-to-cloud connection



What is Tekomar XPERT™ marine - Hull & Propeller module?

What is it?

The Hull & Propeller module **assesses the condition of hull and propeller:**

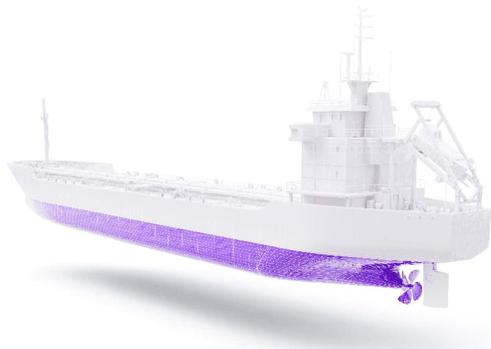
- Determines the overconsumption compared to technical and charter party reference
- Offers **advisory** on maintenance task timing

How does it work?

- Calculates the hull resistance of a vessel based on the additional power required to run at a specific speed compared to technical reference
- Deviation of consumption is compared to charter party reference or technical reference

What does it deliver?

- **Hull resistance KPIs and trends**
- **Assessment of overconsumption** based on reference values
- **Hull cleaning advisory**



Data based on last 30 days

10 %

Hull Resistance ⓘ



Vessel count overconsumption (CP) ⓘ

-7 %

Overconsumption (CP) ⓘ

Tekomar XPERT **marine**

8 %

Overconsumption (TECH.) ⓘ



Tekomar XPERT™ marine – Hull & Propeller module

Hull & Propeller Dashboard

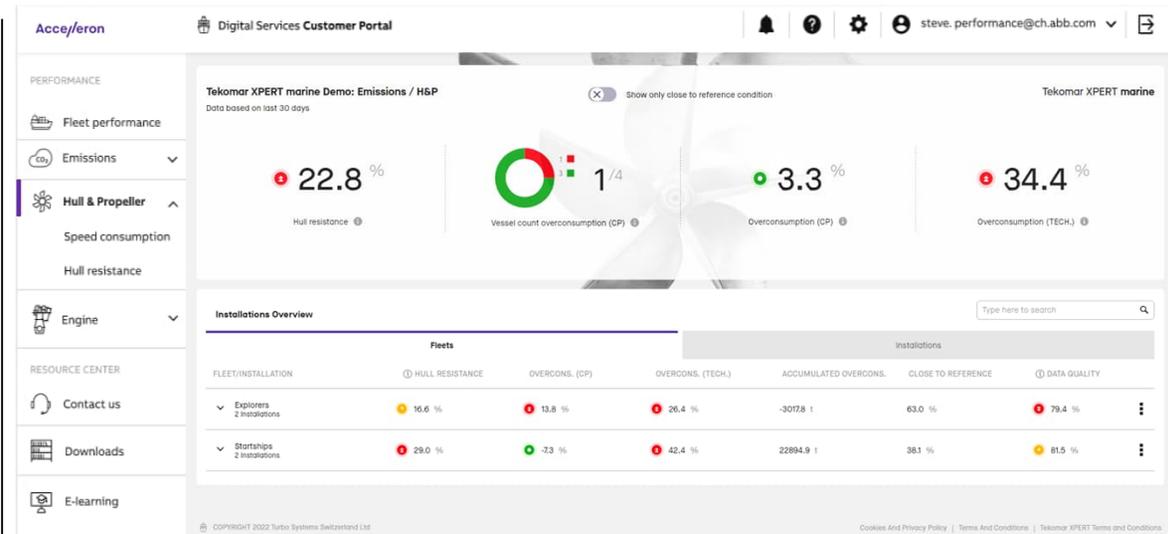
- KPIs related to hull and propeller overconsumption
- Comparison to charter party and technical reference
- Quality indication of datasets

Speed consumption

- Speed vs consumption curves for charter reference including information of applied corrections

Hull resistance advisory

- Calculation of hull resistance to reference and trendline
- Hull cleaning advisory based on variable input parameters like hull cleaning cost, fuel cost and speed



Connectivity of Tekomar XPERT™ marine

Tekomar XPERT™ marine

Engine

- Engine Performance Diagnostic
- Automatic and specific advisory

≈ 1.8 t/d
Fuel saving potential ⓘ

Emissions

New launch

- EU-MRV and IMO-DCS reporting
- CII trending & forecasting

Category	Value
E	3
D	11
C	15
B	2
A	0

Carbon intensity index ⓘ

Hull & Propeller

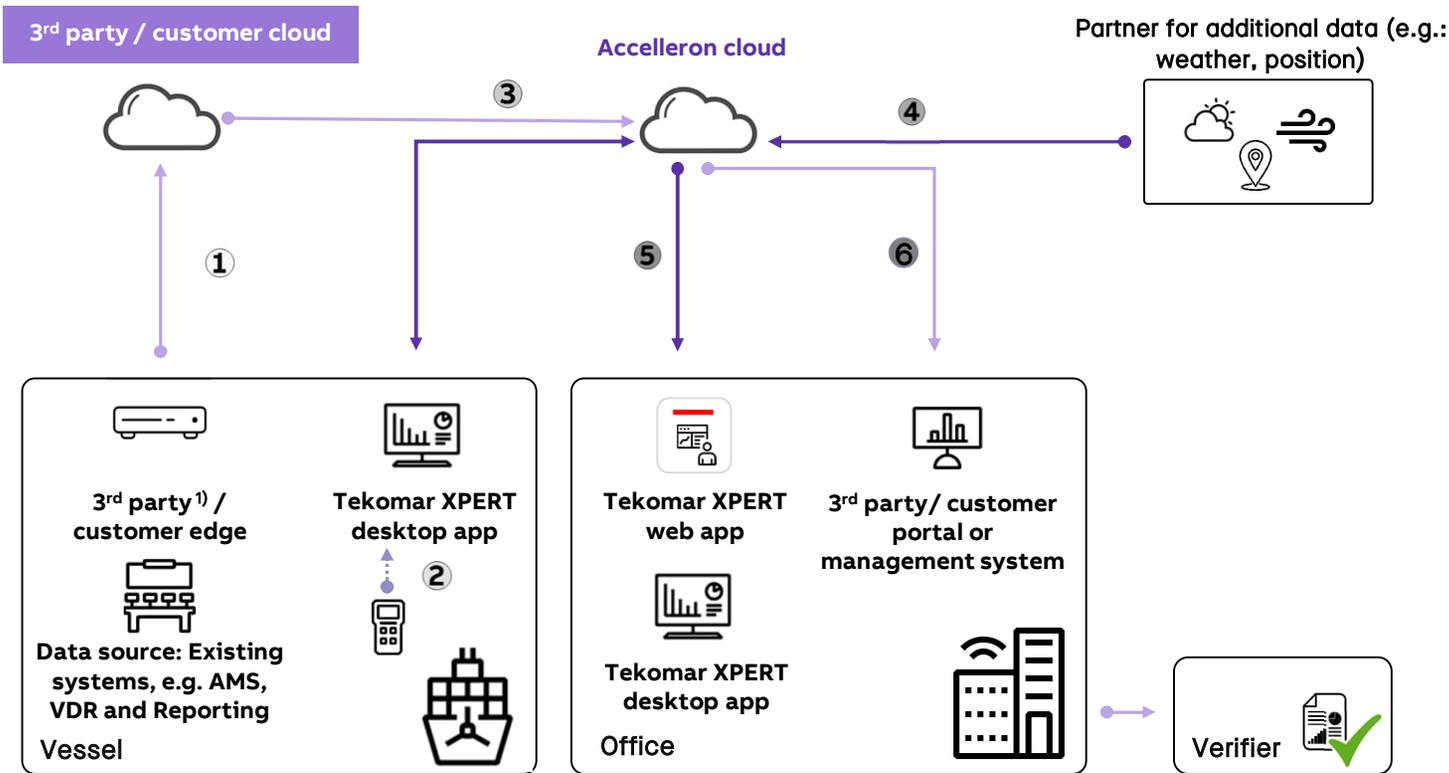
New launch

- Hull resistance determination
- Fuel consumption compared to charter party or sea-trial
- Hull cleaning advisory

10 %
Hull Resistance ⓘ

Connect package: Continuous data evaluation, based on cloud-to-cloud connection

Connectivity Scheme of Tekomar XPERT™ marine



- 1 Data collection onboard: Tekomar XPERT marine utilizes **existing systems**, typically from AMS + VDR¹⁾
- 2 Manual data input via desktop app for the Engine module, if necessary
- 3 The data transfer from onboard via 3rd party customer's cloud to the Accelleron cloud. Accelleron is **compatible with vast majority** of them
- 4 Tekomar XPERT marine utilizes **additional data sources** from Accelleron Partners to enhance the data set from your system
- 5 **Data analytics**, visualization of KPIs and enabling ease of reporting and instant forecasting
- 6 ODATA API for integration of evaluated Tekomar XPERT marine data into other systems

Thank you !

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