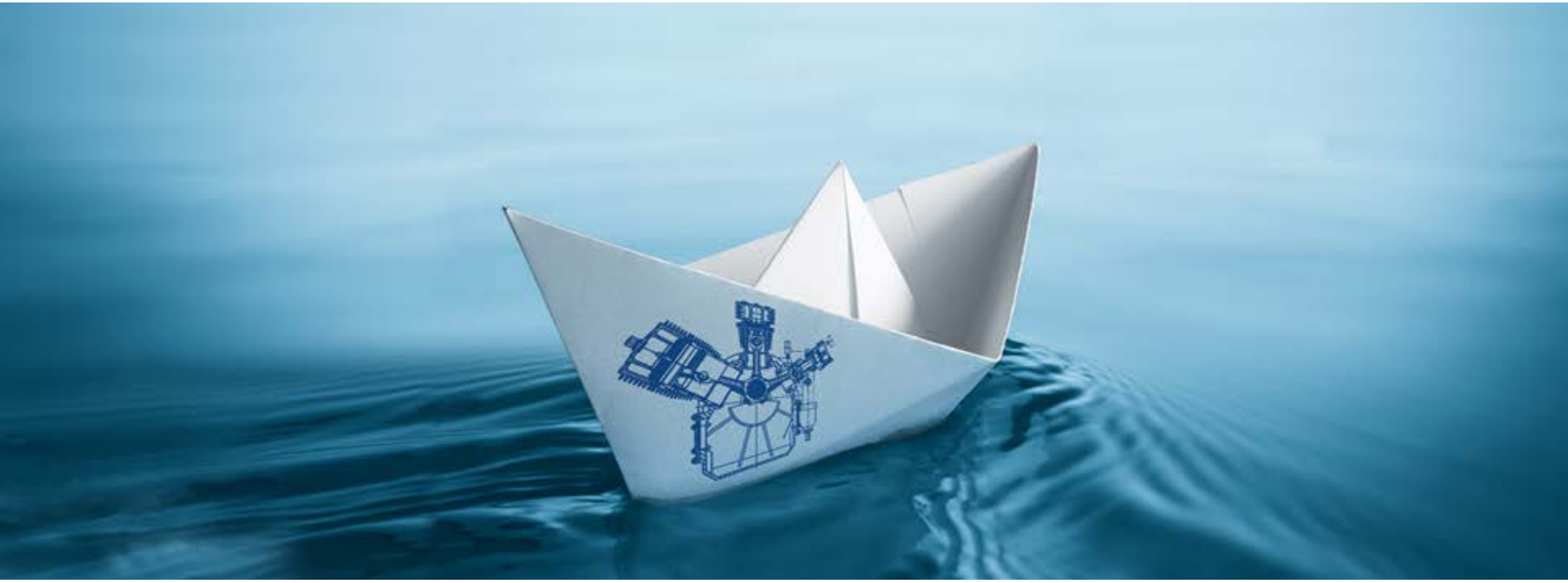
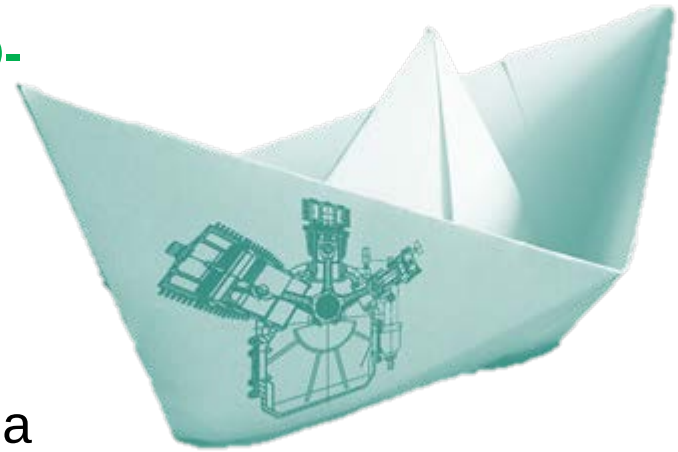
Technical Seminar

3-Stage Air Cooled Compressors:
ECO-solutions for ECO Ships?



“3-Stage Air Cooled Compressors - ECO-solutions for ECO Ships?”



or:

„Can starting air compressors contribute to a more cost effective, eco-friendly ship operation?“

What is the opinion of old and experienced sea dogs?

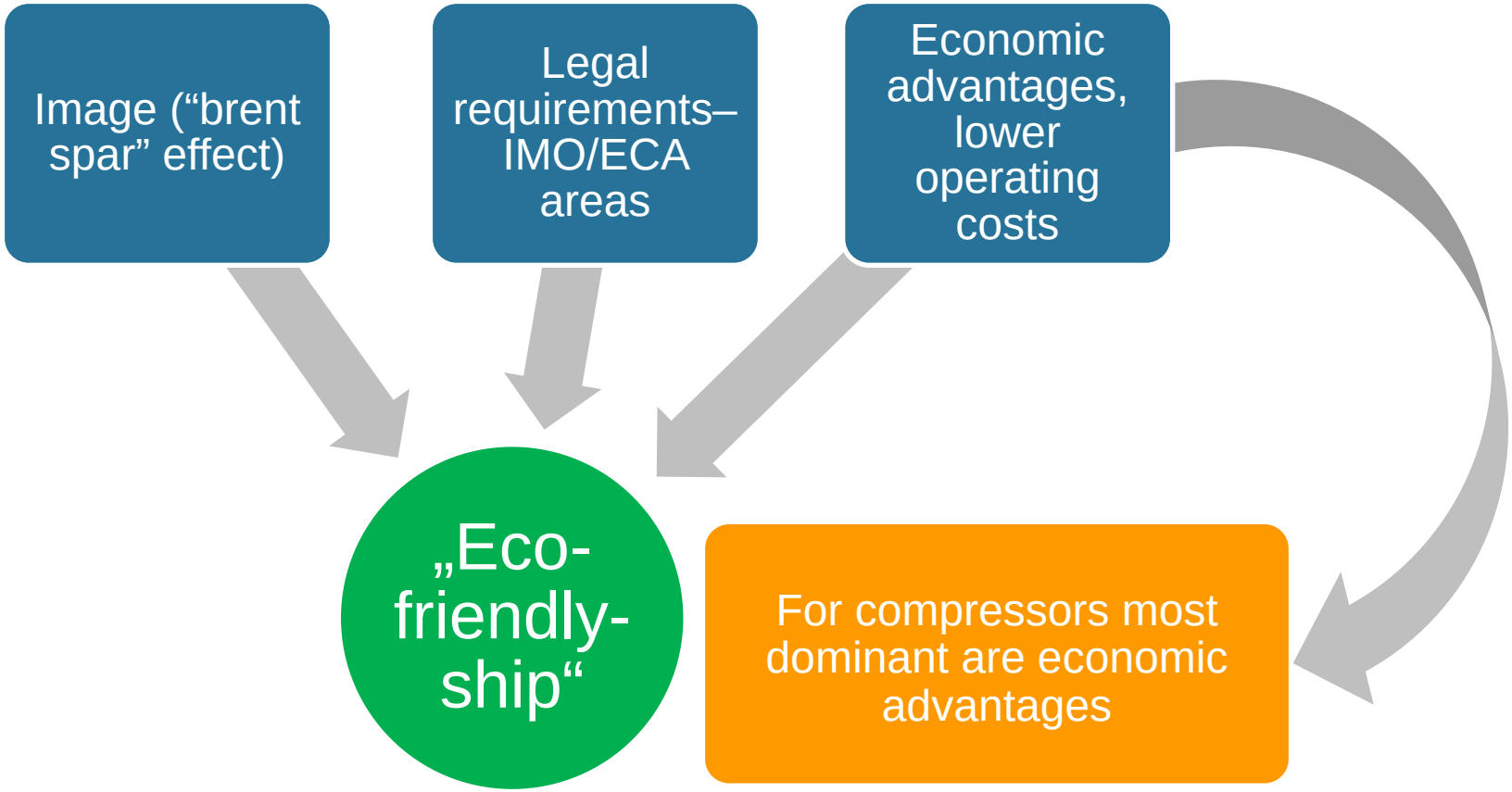

Compressors? These are all peanuts!
But many small peanuts are as effective as a coconut!

In order to progress from today we need to think „out of the box“!

?

- **How can starting air compressors contribute to a more cost effective and “eco-friendly” ship operation?**
- **„Eco-friendly“ can be translated best by sustainable ship-operating concept, i.e. protection of limited natural resources**

Why we need to check today more than ever if our ship operation concept is eco-friendly/sustainable?



Factors which influence the economic operation of compressors

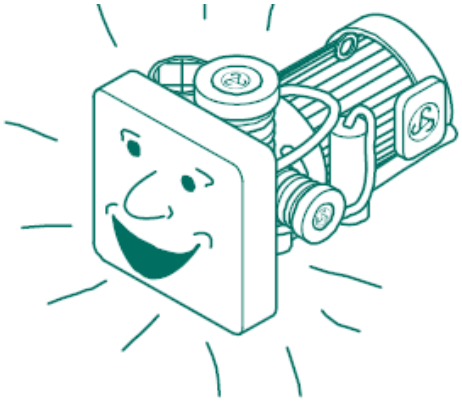
Internal factors „more m³/h per kW“

3-stage compression

Sauer Easy Care

Drainage

IE 2 motors



External factors „less € per m³/h“

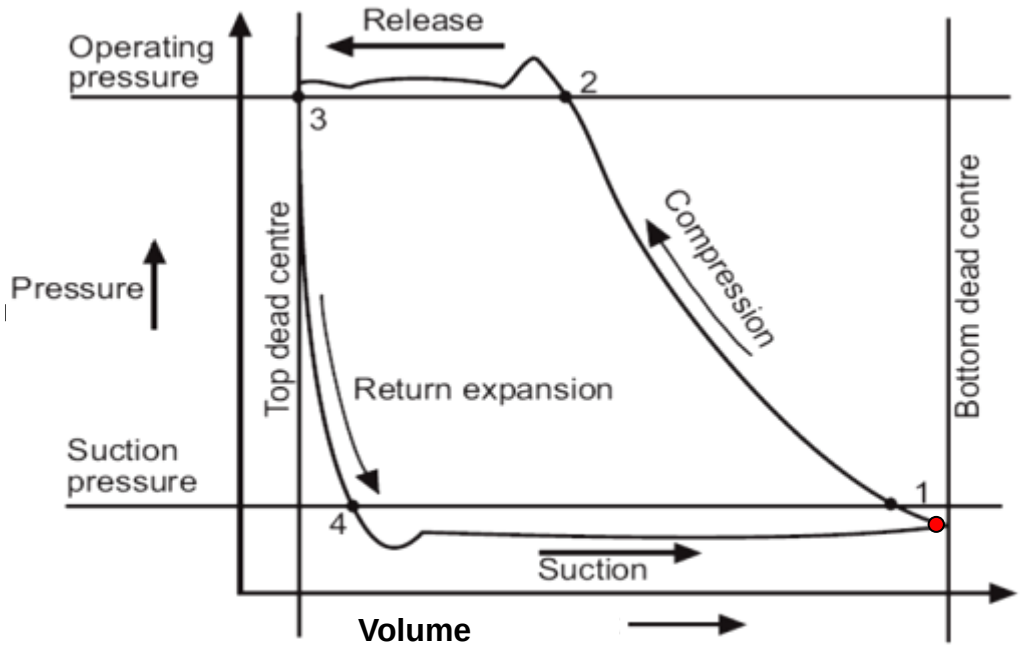
Air cooling

Lubrication oil

Sauer ECO Box® Plus

Compressors selection

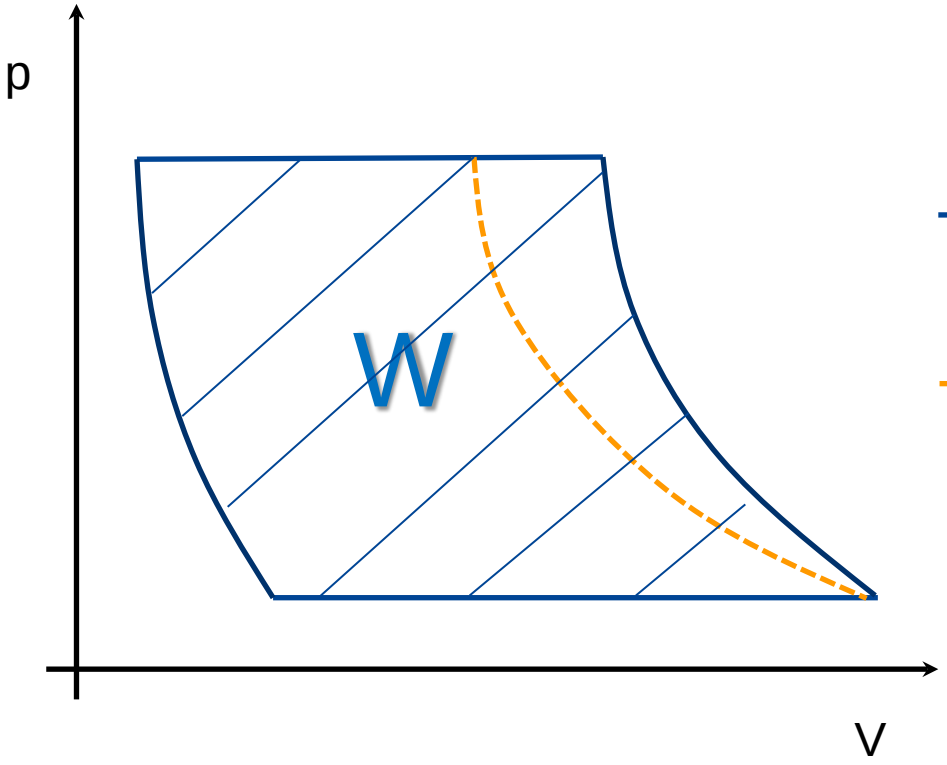
Basics of Compressors Technology



„p-V diagram“ for compression

Internal Factor: 3-stage Compression:

- **Better thermal efficiency by 3-stage compression**
- **Here: Physical compression work at 1-stage compression**



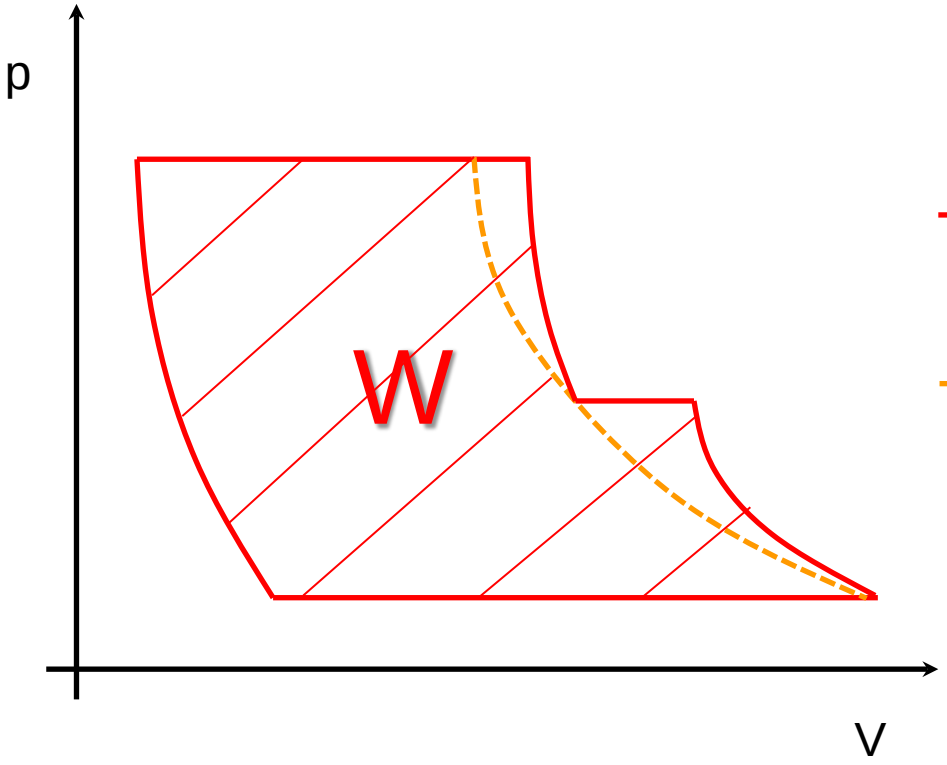
1-stage polytrophic compression

Isothermal compression

W = Compression work

Internal Factor: 3-stage Compression:

- **Better thermal efficiency by 3-stage compression**
- **Here: Physical compression work at 2-stage compression**



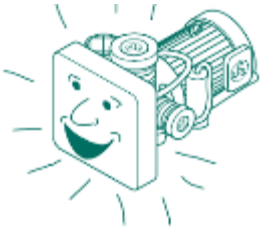
2-stage polytrophic compression

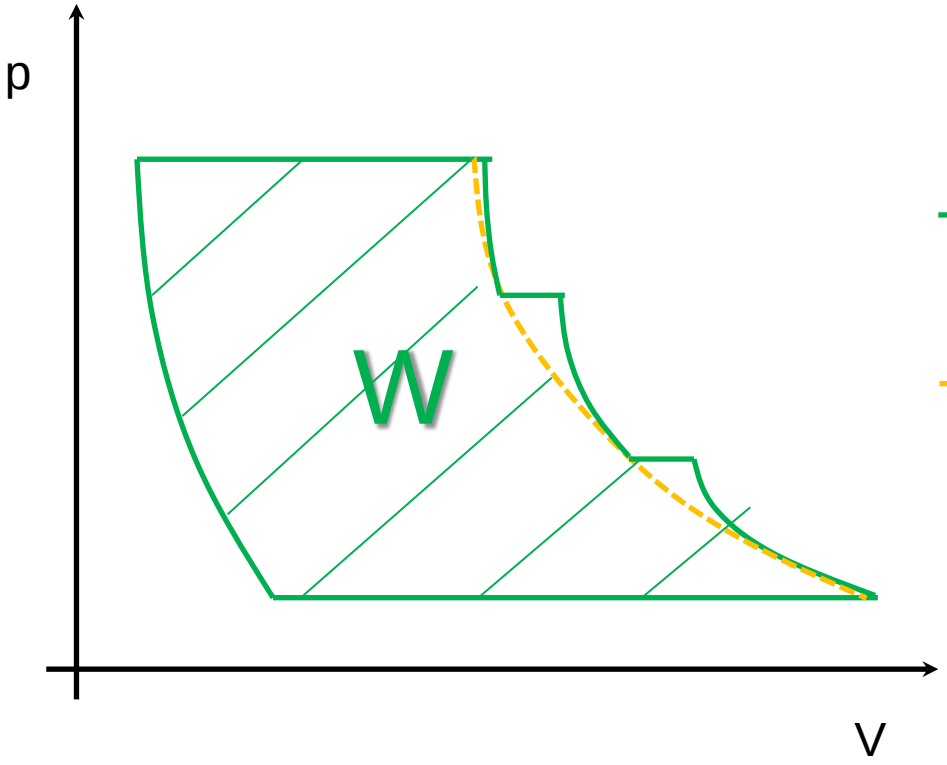
Isothermal compression

W = Compression work

Internal Factor: 3-stage Compression:

- **Better thermal efficiency by 3-stage compression**
- **Here: Physical compression work at 3-stage compression**





3-stage polytrophic compression

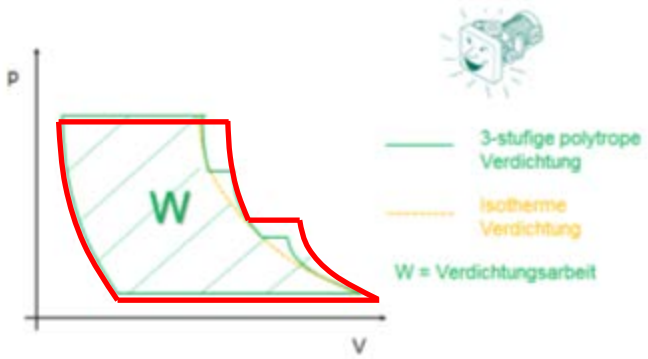
Isothermal compression

W = Compression work

Internal Factor: 3-stage Compression:

- **Theoretical difference between 2- and 3-stage compression up to 30 bar at otherwise comparable conditions**

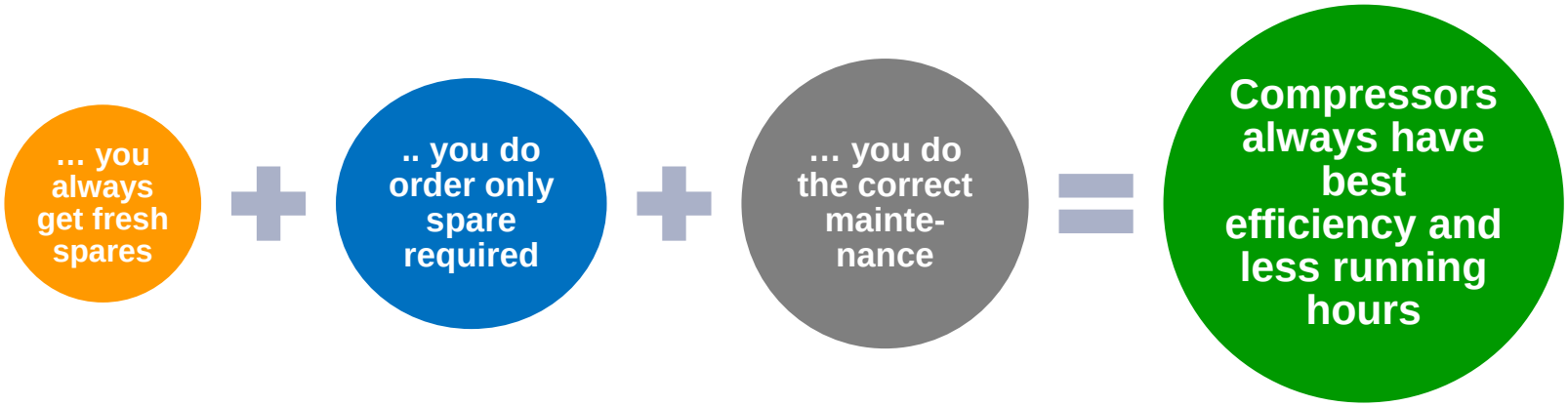
$$x = \frac{3\sqrt[3]{\frac{30+1{,}013}{1{,}013}}^{\frac{æ-1}{æ}} - 3}{2\sqrt[2]{\frac{30+1{,}013}{1{,}013}}^{\frac{æ-1}{æ}} - 2} = 0{,}917$$



- **About 8 % physical work reduction at 3-stage compression**

Internal Factor: Sauer Easy Care ®

- **Sauer Easy Care is an innovative, economical and „easy to do“ maintenance concept for Sauer Compressors**
- **This concept ensures that …**



Sauer Easy Care

Sauer
Easy Care

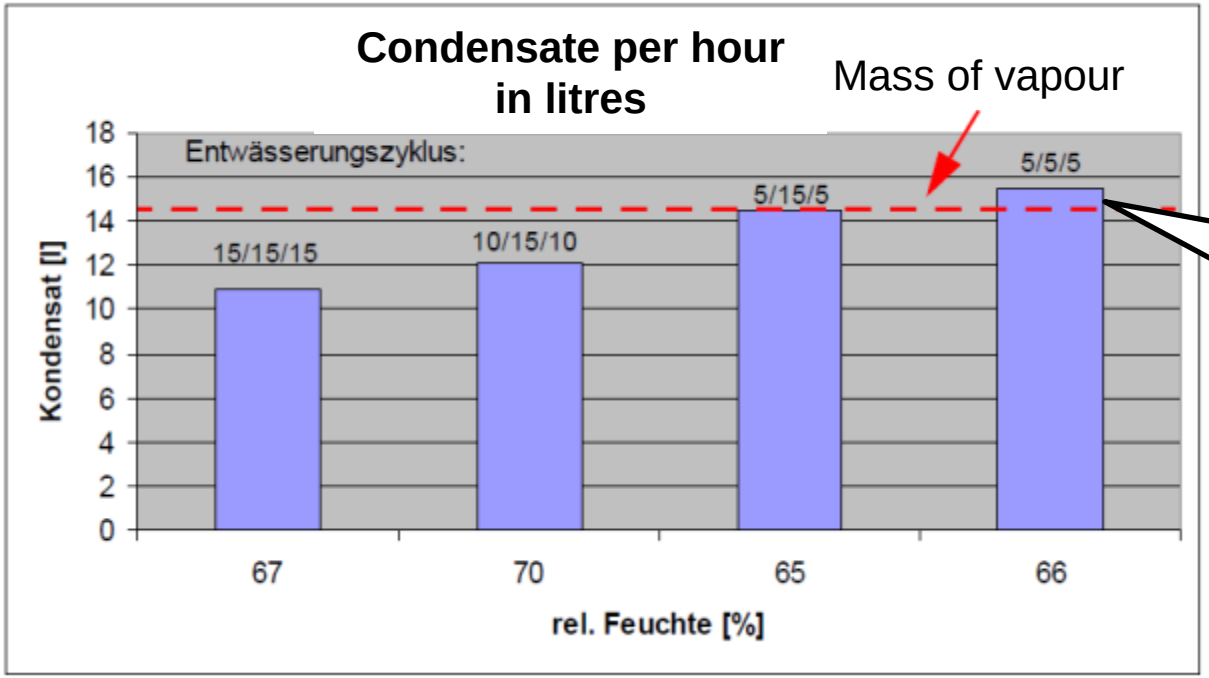
A case study:

- **A topping-up compressors –totally maintained by the Sauer Easy Care ® concept - of the German ship-owner Buss was examined after total 55.000 operating**
- **All main running parts have been inside permissible tolerances and did not show any signs of wear**

Analyse of more than 50 fleets → **Influence of the use of Sauer Care®** → **In average the running time are reduced by 10%**

Internal Factor: Drainage – how often and for how long?

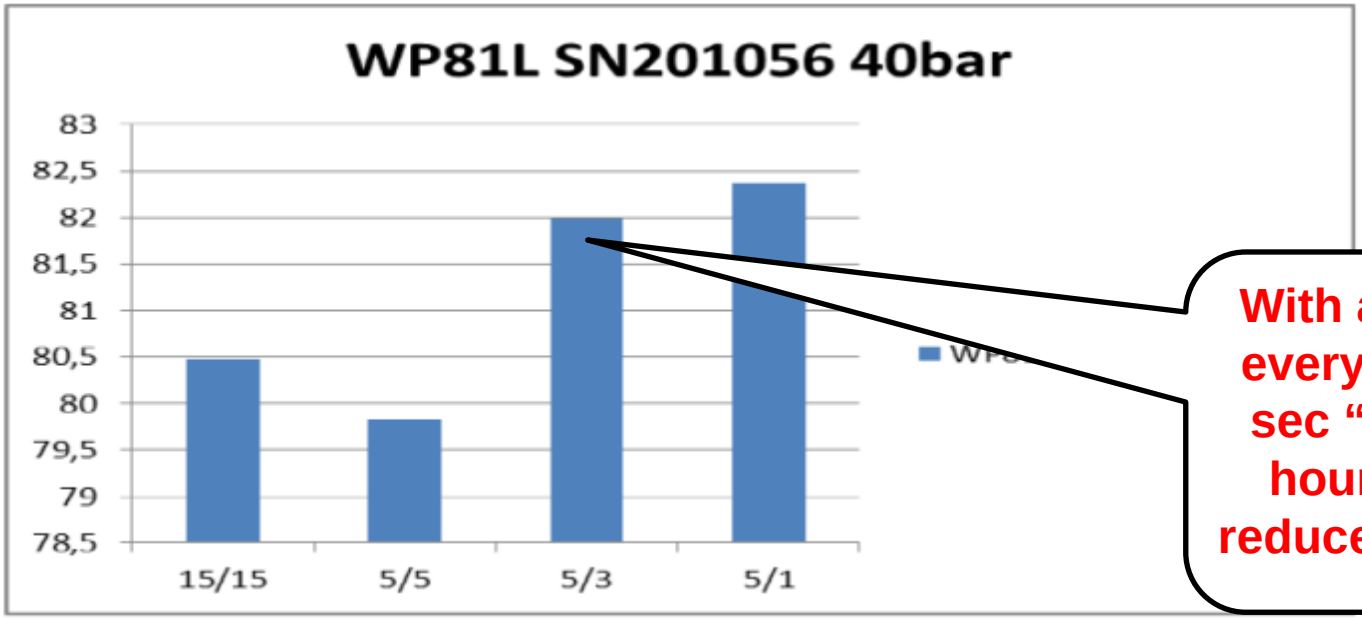
- **Sauer initiated test in the climate chamber of the Technical University of Braunschweig**
- **The more often the compressors is drained the better it is protected from free water in the air damages or wear as a result**



Best result if drained every 5 minutes!

Internal Factor: Drainage – how often and for how long?

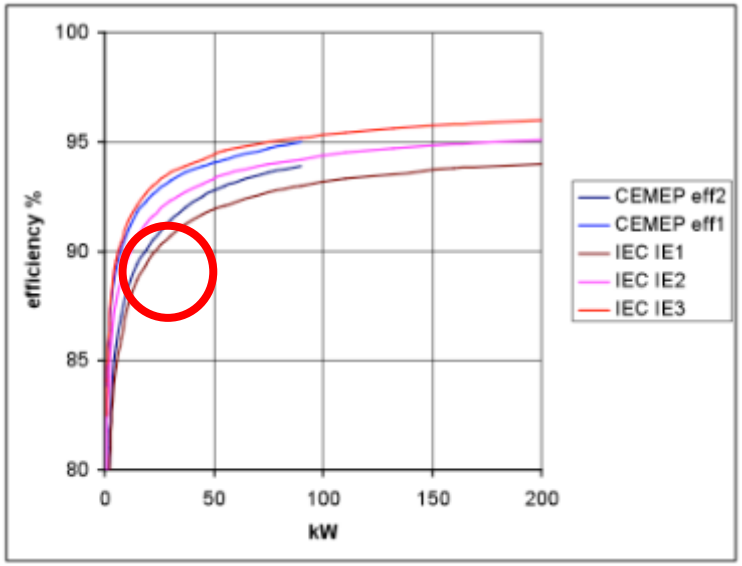
- **At each drainage air is lost to the ambient**
- **At a drainage every 5 minutes for 3 seconds there is an optimum: Best separation and lowest loss of air**



With a drainage every "5 min / 3 sec "operating hours can be reduced up to 2%

Internal Factor: Sauer IE2 Motors

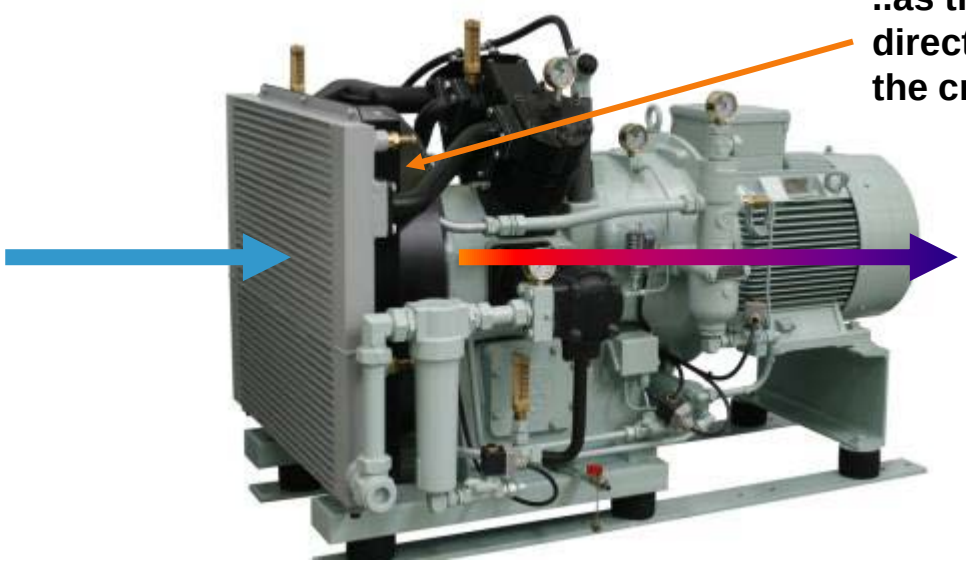
- **Electrical power saving for IE2 motors are around 2-3%**



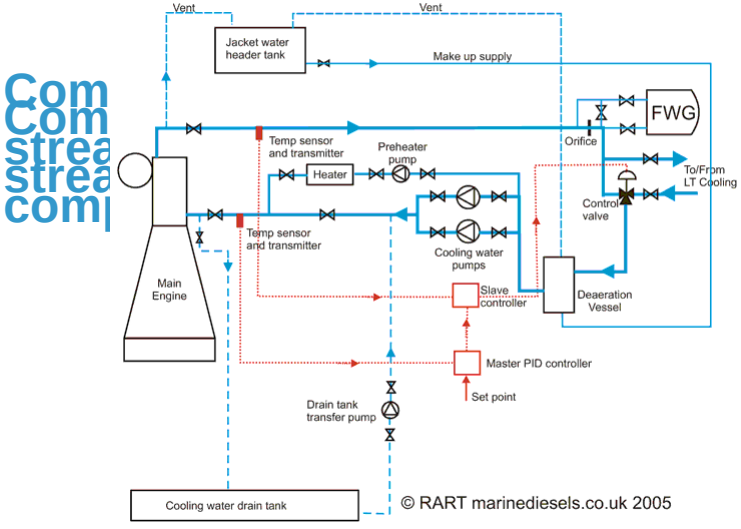
- **Sauer is the only compressor manufacturer which offers IE2 motors for shipping (standard normally not applicable as T> 40 °C)**
- **IE2 are supplied by Sauer without any additional costs as a standard**

External Factor: Air cooling:

- An additional ventilation of the engine room is not required
- The power required for the fan-wheel (about 4 % of compressor power) will only be used when the compressor is running…
- For water cooled compressors the cooling water supply must be always available as a back-up though needed only few hours a day

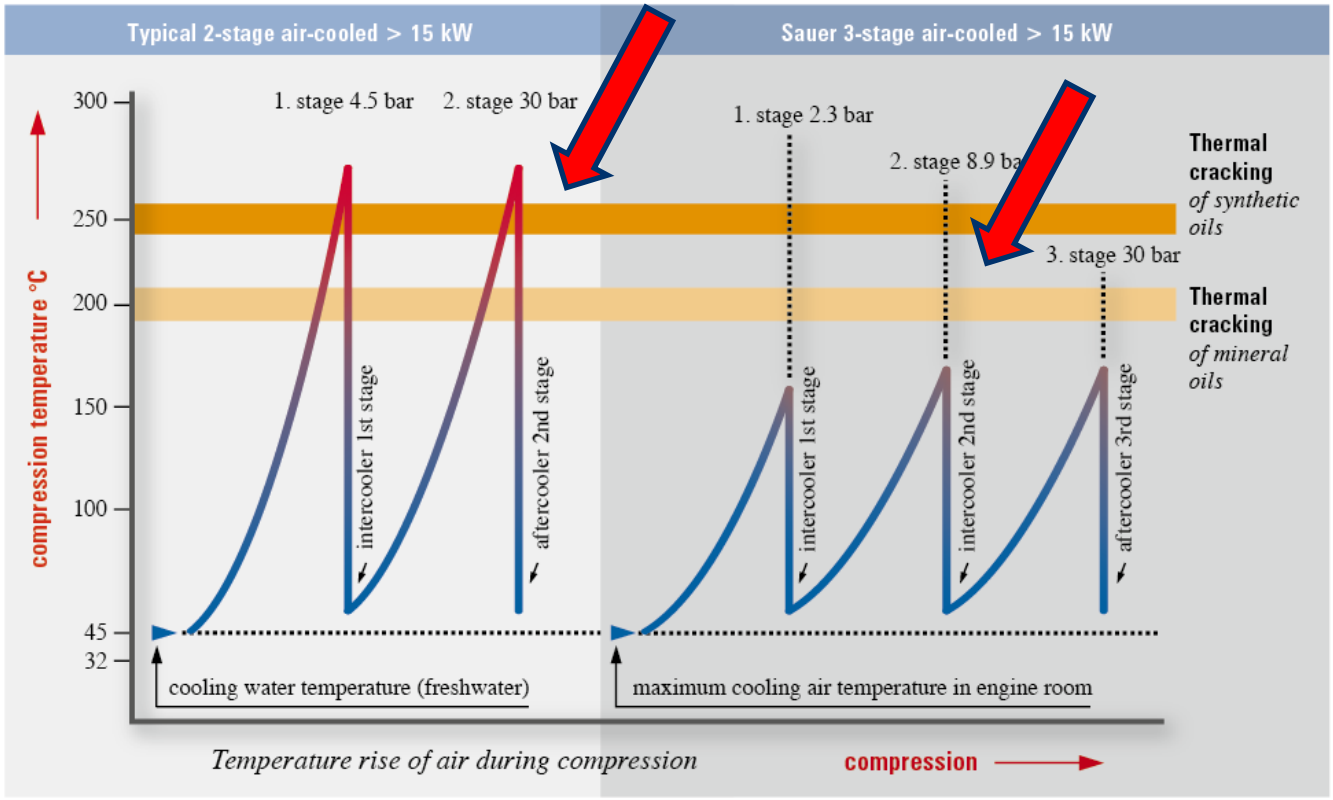


..as the fan wheel is directly connected to the crankshaft



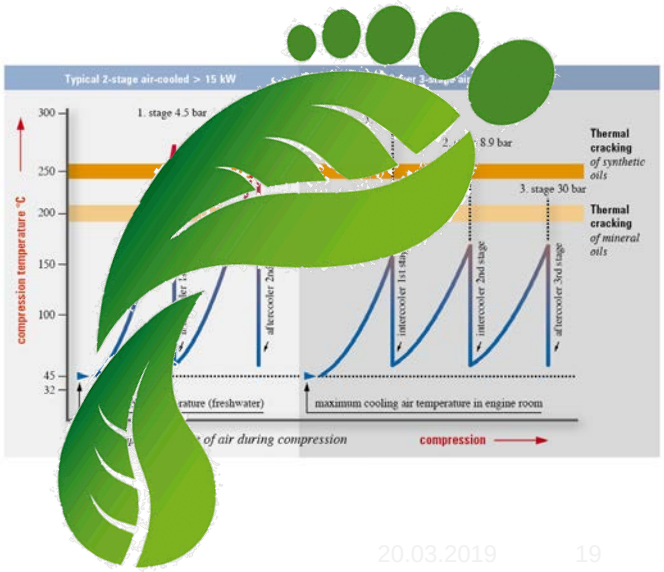
External Factor: Use of standard SAE30 mineral lube oil

- **At 3 stage air cooled compressor there is no advantage using synthetic oils:**



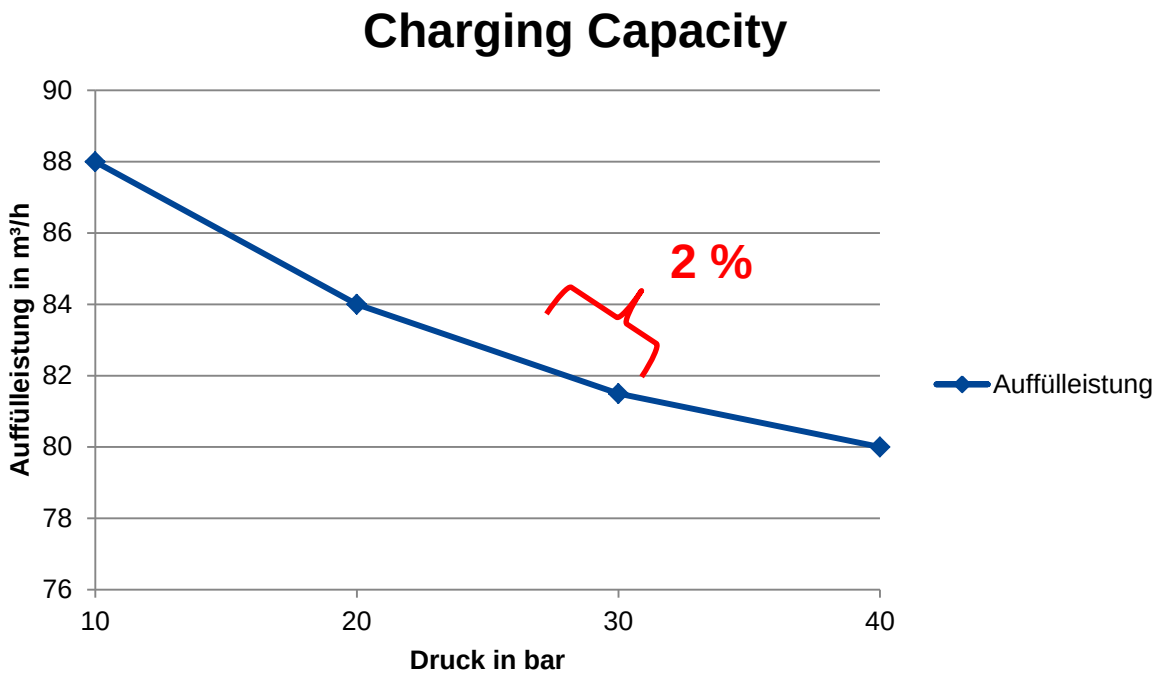
Use of standard SAE30 mineral lube oil

- **No coking of the valve while using standard mineral oil SAE 30 at 3-stage air cooled compressors**
- **Example: Oil consumption WP151L about 10 litres in 1.000 h = 10 litres annual consumption plus 10 litres for oil change**
- **Cost of synthetic oil about 8 € / litres– normal SAE 30 practically „zero“ €**
- **Thus at 20 litres p.a. about 160 € p.a. cost savings = 8% of maintenance costs**
- **In addition reduced ecological footprint (e.g. disposal)**



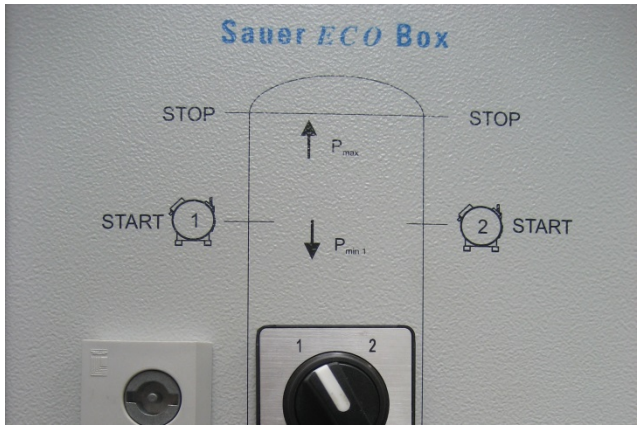
External Factor: Sauer Eco Box Plus ®

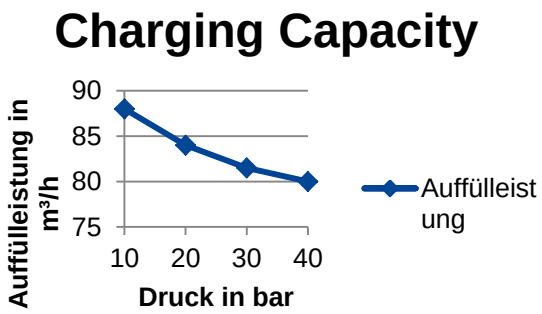
- **The filling capacity of each compressor is reduced by internal losses between 25 and 30 bar at about 2 %**



External Factor: Sauer Eco Box Plus ®

- **The Sauer Eco Box Plus is reducing the cut-off pressure of all compressors from 30 to 25 bar by a “pushbutton” during sea cruising**
- **During manoeuvring periods the cut-off pressure can be set back to 30 bar also by a “pushbutton”**
- **I.e. on sea about 2% of compressor running time can be saved . At a ratio of 75:25 sea-operation versus manoeuvring operation the total saving will be 1,5%**





External Factor: Compressor selection or how many compressors with what capacity?

- **Less cost by the use of several smaller main compressors or the use of a Topping-Up with smaller starting currents**
- **Such a selection with lower starting current is reducing the „Fear-Surcharge“ when providing the required electrical power of the generator sets to avoid blackouts**
- **Less operating costs for generator sets**
- **No Black-Outs**
- **Savings „x%“**

Summary of Internal and External Factors:

Internal Factors		External Factors	
Factor	*Savings*	*Factor*	*Savings*
3-stage Compression	8 %	Air Cooling	4 %
Sauer Easy Care	10 %	Lubrication Oil	8 %
Drainage	2 %	Sauer Eco Box® Plus	1.5 %
IE 2 Motors	2,5 %	Compressor Selection	x %

- **In total a saving potential of 36 %“ plus X“!**


However compared with the 50.000 kW of the main engine these are all peanuts!
But many small peanuts are as effective as a coconut!
Or what is your opinion?