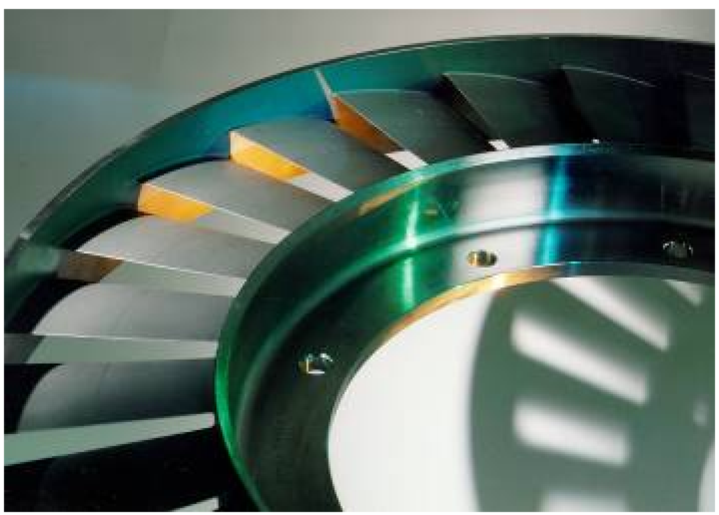
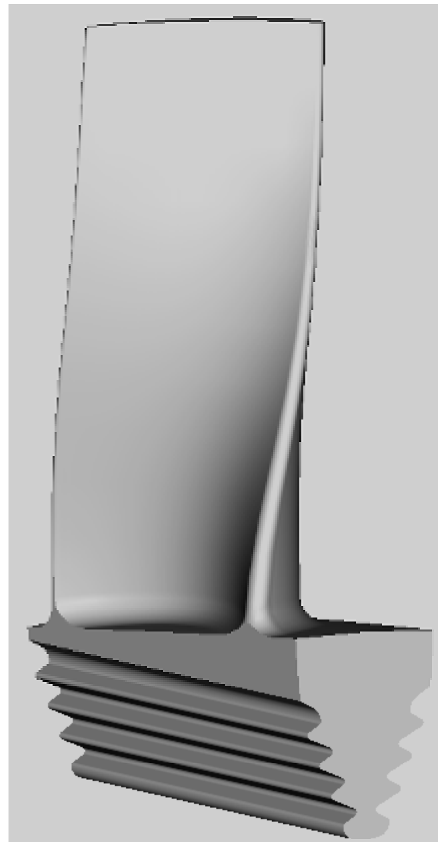
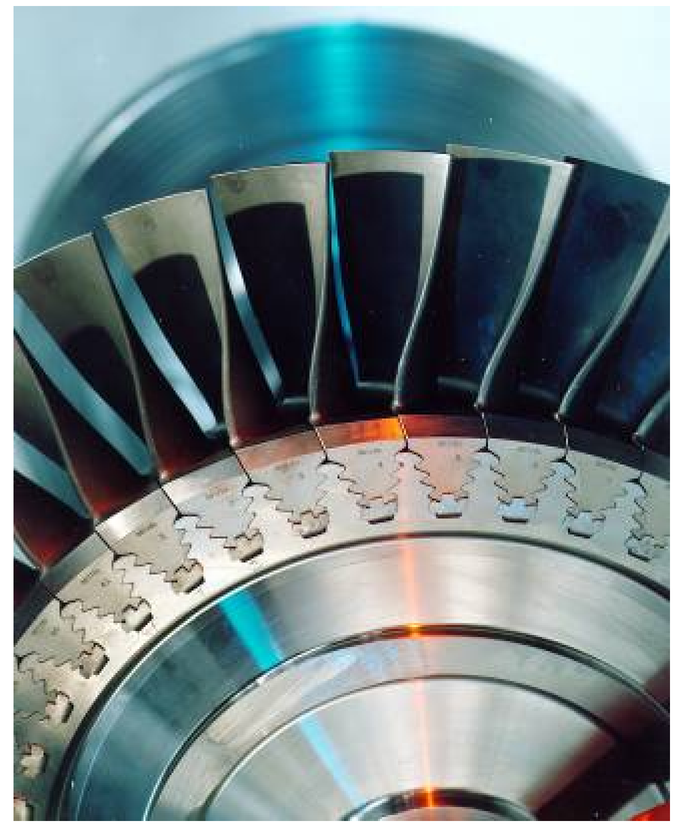
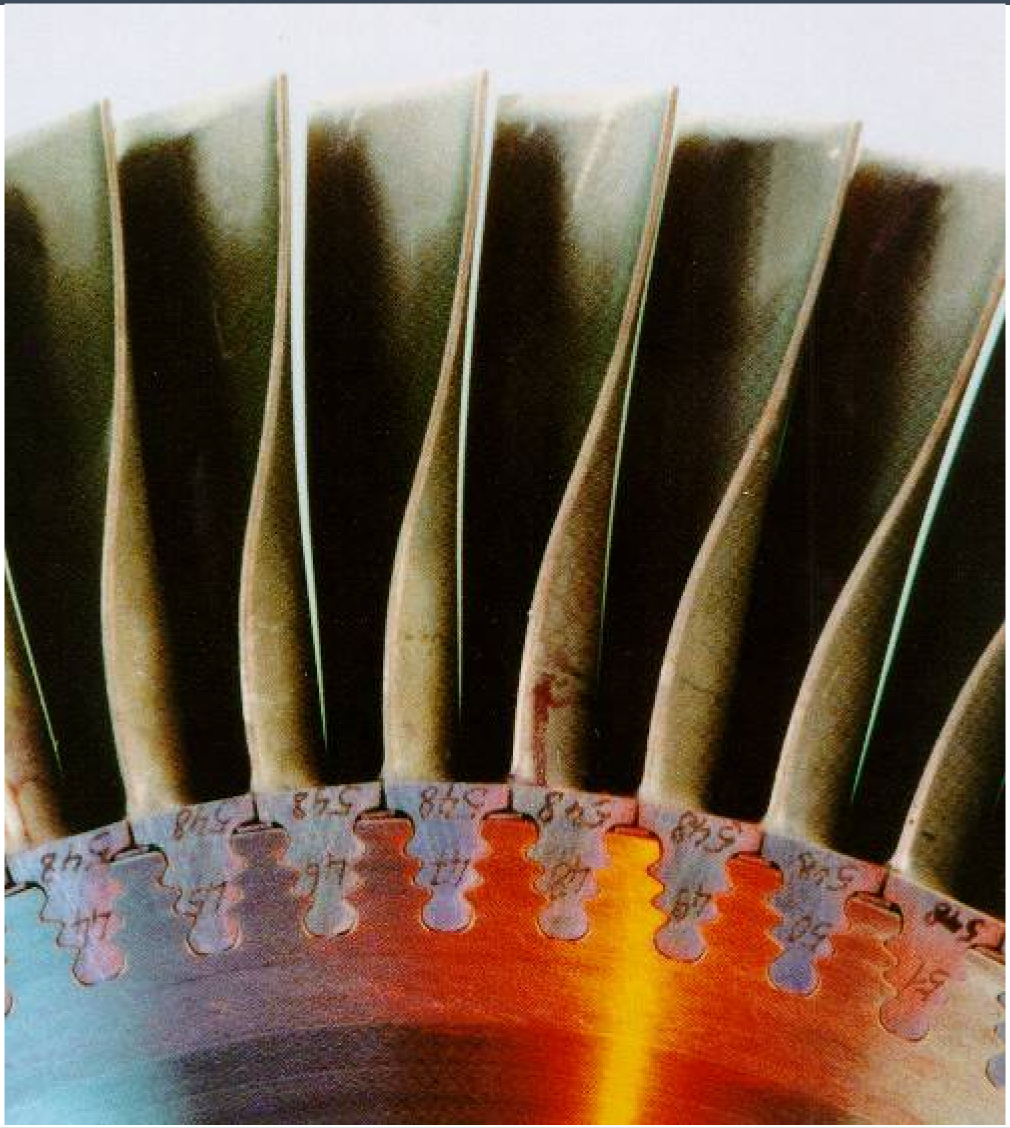
TURBO CHARGER, AIR COOLERS





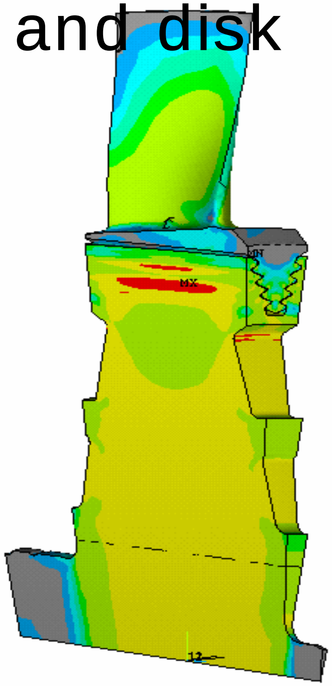


NA Charger.

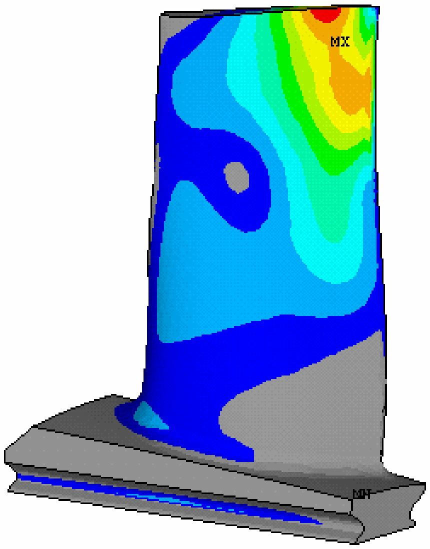


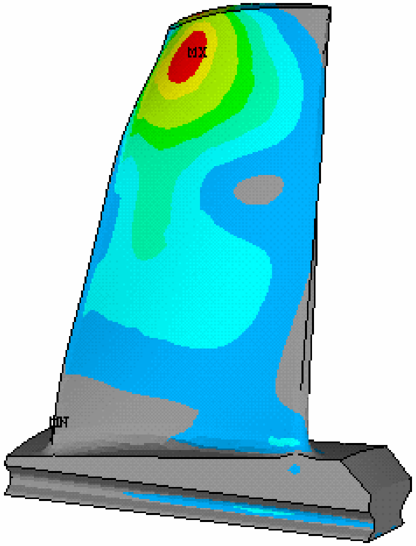
The technically elaborate fir-tree root connection provides for a positive, stressfree mounting of the flow-optimised blades in the turbine disc. This solution permits replacement of individual blades.

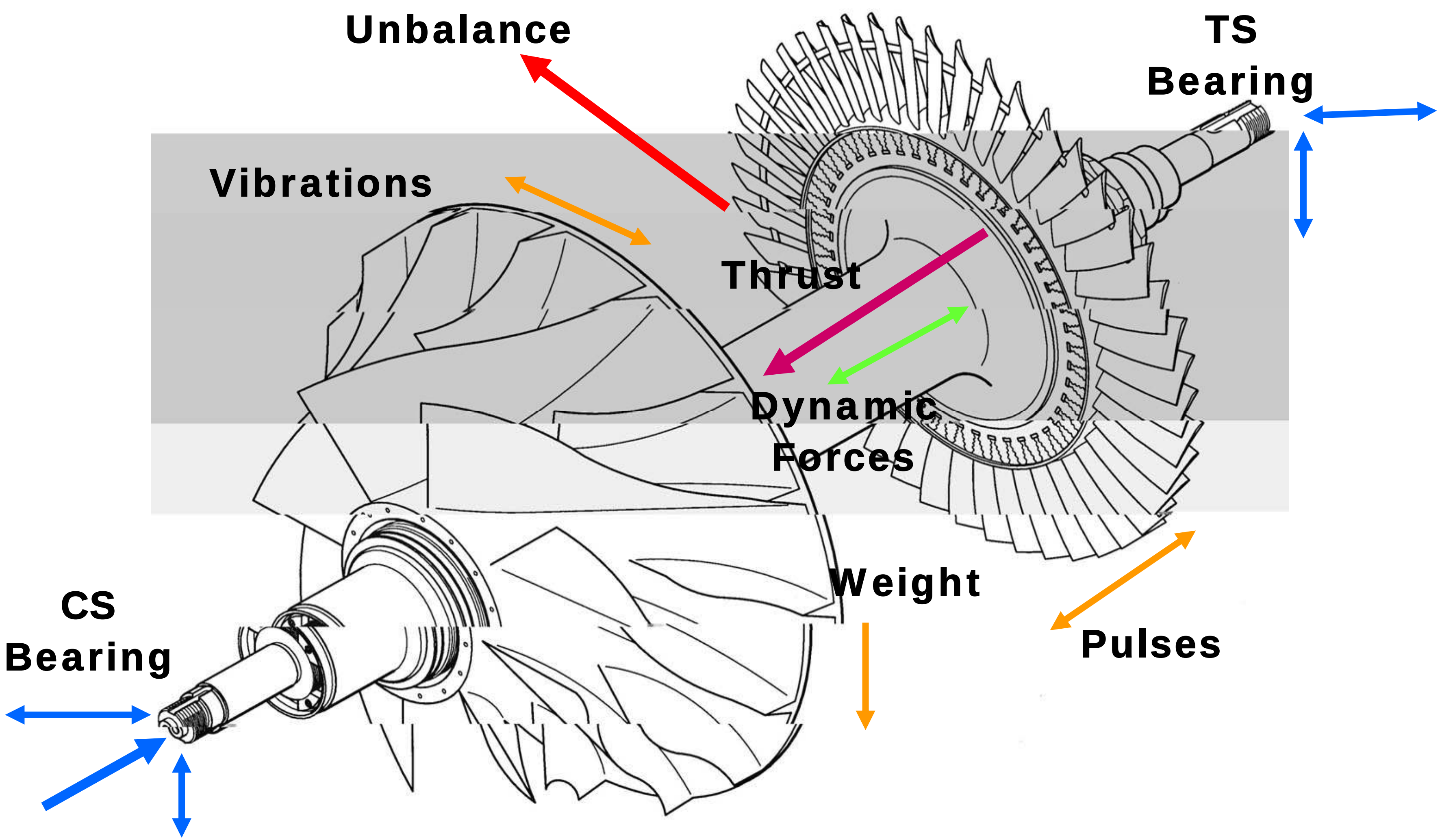
- Centrifugal stress in
  - blade and disk



- Vibration mode stress distribution
  - of the turbine blade

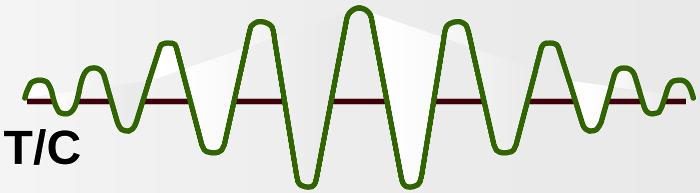






Compliments from ABB

Low frequency vibrations

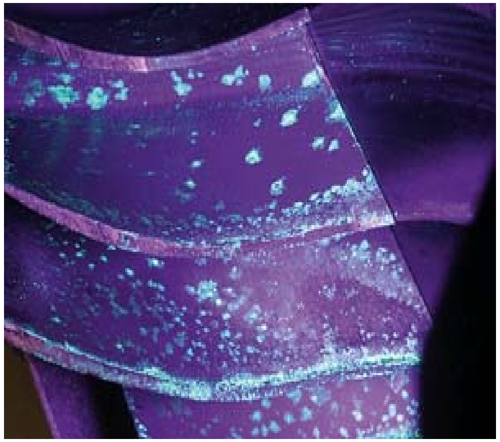


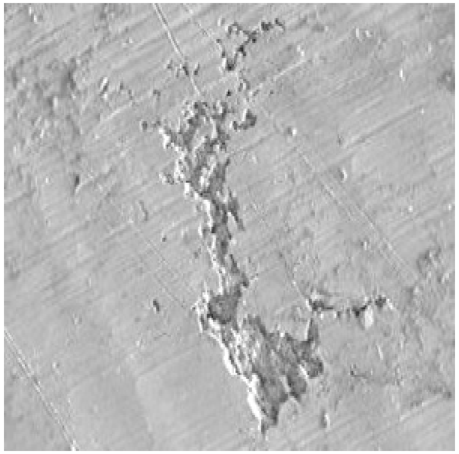
- ⇨ **3 < f < 100 Hz**
- ⇨ **can lead to damages of the T/C**
- ⇨ **max. admissible velocity RMS : < 50mm/sec** (e.g. VTR454)

High frequency vibrations

- ⇨ **100 < f < 1000 Hz**
- ⇨ ***give an indication of the running behaviour of the rotor***
- ⇨ **if 10 mm/sec is exceeded, the rotor has to be balanced (for more details consult ABB Service Stations)**

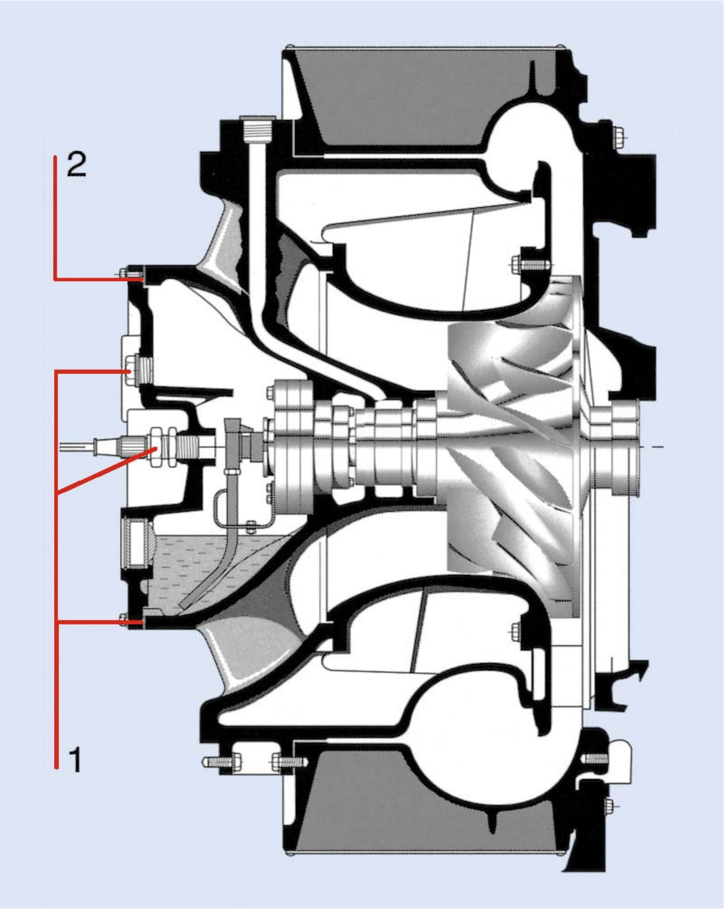
- Compliments from ABB





- **Sulphur (in the exhaust gas) and salt in the air intake can cause corrosion of the inducer blades.**
- **Pitting corrosion may lead to notch effect, resulting in high cycle fatigue (HCF) failure.**
- **=> Fluorescent penetrant inspection of the blades is recommended.**

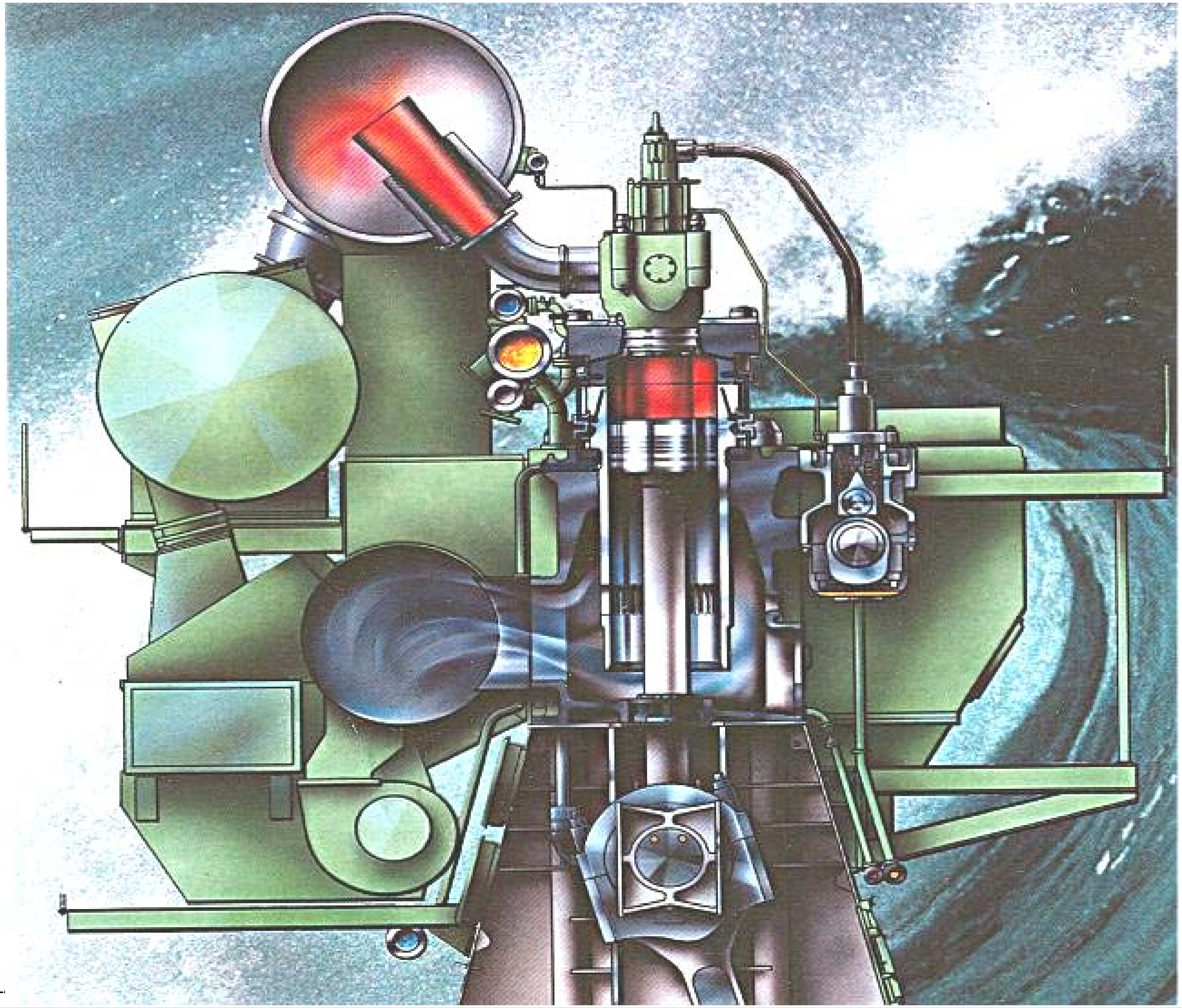
- Compliments from ABB



- During standard operation there is a slight underpressure in the CS bearing chamber.
- If a plug is not tight enough or an old gasket is used, the underpressure can cause air to flow through the bearing chamber to the compressor.
- Oil mist will be carried away by this air flow, resulting in oil loss.

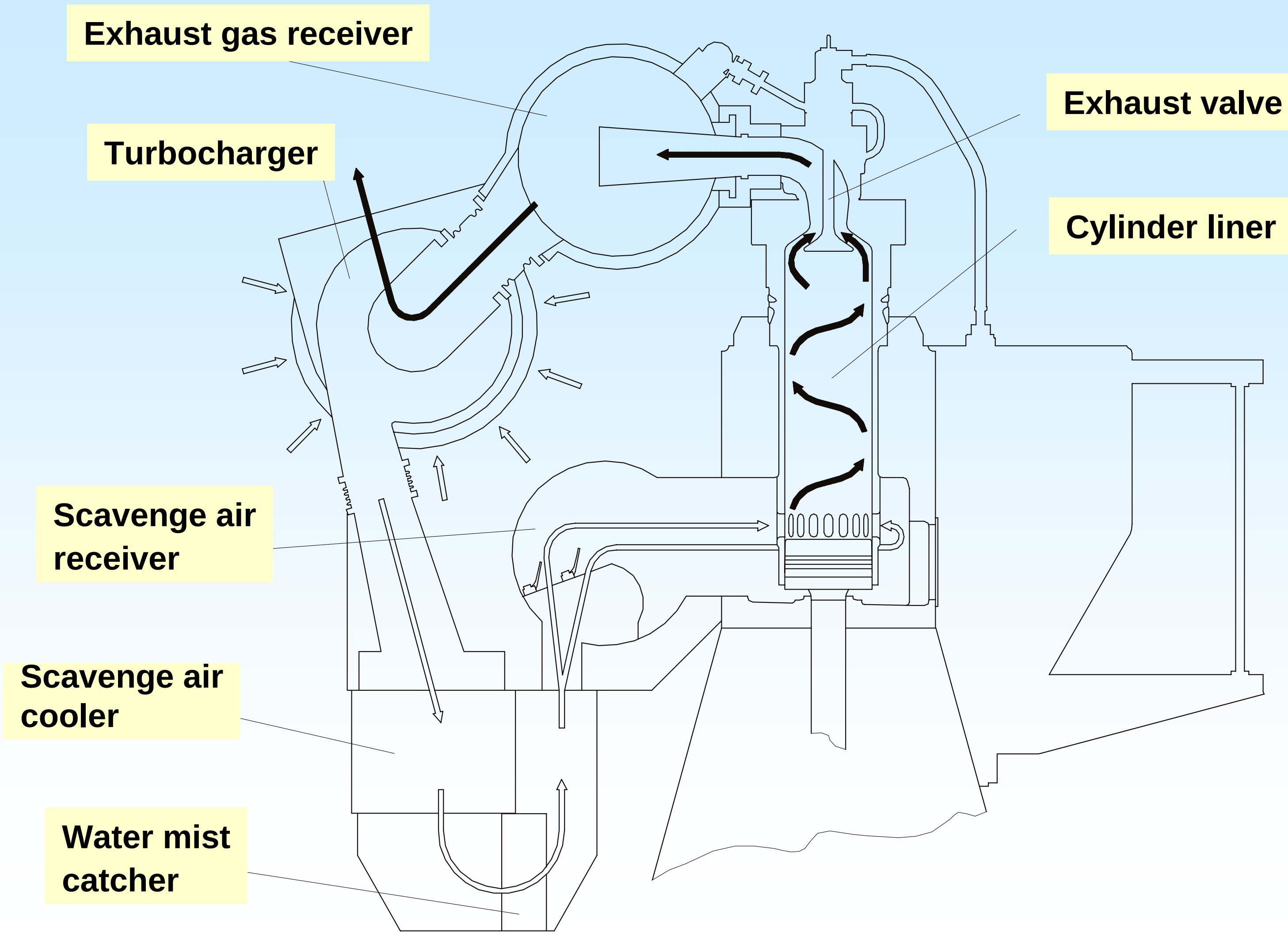
- Compliments from ABB

THE UNIFLOW SCAVENGE SYSTEM



L.

The Air / Gas Flow.



WHAT IS A TURBOCHARGER?

A Turbocharger is a Turbine driven by the Exhaust Gas and gives power to a Compressor positioned on the same shaft as the Turbine.

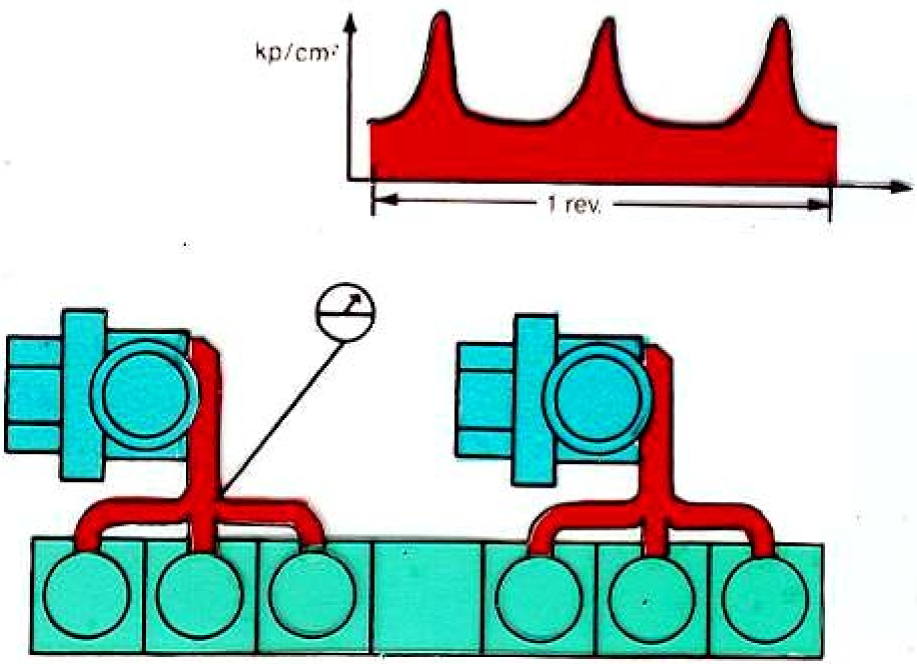
This gives more air to the Combustion than normal aspiration.

Normal aspiration about 1bar air pressure.

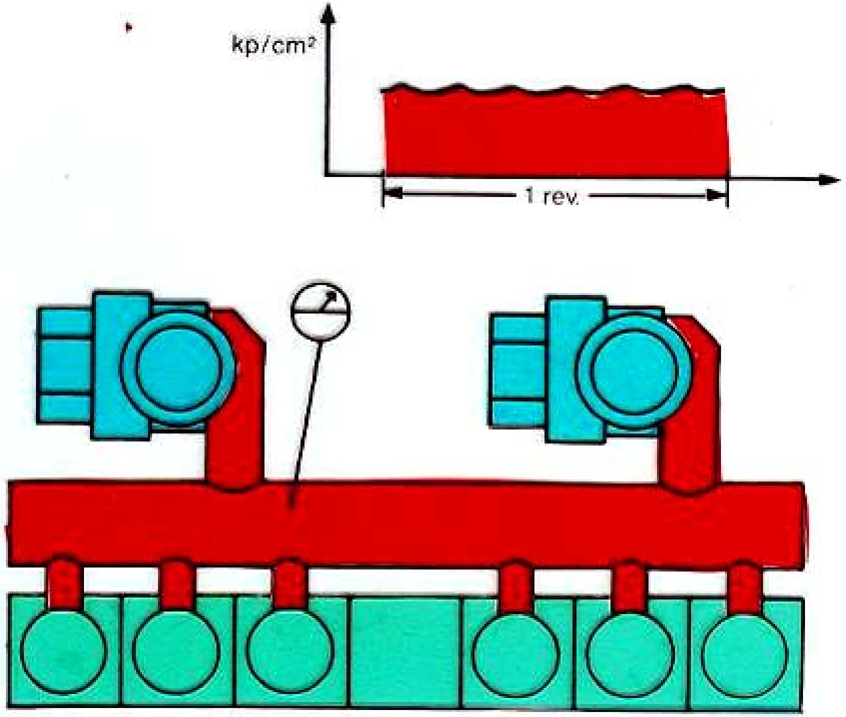
Turbocharged ”aspiration” 3.8 bar air pressure.

TURBOCHARGING

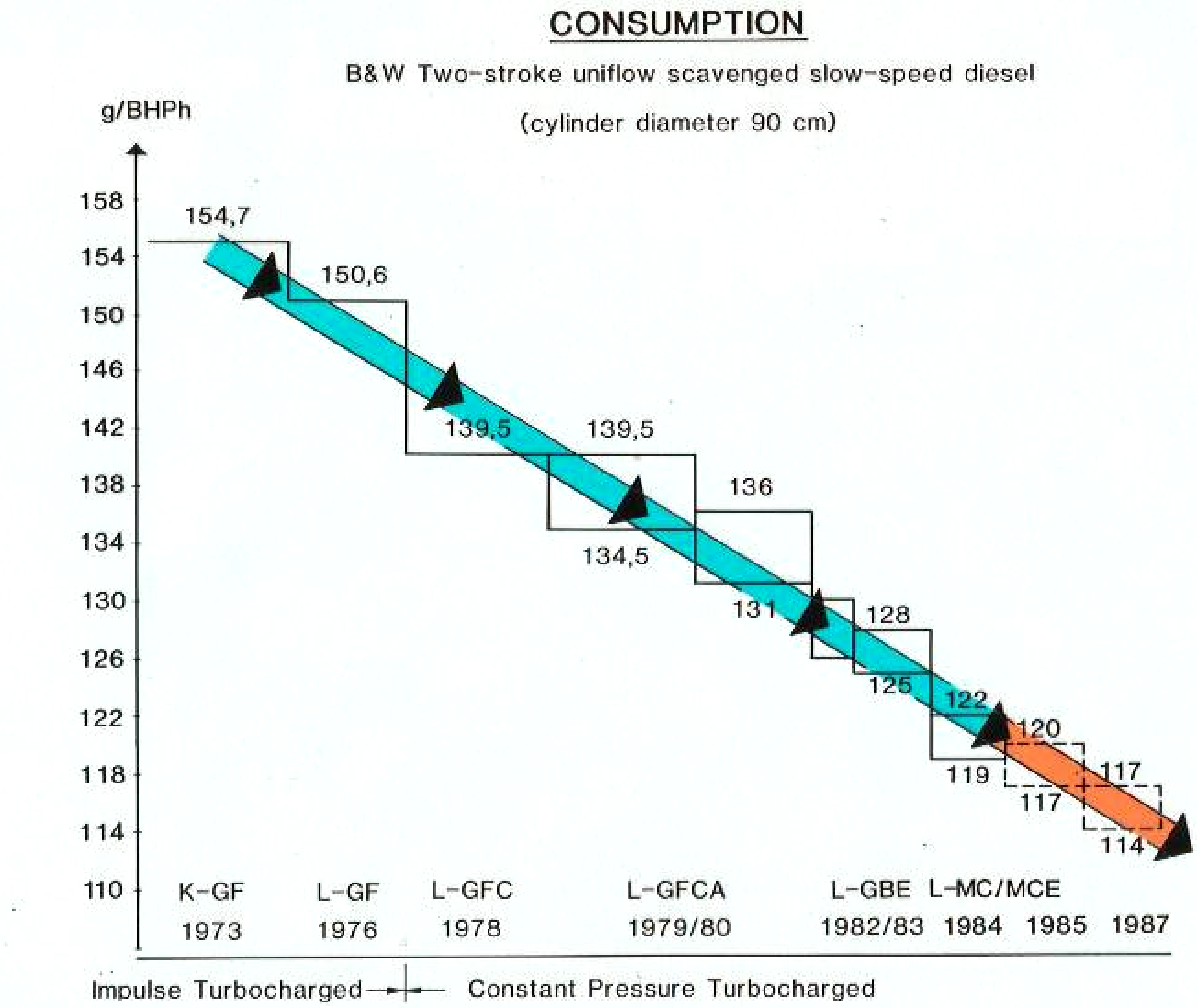
Impulse Turbocharging



Constant Pressure Turbocharging

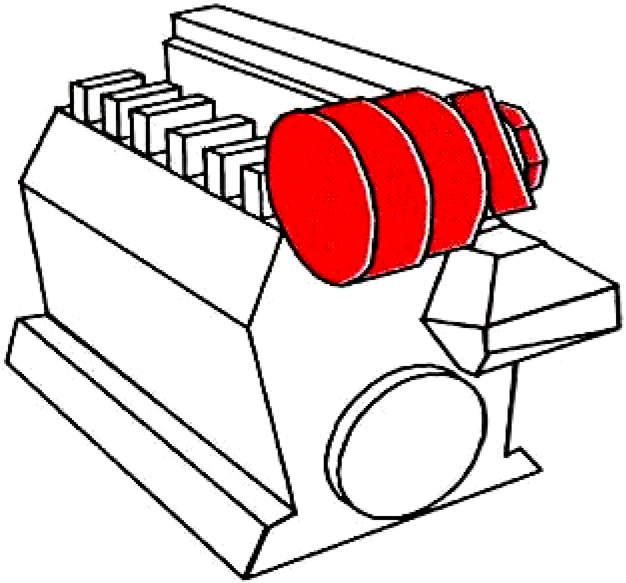


Performance.



Turbocharging.

The Turbocharger is a Vital Part of the Diesel Engine



Increase of the specific power output

+ *300%*

Supercharging/Turbocharging.

VTF	1,02 ATA	Supercharging.
VTBF	1,45 "	Turbocharging
VT2BF	1,75 "	
K-EF	1,90 "	
K-FF	2,00 "	
K-GF	2,1 "	
L-GF	2,1 "	
K/L-GFC	2,6 "	
K/L-GFCA	2,9 "	
L-GA	2,9 "	
L-GB	3,1 "	
L-GBE	2,9 "	
L-MC	2,9 "	
S/K/L/MC, MC-C	3,5 – 3,8 ”	

TURBOCHARGING

Required turbocharging data for MC/MC-C engines:

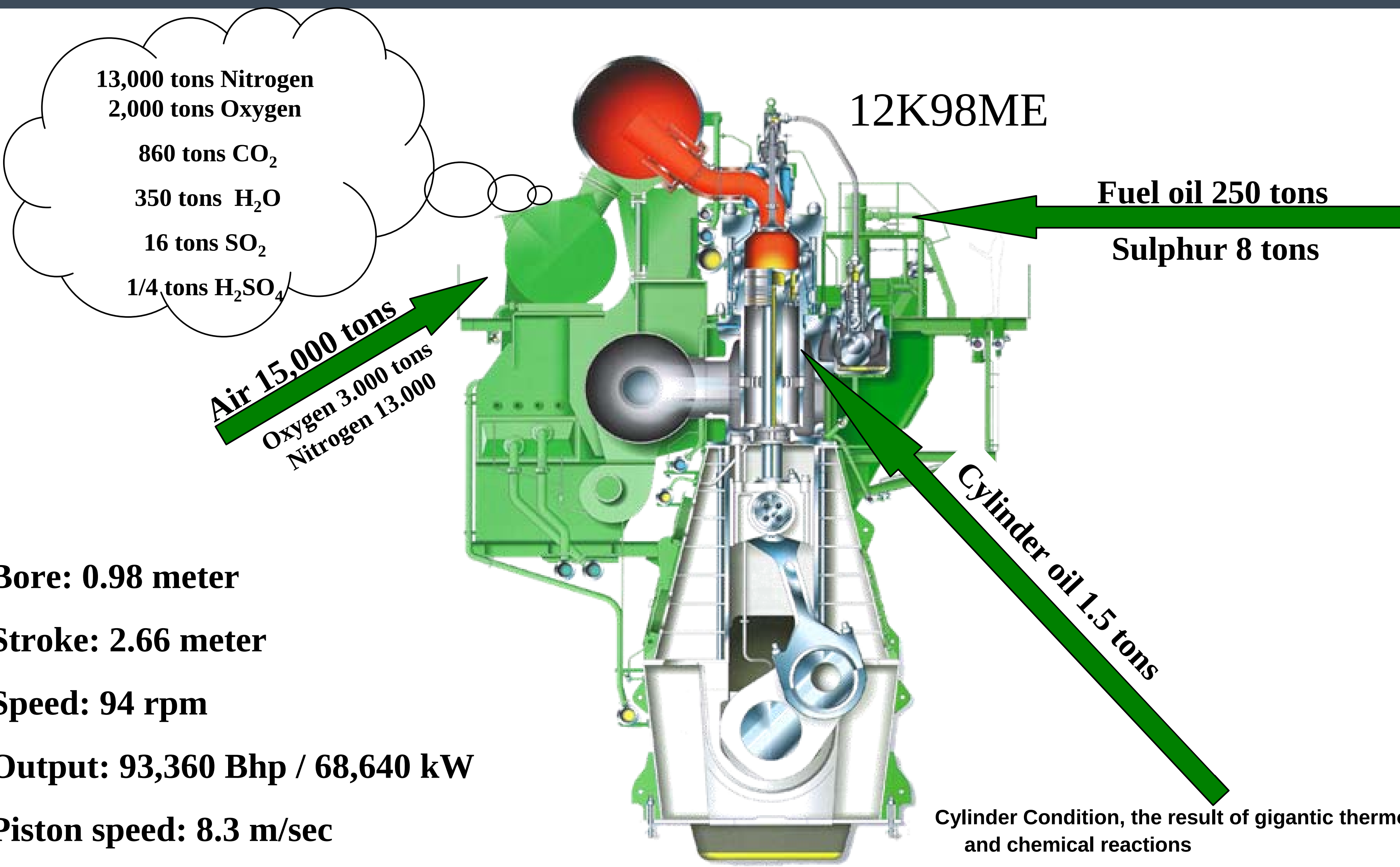
High efficiency turbocharger ~68% (standard)

Pscav ~3.5-3.8 bar (abs)
Specific air amount ~6.4-6.9 kg/bhph
Temperature before turbine ~390-400 dg. C

Conventional efficiency turbochargers ~64% (option)

Pscav ~3.5-3.8 bar (abs)
Specific air amount ~5.9-6.4 kg/bhph
Temperature before turbine ~420-430 dg. C

Introduction to Cylinder Condition



Bore: 0.98 meter

Stroke: 2.66 meter

Speed: 94 rpm

Output: 93,360 Bhp / 68,640 kW

Piston speed: 8.3 m/sec

Cylinder Condition, the result of gigantic thermo- and chemical reactions

Exhaust Emissions.

Flow process

Air

8.5 kg/kWh
21% O_2
79% N_2

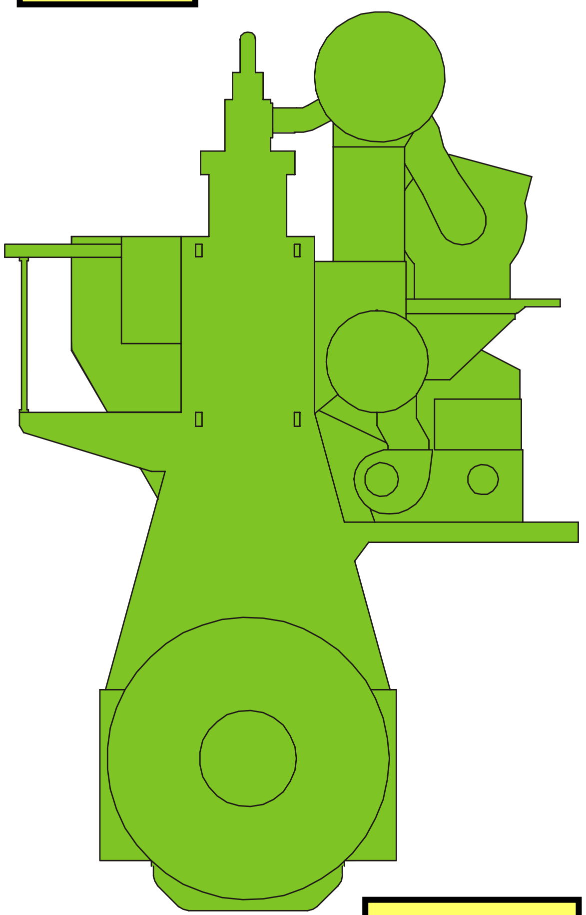
Fuel

175 g/kWh
97% HC
3% S

Lube

1 g/kWh
97% HC
2.5% Ca
0.5% S

Heat



Work

Exhaust gas

13.0% O_2
75.8% N_2
5.2% CO_2
5.35% H_2O

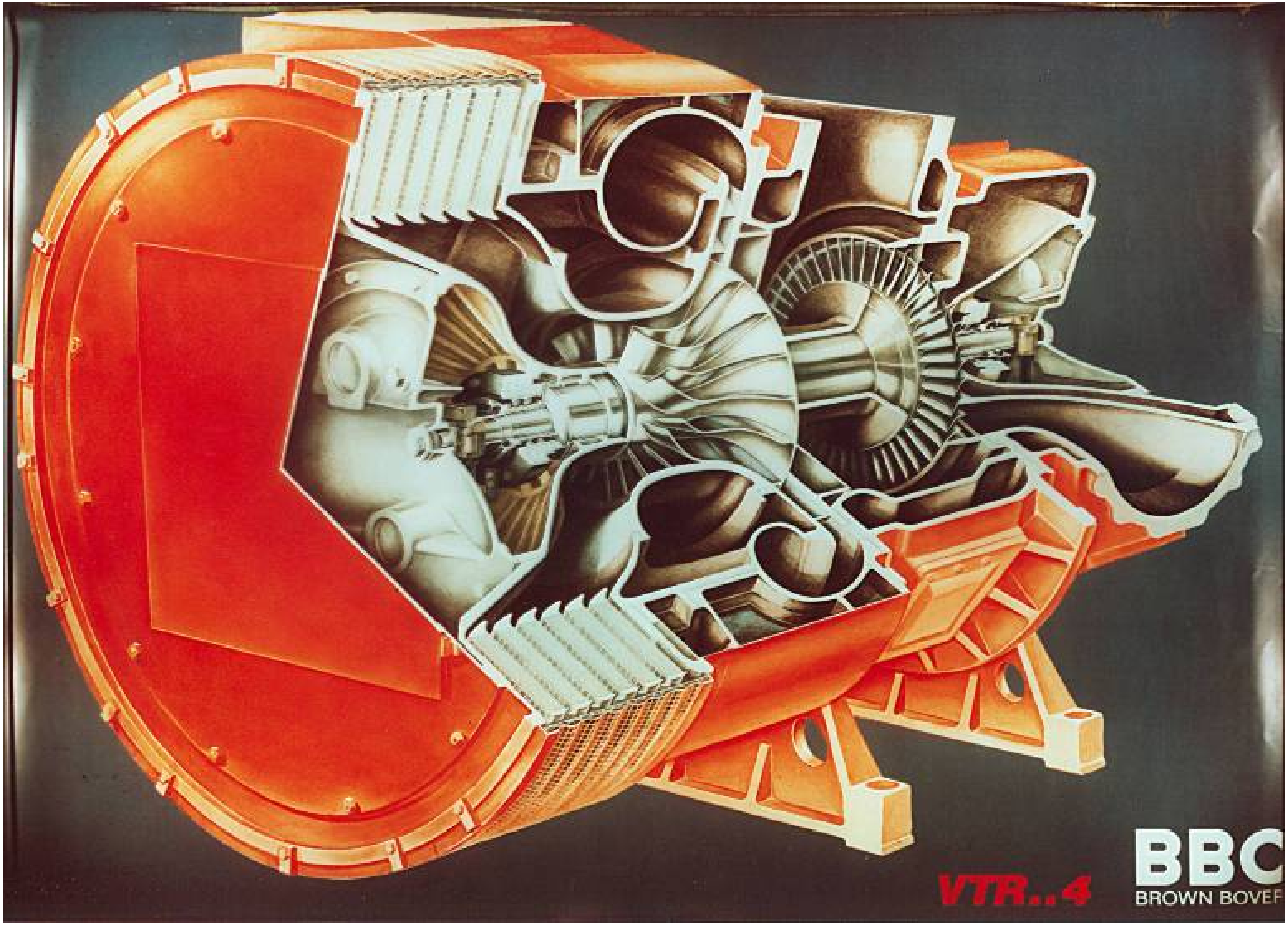
1500 vppm NO_x
600 vppm SO_x
60 vppm CO
180 vppm HC
120 mg/Nm^3 Part

TURBOCHARGER MAKER

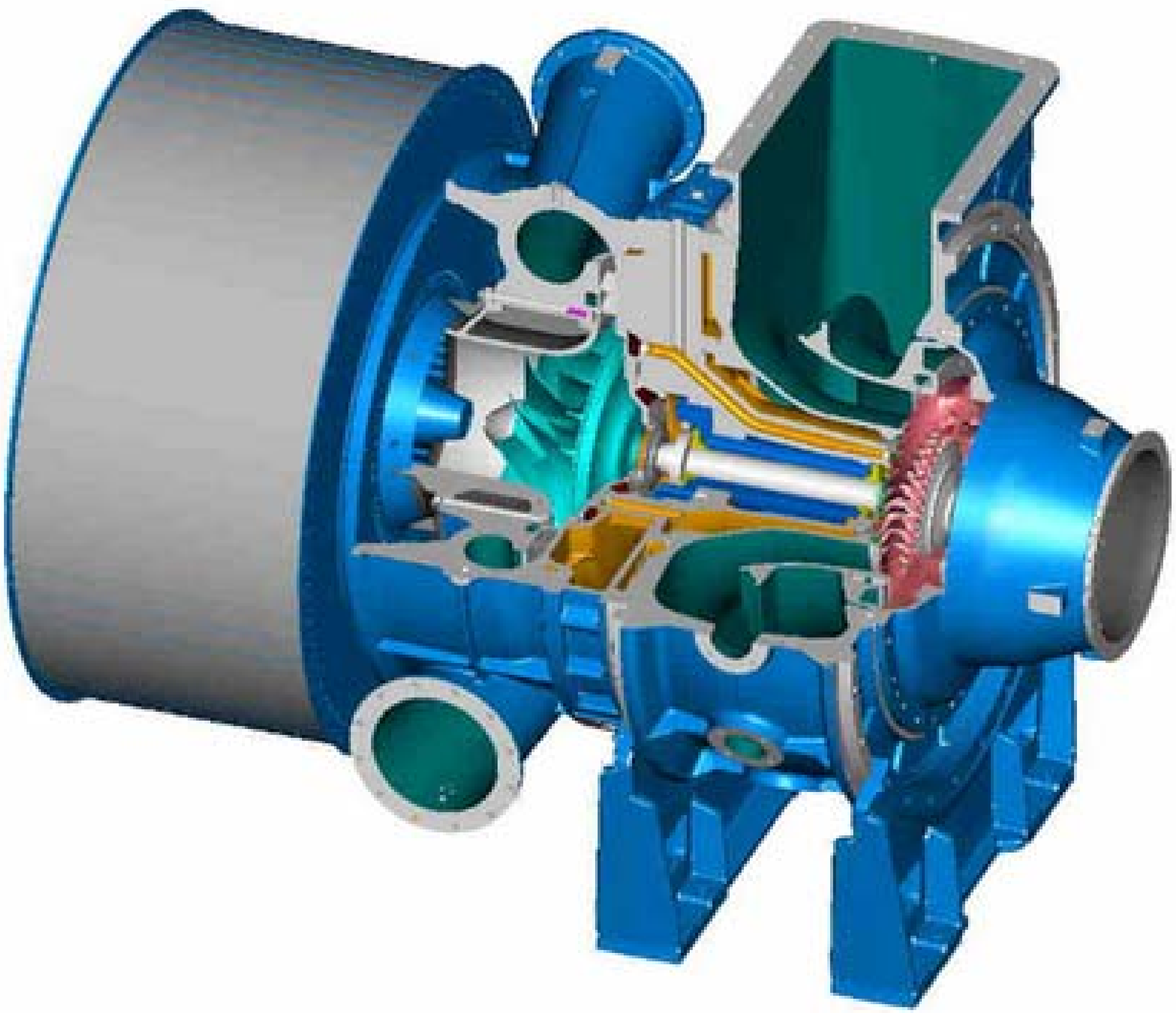
Makes:	Types:
MAN B&W	NR24/R, NR29/S NR34/S, NA40/S, NA48/S NA57/T9, NA70/T9
ABB	VTR 254, VTR304, VTR354 VTR454, VTR564, VTR714 Available as VTR ...D and VTR ...E
MHI	MET26SR, MET30SR MET33SD, MET42SD MET53SD, MET66SD, MET83SD MET53SE, MET66SE, MET83SE

- Alternative suppliers
- Worldwide availability

ABB – VTR.



TCA TURBOCHARGER



TURBO CHARGER TCA

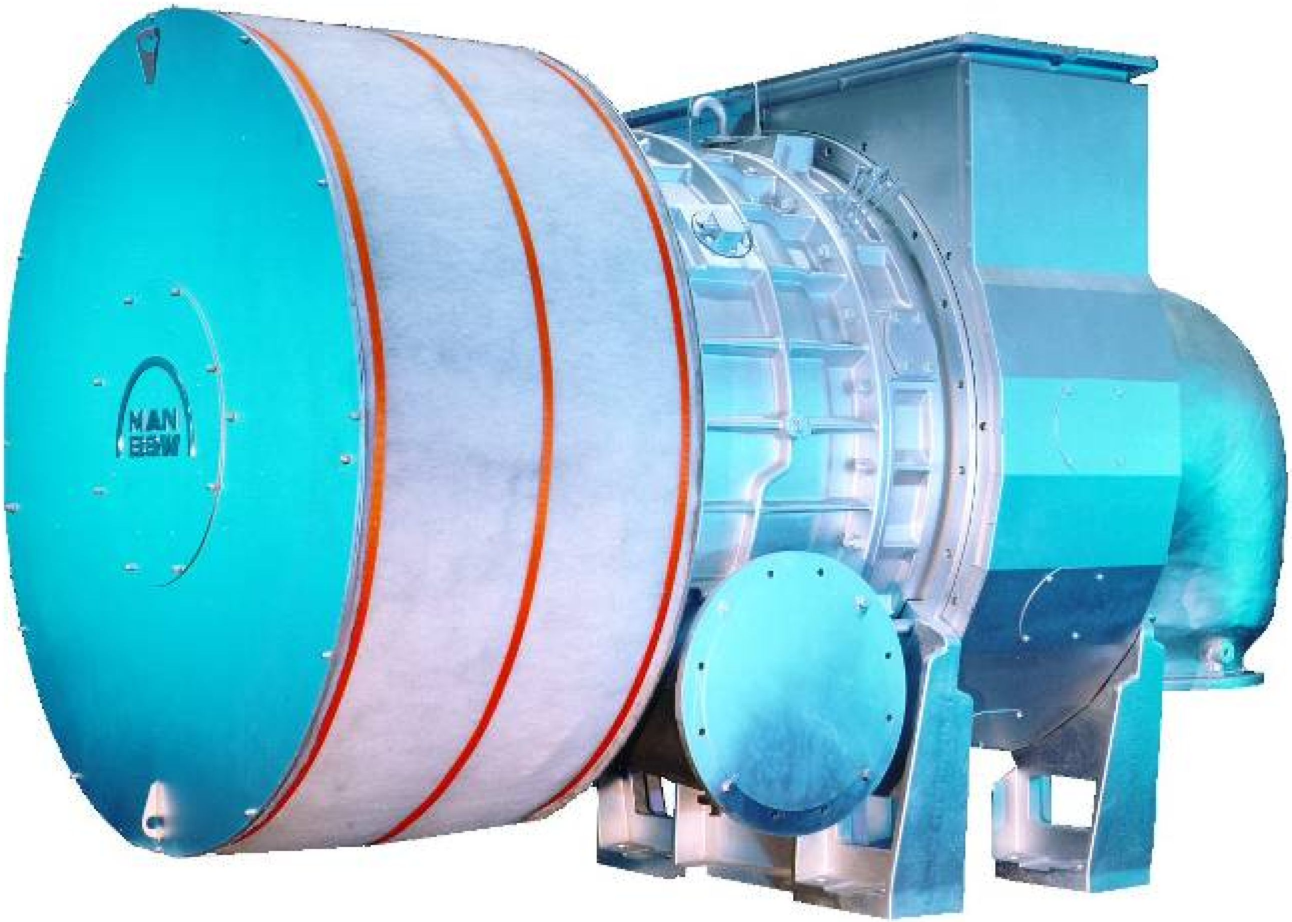
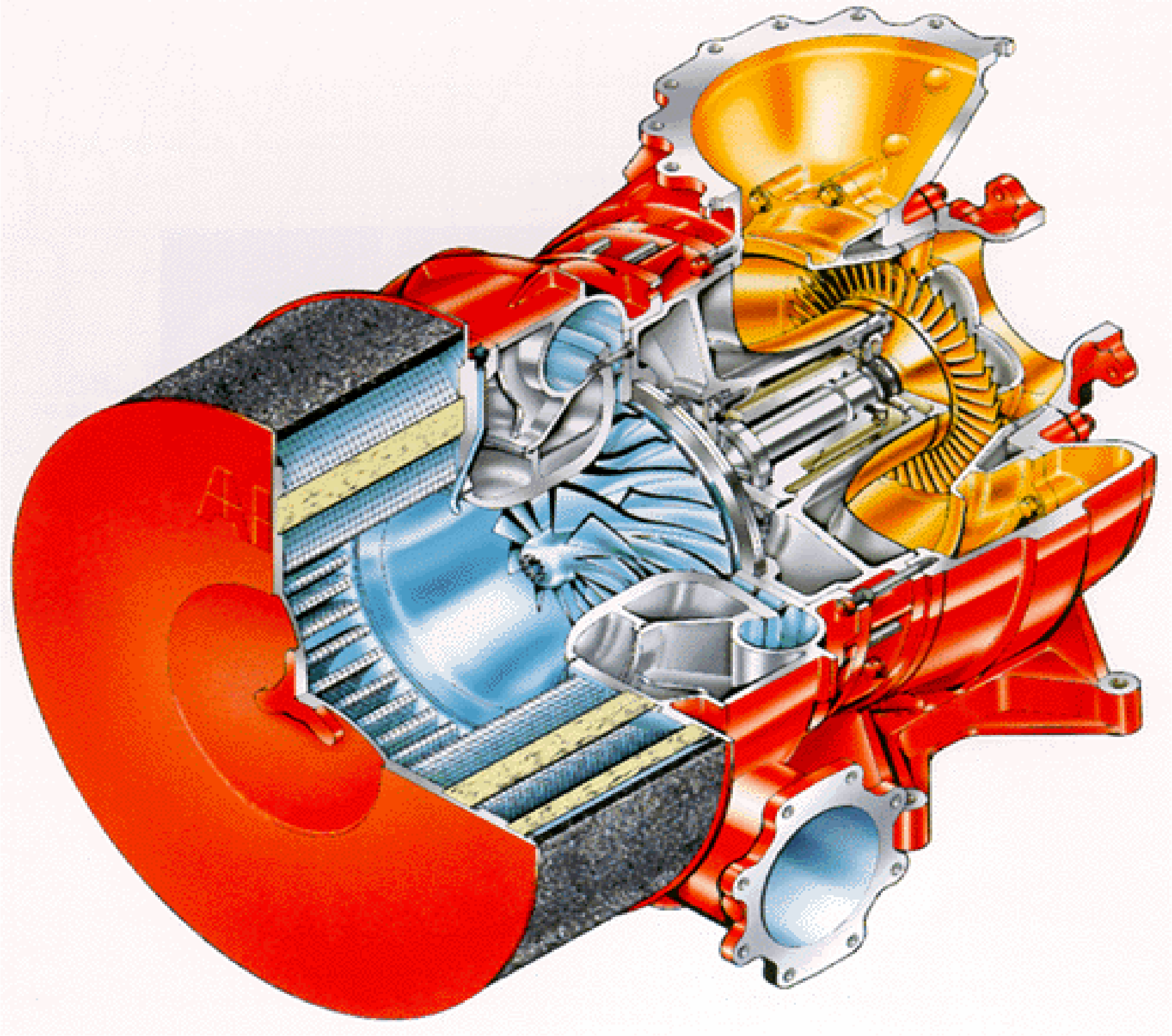
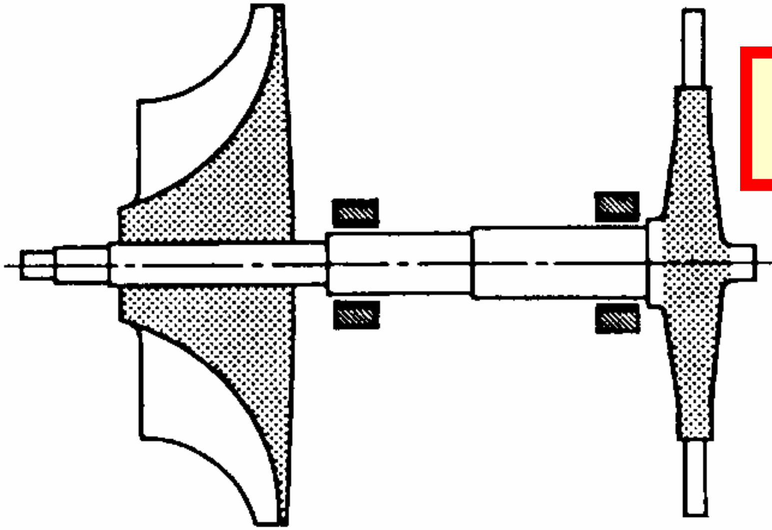


ABB TPL 91

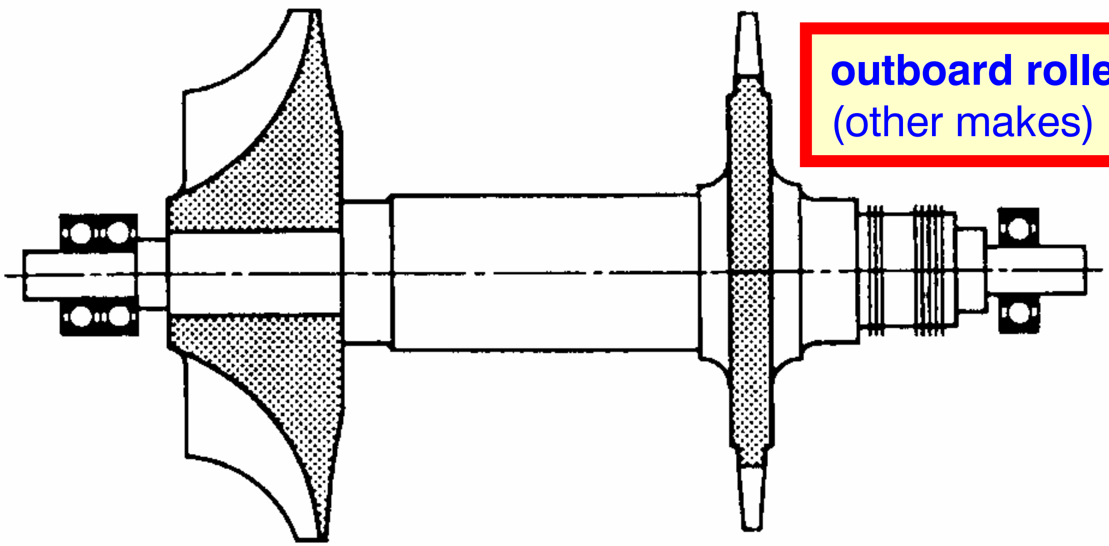
TURBO POWER LARGE



Bearing Arrangements.

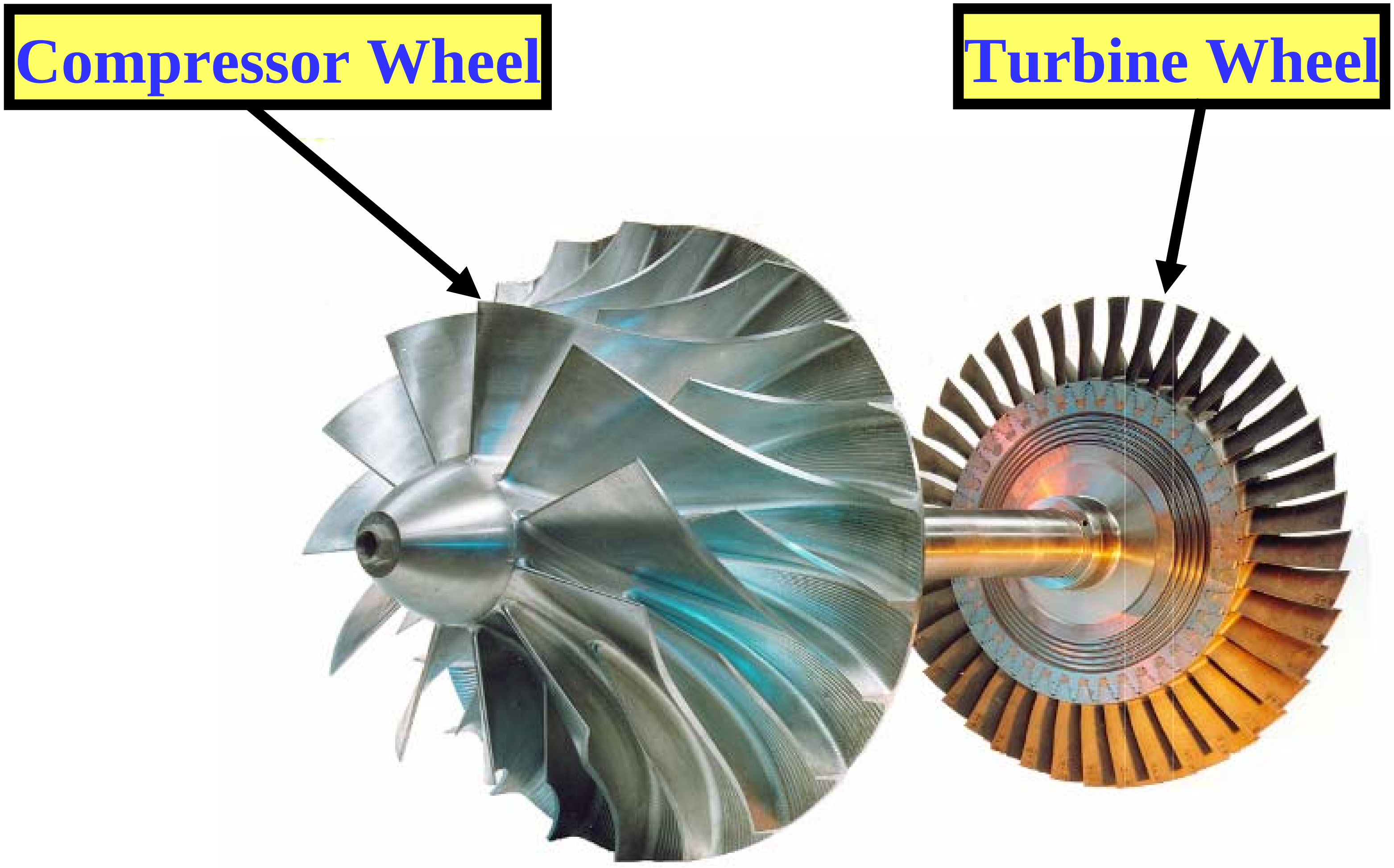


inboard plain bearings
(MAN B&W turbochargers)

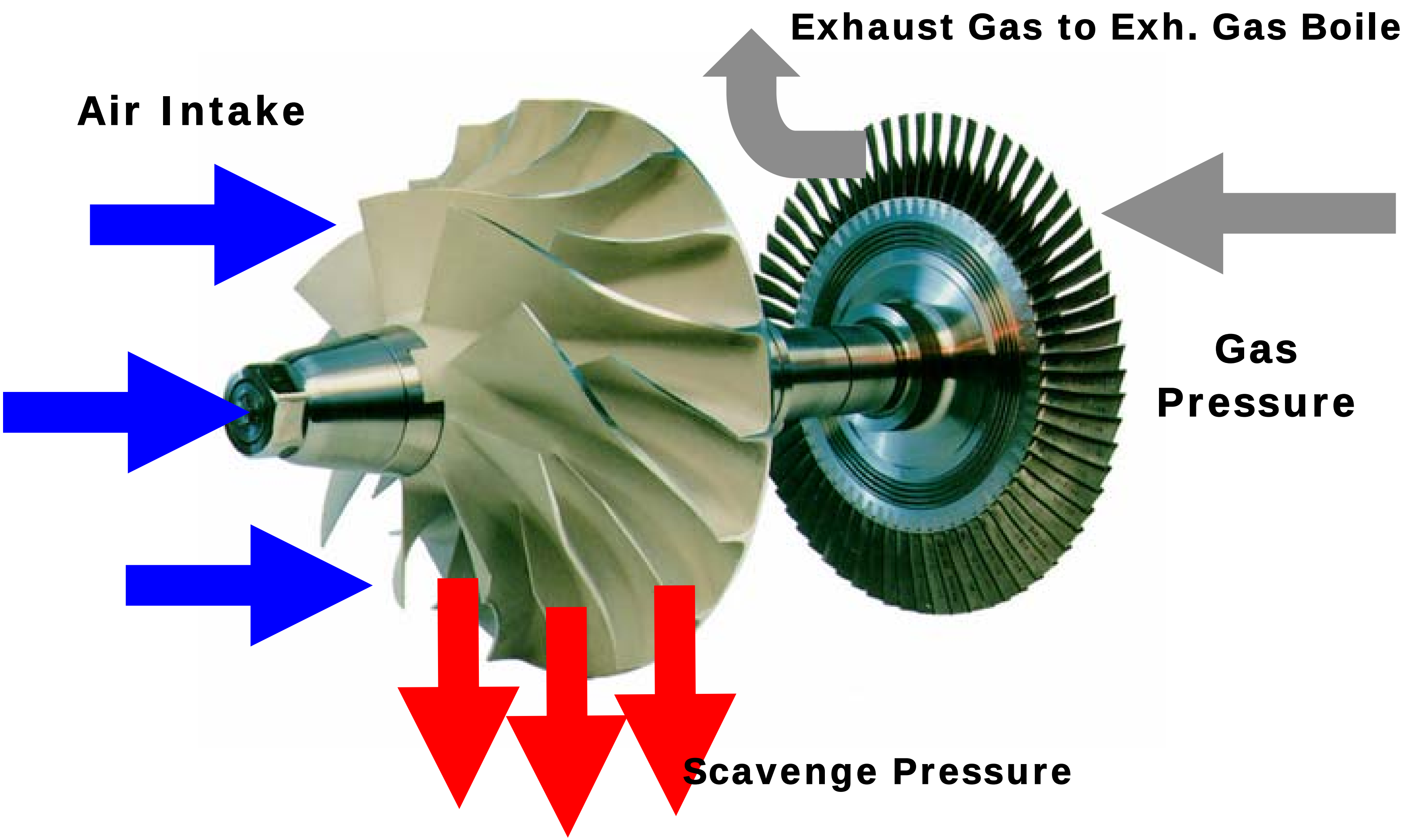


outboard roller bearings
(other makes)

TCA TURBOCHARGER

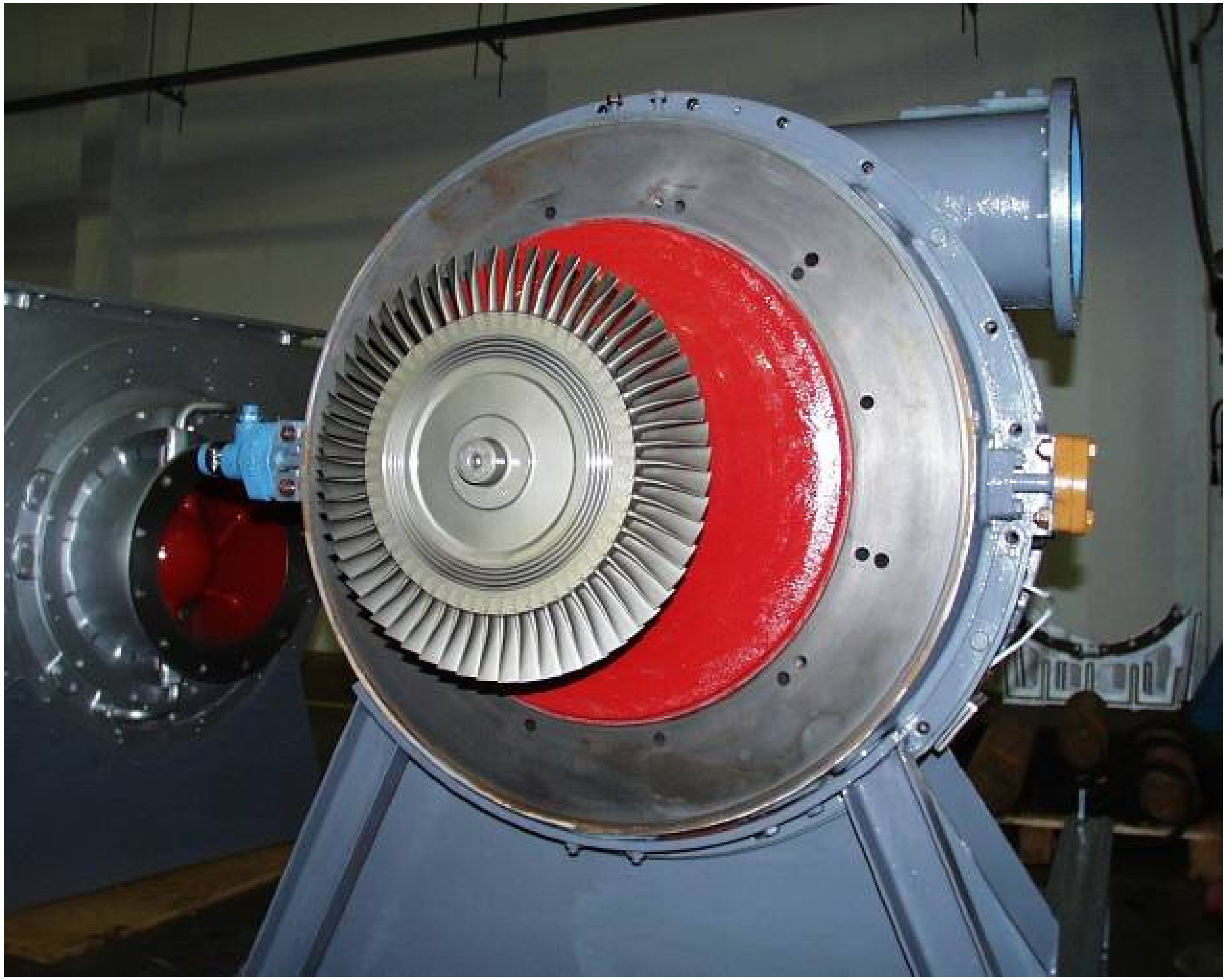


ROTOR



Exhaust Gas to Exh. Gas Boiler
Air Intake
Gas
Pressure
Scavenge Pressure

MAN NA Charger.



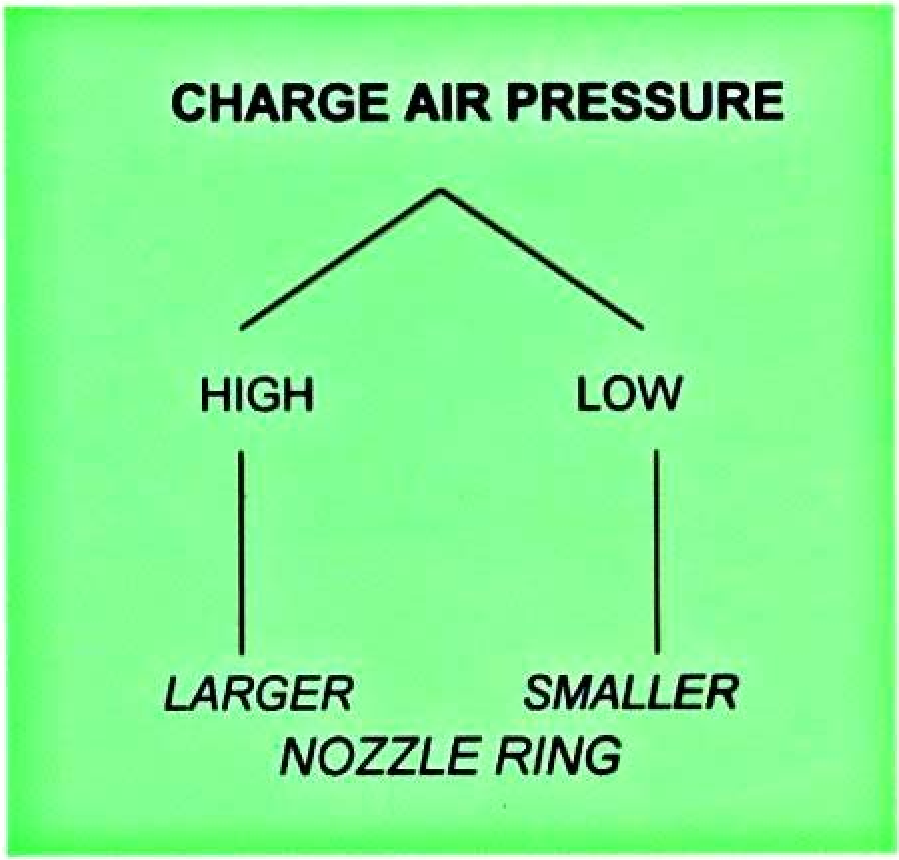
Turbine Side.

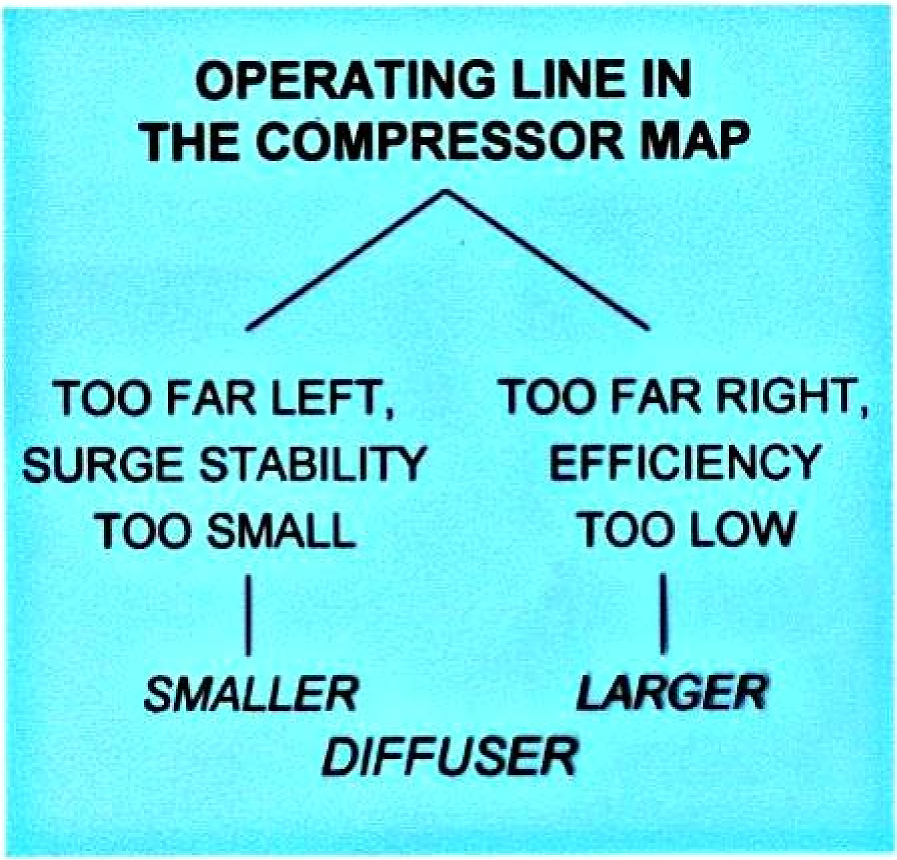
MAN NA Charger.

Air Inlet.

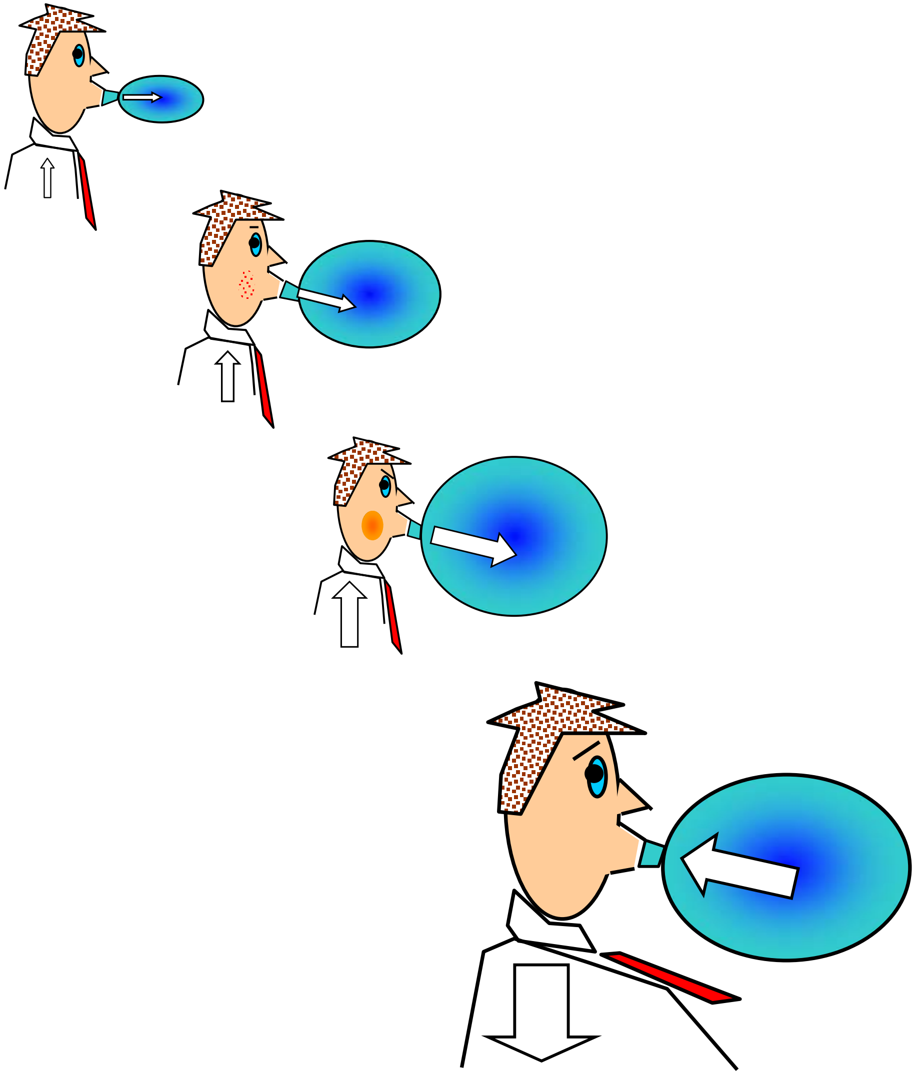

BBC
60
80
100
40
120
20
140
0
160

Turbocharging.



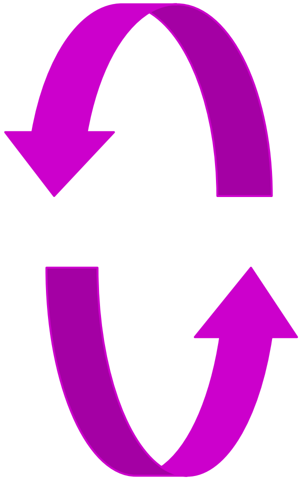


Surging



Ballon

Surge

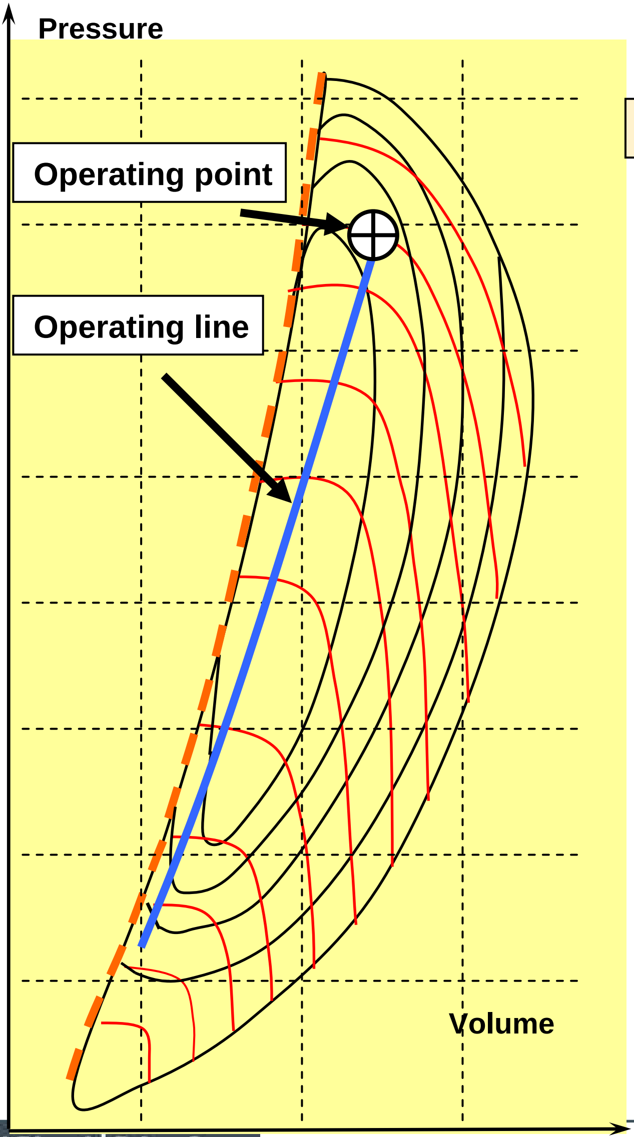


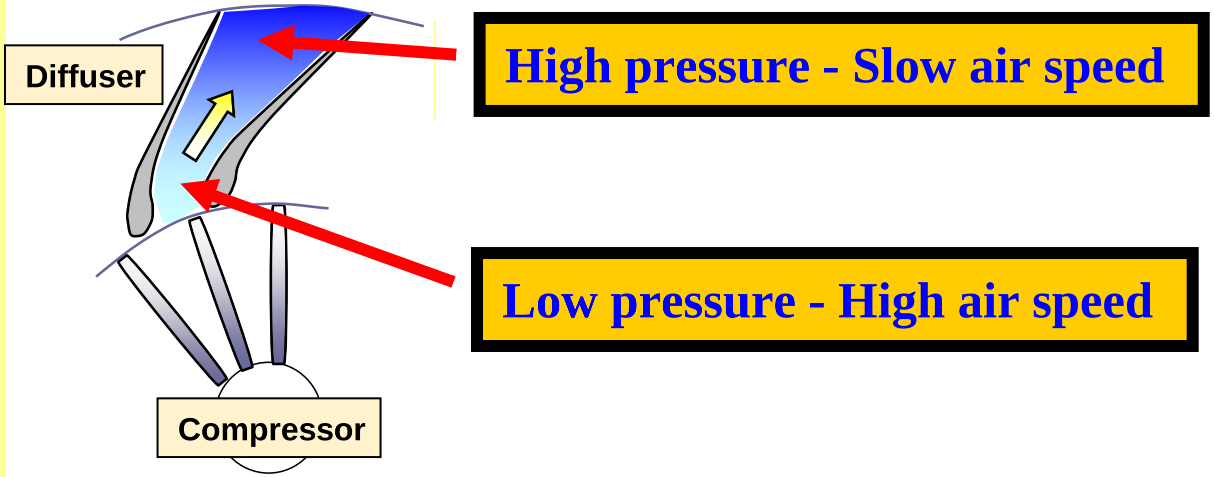
Under normal operating conditions, the turbocharger follows the operating line in accordance with three criteria:

- **pressure ratio**
- **air volume flow**
- **turbocharger speed**

- Compliments from ABB

Surging

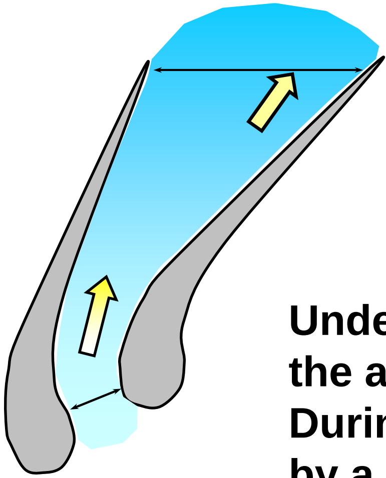


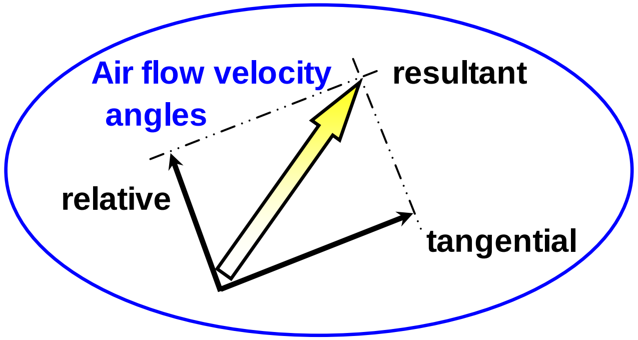


Under normal operating conditions, the turbocharger follows the operating line, based on the criteria of :

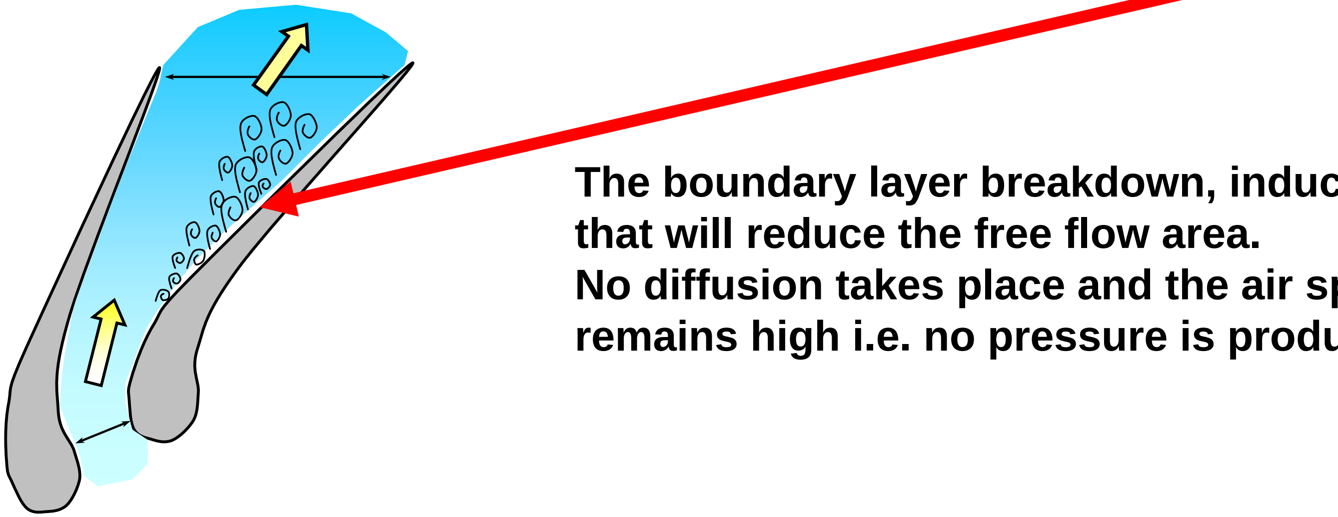
- **Pressure ratio**
- **Air volume flow**
- **Turbocharger speed**

Surging



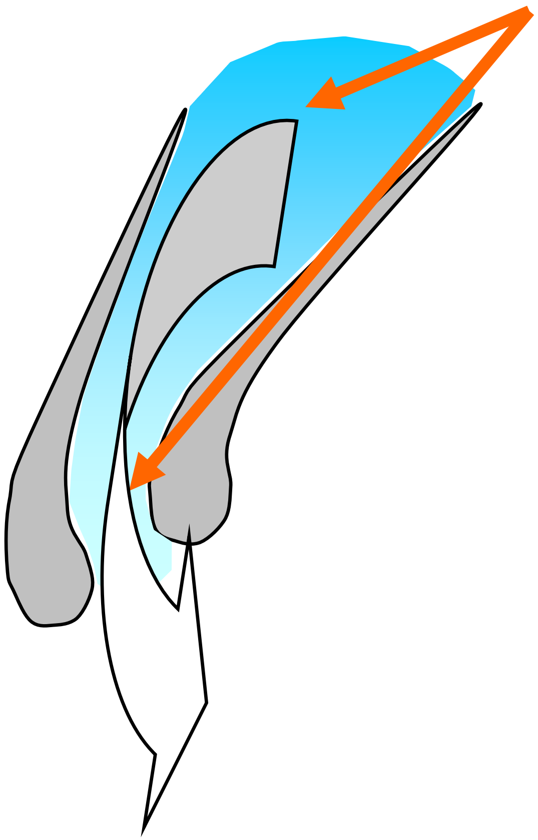


Under normal operating conditions the air flow follows the diffuser van directions. During abnormal conditions, when for example the air flow is reduced by a fouled air filter,charge air cooler or at rapid load changes. The velocity angles are changing,causing the boundary layer breakdown.



The boundary layer breakdown, induces whirling that will reduce the free flow area. No diffusion takes place and the air speed remains high i.e. no pressure is produced.

Surging



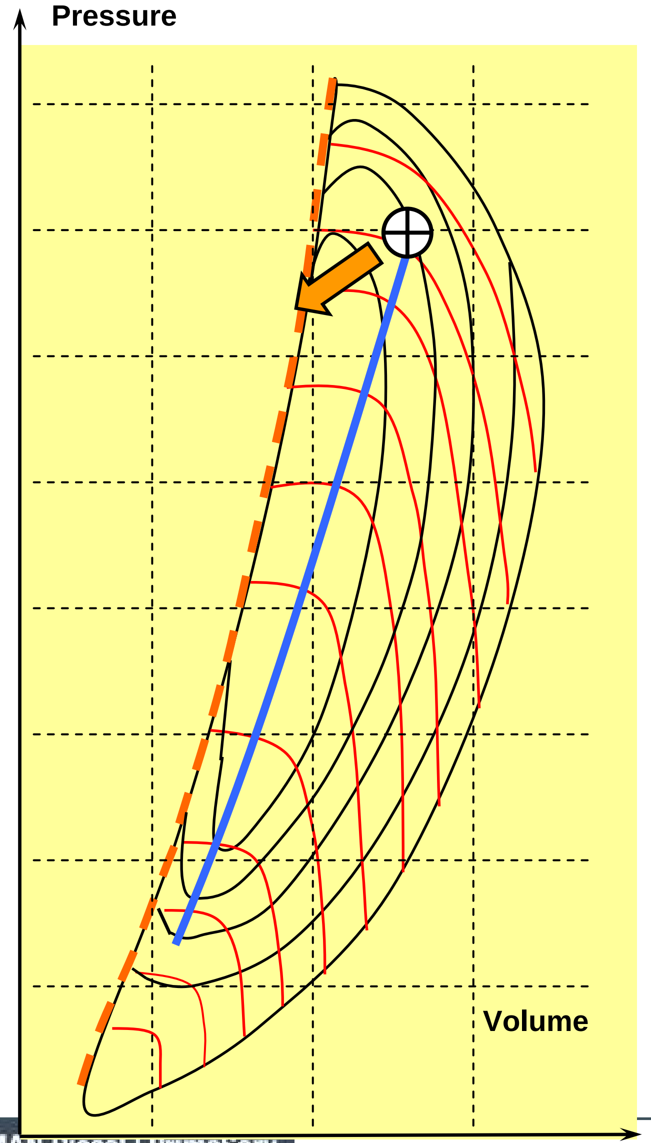
Air speed high - pressure low

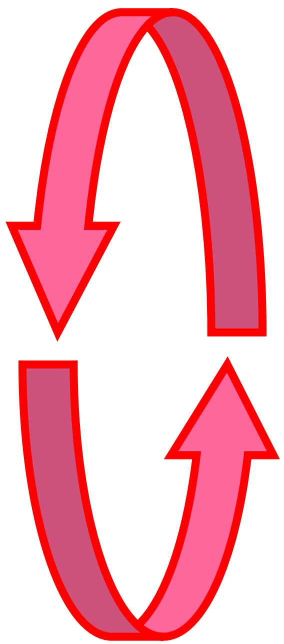
Surge occurred as the pressure down stream the diffuser was higher than the diffuser pressure.

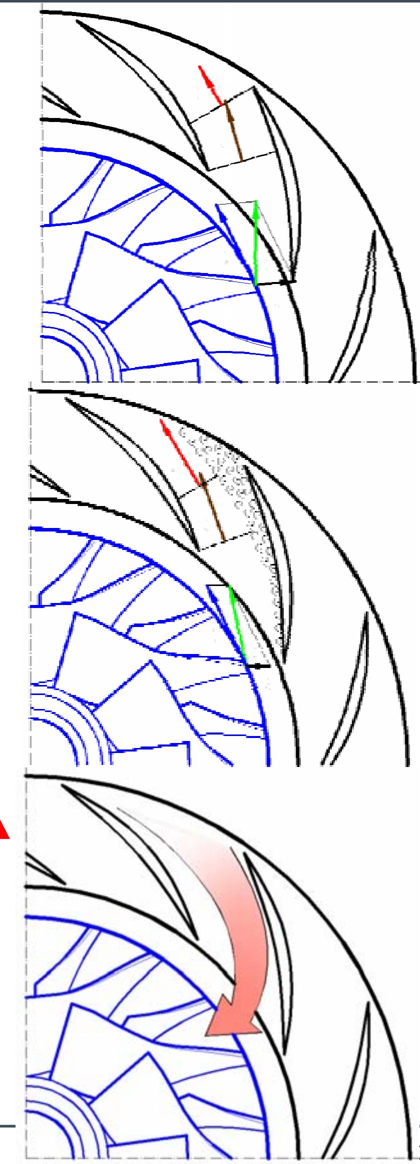
The frequency of this flow reversal, or surge will depend on the level of flow restriction, and system stability.

SURGE !

Surging







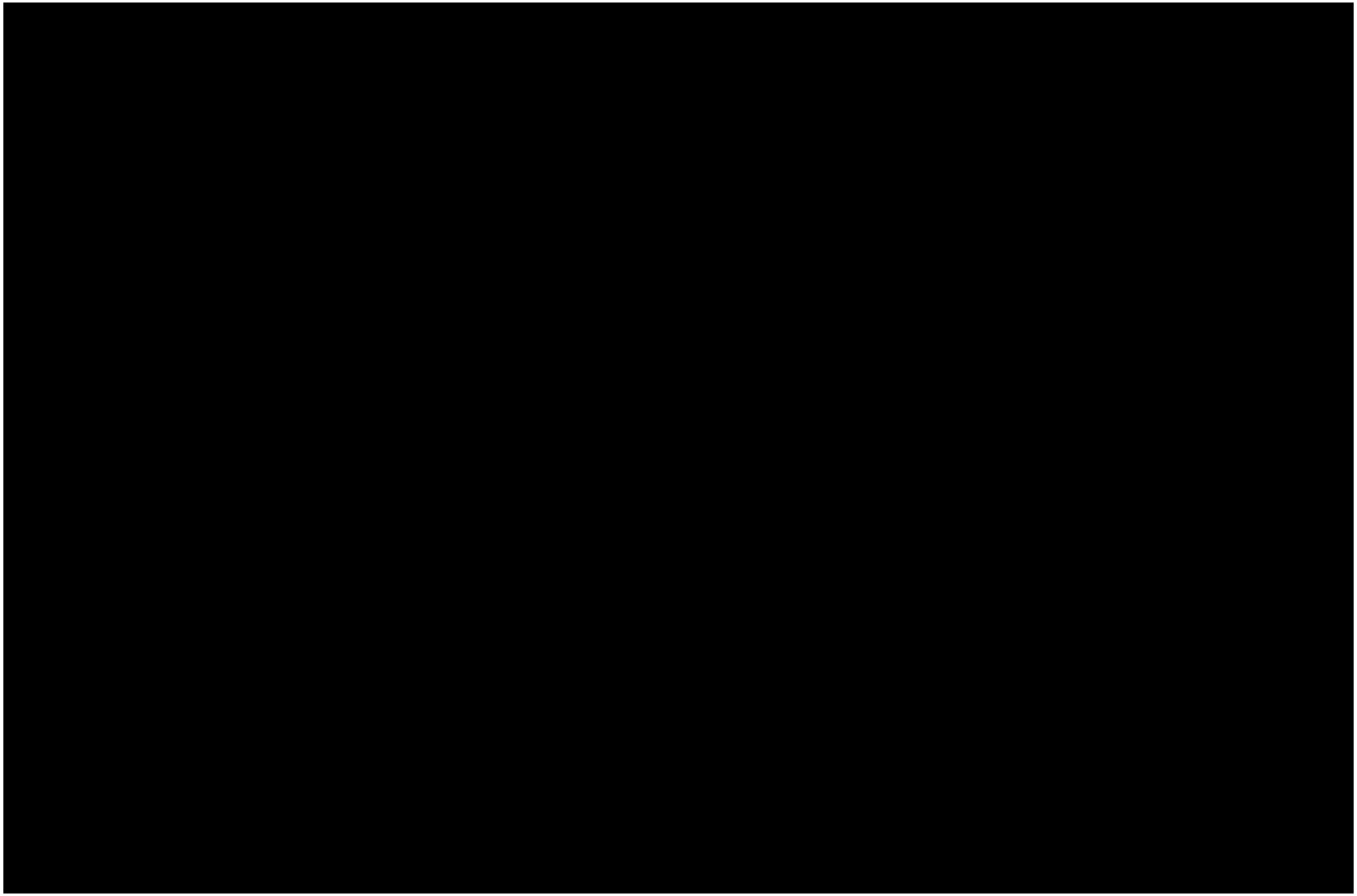
1) Normal operation

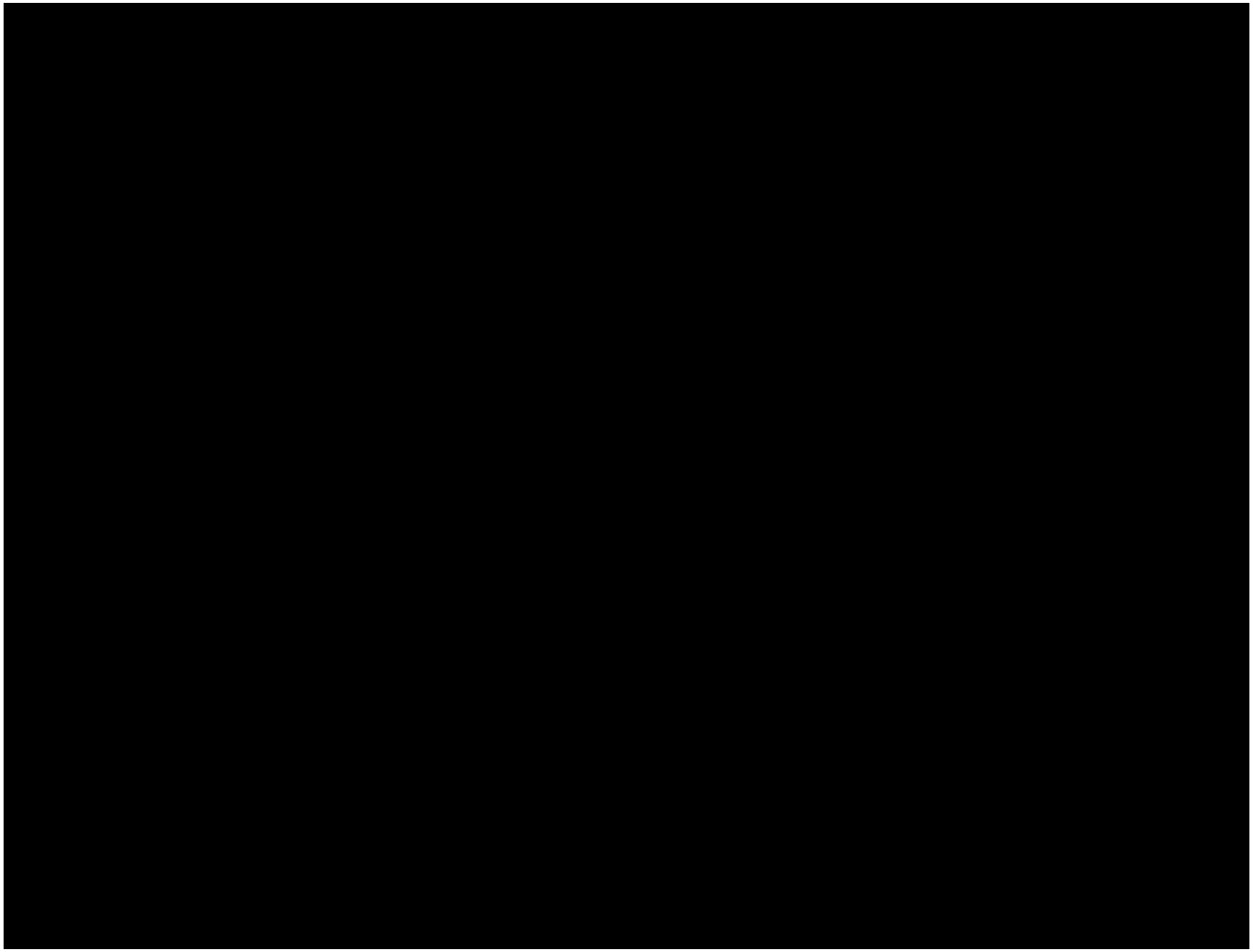
2) Boundary layer breakdown.
Air speed not converted into pressure.

3) Compressor flow reversal.

- Surge -

COMPLIMENTS FROM ABB TURBO





Surging!

What is Surging?

Why does Surging occur?

What might be the reasons for Surging?

Possible causes:

Fuel oil system:
- Low circulating or supply pump pr.
- Air in fuel oil.
- Water in fuel oil.
- Low pre-heating temperature.
- Malfunctioning of deaerating valve on top of venting tank.

Exhaust system :
- Exhaust valve not opening correctly.
- Damaged or blocked protective grating before turbine.
- Increased back pressure after turbine.

Turbocharger :
- Fouled air filter box.
- Fouled or damaged compressor side.
- Fouled or damaged turbine side.

Scavenge air system :
- Fouled CAC, water mist catcher and / or ducts.
- Fouled water circulation to CAC.

Miscellaneous :
- Hunting governor.
- Rapid changes in engine load.
- Too rapid rpm change .

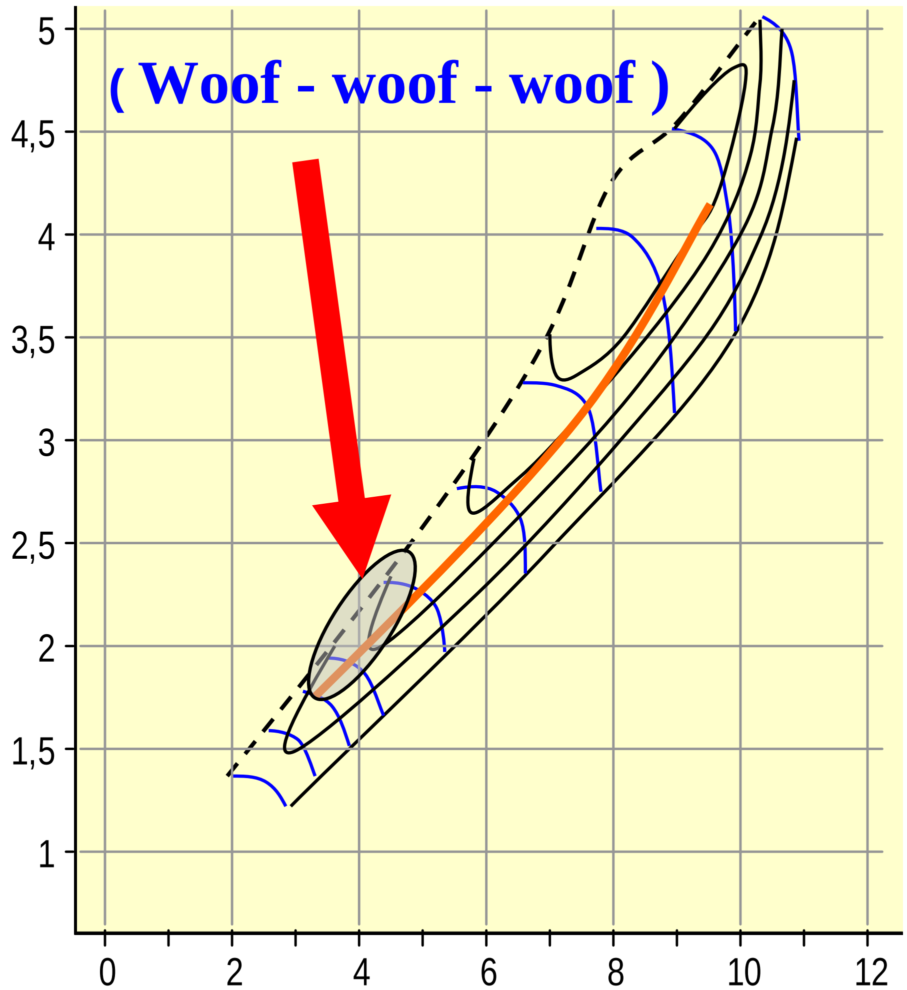
Surging of turbocharger

Surging at high load has to be avoided !

Kinematics of rotor during surging will lead to damage of the rotating elements !

Speed of the rotating components may momentary rise by some 15% !

Aerodynamic Noise.



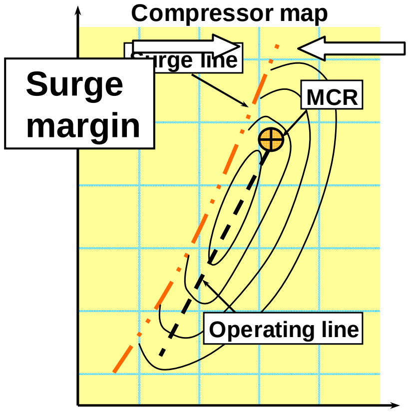
From time to time we experience sound coming from the compressor during low load conditions.

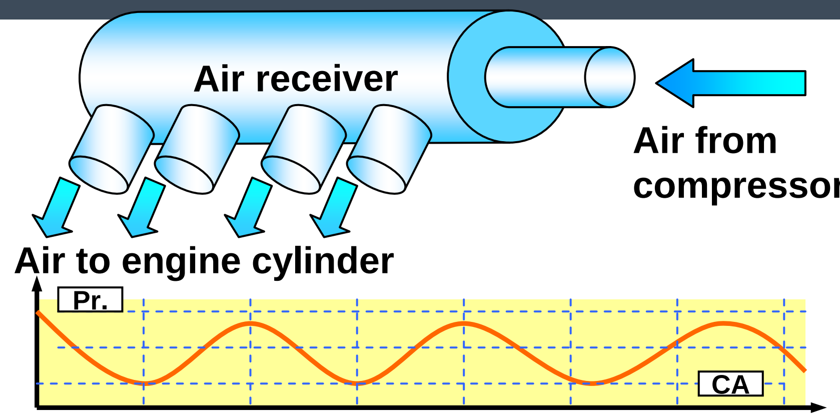
i.e. low compressor pressure ratio

The sound is **NOT** the initiation of Surge !

The noise can be considered cosmetic and have no influence on the performance of neither the engine no the turbocharger.

No. of cylinders





Surging are also related to number of cylinders and therefore also related to receiver volume.

The receiver volume required, relative to the swept volume of the engine, will reduce with increasing number of cylinders and will be more critical with a 2-stroke engine than a 4-stroke,
i.e. less cylinders require more surge margin..

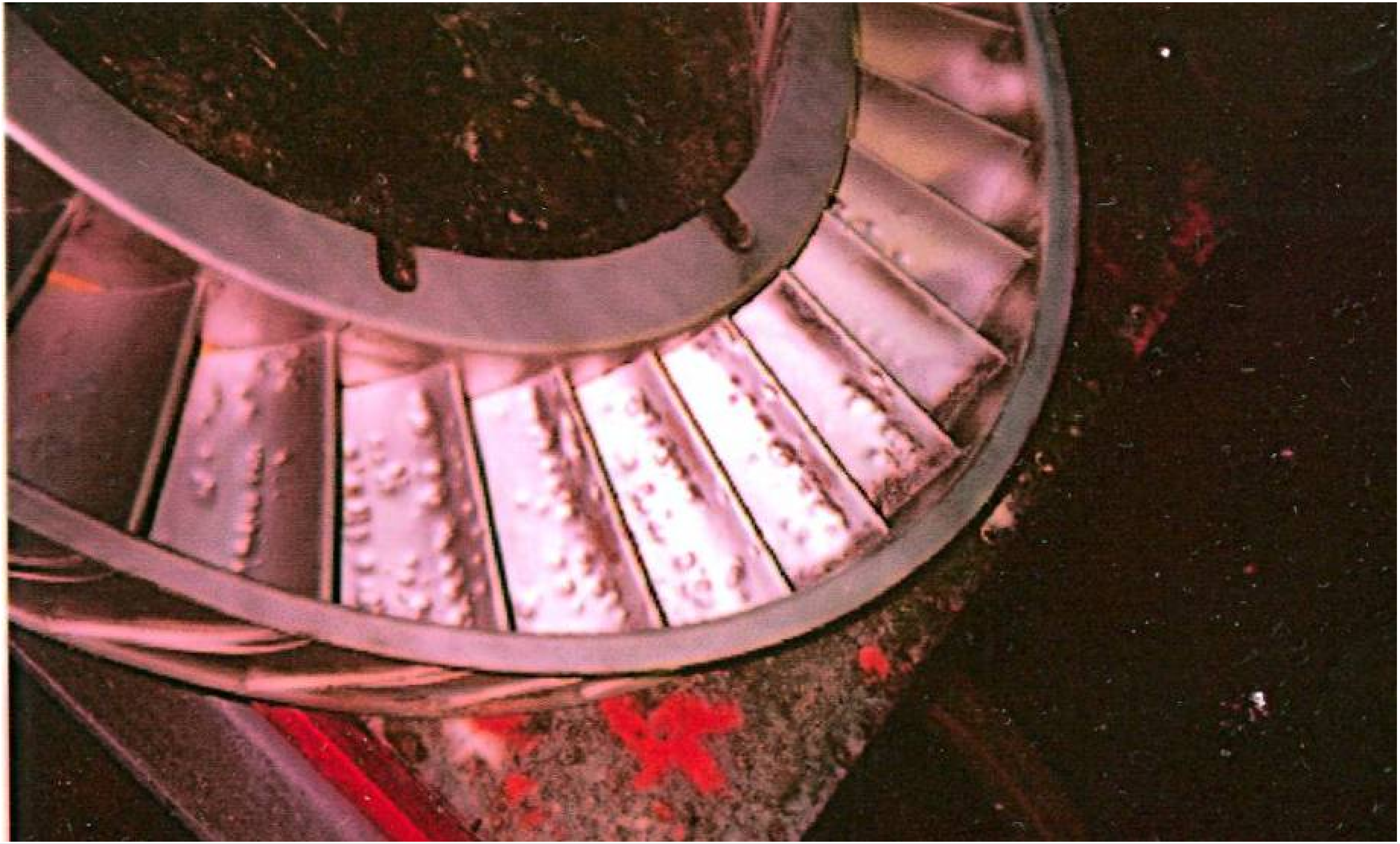
In case of the receiver volume is too small, or there are a small numbers of cylinders, pressure will reduce toward the end of each induction process, and since the compressor maintains almost constant speed, the compressor may surge.

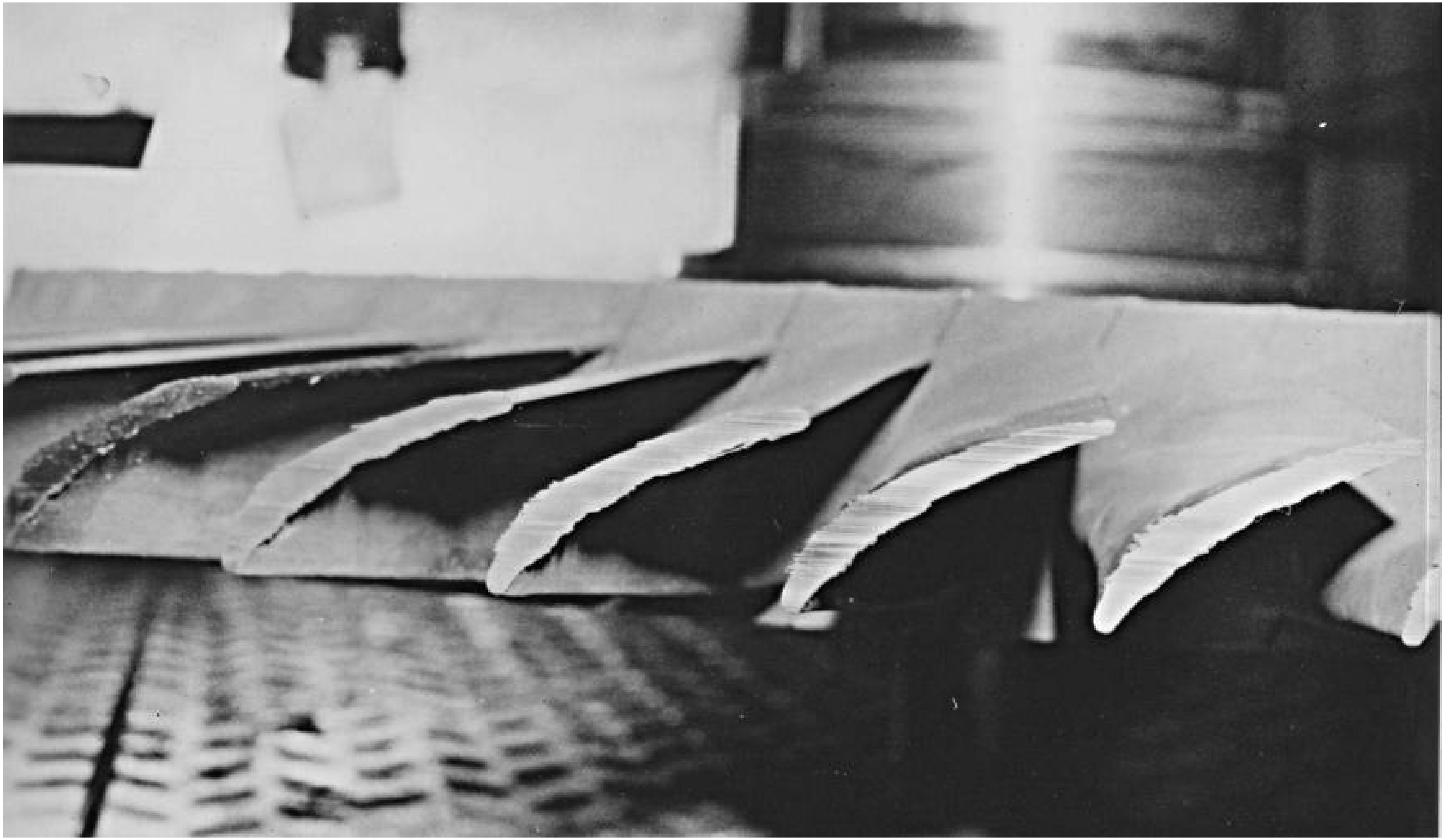
AIR INLET FILTER

AIR INLET FILTER

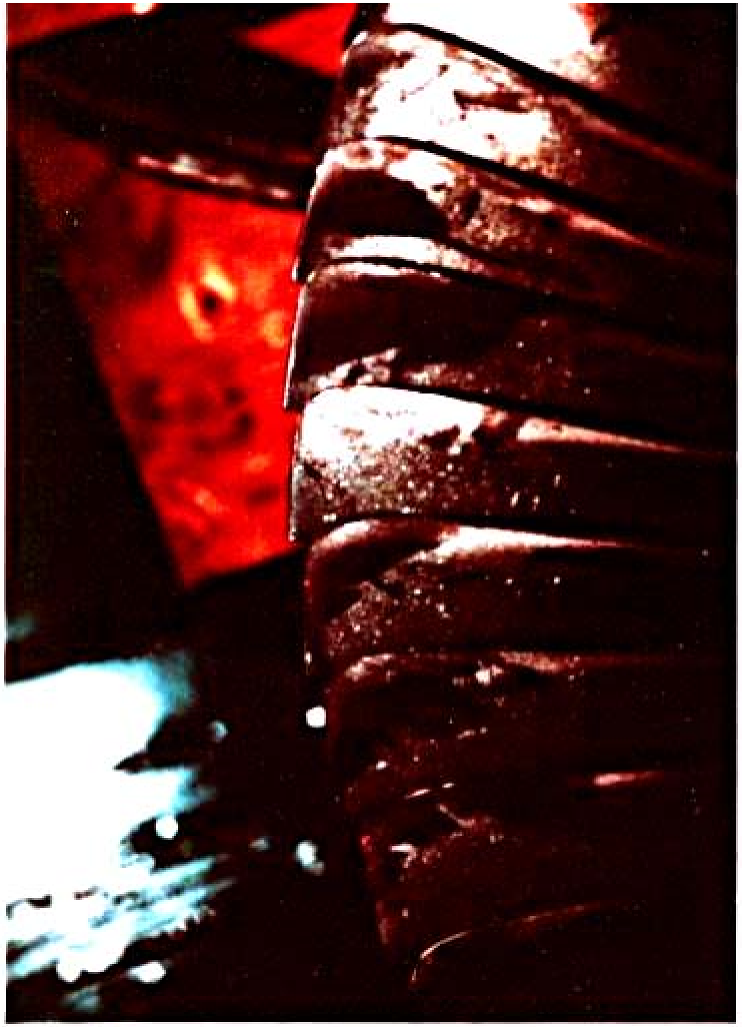
INLET FILTER?

Turbocharging.





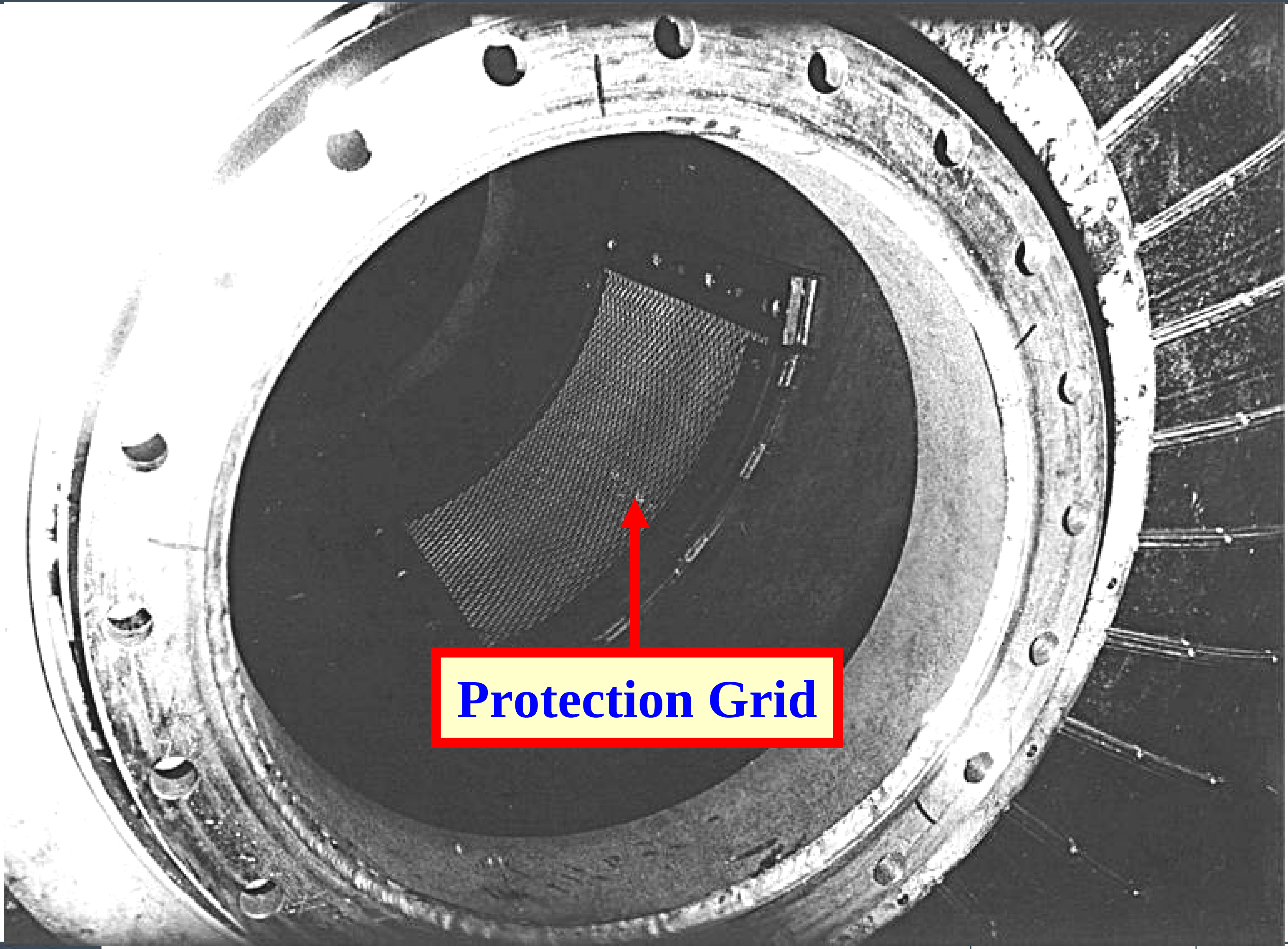
ROTOR



Worn and rounded blades

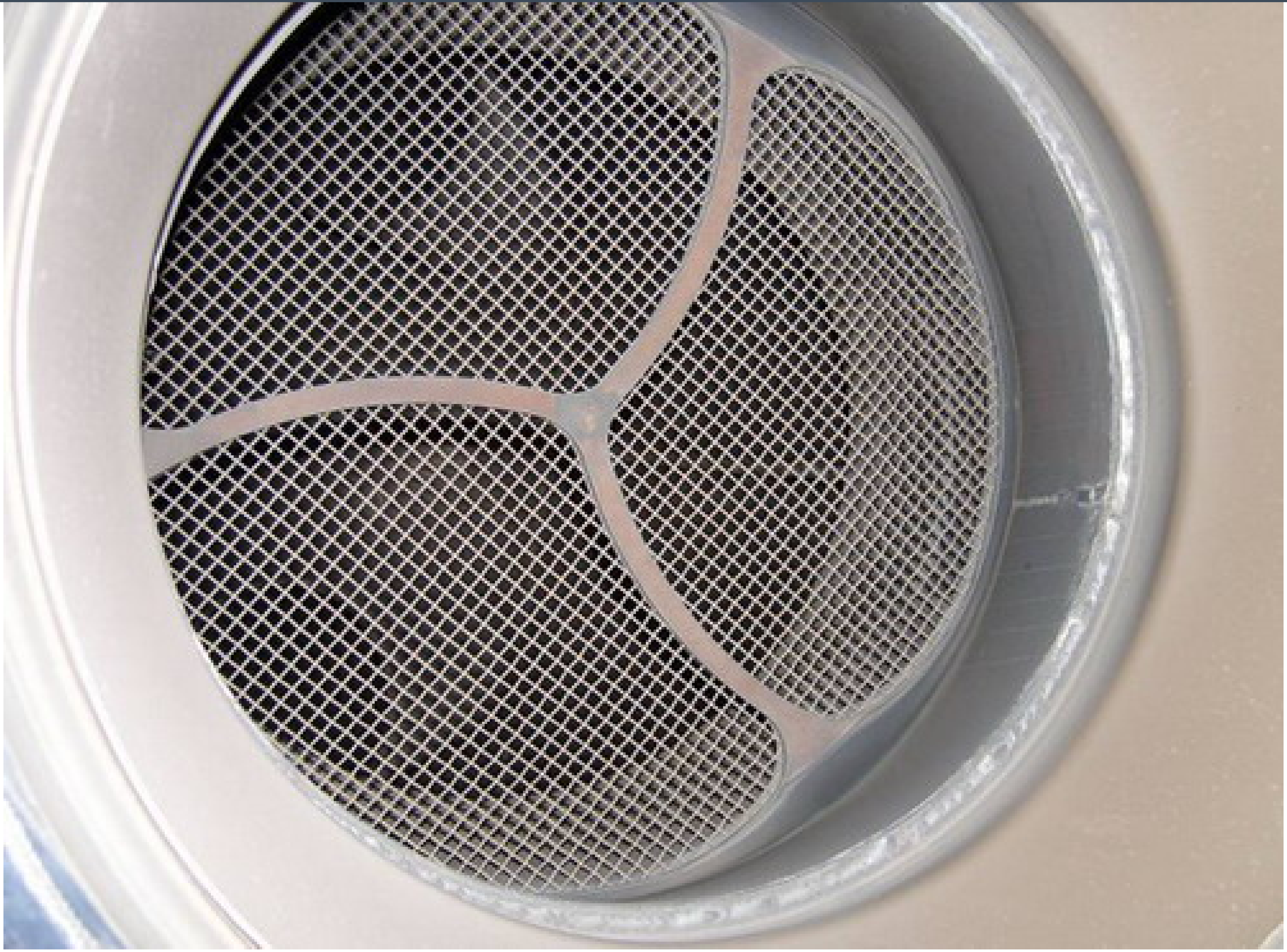
Blades in good condition

Turbocharging.

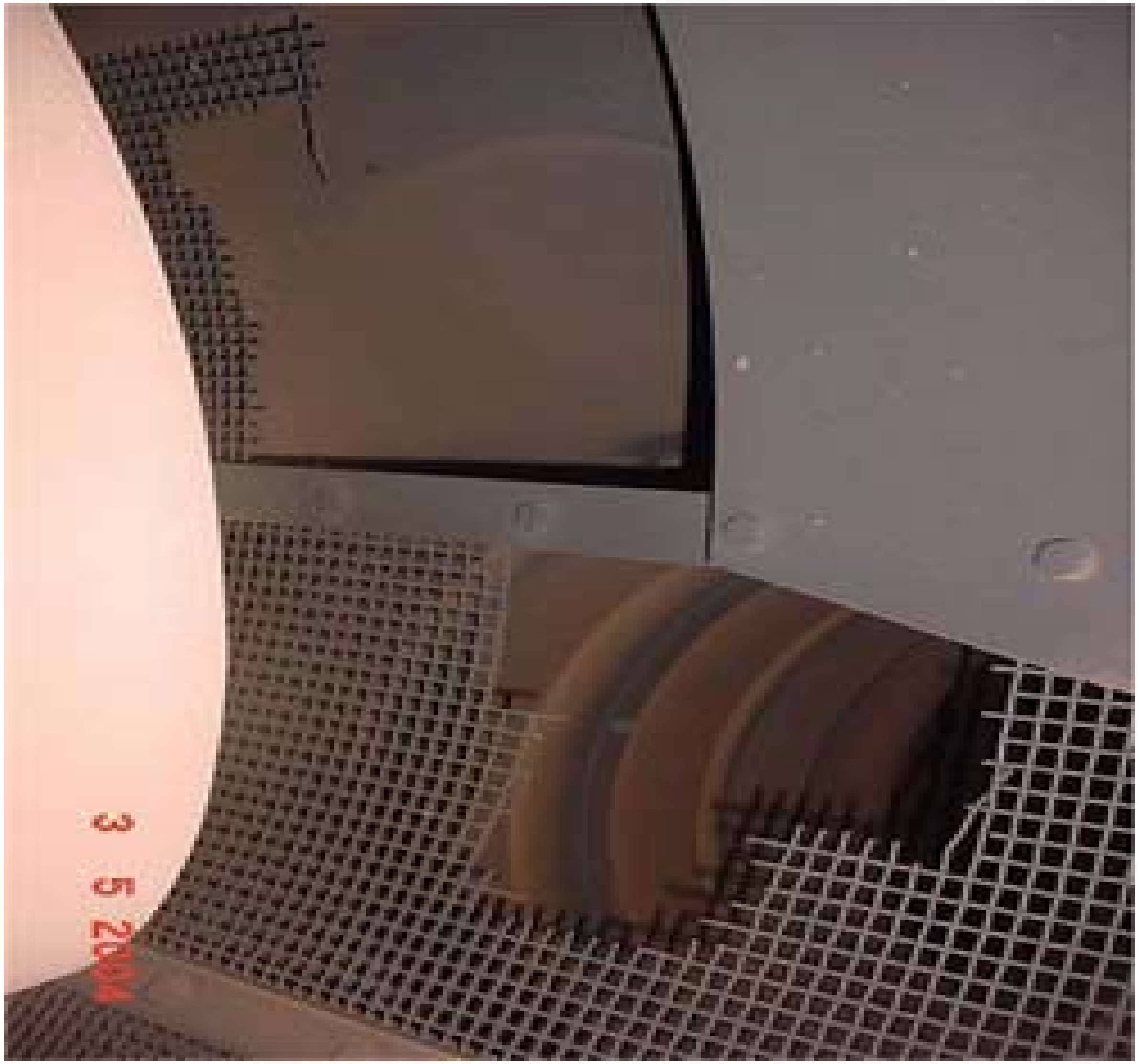


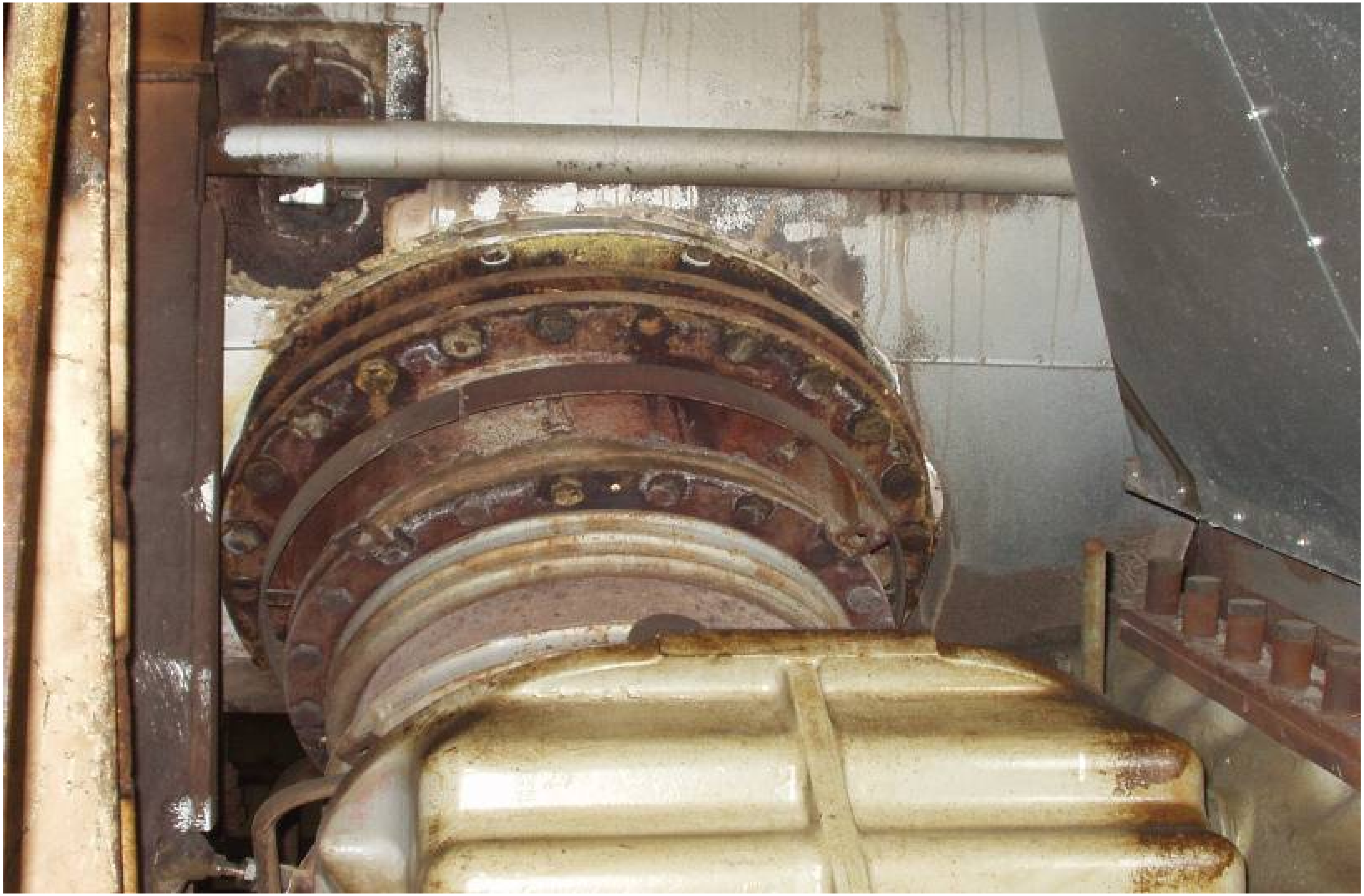
Turbocharging.

Turbocharging.



Damaged T/C grid.





Turbine Cleaning Methods Comparison

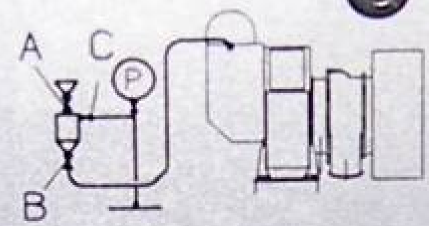
Wet Cleaning

- 😐 Exhaust gas temperature before turbine : ***300 < x < 430°C***
- 😐 Material: Fresh water
- 😐 Water return through drain cock: 0,1 lt -10% injected water
- ☺ Cleaning frequency : ***every 48 to 500 hours***

Dry Cleaning

- ☺ Exhaust gas temperature before turbine : ***< 590°C***
- ☺ T/C speed as high as possible
- 😐 Materials: natural kernel granules soft blast media or activated charcoal particles (diam. 1,2-2 mm)
- 😐 Cleaning frequency : ***every 24 to 48 hours***

DRY CLEANING OF TURBOCHARGER (TURBINE SIDE)



1 Carry out cleaning for every 24 to 50 hours of operation, based on observations.

2 Preferably clean the turbocharger at full load. Do not clean below half load.

3 Close valve A.

4 Open valves B and C, to blow out possible deposits and/or condensate in the connecting pipe after about 2 minutes, close valves B and C.

5 Slowly open valve A, to vent the container.

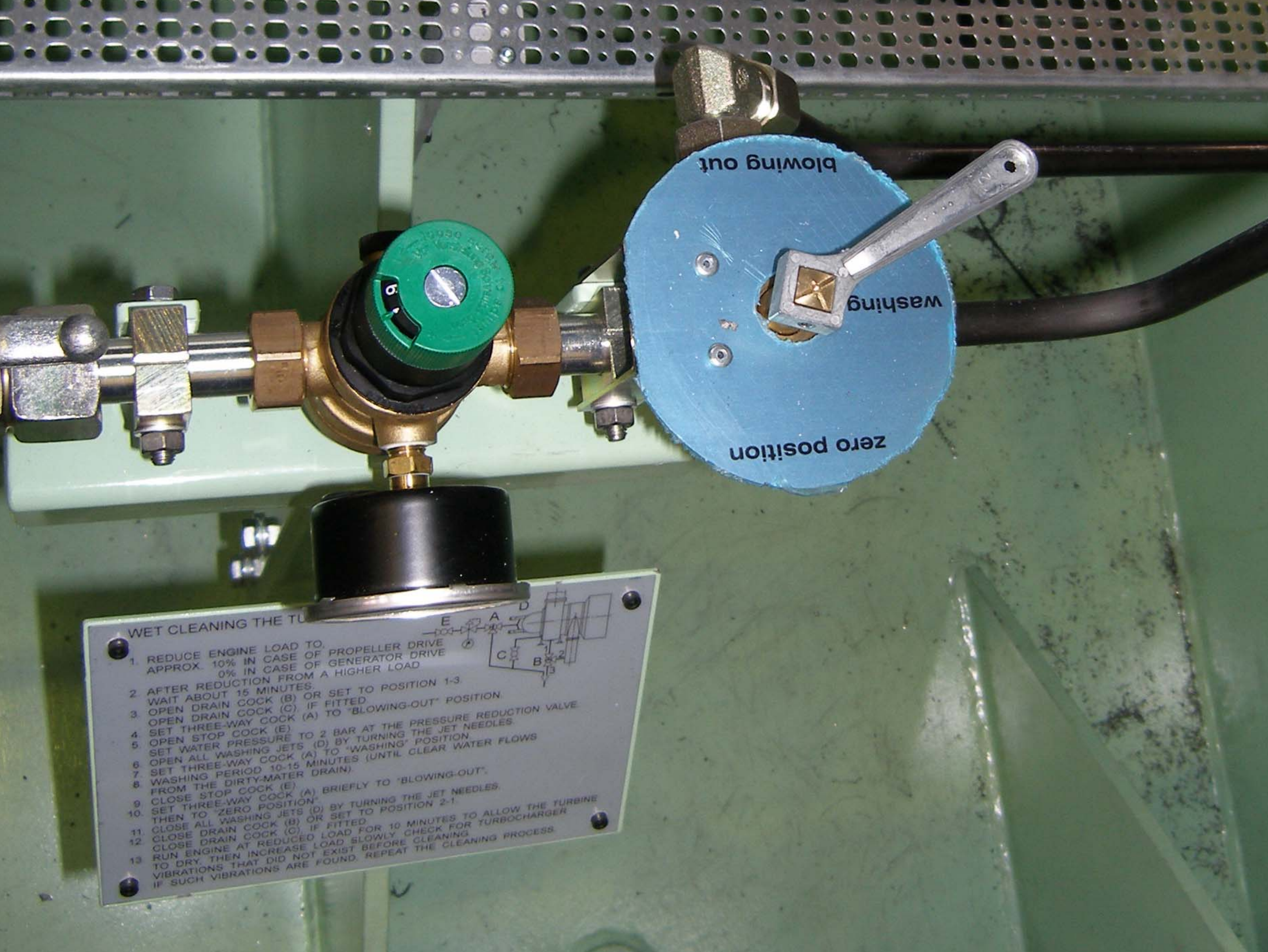
6 Fill the container with the quantity of granules specified in the table.

7 Close valve A.

8 Open valves B and C, to blow-in the granules, after 1 to 2 minutes, close valves B and C.

9 Slowly open valve A, to vent the container.

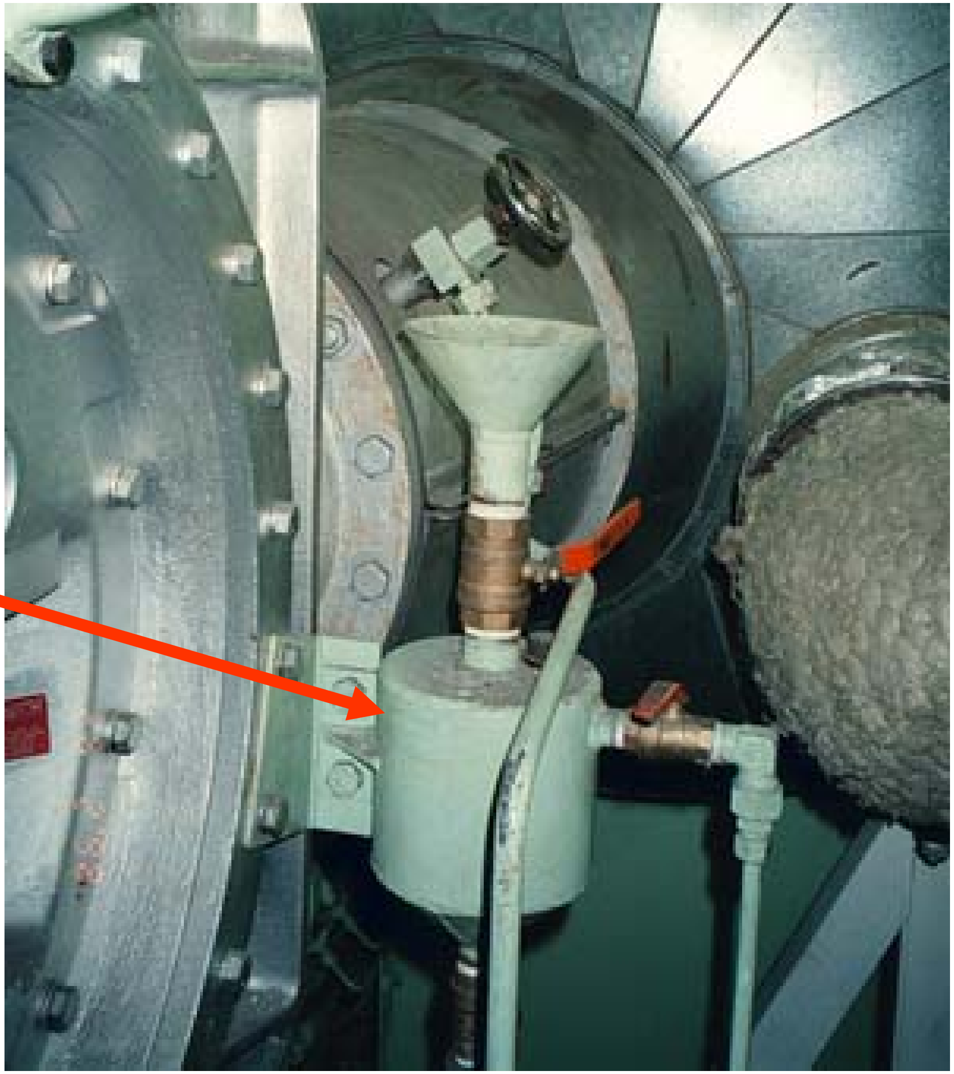
TC type	Amount dm^3
NA34	0.5
NA40	1.0
NA48	1.5
NA57	2.0
NA70	3.0
NA83	3.5
VTR354/TPL77	1.5
VTR454/TPL80	2.0
VTR564	2.5
VTR714/TPL85	3.0
MET53SD/E	1.6
MET66SD/E	2.6
MET71SD/E	2.6
MET83SD/E	3.5

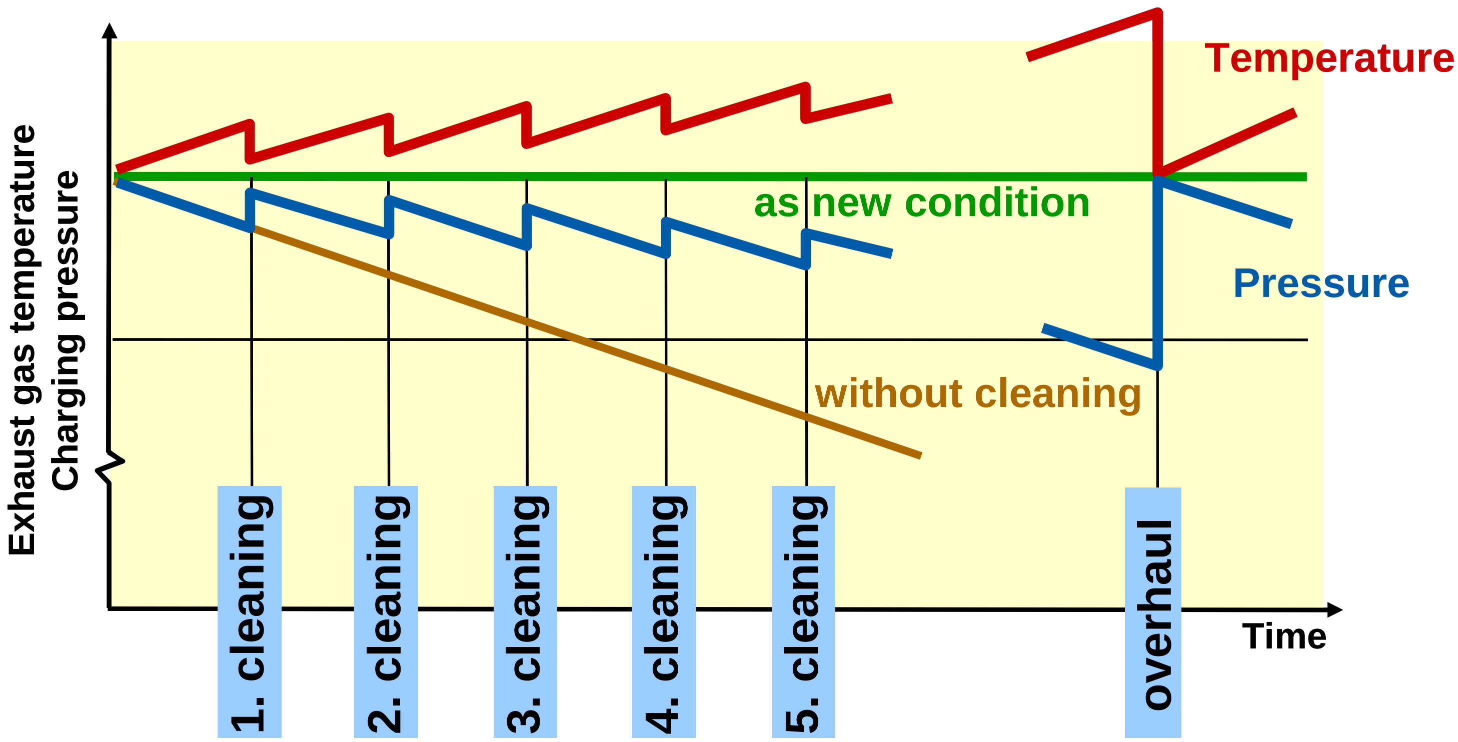

blowing out
washing
zero position
WET CLEANING THE TU
E
A
D
C
B
1
2
3
1. REDUCE ENGINE LOAD TO,
APPROX. 10% IN CASE OF PROPELLER DRIVE
0% IN CASE OF GENERATOR DRIVE
FROM A HIGHER LOAD
2. AFTER REDUCTION
WAIT ABOUT 15 MINUTES.
3. OPEN DRAIN COCK (B) OR SET TO POSITION 1-3.
OPEN DRAIN COCK (C), IF FITTED
4. SET THREE-WAY COCK (A) TO "BLOWING-OUT" POSITION.
5. OPEN STOP COCK (E).
SET WATER PRESSURE TO 2 BAR AT THE PRESSURE REDUCTION VALVE
6. OPEN ALL WASHING JETS (D) BY TURNING THE JET NEEDLES.
7. SET THREE-WAY COCK (A) TO "WASHING" POSITION.
8. WASHING PERIOD 10-15 MINUTES (UNTIL CLEAR WATER FLOWS
FROM THE DIRTY-MATER DRAIN).
9. CLOSE STOP COCK (E).
10. SET THREE-WAY COCK (A) BRIEFLY TO "BLOWING-OUT",
THEN TO "ZERO POSITION".
11. CLOSE ALL WASHING JETS (D) BY TURNING THE JET NEEDLES.
12. CLOSE DRAIN COCK (B) OR SET TO POSITION 2-1.
CLOSE DRAIN COCK (C), IF FITTED.
13. RUN ENGINE AT REDUCED LOAD FOR 10 MINUTES TO ALLOW THE TURBINE
TO DRY. THEN INCREASE LOAD SLOWLY. CHECK FOR TURBOCHARGER
VIBRATIONS THAT DID NOT EXIST BEFORE CLEANING.
IF SUCH VIBRATIONS ARE FOUND, REPEAT THE CLEANING PROCESS.

NA 70 Turbocharger.

Dry Cleaning on 6L60MC.

Dry Cleaning.





- Compliments from ABB

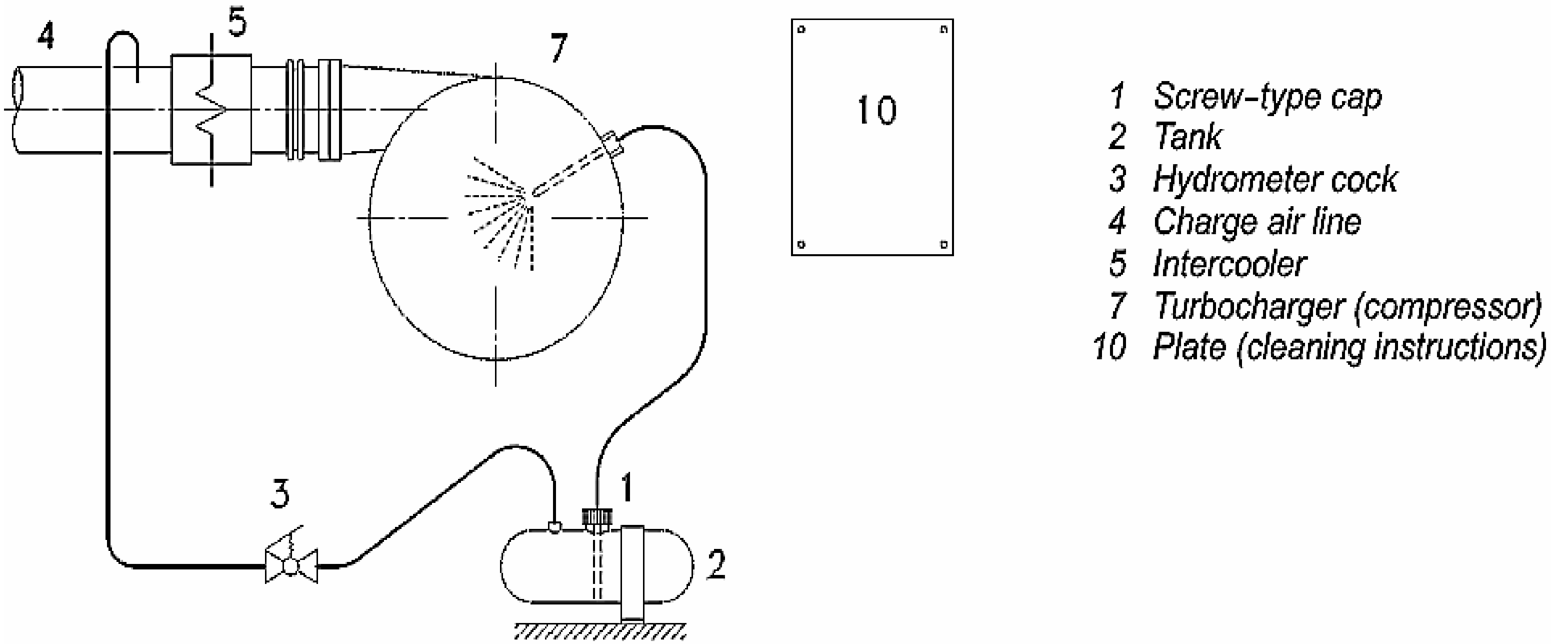
The cleaning frequency is influenced by the following conditions:

- **Ambient conditions**
- **Fuel quality and fuel separation**
- **Load profile**
- **Cleaning efficiency**
- **Engine condition**

Manual overhauls are still necessary to remove deposits which the cleaning in operation does not remove.

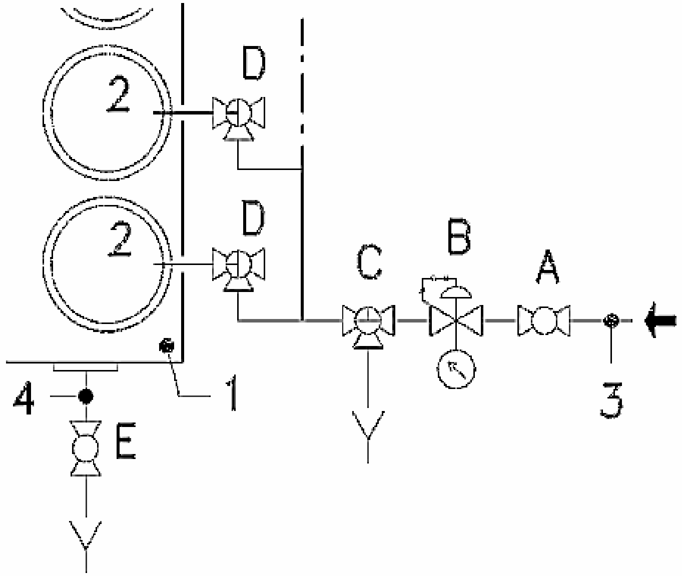
- Compliments from ABB

Cleaning the compressor with fitted tank



- **Clean compressor wheel every 150 working hours. The cleaning intervalls depend on degree of contamination.**
- **Use exclusively fresh water.**
- **Cleaning must be made with warm engine and running at full load. Let the engine still run a short period after cleaning.**

Wet cleaning the turbine

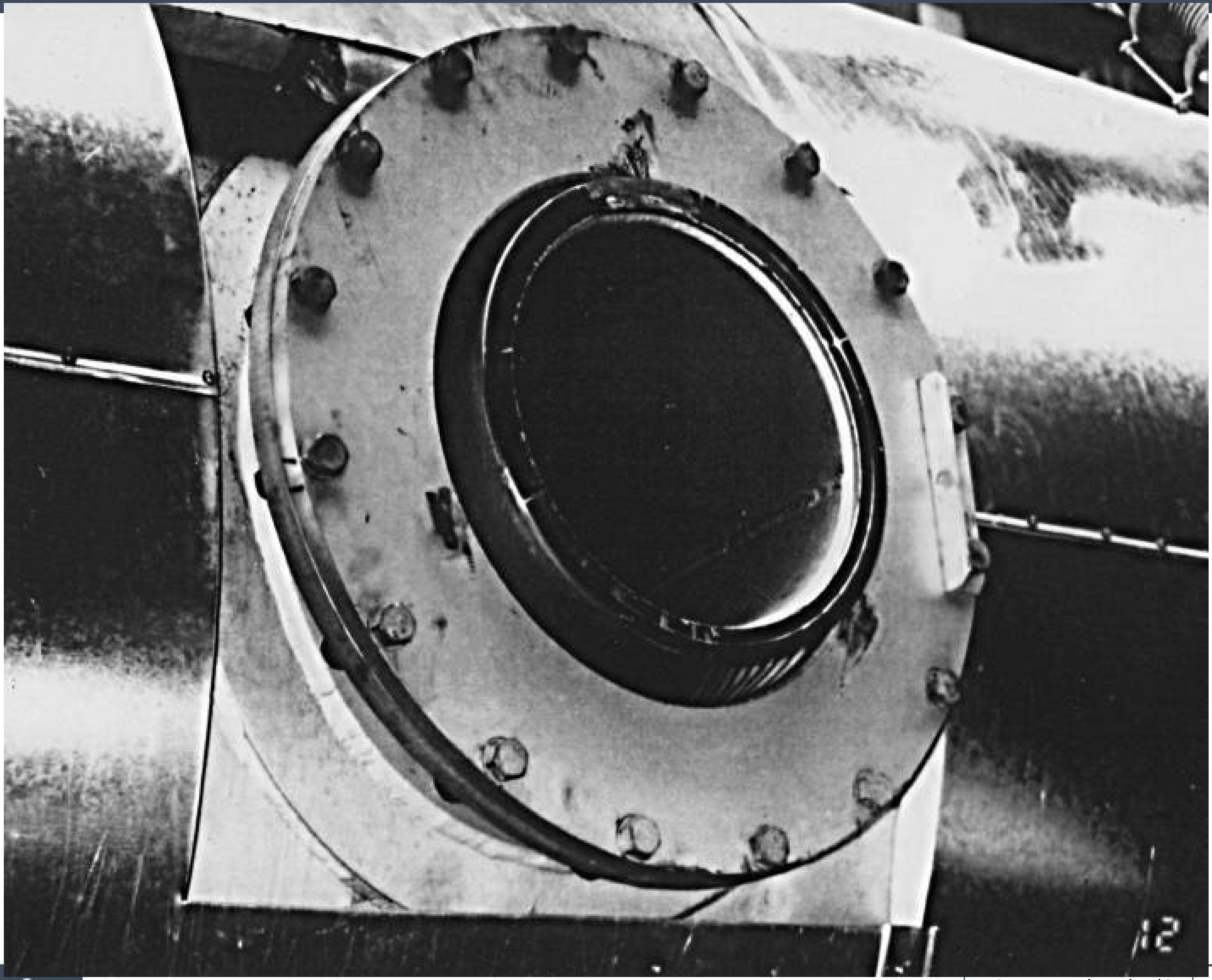


1 *Turbocharger*
2 *Exhaust gas pipe upstream of turbine*
3 *Water admission (freshwater)*
4 *Dirt water discharge downstream of turbine, if fitted*
A *Stop cock*
B *Pressure reducing valve with pressure gauge*
C *Three-way cock:*
ZERO POSITION
BLOW-OUT
WASHING
D *Three-way cock:*
● (= zero position)
●● (= control position)
●●● (= washing position)
E *Drain cock, if fitted*

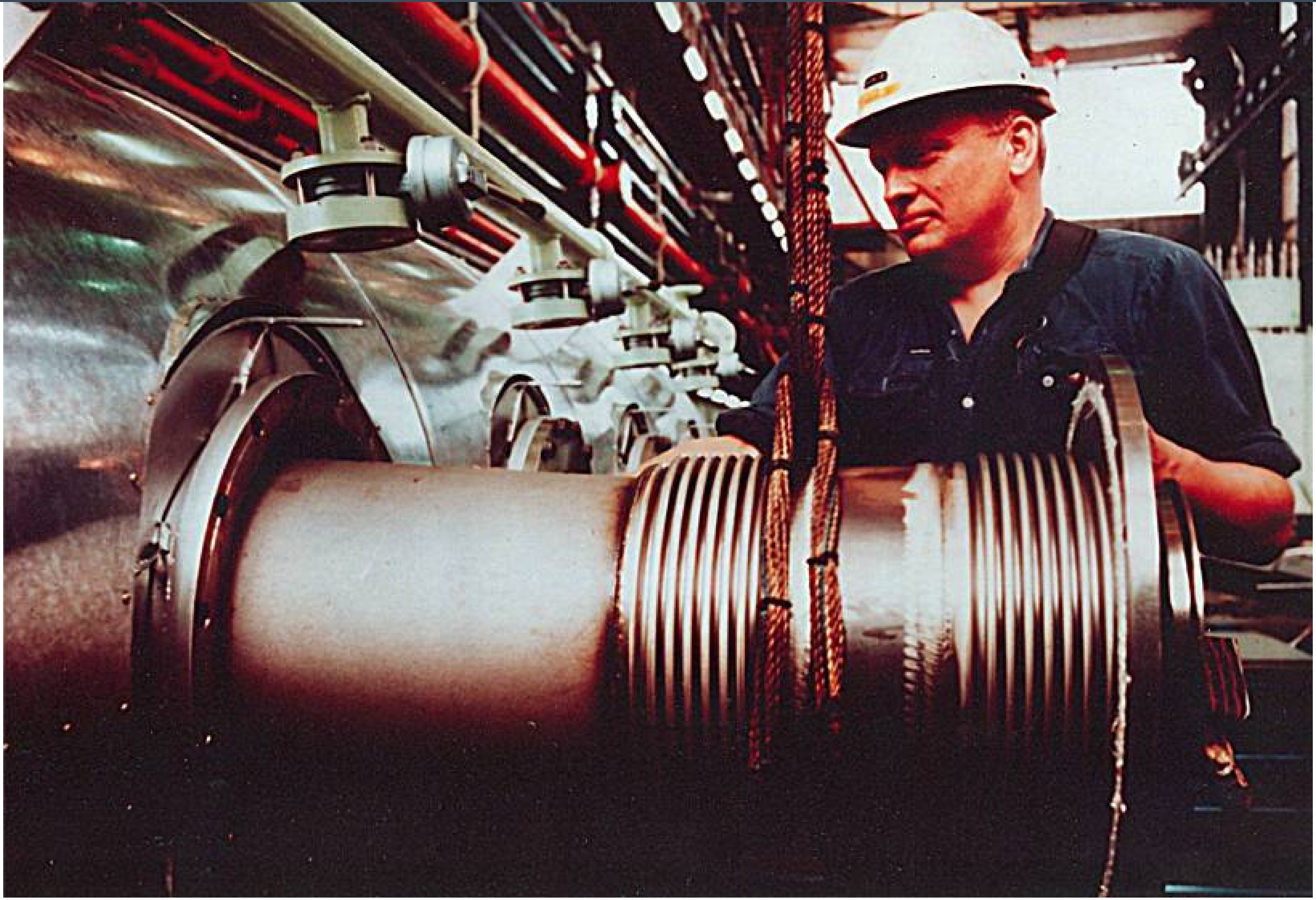
- **Clean every 150 working hours**
- **15 min before cleaning, reduce engine load to idle speed**
- **wash with 2 bar until clear water is coming out of drain pipe**
- **wait again 10 min to dry the turbocharger**
- **increase engine load**

Turbocharging.

Turbocharging.

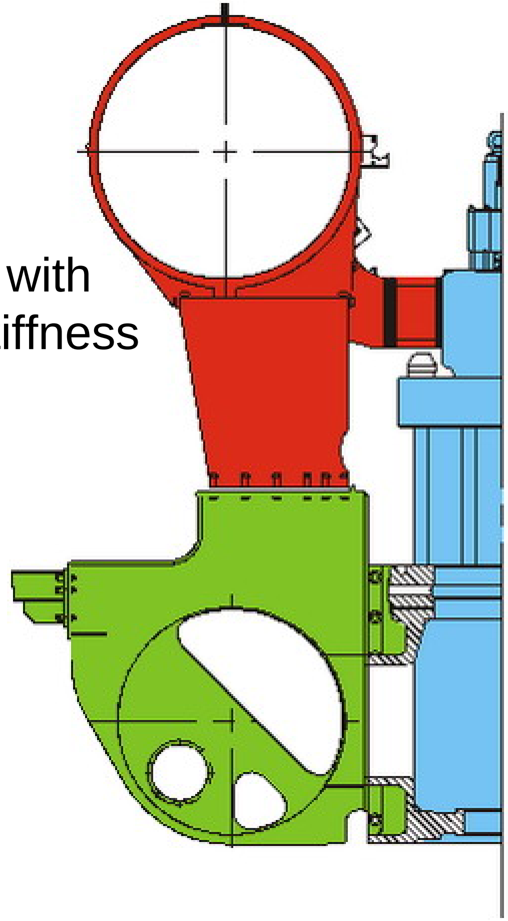


Turbocharging.

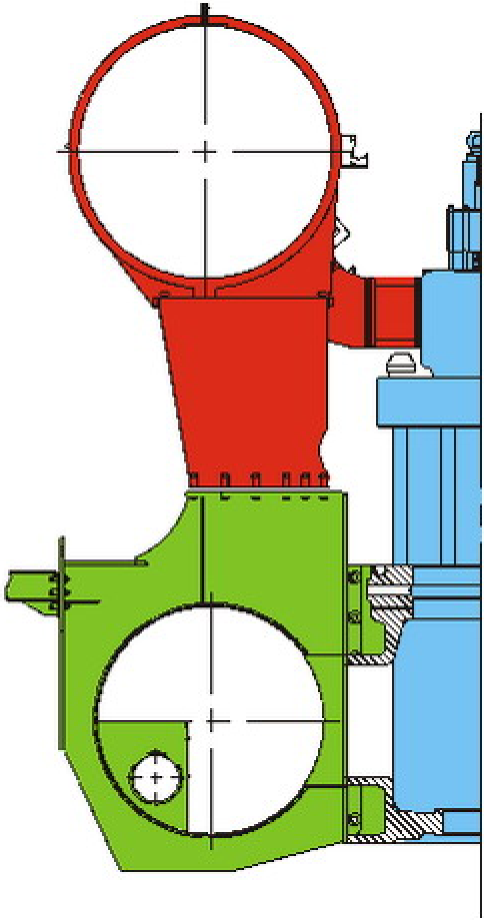


Scavenge Air Receiver

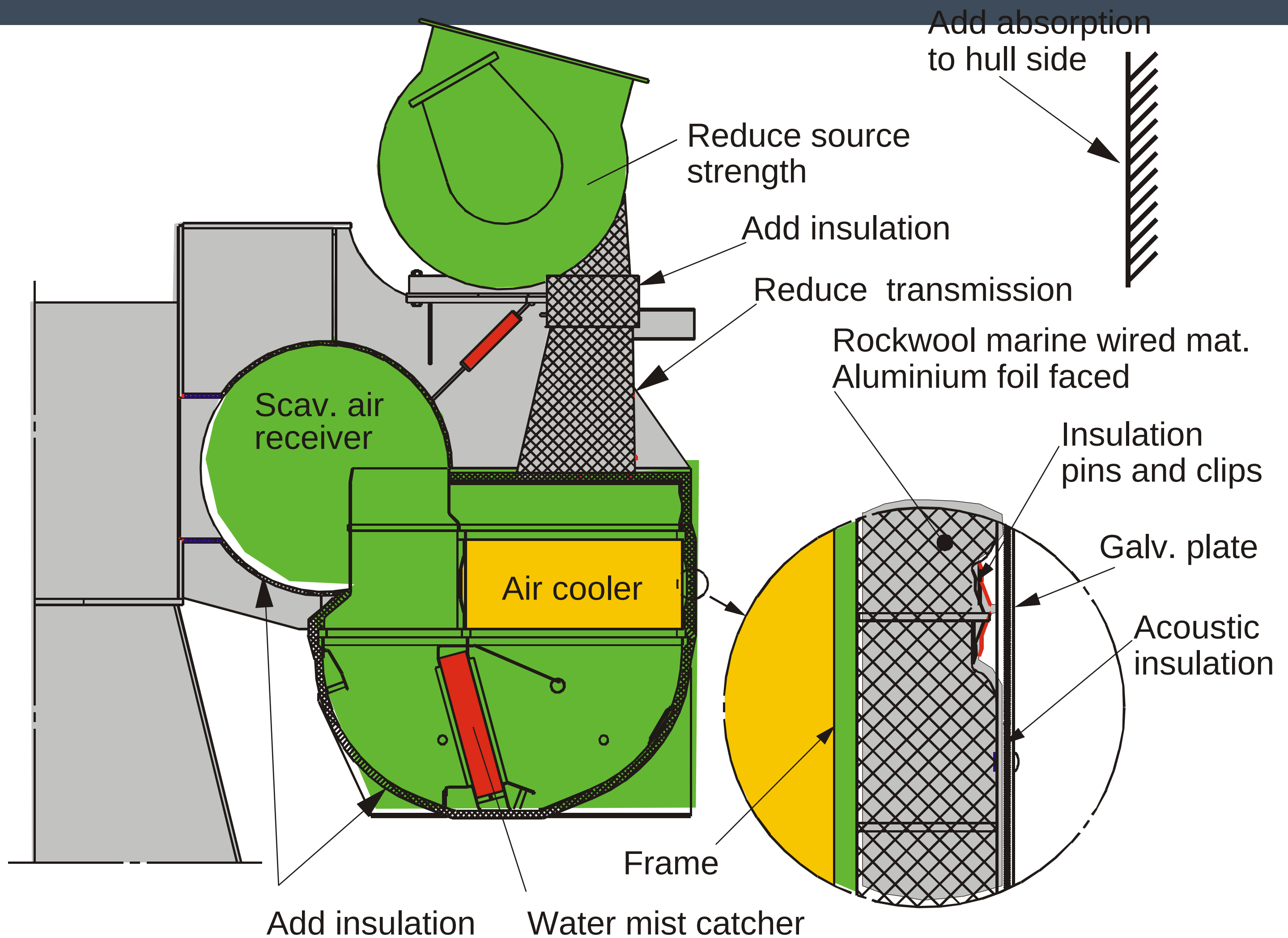
New design with increased stiffness



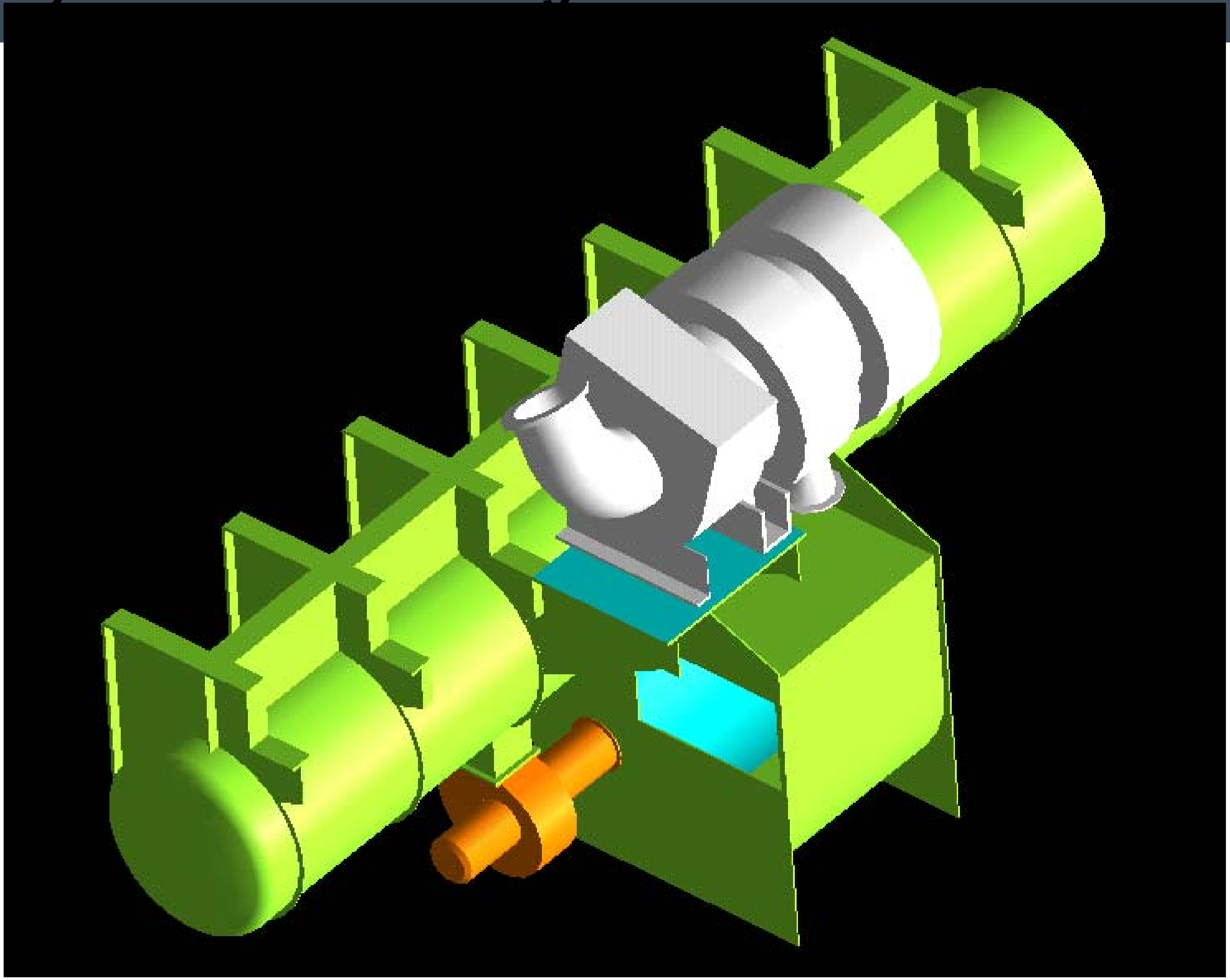
Previous design



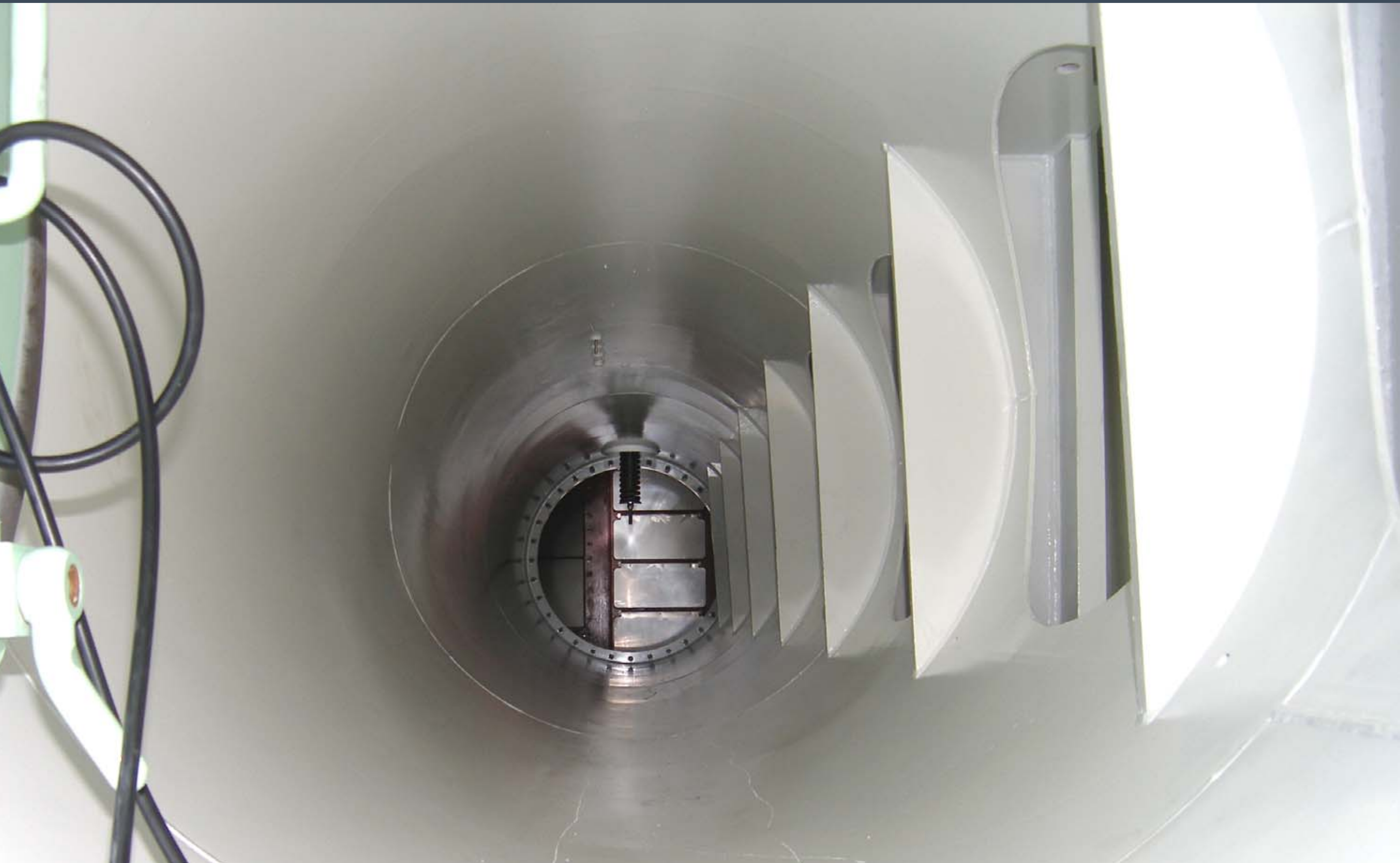
Engine Acoustics,
T.C. Noise, Countermeasures



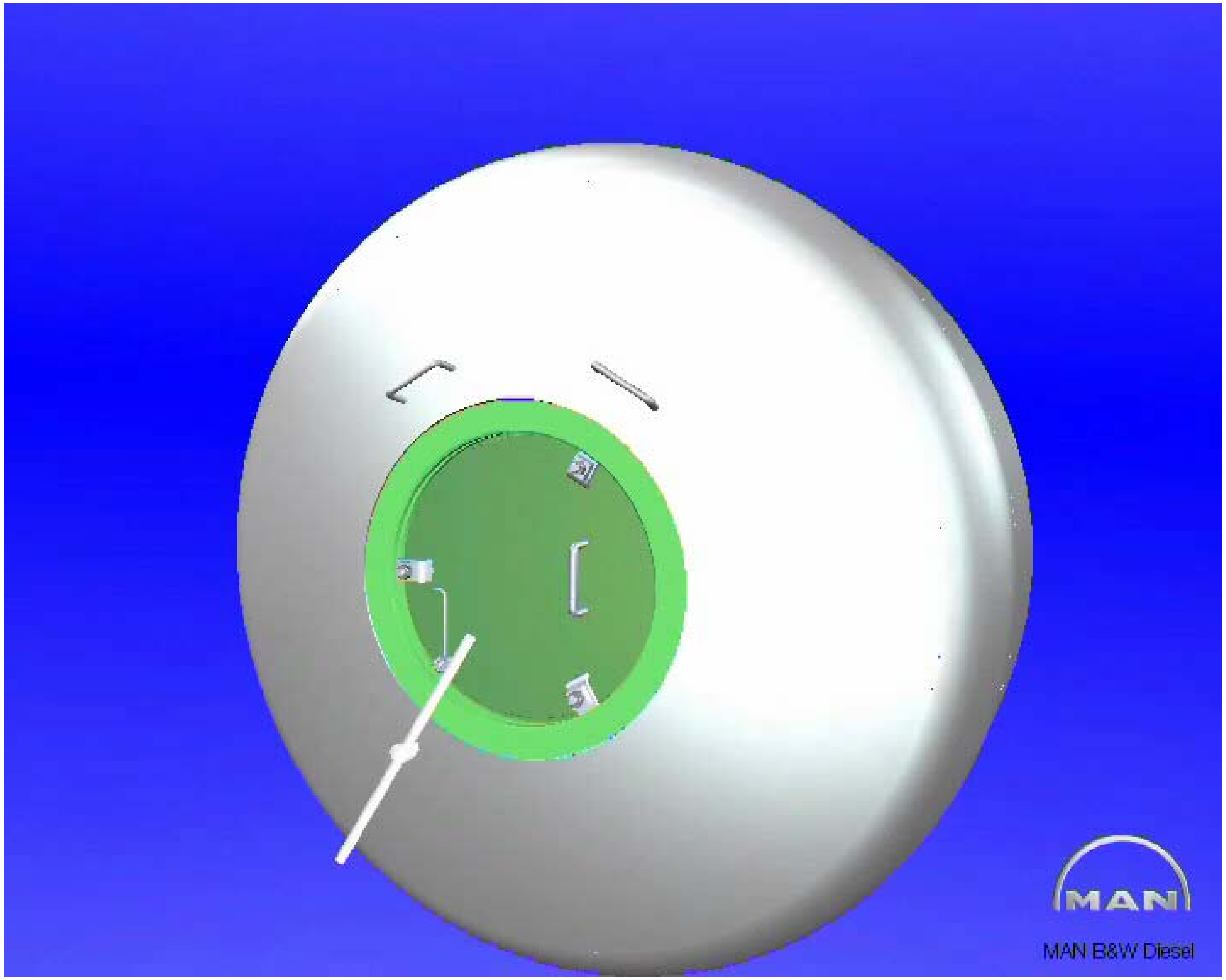
Cylinder Frame Design

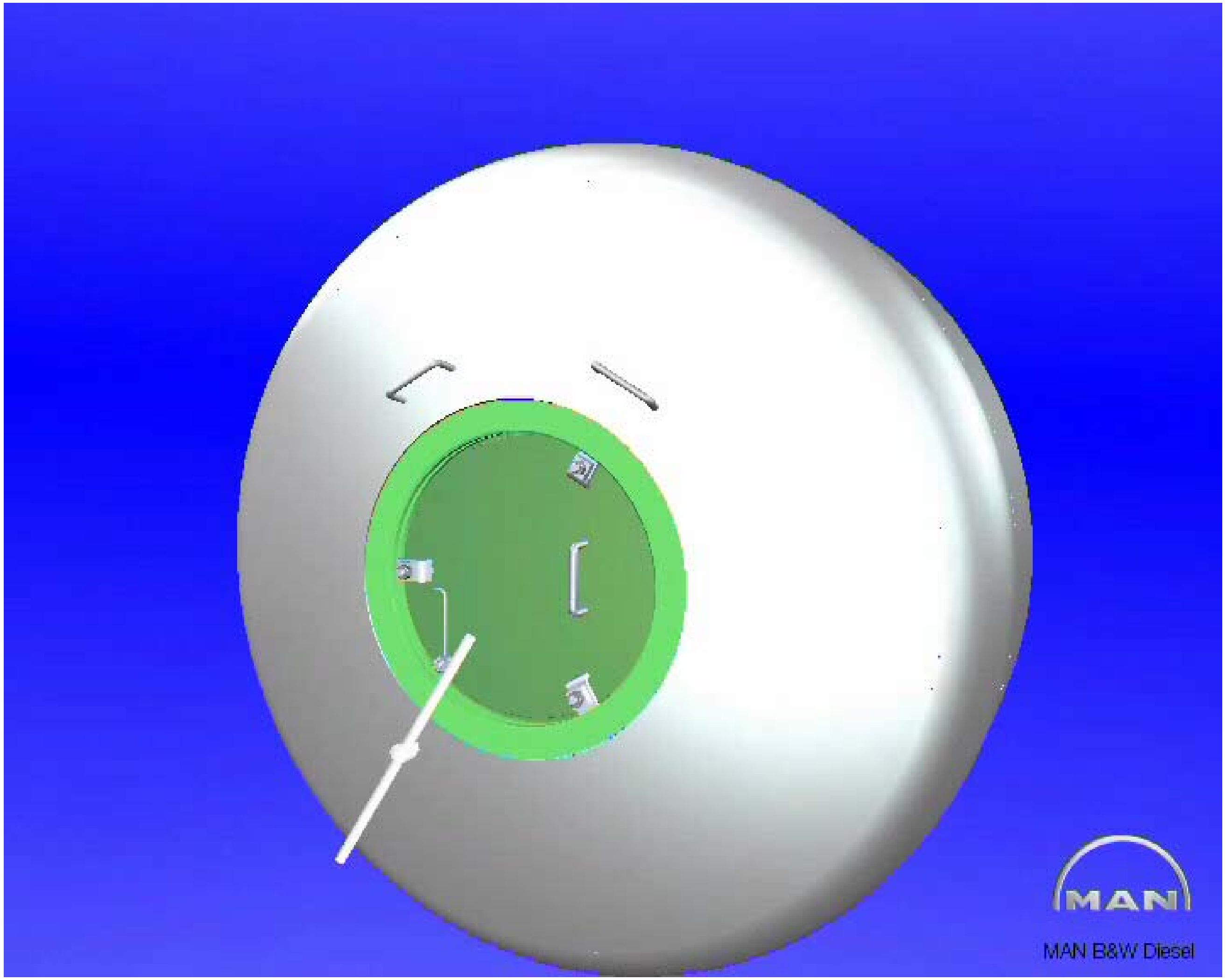


Scavenge Air Receiver.

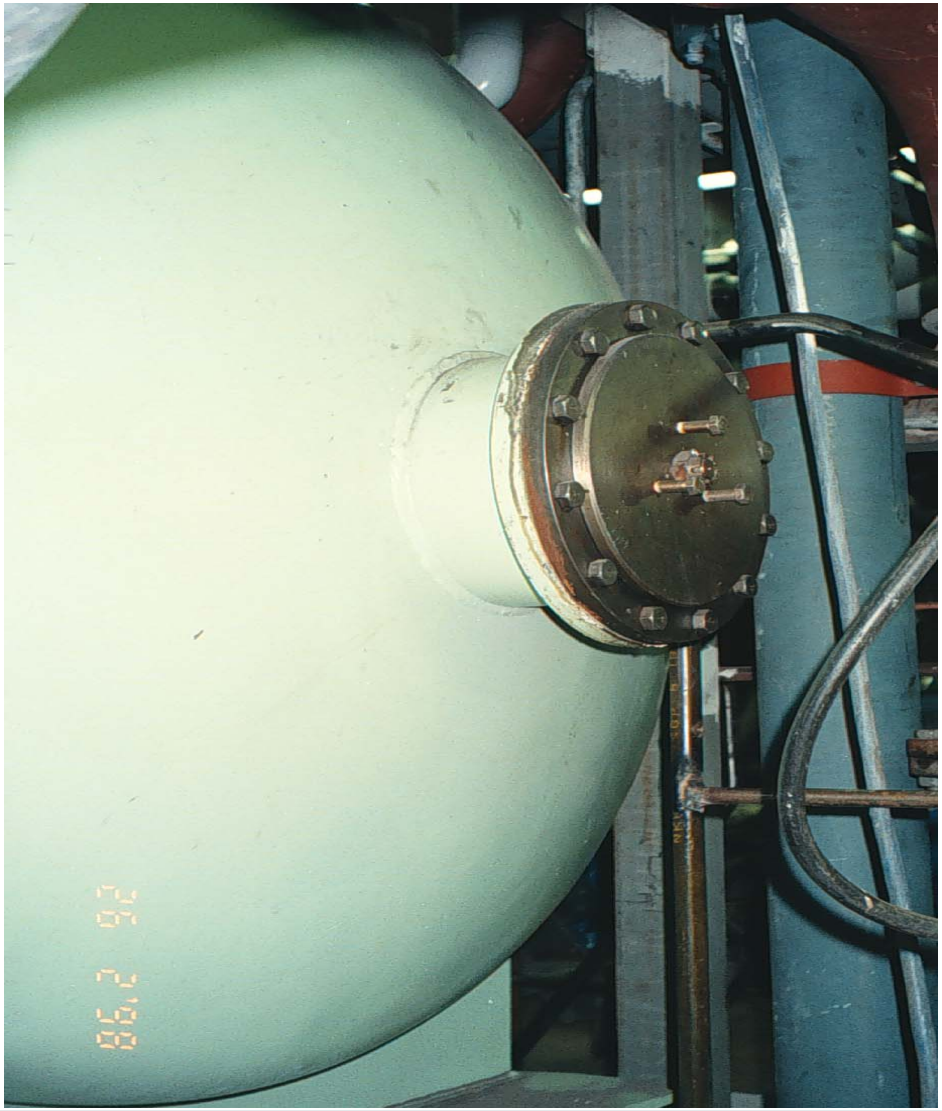


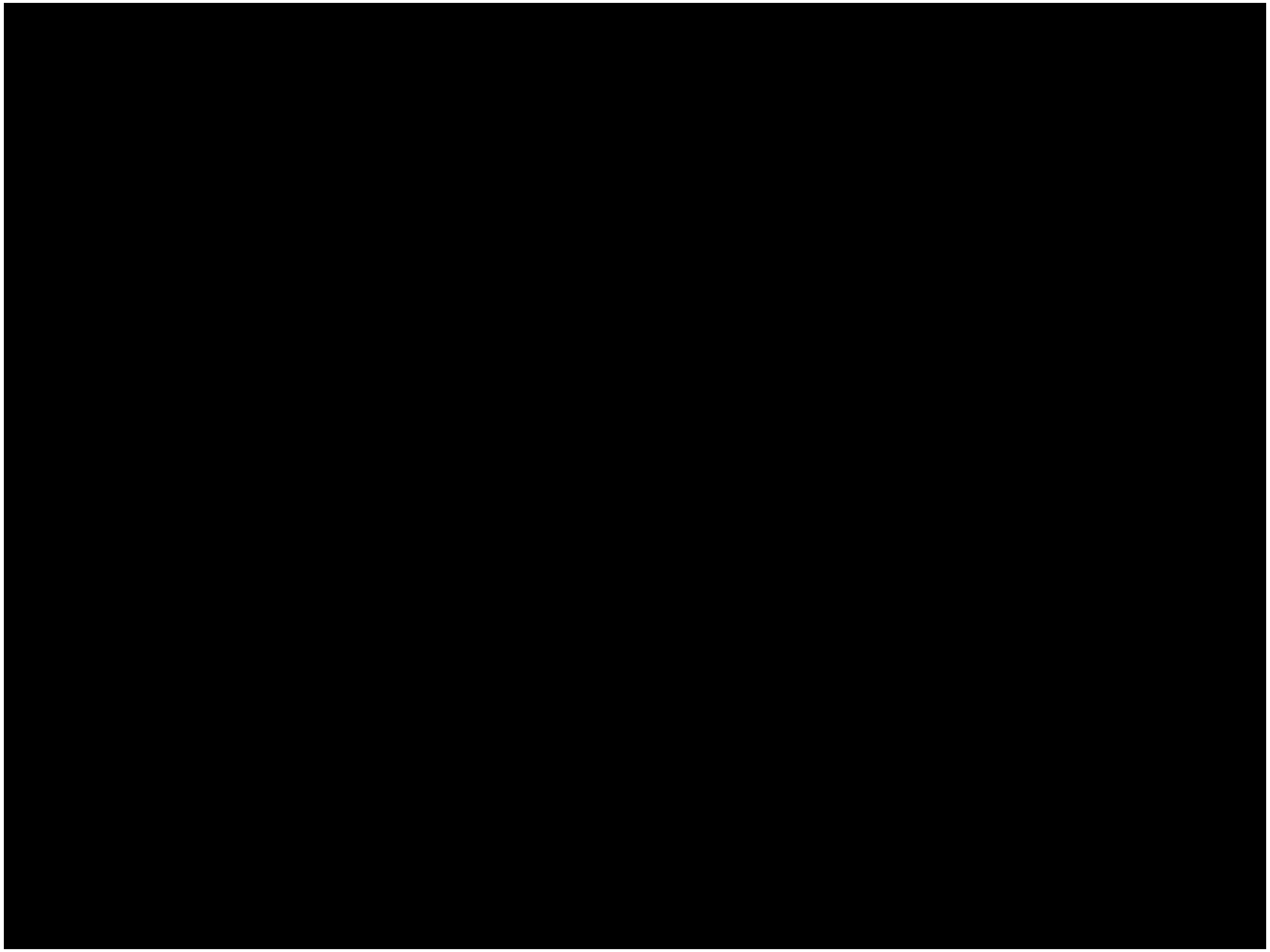
MAN HOLE COVER




MAN B&W Diesel

SAFETY VALVE SCAVENING RECIEVER



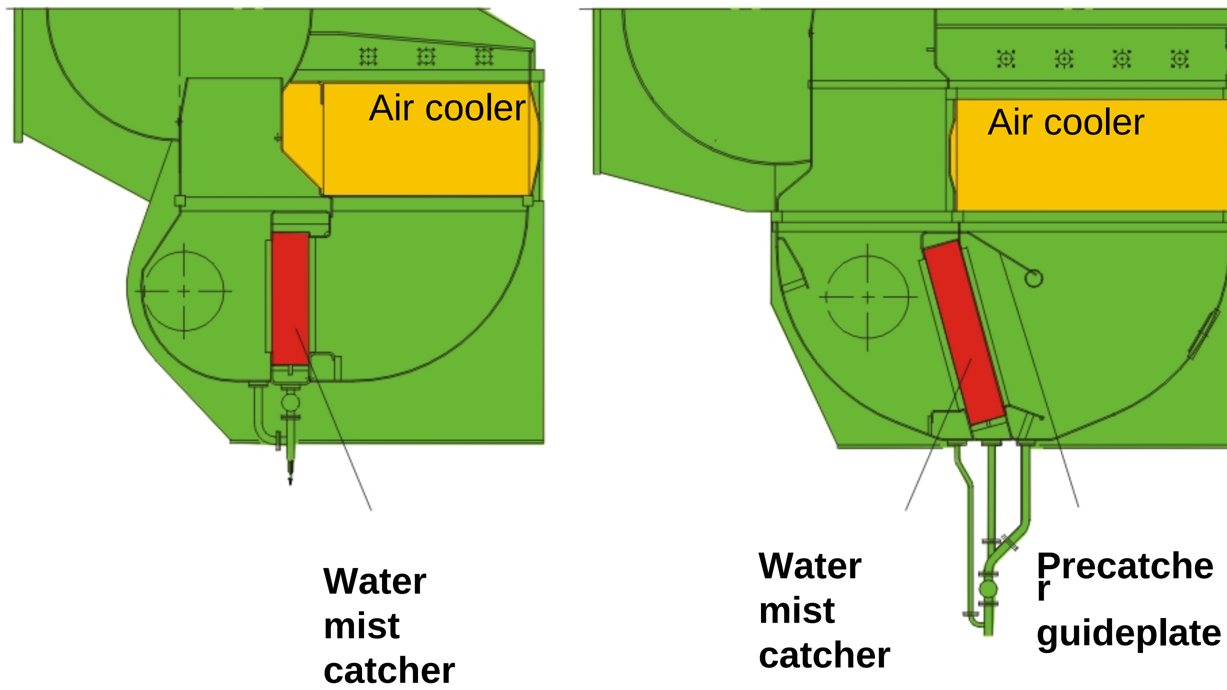


SAFETY VALVE

Design Features.

Previous design

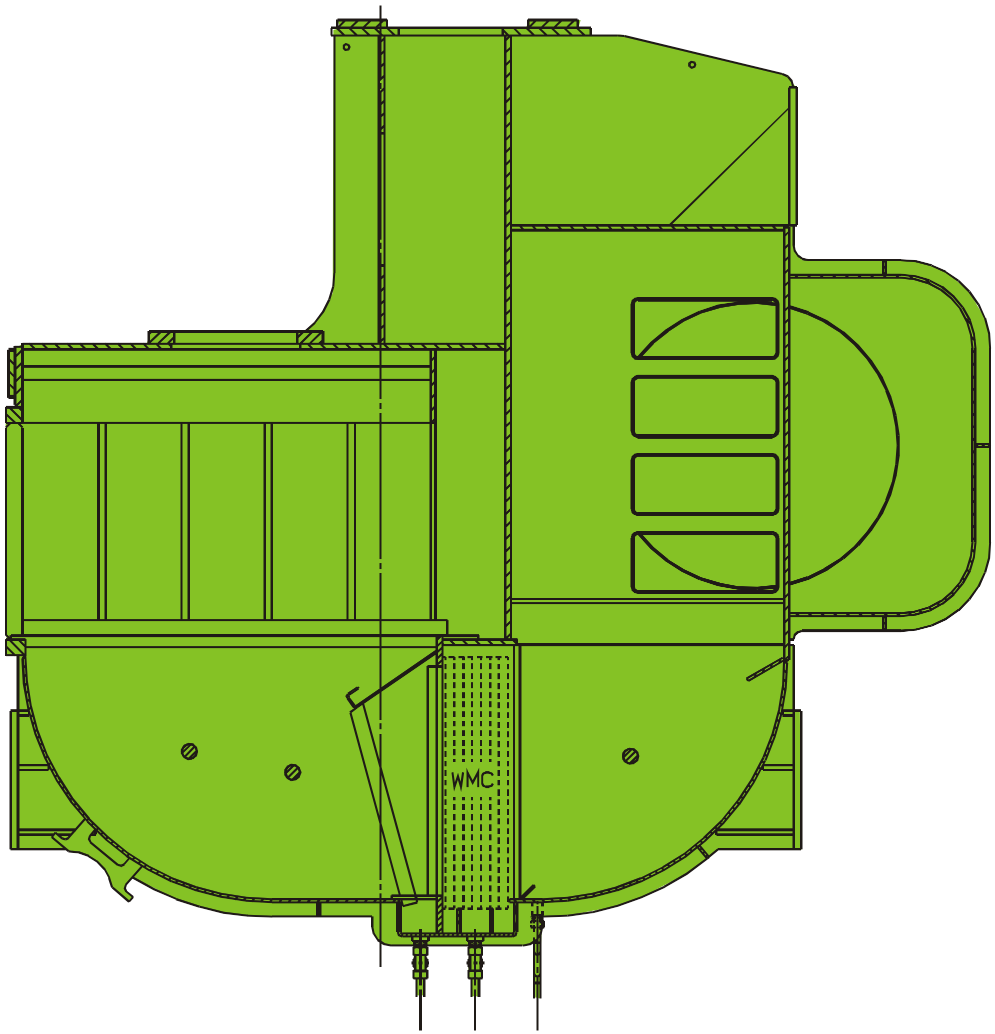
Improved design

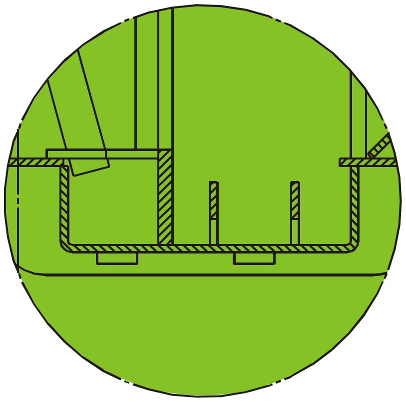


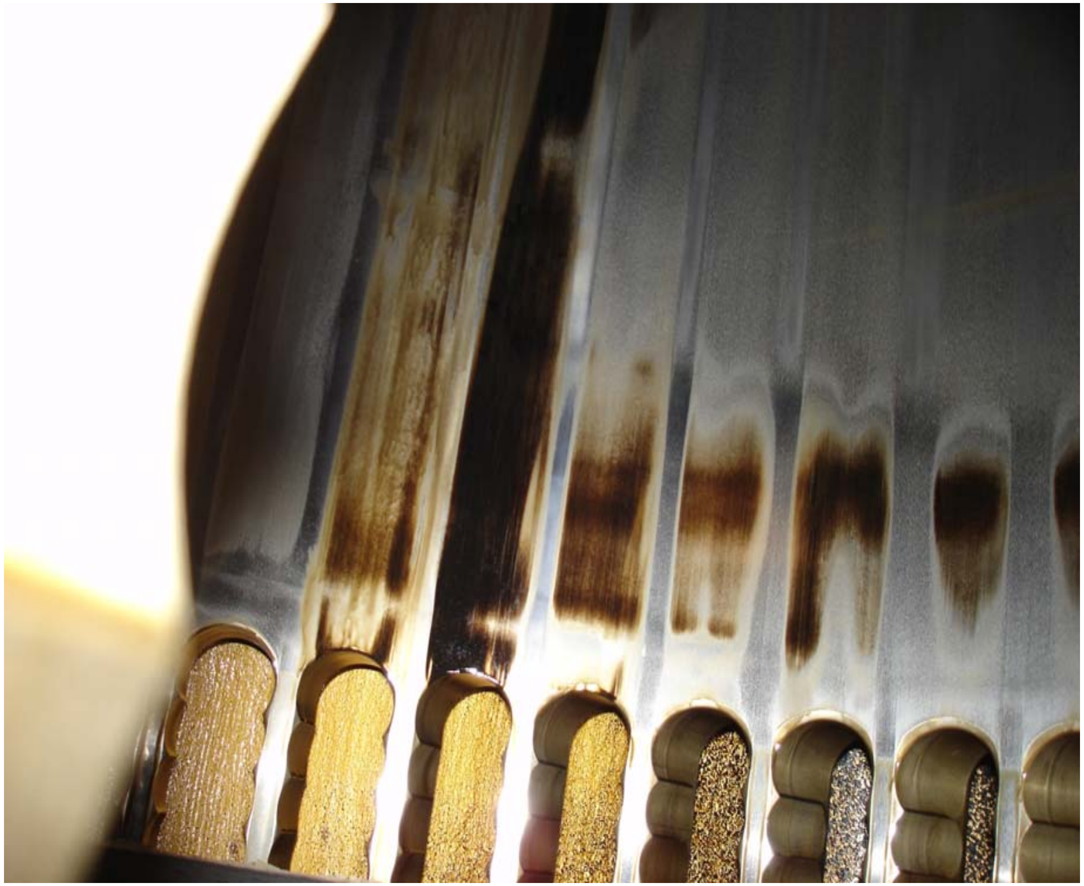
- **Precatcher guide plate provides 80 % water separation before normal water mist catcher element**
- **Inspection covers are fitted before and after the air cooler element**
- **Improved drains (to prevent re-entry of water)**

Water Mist Sensor

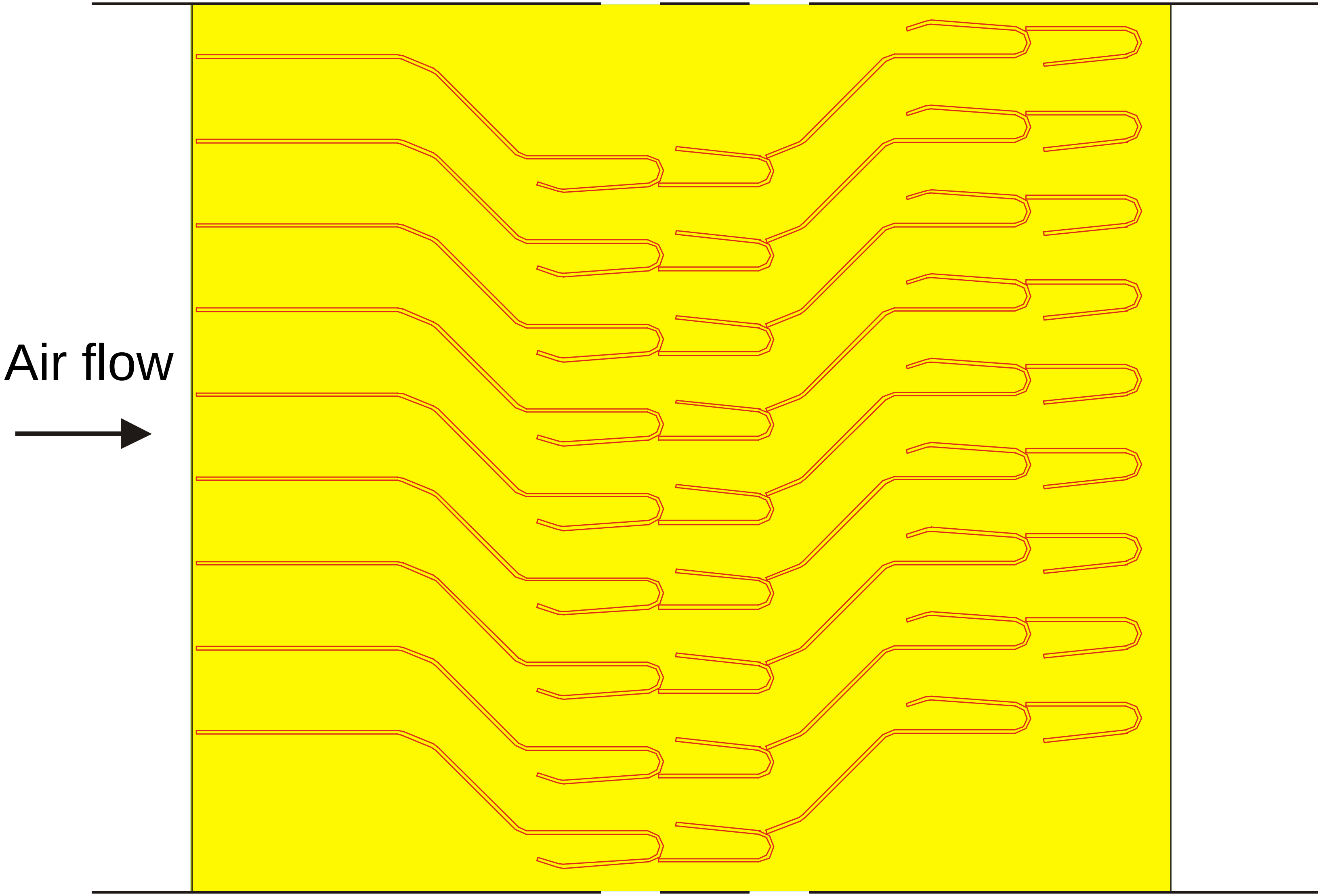
AIR COOLER

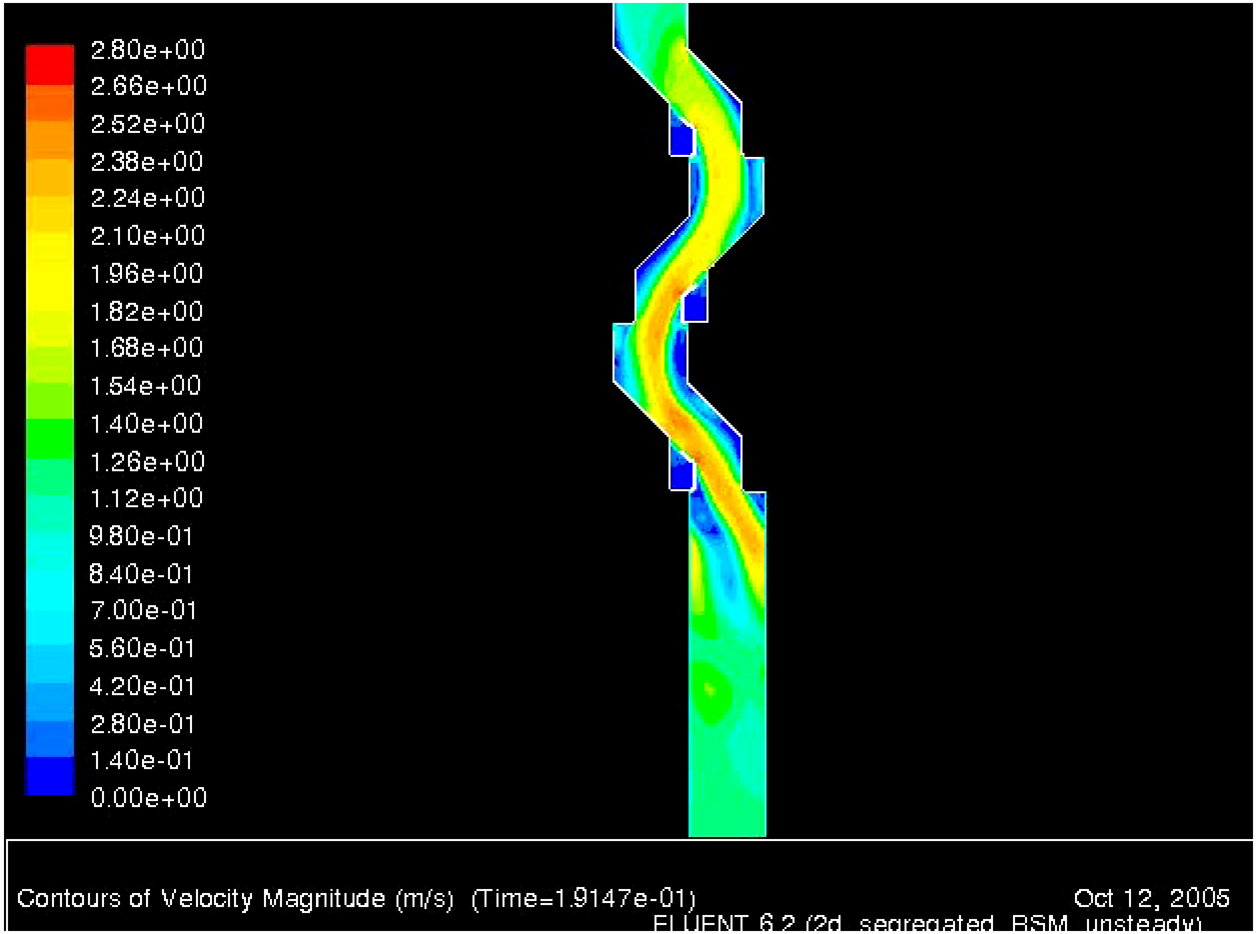






Improved
Water Mist Catcher Geometry.

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2.66e+00
2.52e+00
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2.24e+00
2.10e+00
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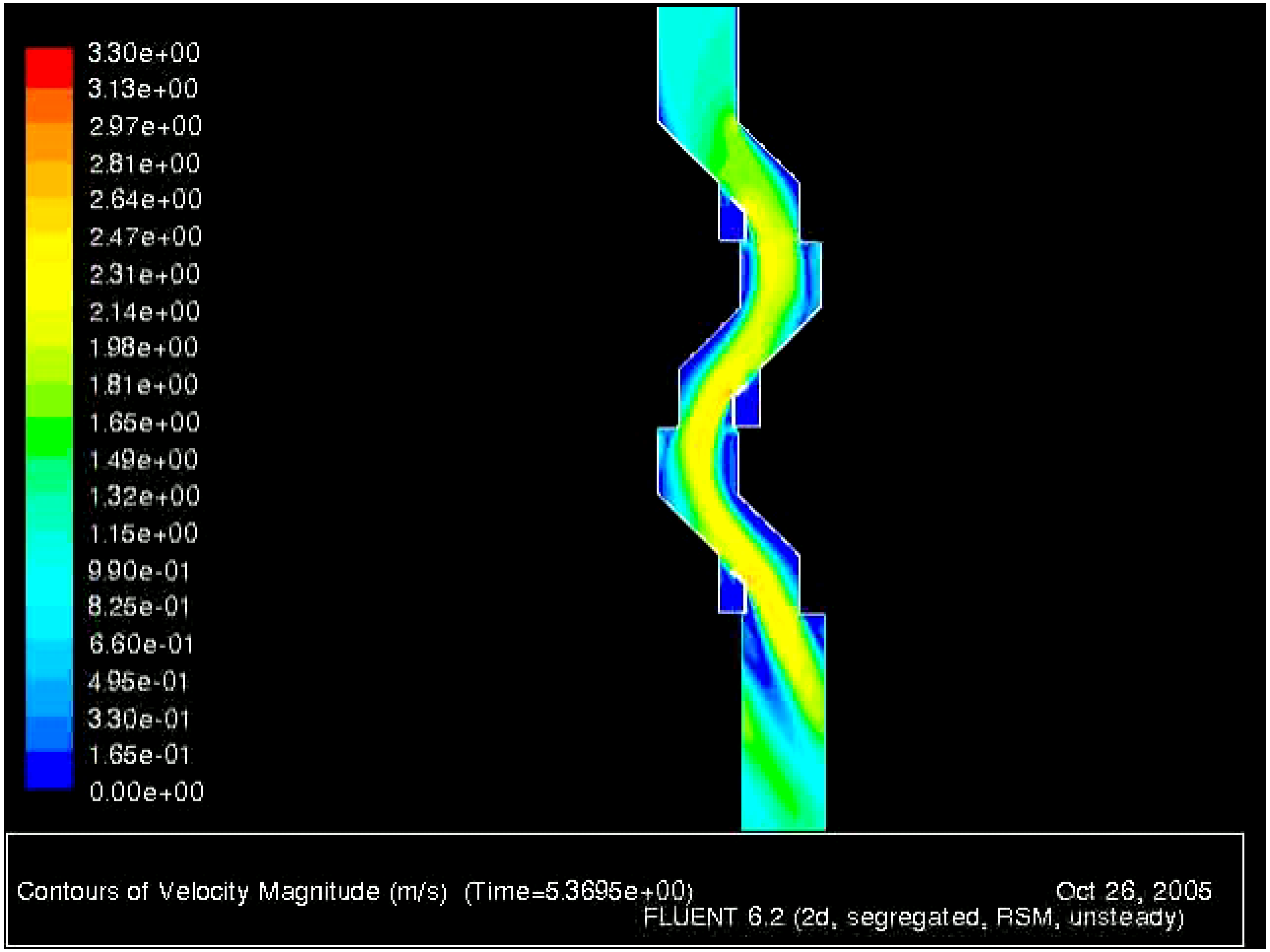
1.68e+00
1.54e+00
1.40e+00
1.26e+00
1.12e+00
9.80e-01
8.40e-01
7.00e-01
5.60e-01
4.20e-01
2.80e-01
1.40e-01
0.00e+00
Contours of Velocity Magnitude (m/s) (Time=1.9147e-01)
Oct 12, 2005
FLUENT 6.2 (2d, segregated, RSM, unsteady)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2.97e+00
2.81e+00
2.64e+00
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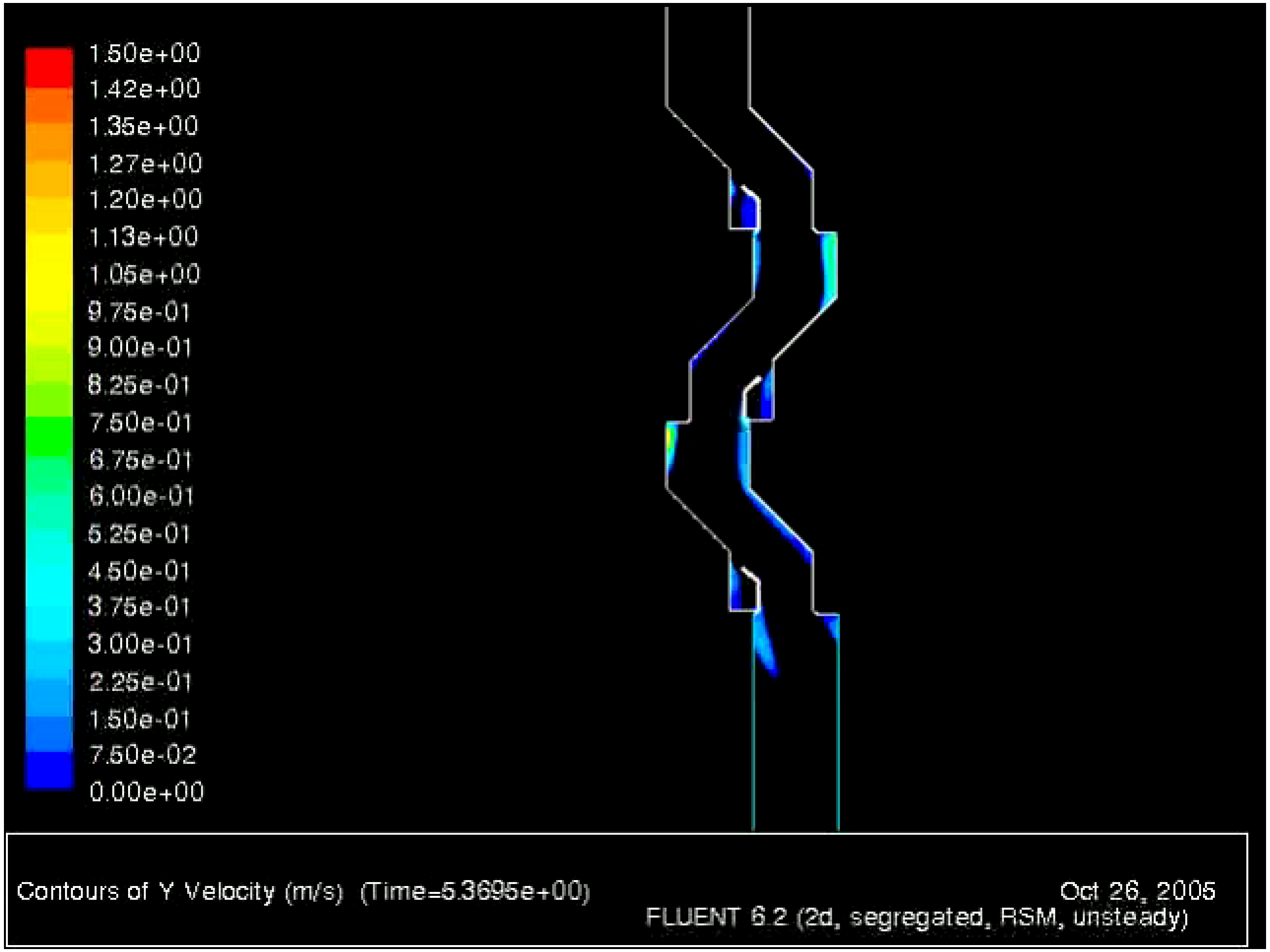
1.65e+00
1.49e+00
1.32e+00
1.15e+00
9.90e-01
8.25e-01
6.60e-01
4.95e-01
3.30e-01
1.65e-01
0.00e+00
Contours of Velocity Magnitude (m/s) (Time=5.3695e+00)
Oct 26, 2005
FLUENT 6.2 (2d, segregated, RSM, unsteady)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1.27e+00
1.20e+00
1.13e+00
1.05e+00
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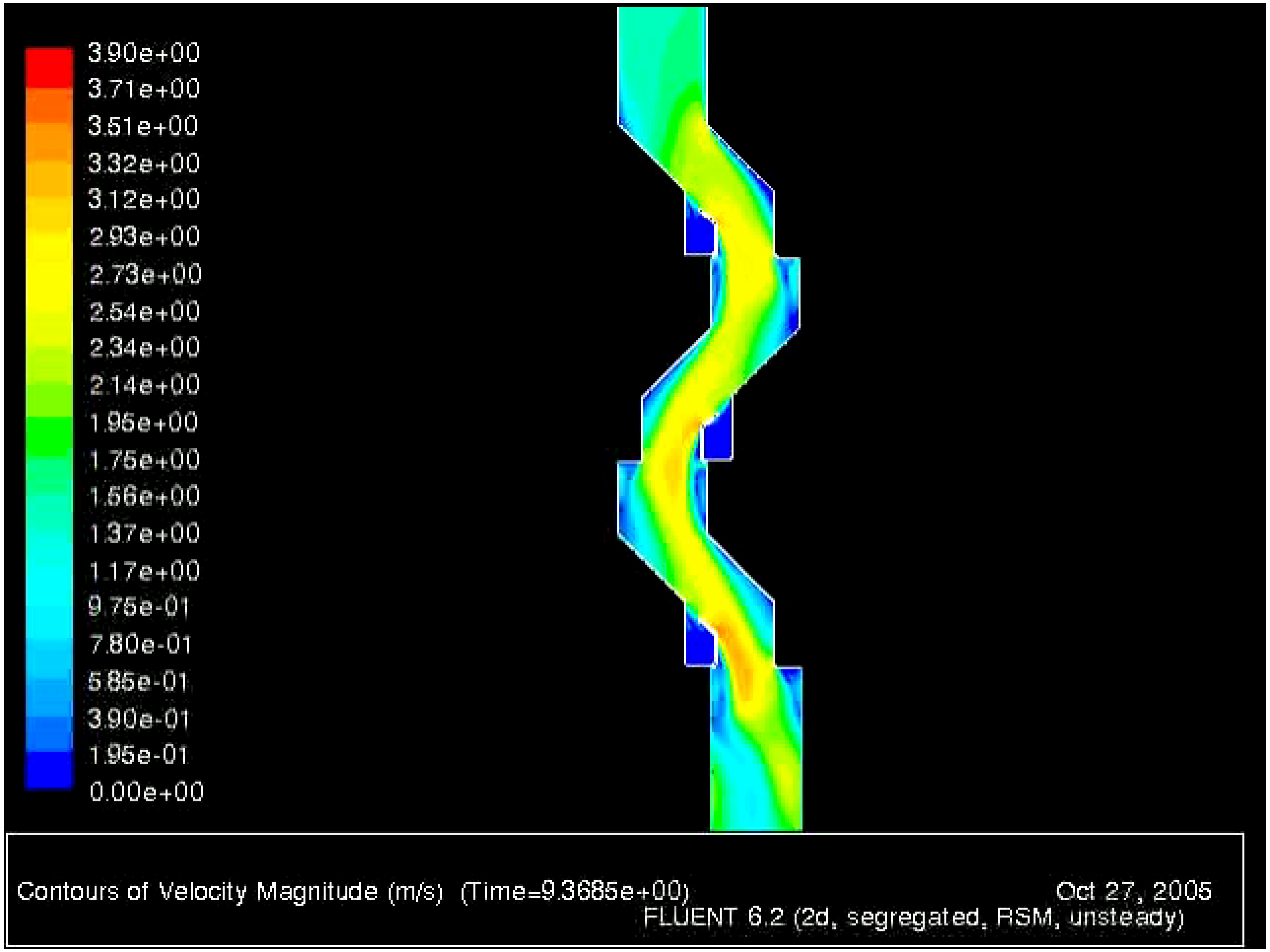
9.00e-01
8.25e-01
7.50e-01
6.75e-01
6.00e-01
5.25e-01
4.50e-01
3.75e-01
3.00e-01
2.25e-01
1.50e-01
7.50e-02
0.00e+00
Contours of Y Velocity (m/s) (Time=5.3695e+00)
Oct 26, 2005
FLUENT 6.2 (2d, segregated, RSM, unsteady)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3.71e+00
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3.32e+00
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2.93e+00
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1.95e+00
1.75e+00
1.56e+00
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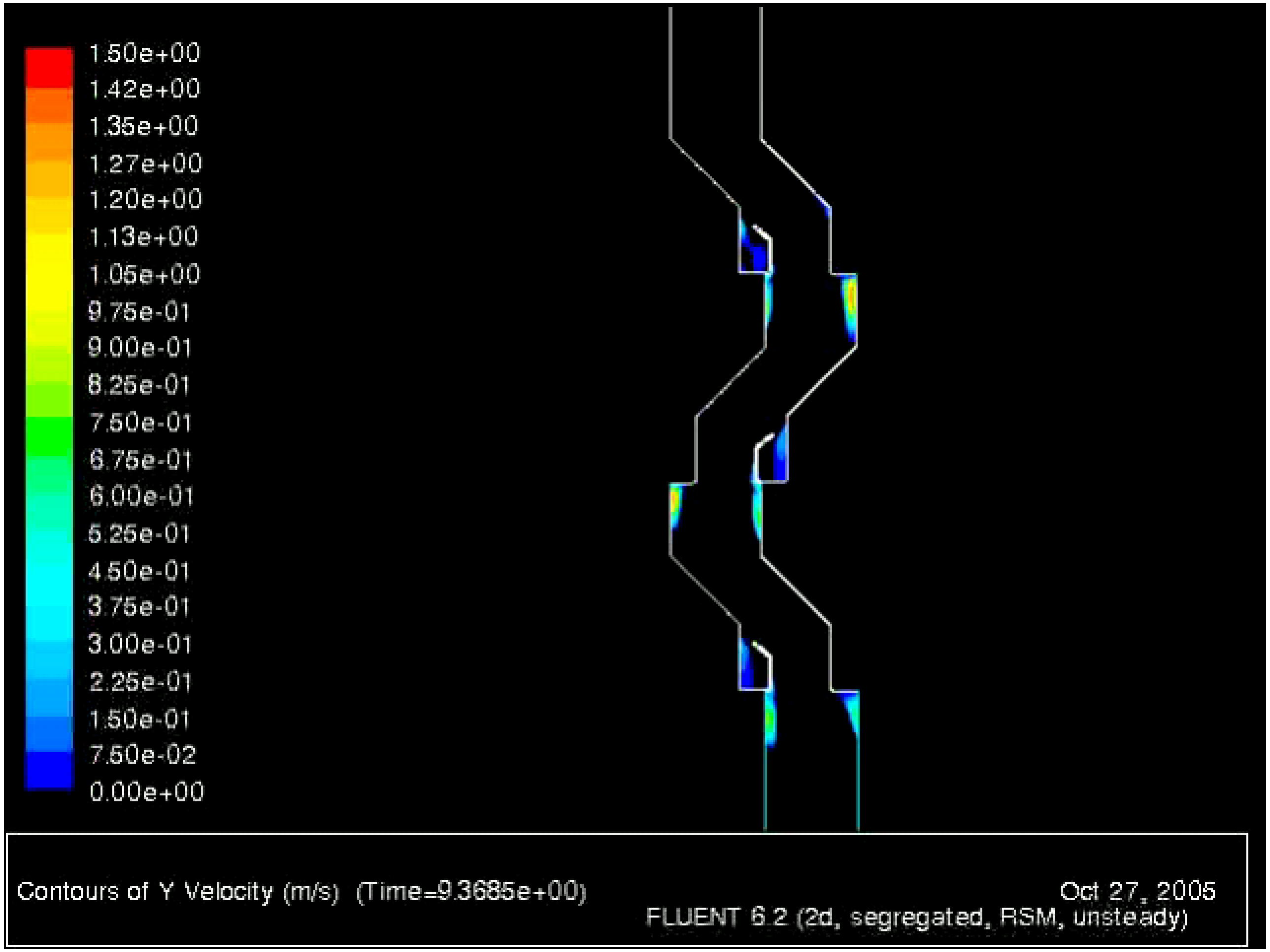
5.85e-01
3.90e-01
1.95e-01
0.00e+00
Contours of Velocity Magnitude (m/s) (Time=9.3685e+00)
Oct 27, 2005
FLUENT 6.2 (2d, segregated, RSM, unsteady)



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1.13e+00
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6.00e-01
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2.25e-01
1.50e-01
7.50e-02
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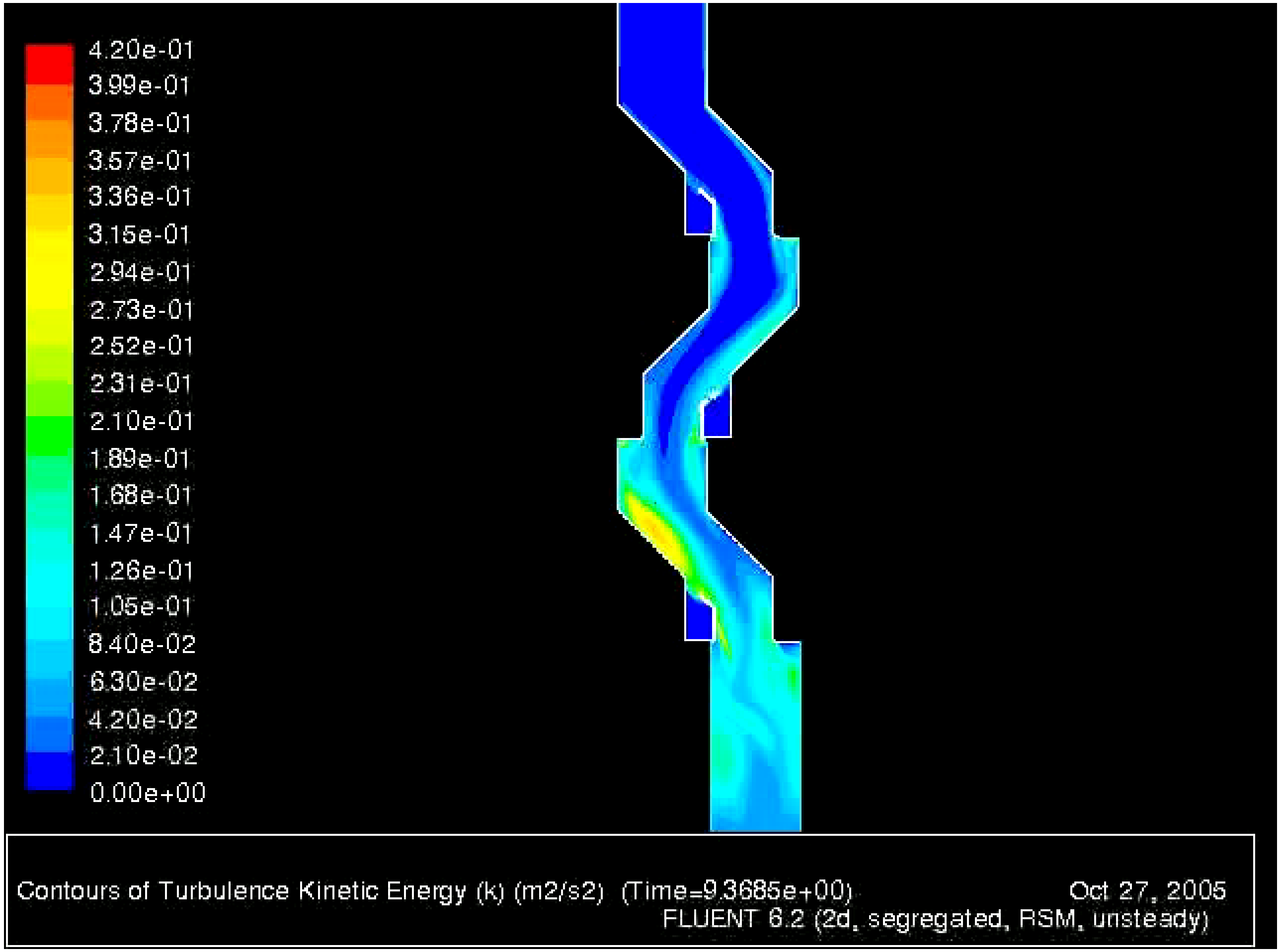
Contours of Y Velocity (m/s) (Time=9.3685e+00)
Oct 27, 2005
FLUENT 6.2 (2d, segregated, RSM, unsteady)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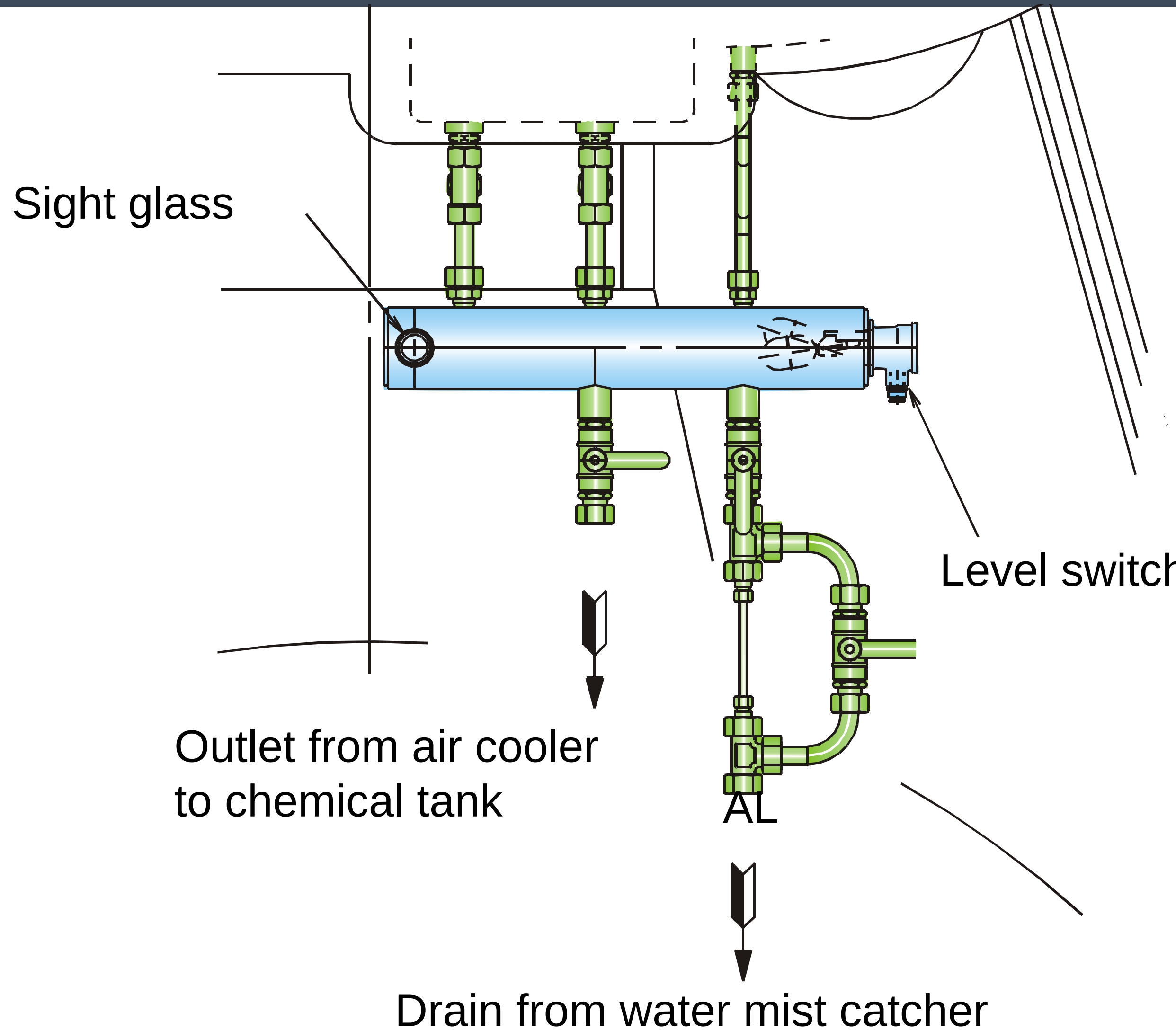
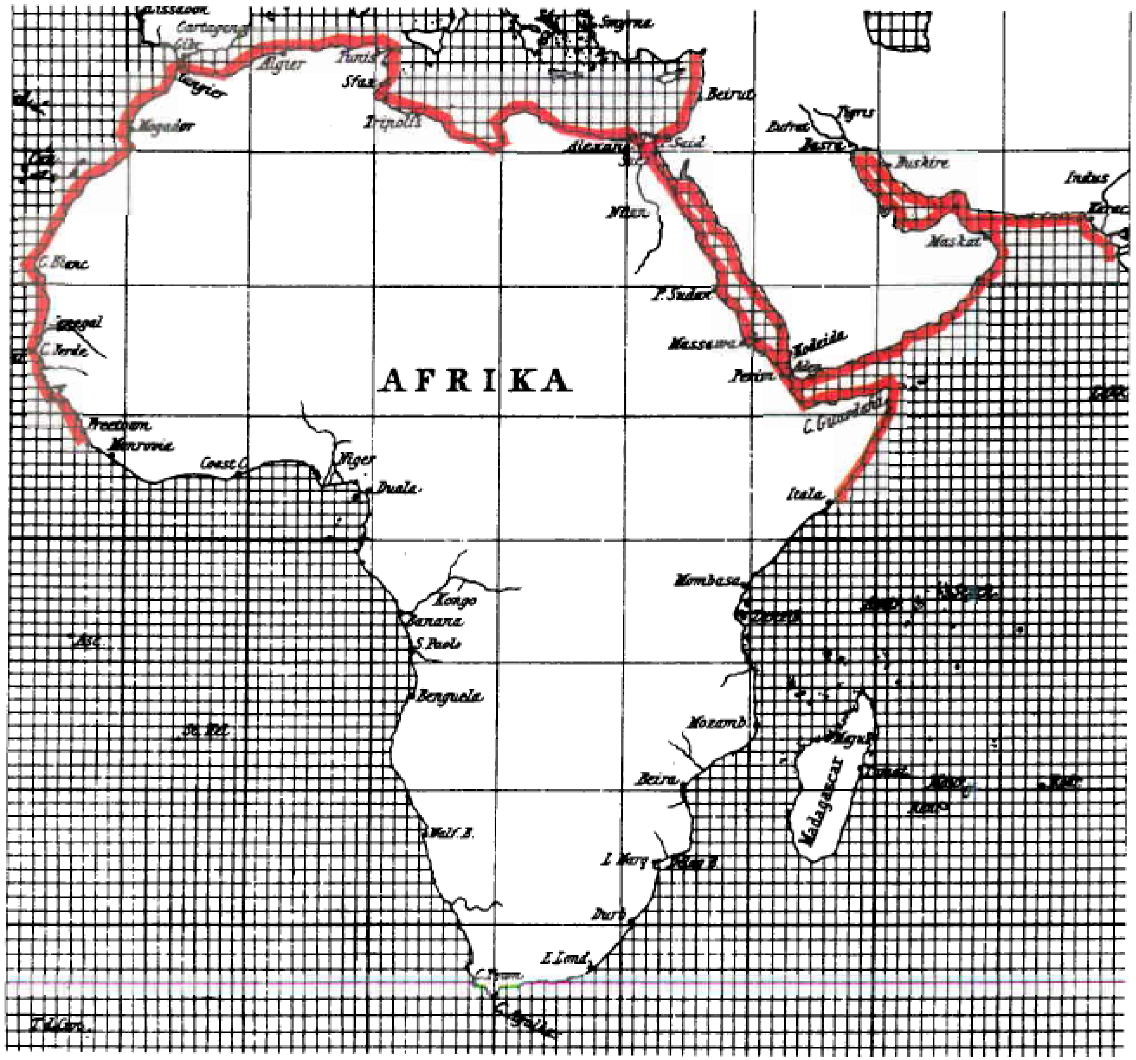
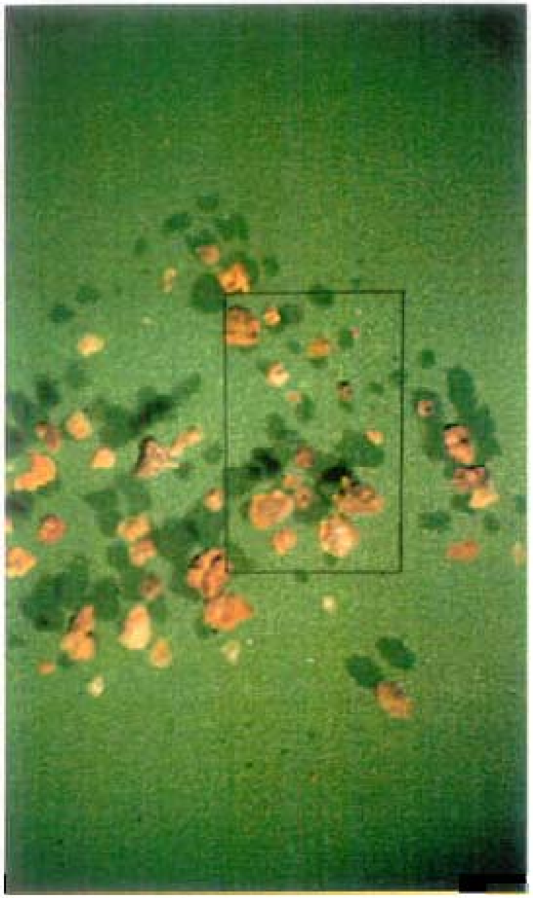
2.10e-01
1.89e-01
1.68e-01
1.47e-01
1.26e-01
1.05e-01
8.40e-02
6.30e-02
4.20e-02
2.10e-02
0.00e+00
Contours of Turbulence Kinetic Energy (k) (m2/s2) (Time=9.3685e+00)
Oct 27, 2005
FLUENT 6.2 (2d, segregated, RSM, unsteady)

AIR COOLER DRAIN



FOR CLEANING THE AIR COOLER ELEMENT


AFRIKA
Cartagena
Algier
Tunis
Sfax
Tripolis
Tangier
Mogador
Smyrna
Beirut
P. Said
Bushire
Indus
Maskat
P. Sudan
Massawa
Hodeida
Perim
C. Blanc
Senegal
C. Verde
Freetown
Monrovia
Coast C.
Niger
Duala
Itala
Mombasa
Kongo
Banana
S. Paolo
Benguela
Mozamb.
Beira
Madagascar
Walf. B.
Durb
E. Lond.



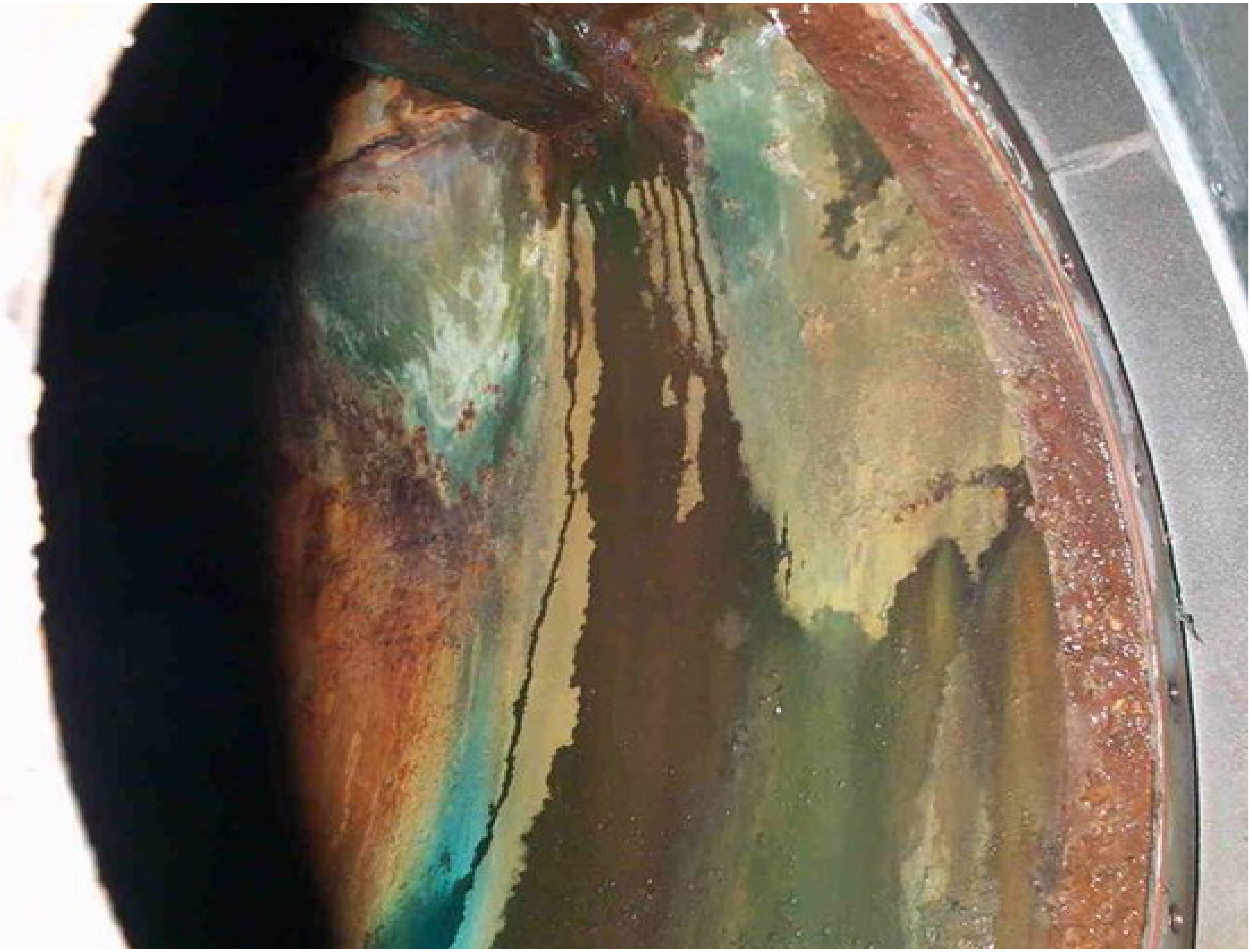
7 times magnified and 22 times


16/9 91
OLIENEDSIVNING
FRA RECIEVER
TIL L.K.

Damaged water mist catcher element.

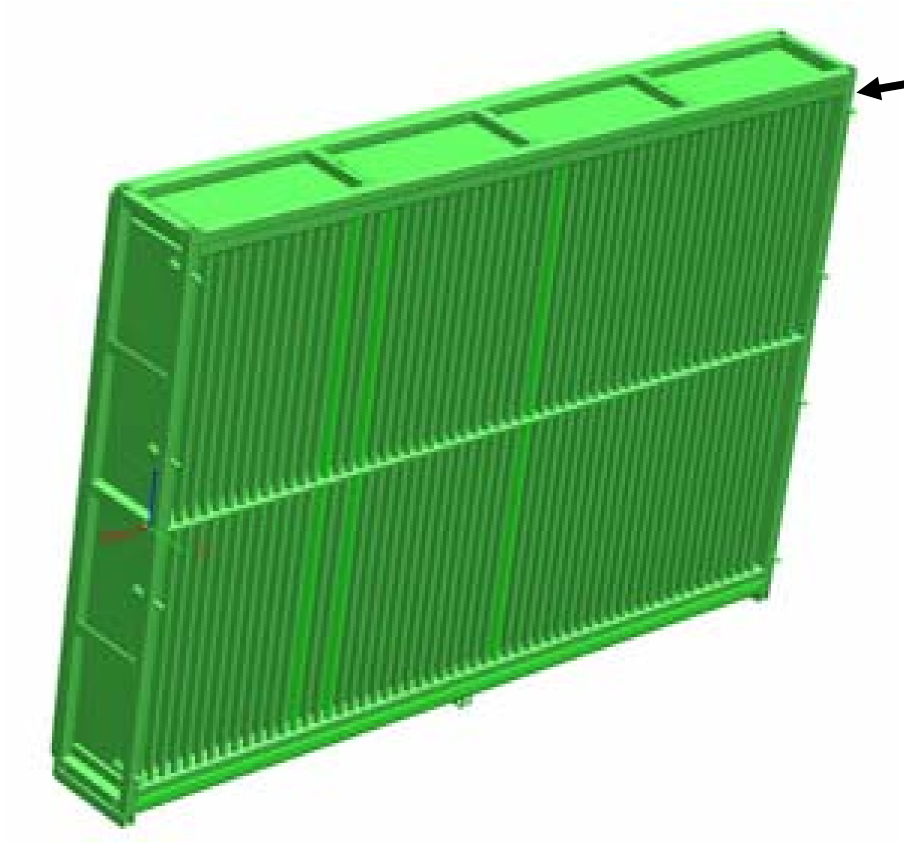
Air cooler box inside, reversing chamber, acceptable paint condition!

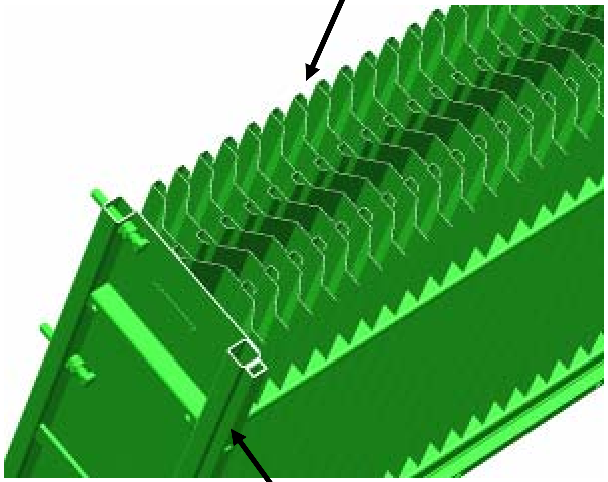
Air cooler box inside, reversing chamber, paint condition!



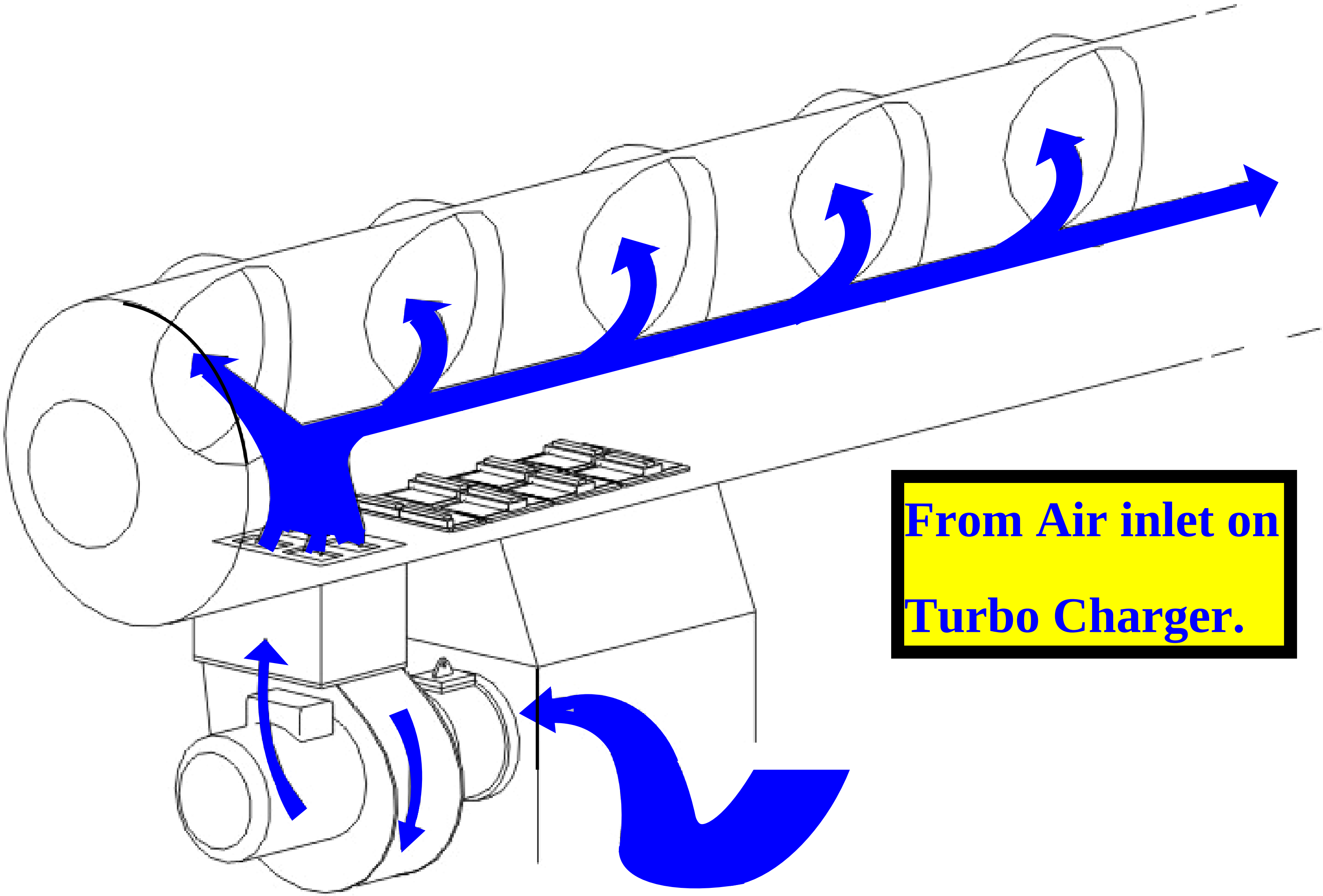
Water mist catcher

New MBD design



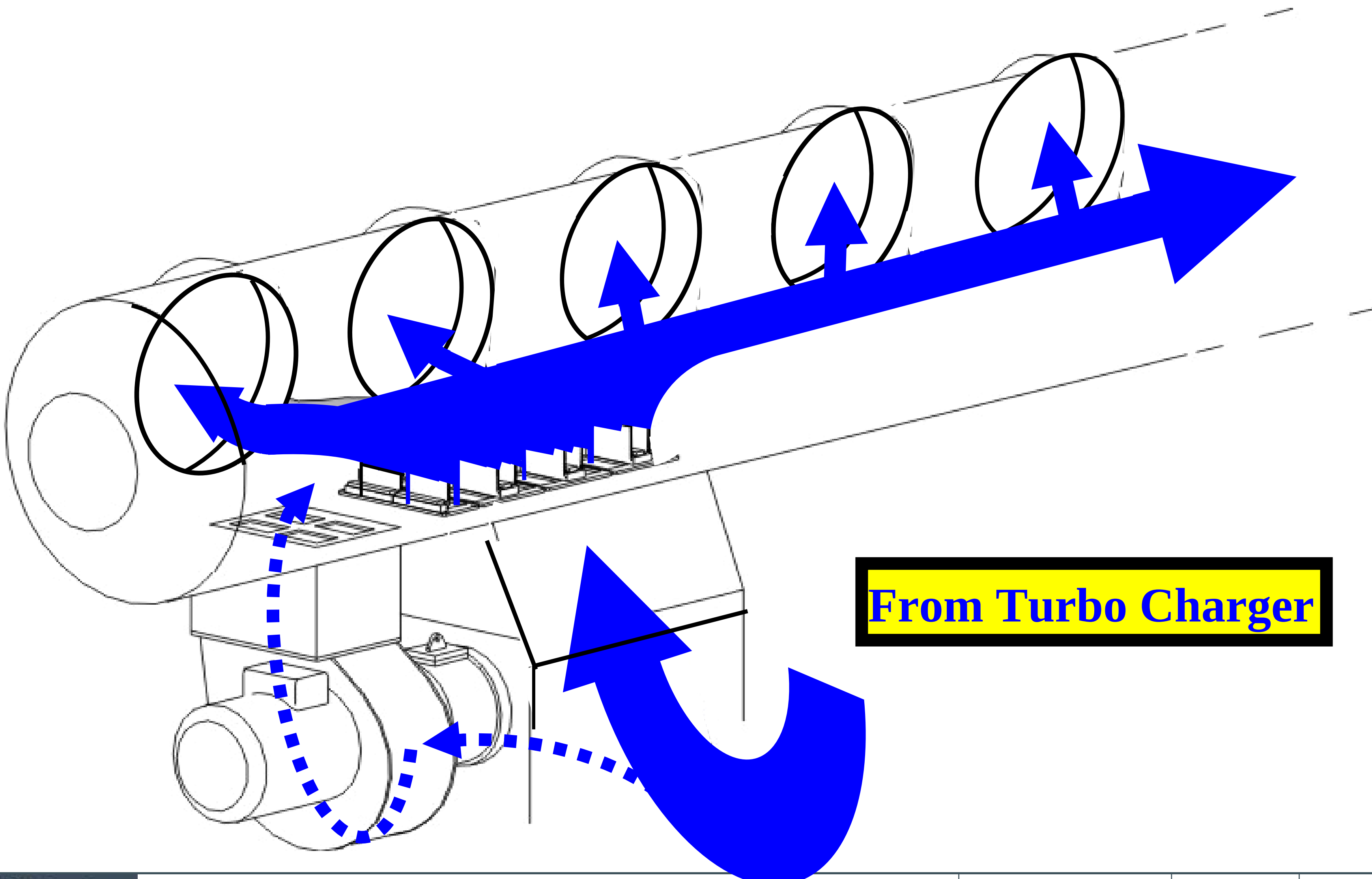


Aux. Blower.



From Air inlet on Turbo Charger.

Aux. Blower.

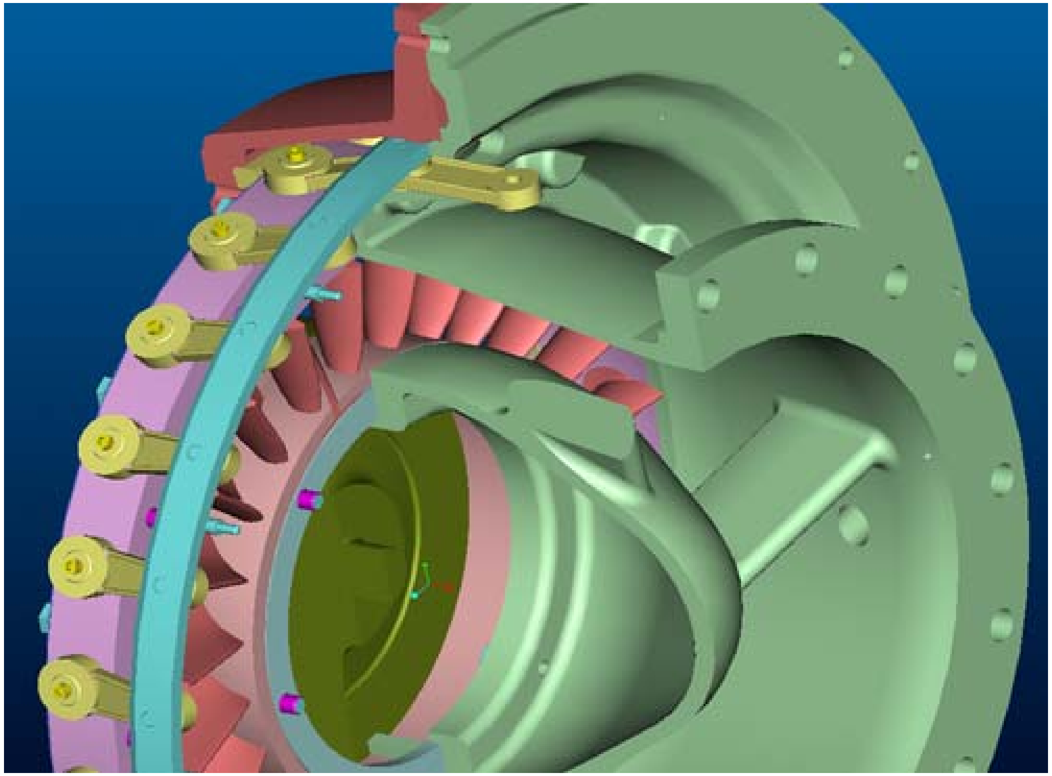


PRESSURE GAUGES FOR SCAV. AIR AND EXHA,GAS RECIVER

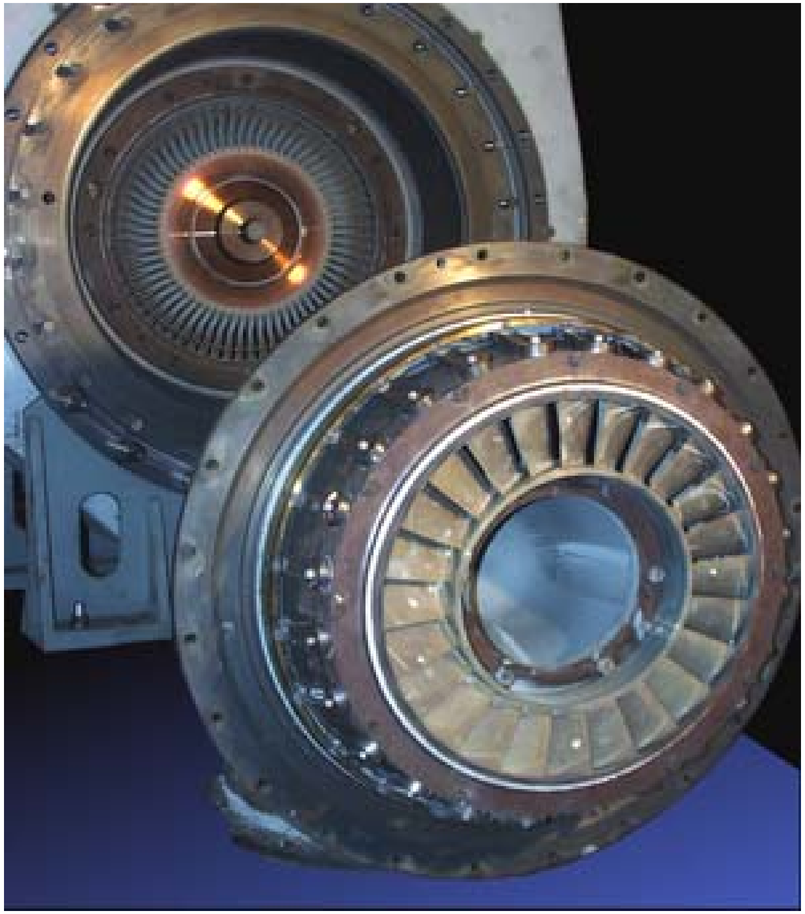
TCA Variable Turbine Geometry (optional)

- Patented, variable nozzle ring design
- Efficiency-optimised

Pro/E-model



Operation on 6L48/60 test engine under HFO conditions



Input			
Ambient Pressure	1.0	Bar a	
Ambient Air temperature	36.0	C	
Relative humidity of ambient air	70%		0-100%, only
Scav. Air Pressure	3.20	Bar a	
Scav. Air Temp.	50.0	C	
Engine load	20000.0	kW	It is assumed that air flow is 8.7 kg/kWh

Max. Partial Pressure at intake temp.	0.0595	Bar
Absolute Humidity in intake air	0.0270	kg/kg

Max. Partial Pressure at scav. air temp.	0.1234	Bar
Max. water content	0.0250	kg/kg
Specific Amount of drain water	0.0021	kg/kg
Amount of drain water	357.7112	kg/h

Thank you for your attention.

SEMI CLEAN FILTER

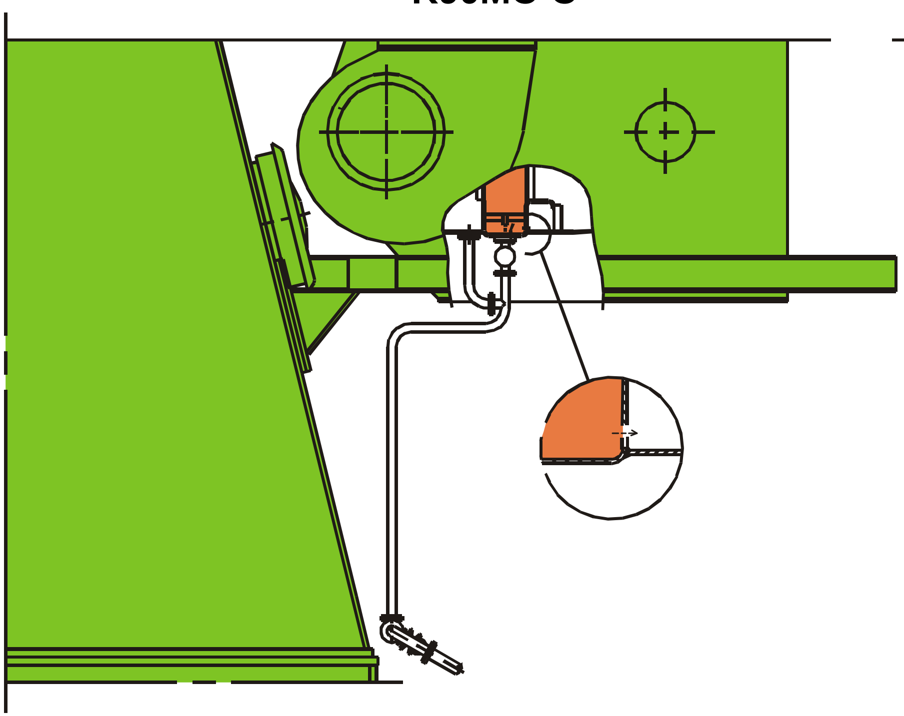
Axial Vibration Damper Monitor.

Design.

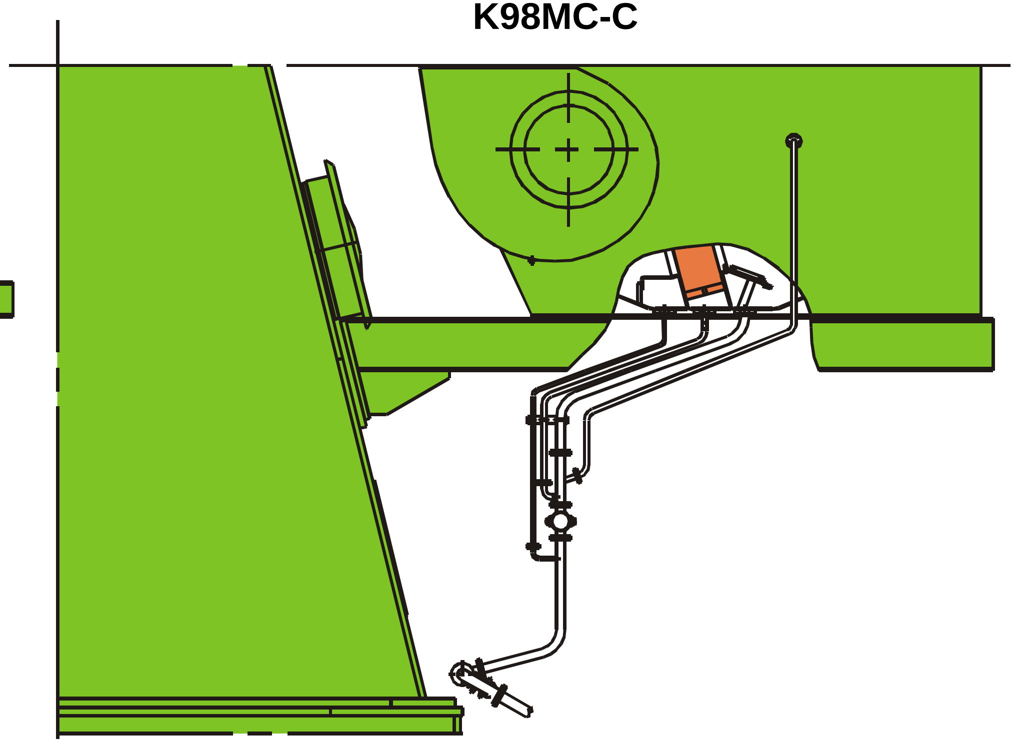
Drain pipes from air flow reversing chamber

Improvements:
Four drain lines for condensed water i.e. two before, one below and after the water mist catcher element

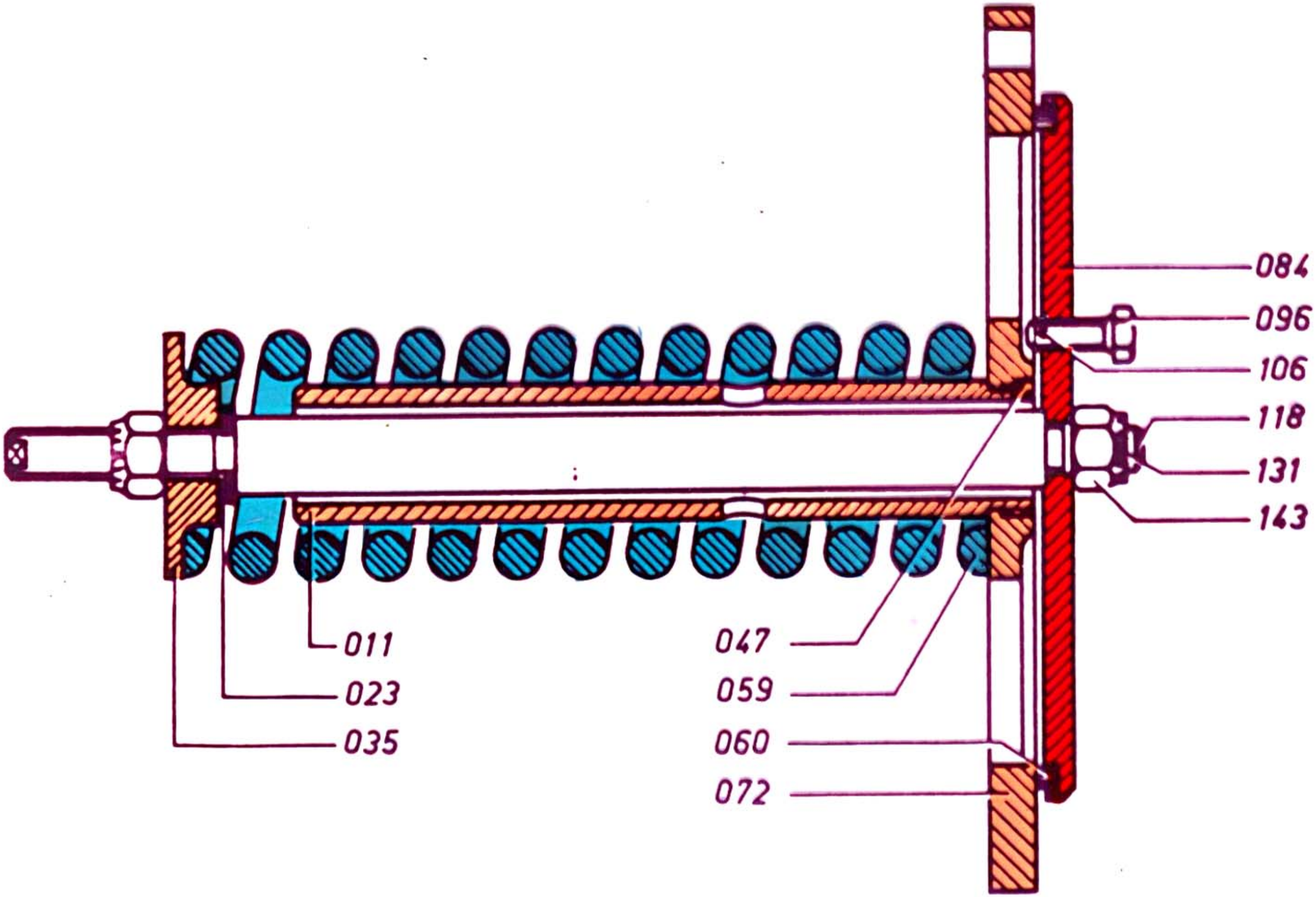
K90MC-C



K98MC-C

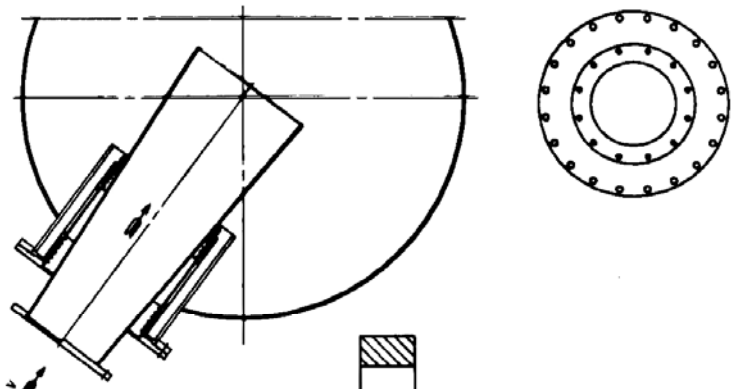


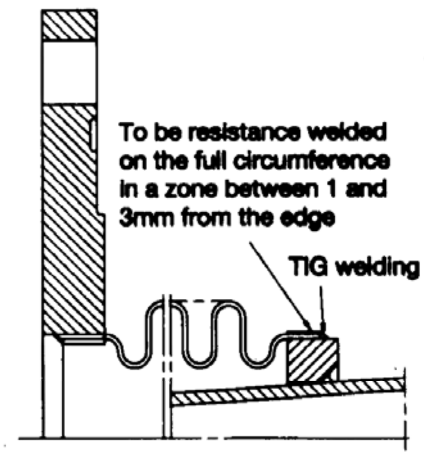
SAFETY VALVE



Turbocharging.

Compensator





Type:
Bredan, BW-021

Testing conditions
Testing pressure: 15 bar abs.

Flow velocity

Peak: Approx.	300 m/sek in 0.05 sec - 2Hz
Average	140 m/sek

Working conditions

Max. temp	
Peak: Approx.	800°C in 0.05 sec - 2Hz
Average	475°C
Working pressure	3.5 bar abs
Axial deflection	+8mm, -4mm
Lateral deflection	+30mm, -30mm
Angular deflection	± 0,5 deg

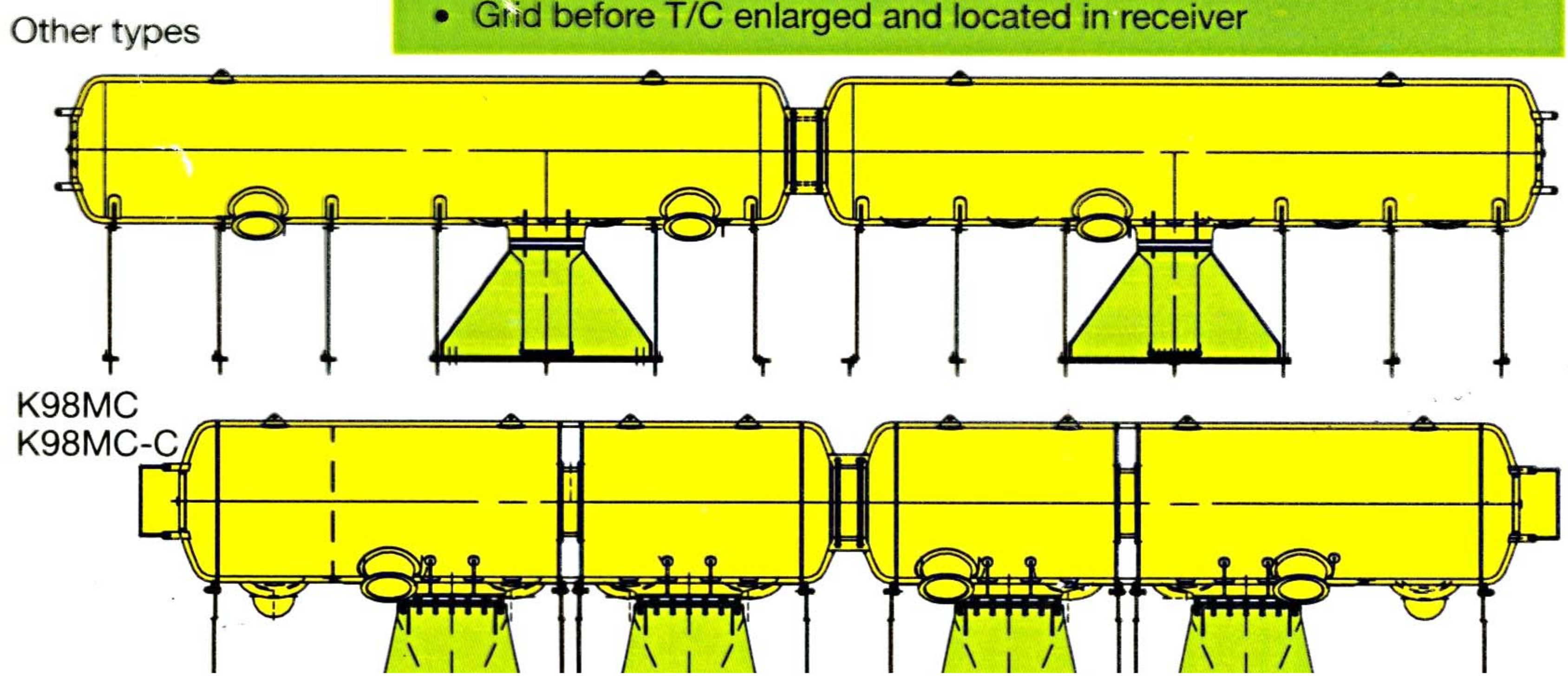
Life rate
Min. 5000 movements (from cold to warm engine)

Turbocharging.

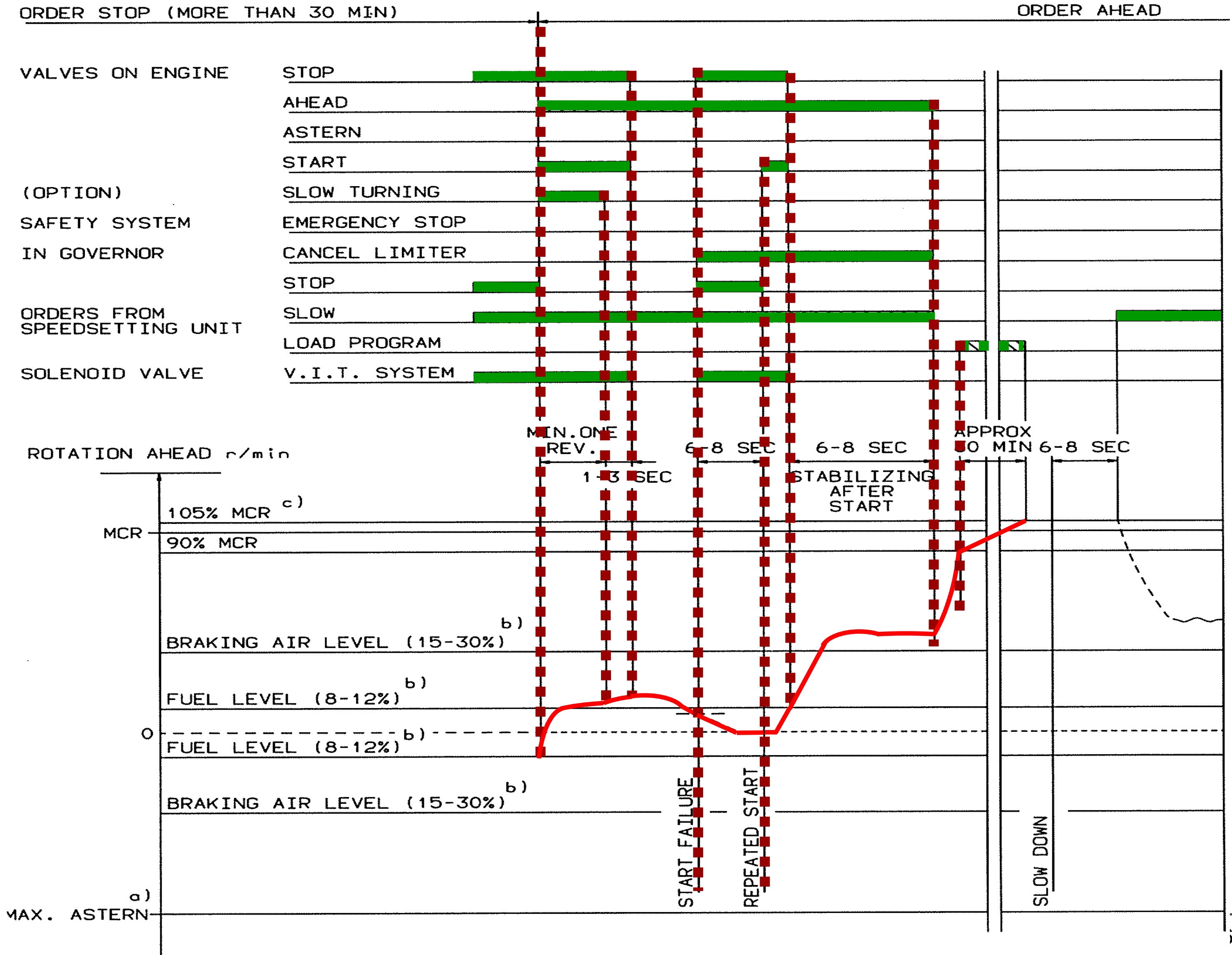
Exhaust receiver

Improvements:

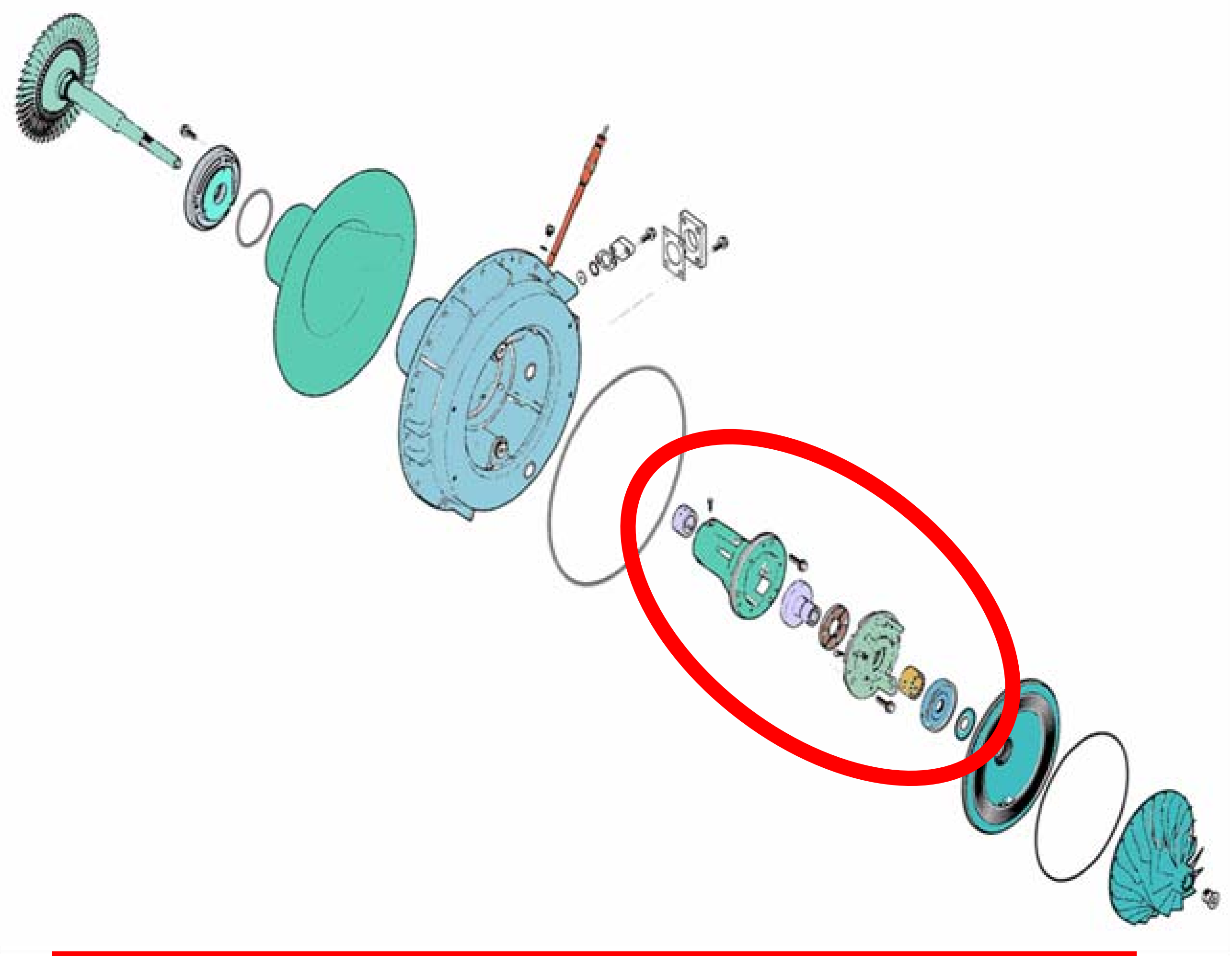
- Increased shell thickness.
- Vessel units for two or three cylinders, with individual longitudinal fixed supports, giving high natural frequencies for longitudinal vibration.
- The shorter vessels result in reduced thermal expansion
- Design of flexible supports changed to eliminate stress "hot spots"
- Grid before T/C enlarged and located in receiver



Manoeuvring.

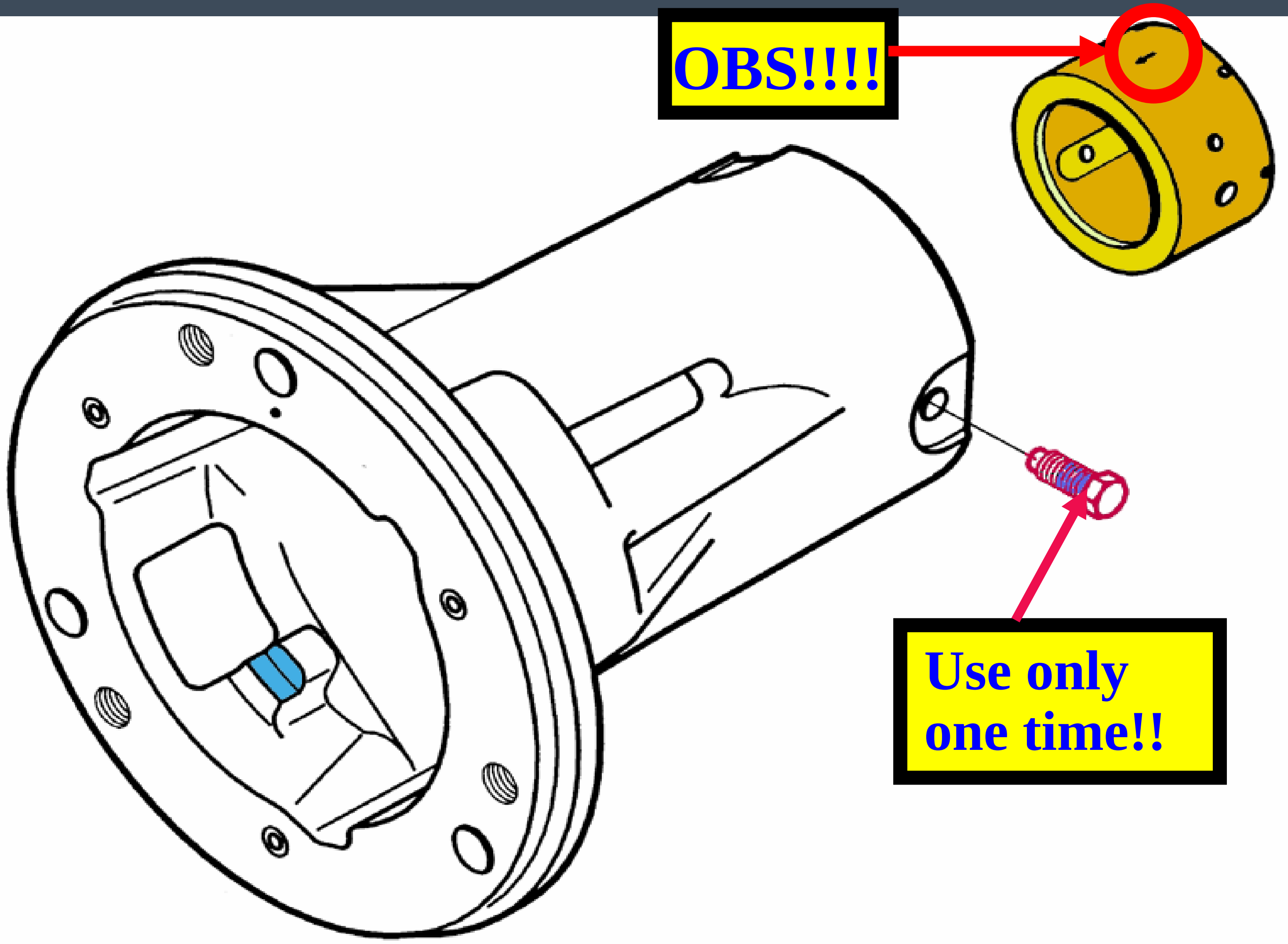


TPL 69-85



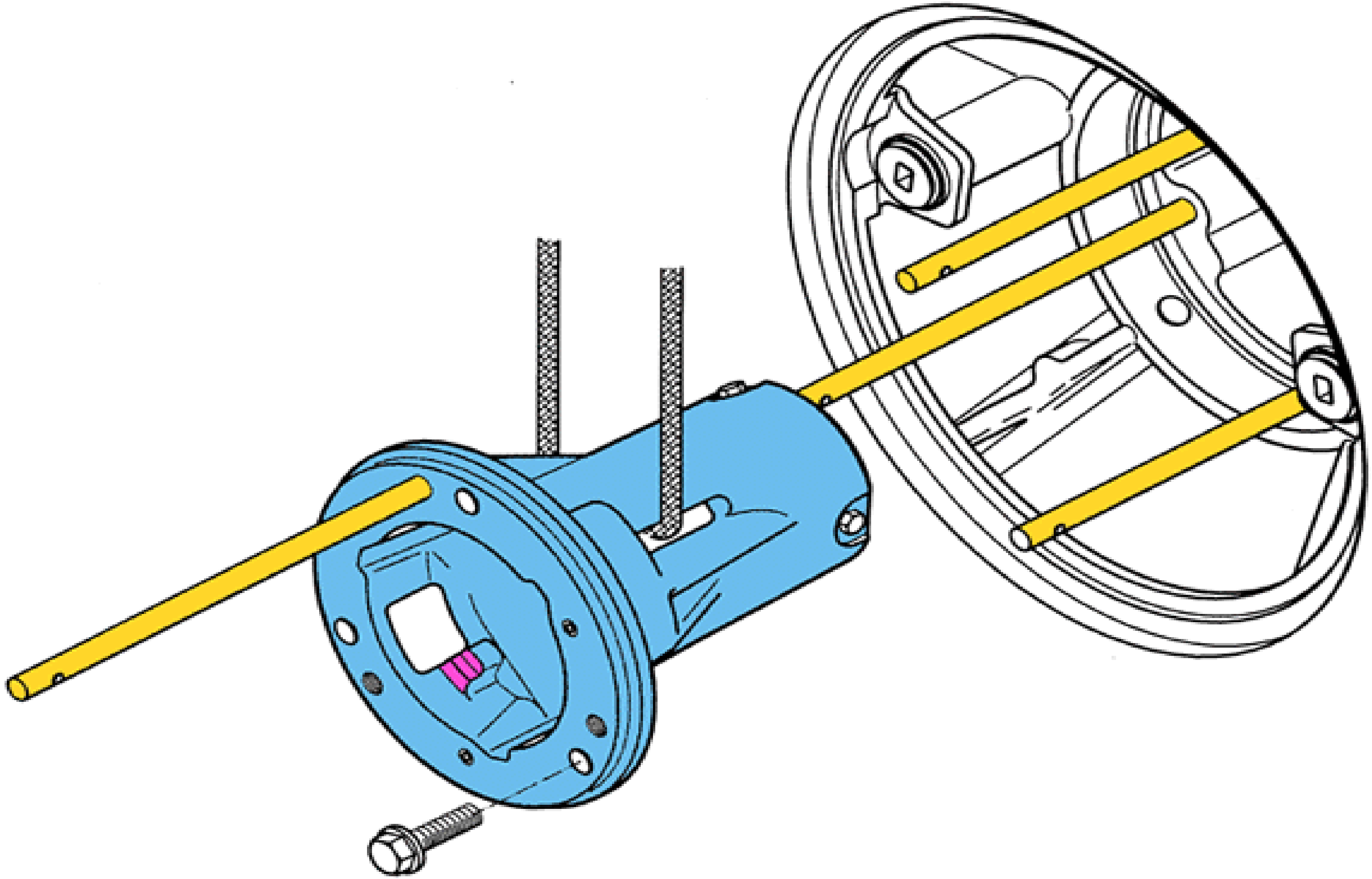
See TPL Operation Manual

TPL 69-85



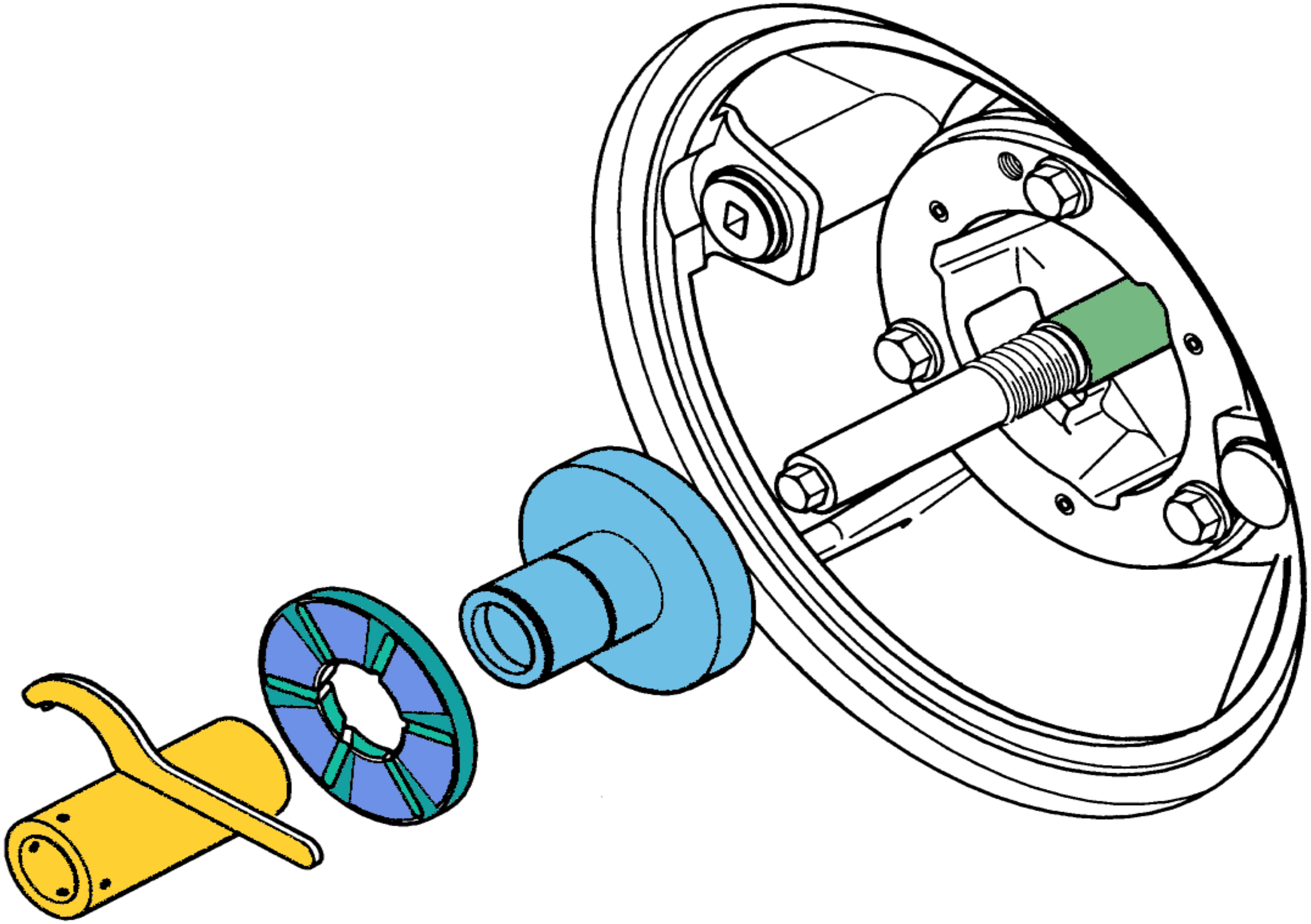
See TPL Operation Manual

TPL 69-85



See TPL Operation Manual

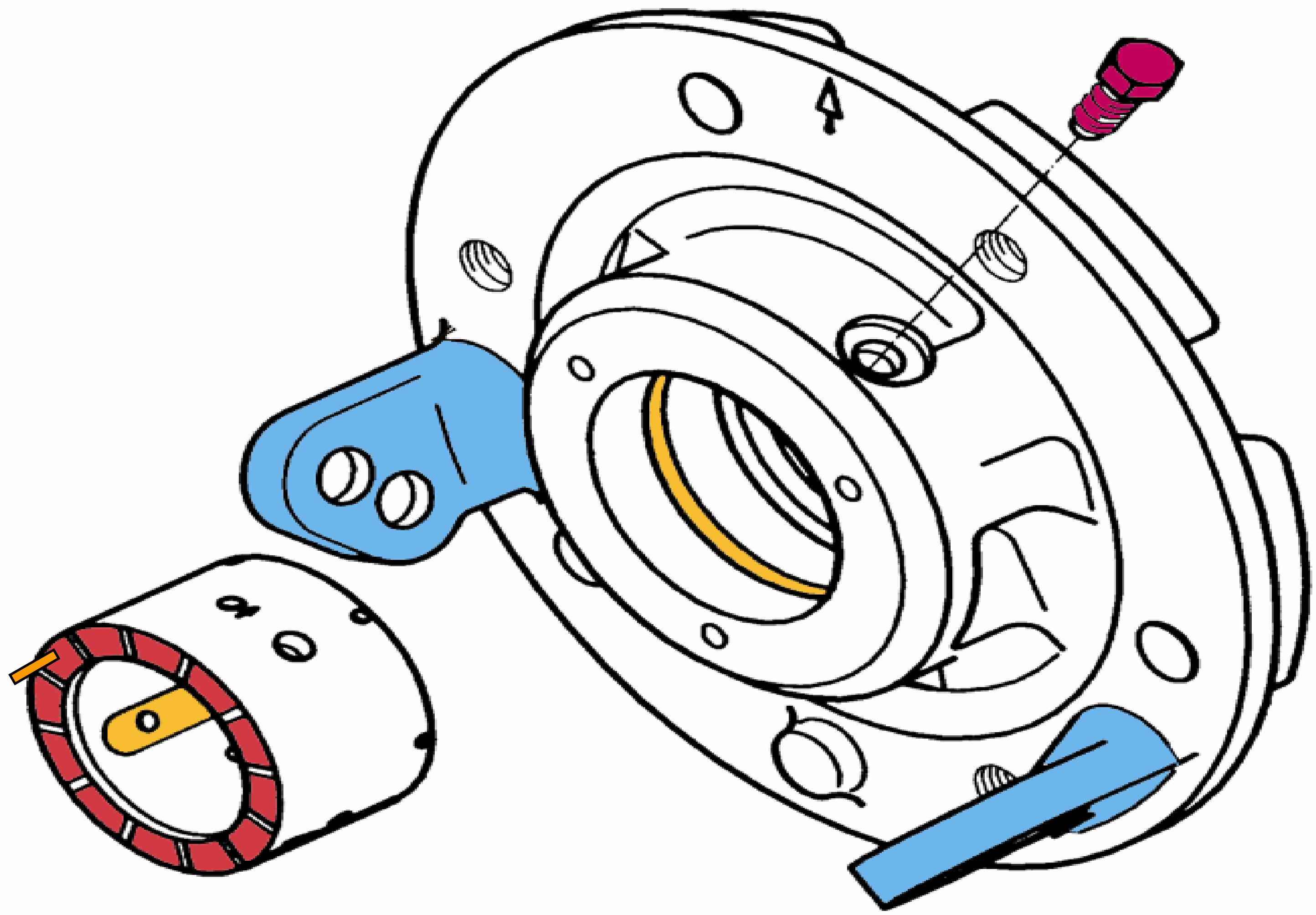
TPL 69-85



Apply Molykote on the friction surface !!!! The trust bearing can also be heated to max 110°C to simplify fitting (put it in hot water) but it must be fully cooled before further fitting operations.

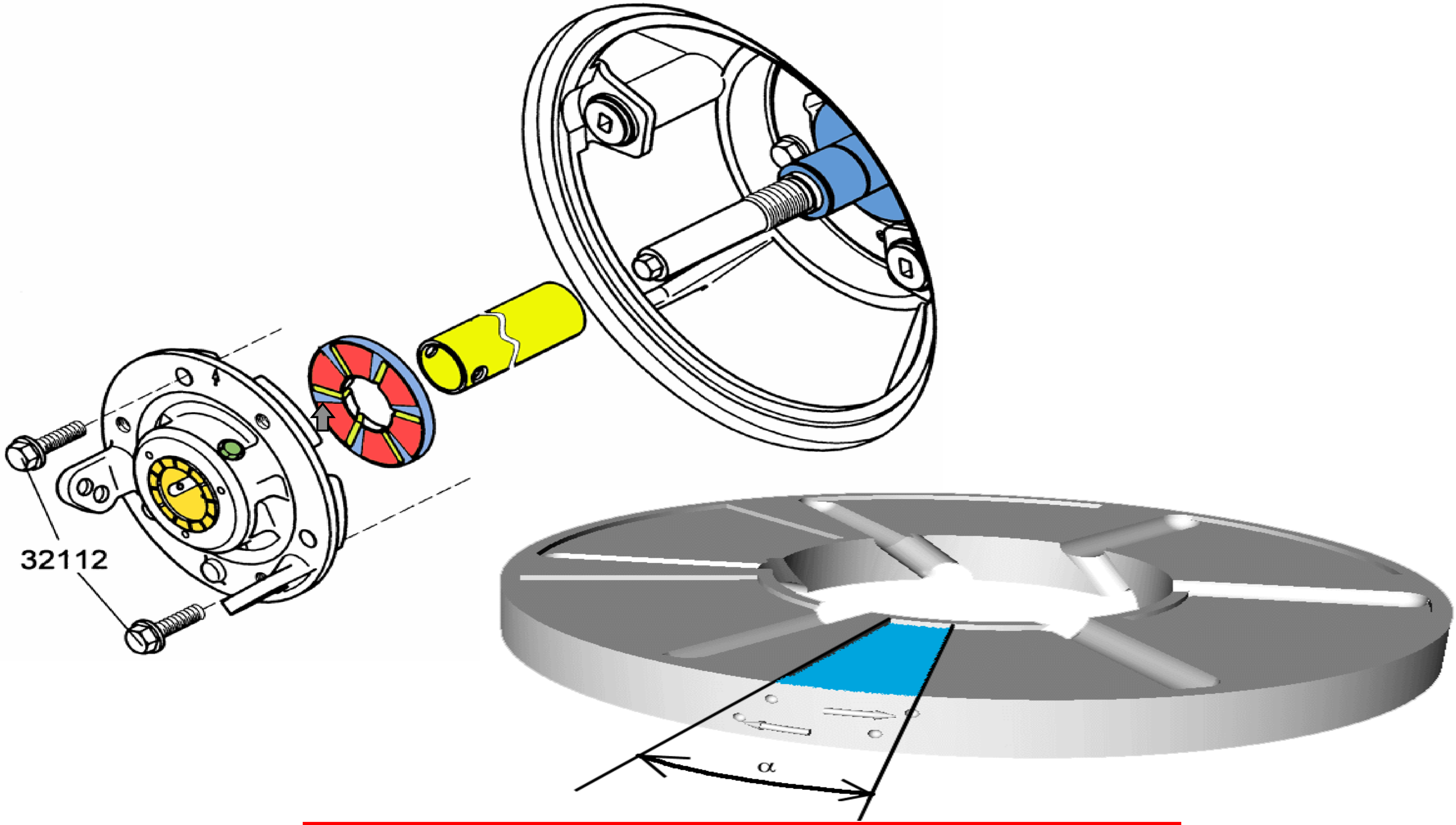
See TPL Operation Manual

TPL 69-85



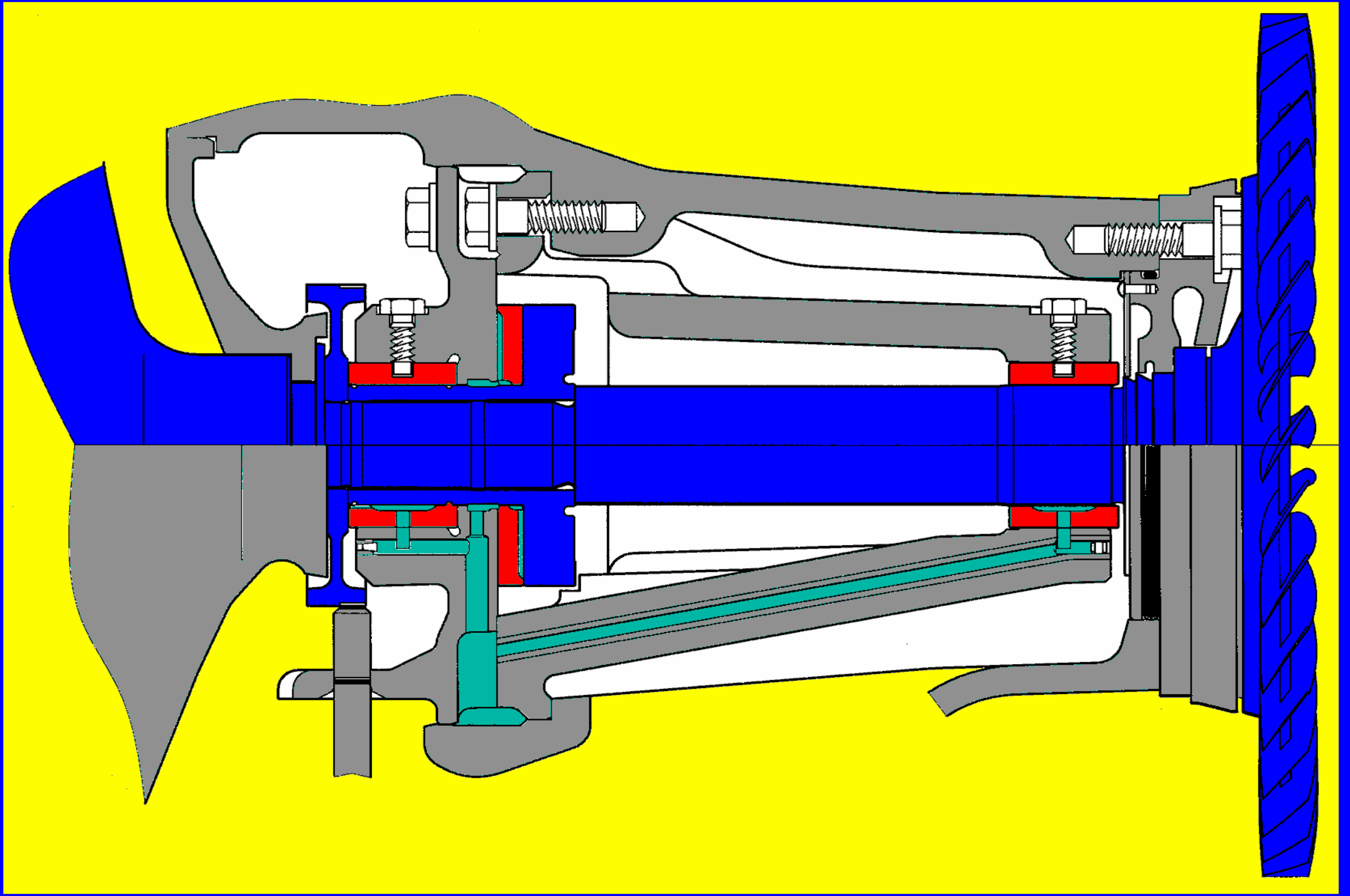
See TPL Operation Manual

TPL 69-85

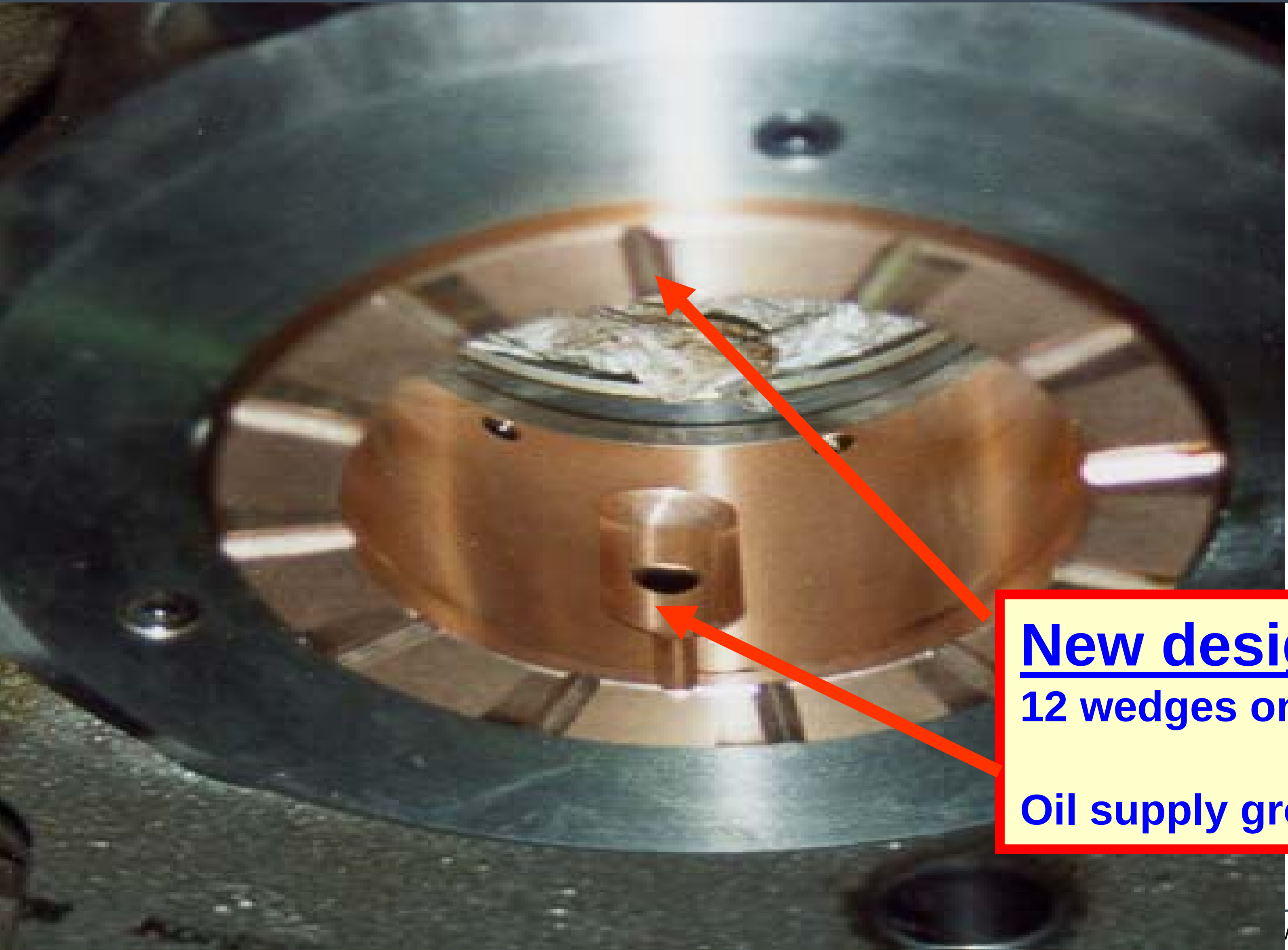


See TPL Operation Manual

TPL 69-85



TPL Improvements

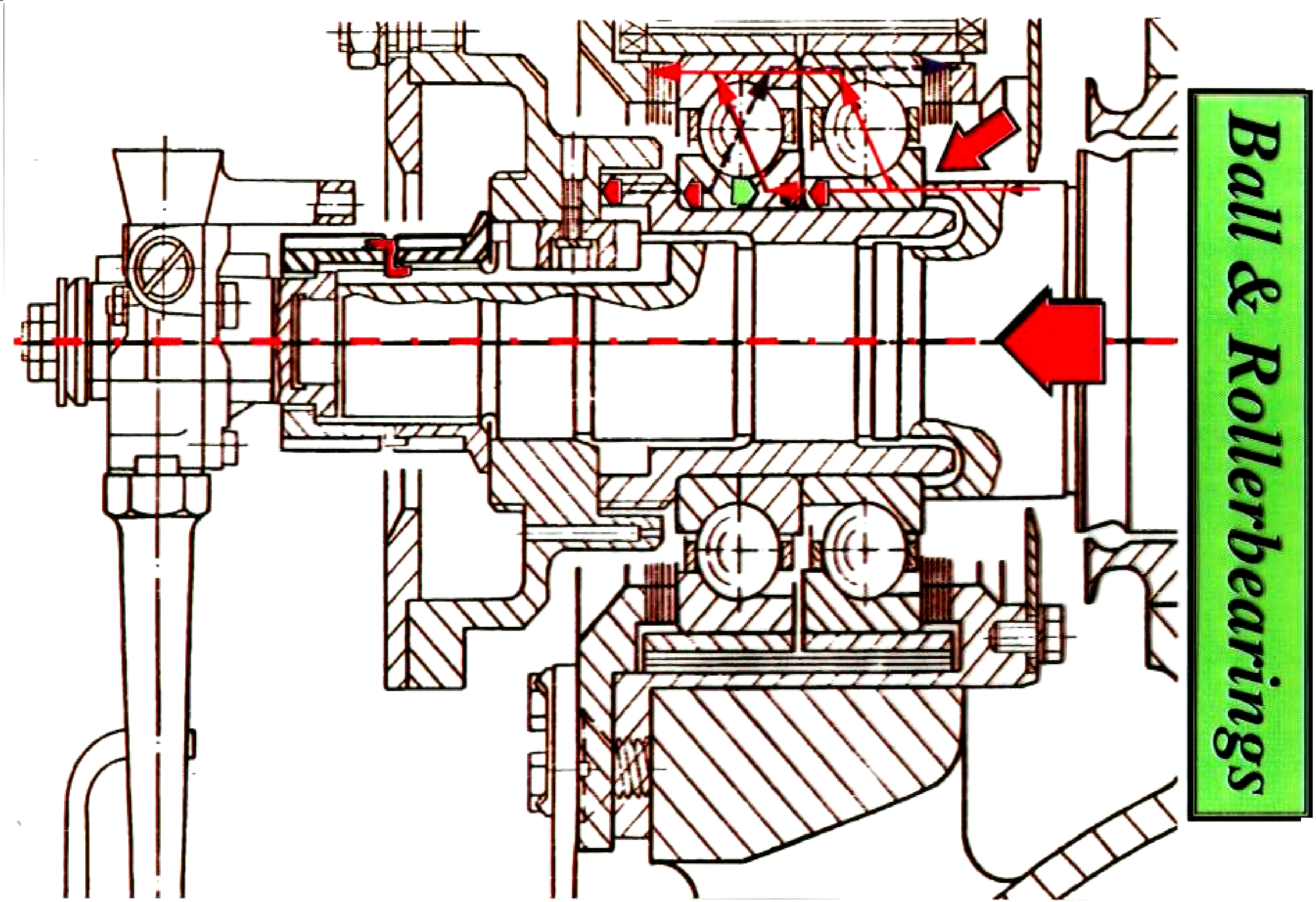


New design

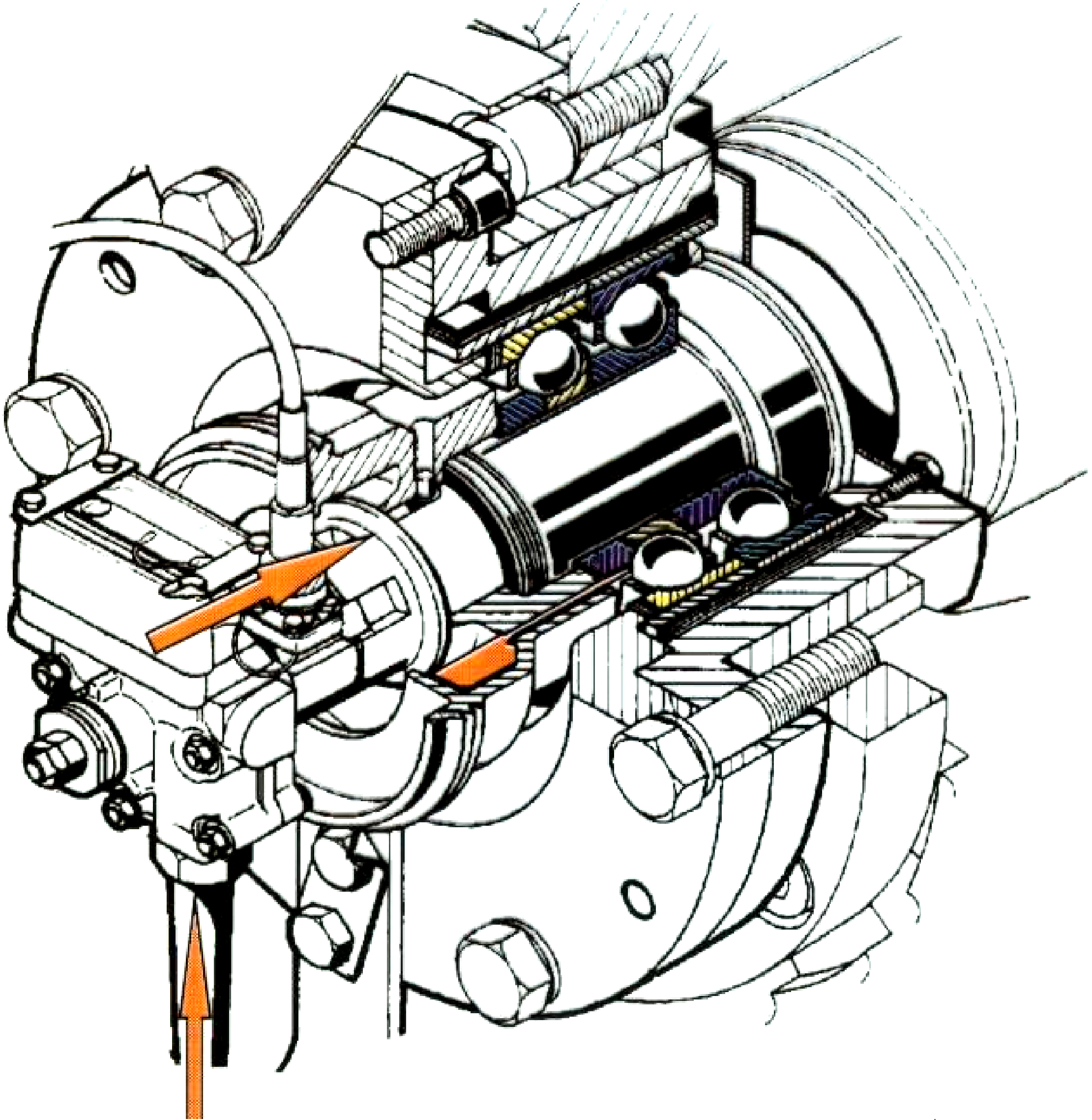
12 wedges on one side

Oil supply groove

VTR Charger



VTR Charger



TCA

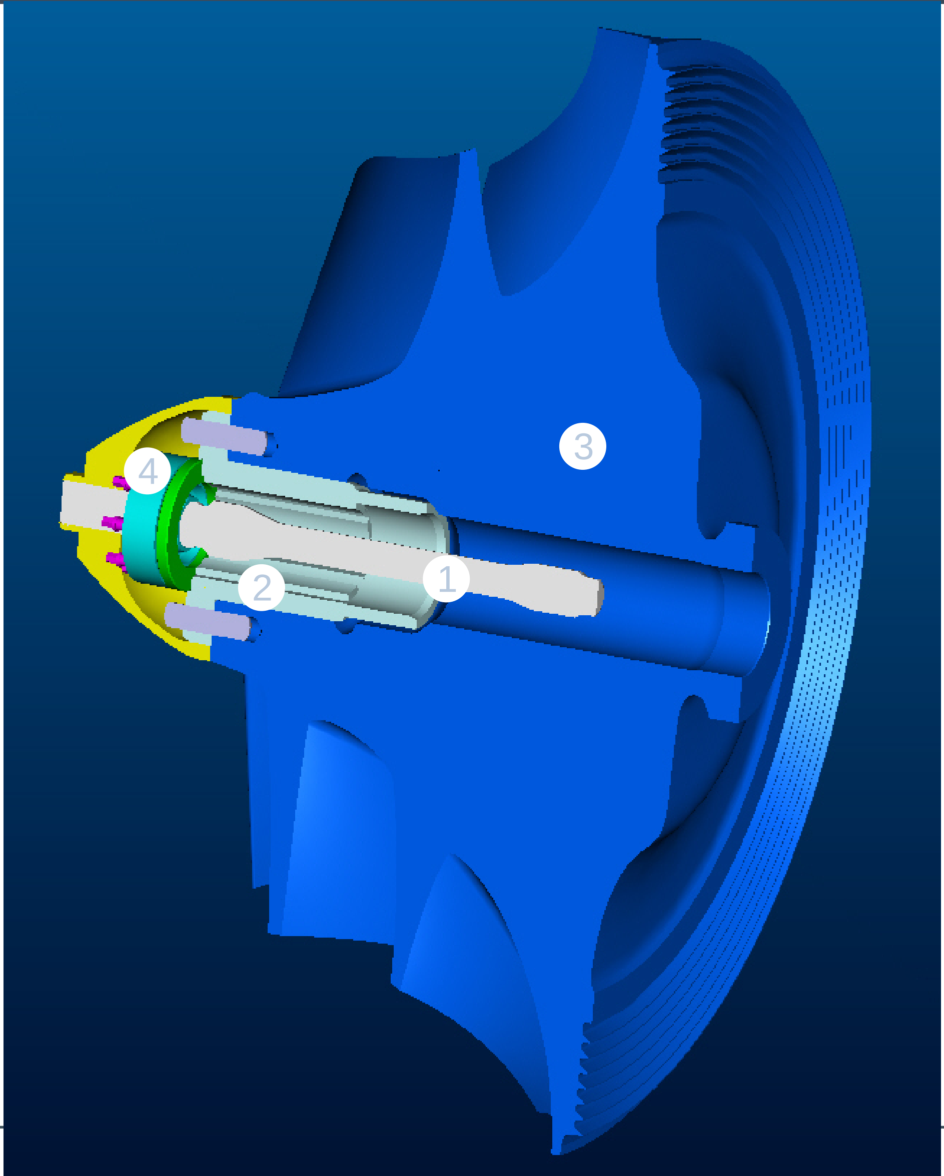
(1) Tension rod

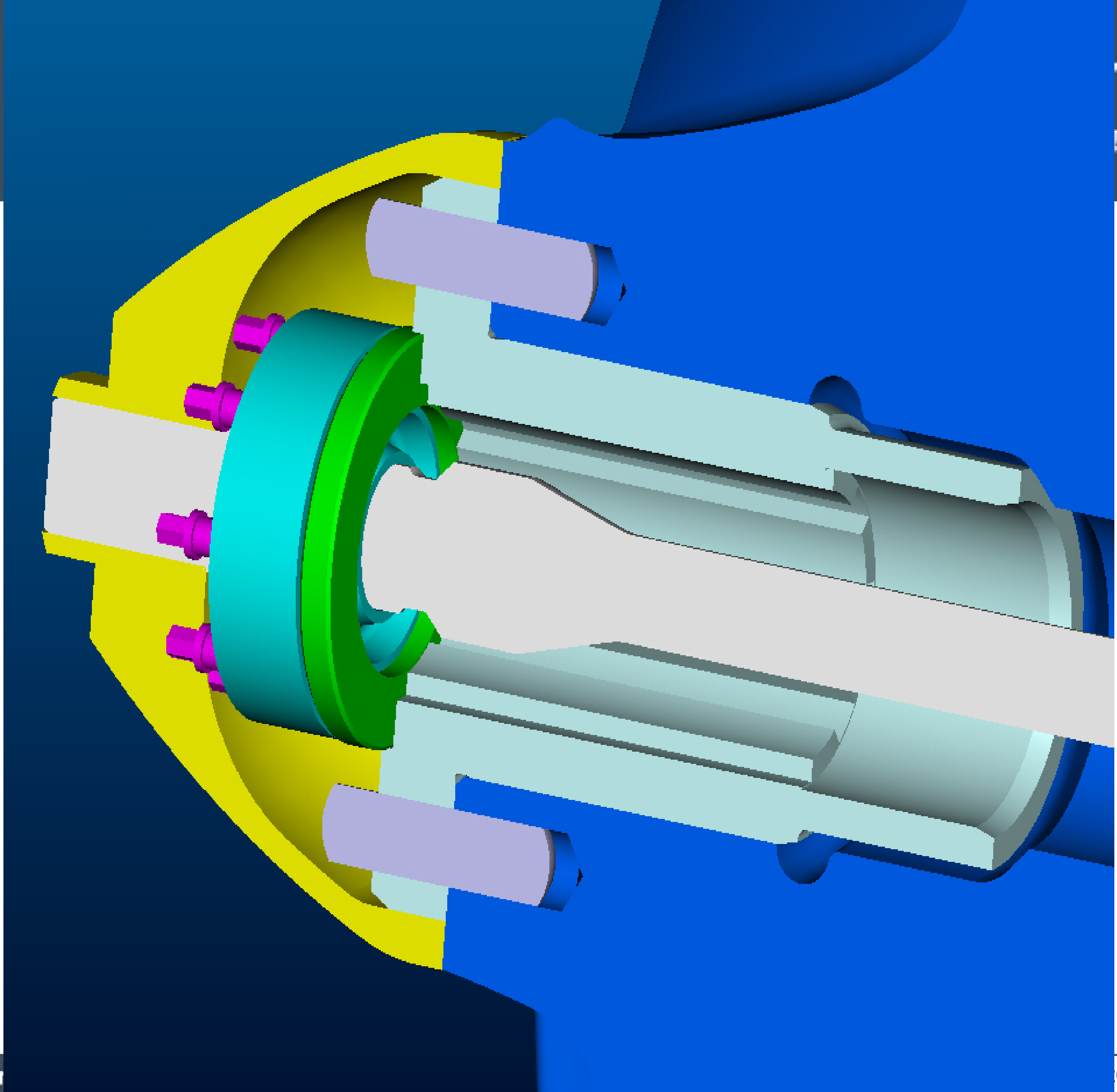
(2) Torque transmission splined shaft sleeve

(3) Minimized stress level on compressor wheel rear side

(4) „Super Bolt“ nut

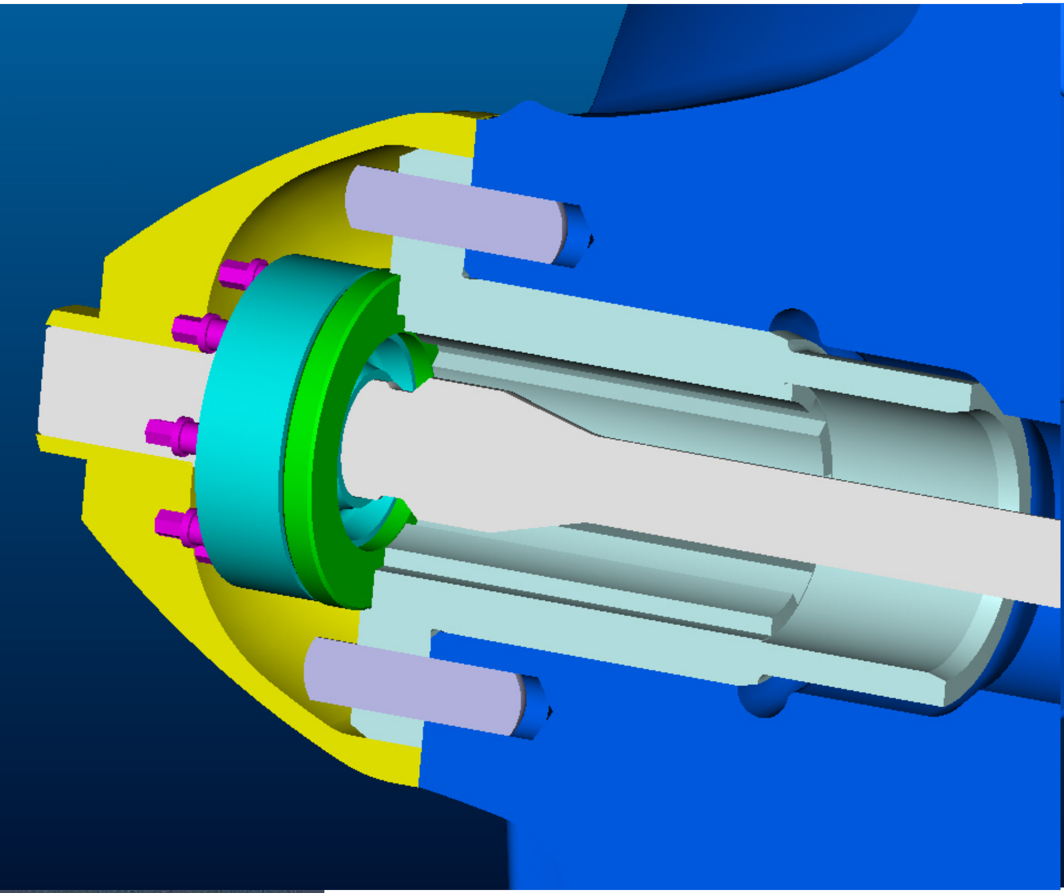
»Mounting of compressor wheel with standard tools«



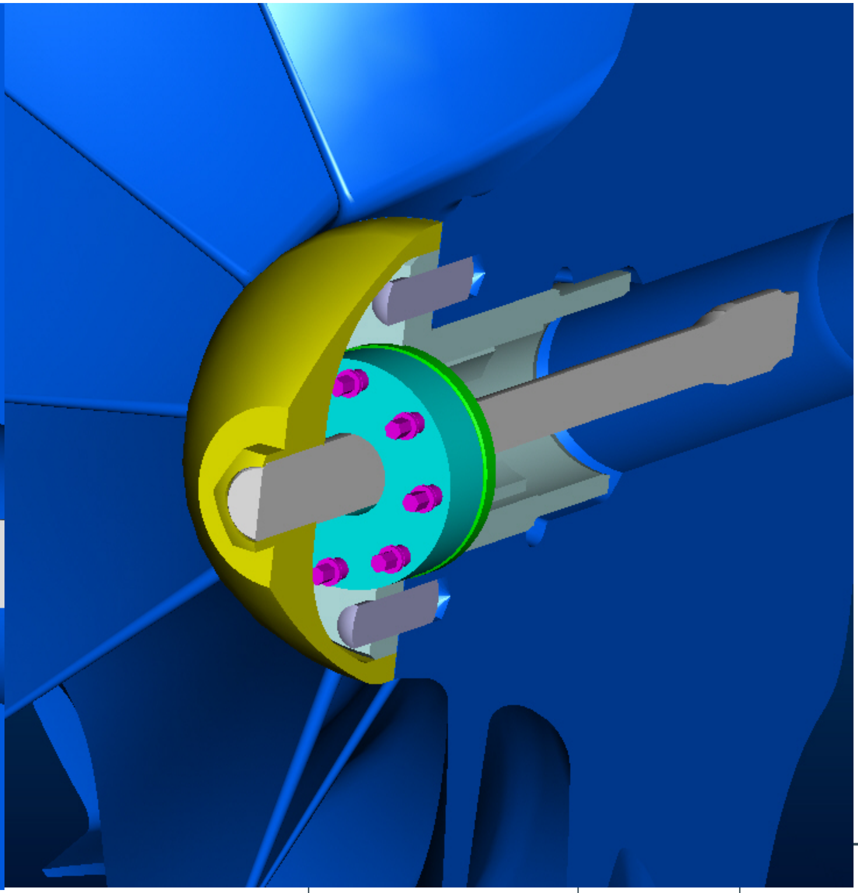


TCA

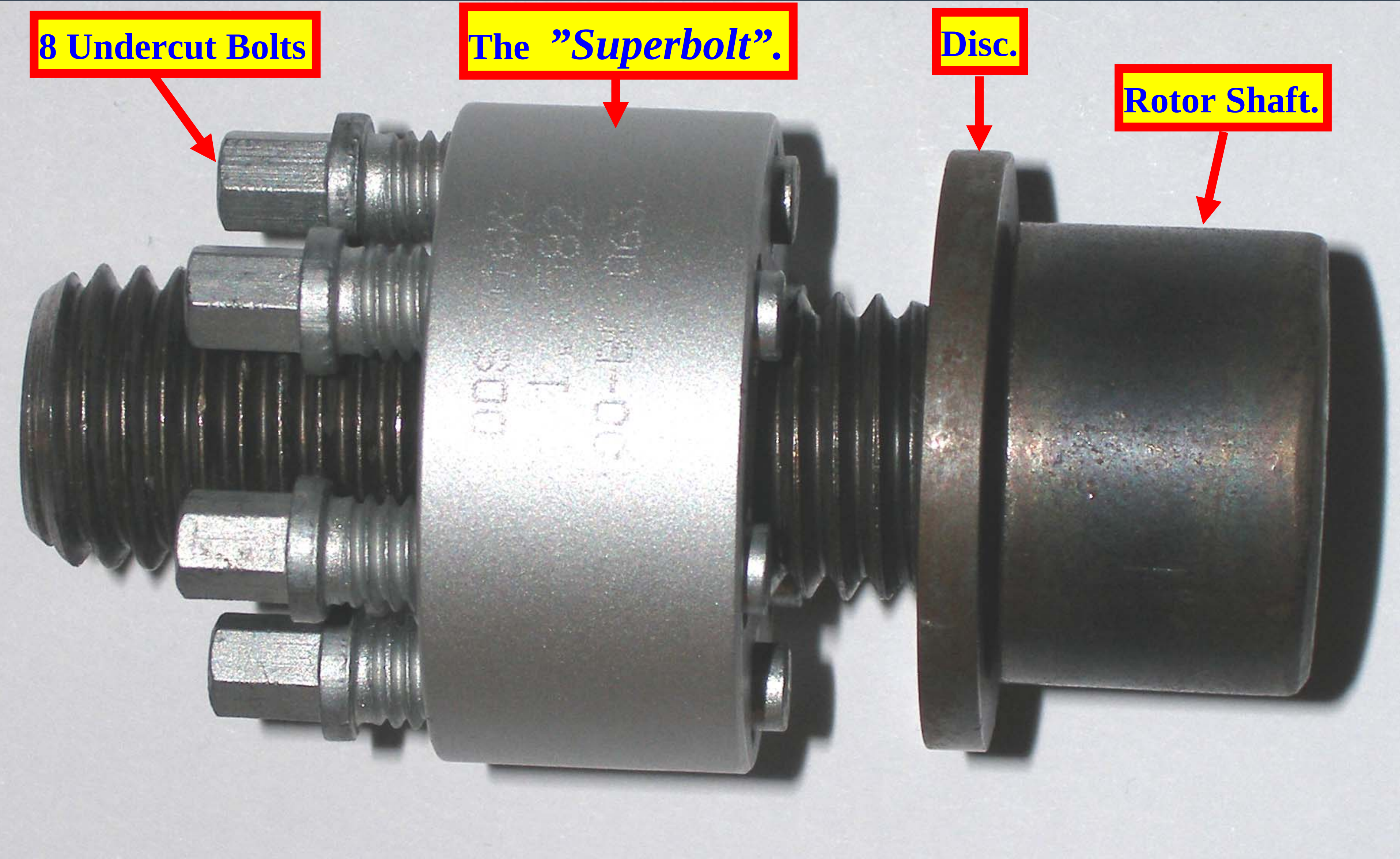
»Torque transmission by splined shaft sleeve«



»Mounting of compressor wheel with standard tools«



The ” *SUPERBOLT*”.



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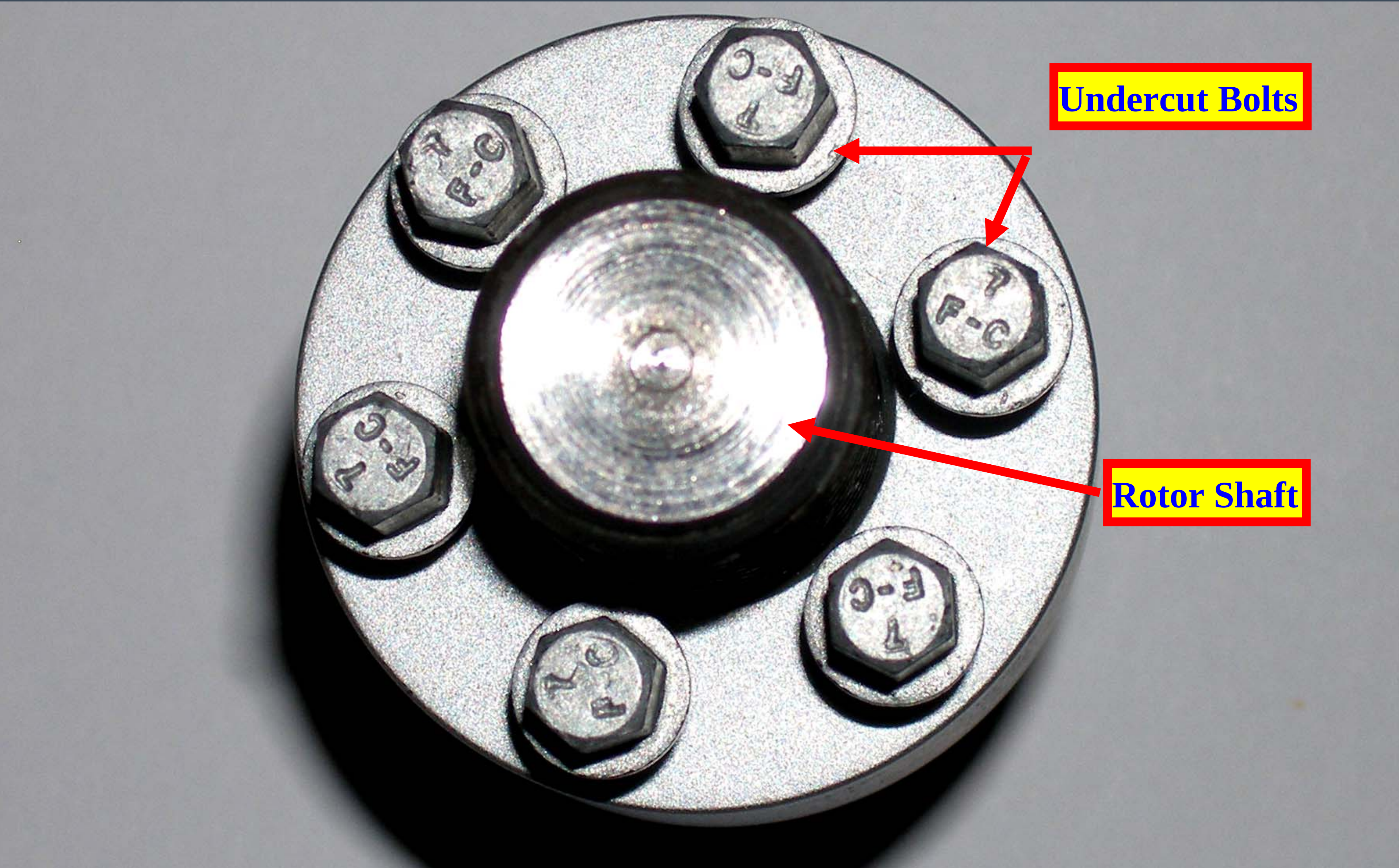

TCA Development Highlights

- Separate thrust and journal bearing
- Reduction of bearing diameter - therefore reduced mechanical losses
- Floating journal bearing bushes
- Thrust bearing inspection without dismantling of the shaft