

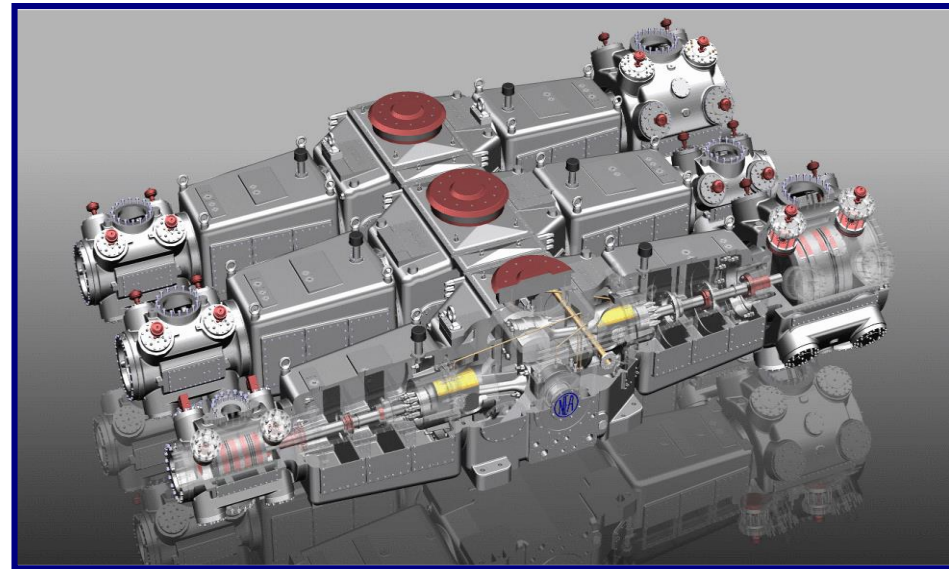
EFRC Training Workshop

Basic Training of Reciprocating Compressor Systems

Installation, Operation and Maintenance
by
René Anke
NEAC Compressor Service

Content of the presentation:

- I. Installation
- II. Operation
- III. Maintenance



Installation

Installation, Operation & Maintenance



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1

The “footwear” of the compressor is that what links it to the foundation:

1. Skid or
2. Anchorage and
3. Grouting



2

When the compressor is dispatched from the workshop it is practically “barefooted”.

At site the “shoes” are fitted to “run” well.



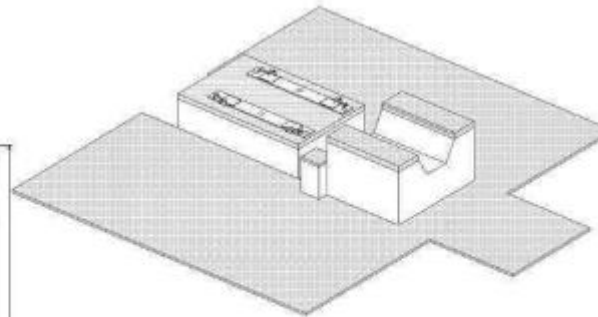
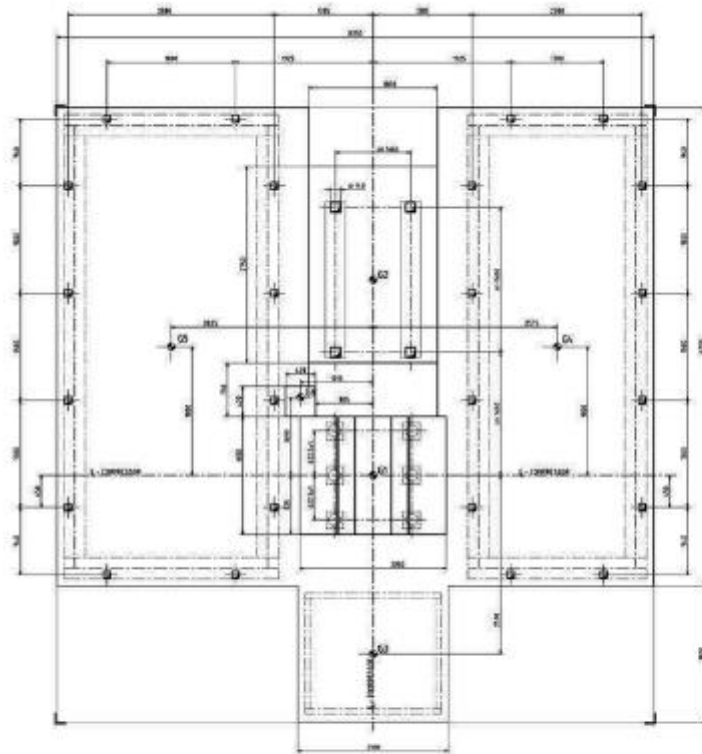
3

... and underneath is the foundation which shall be designed and built such to be a solid “walkway” !

Installation, Operation & Maintenance

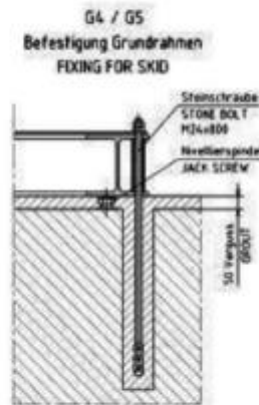


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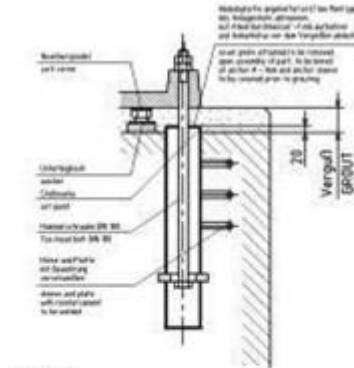


Check:

- Dimensions
- Position of Fixation Points
- Orientation of Anchor Sleeves



G1
Verankerung für Kompressoren
Details siehe Werknorm 4740 / 200
ANCHORINGS FOR COMPRESSORS
DETAILS SEE WORKSHOP STANDARD 4740 / 200



Bemerkungen

Die Stahlscheibe der Ankerplatte muß stets in Richtung Außenkante Fundament zeigen. Das Fundament wird mit den genau eingestellten Ankerbolzen zusammen verschraubt. Die auf die Fundamentschraube geschweißte Scheibe zeigt die Stellung des Kompressors an. Der Schaft der Fundamentschraube ist mit Blättern zu streichen.

Notes

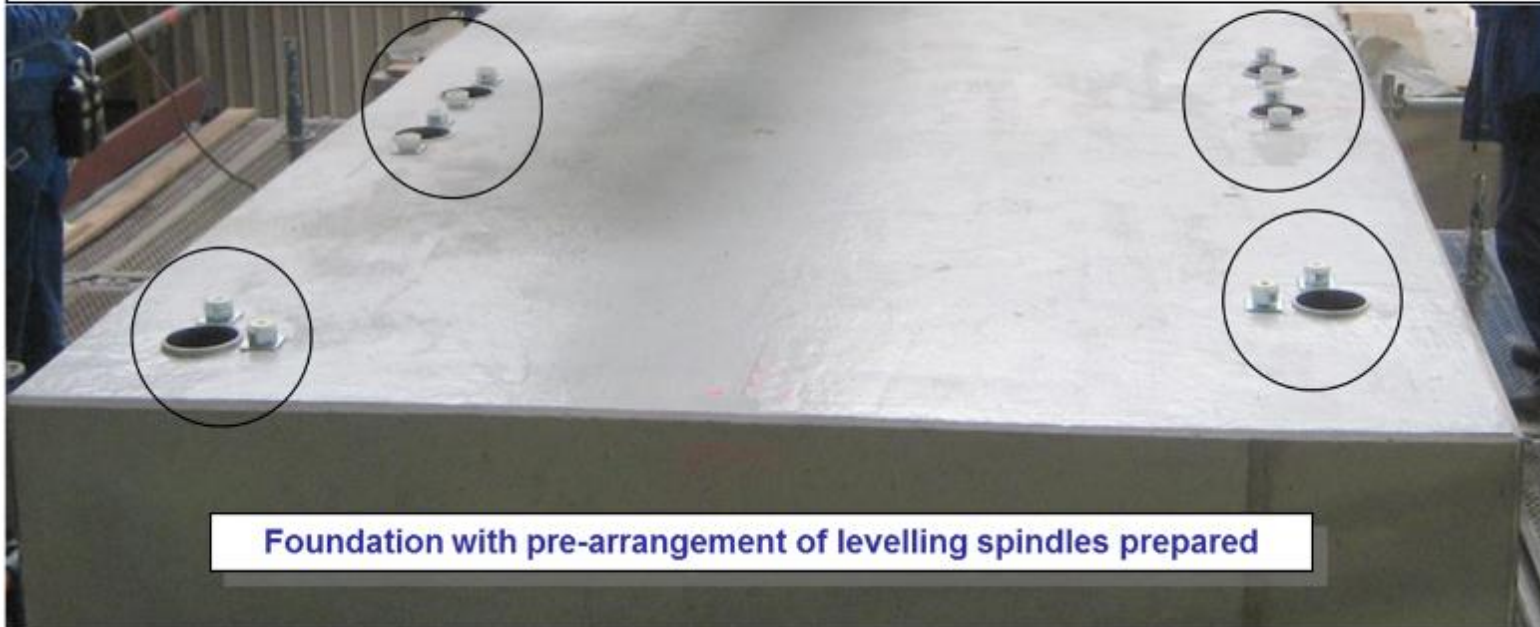
The steel plate of anchor sleeve must always show in direction of the outer foundation edge. The foundation is cast together with the exactly adjusted anchor sleeves. The plate welded on the Tee-head screw shows the position of the Tee-head. The shaft of the Tee-head bolt is to be painted with bluish.

Dynamic conditions such as max. permissible foundation movement (vibrations) and dynamic foundation loads shall be forwarded with the plan !

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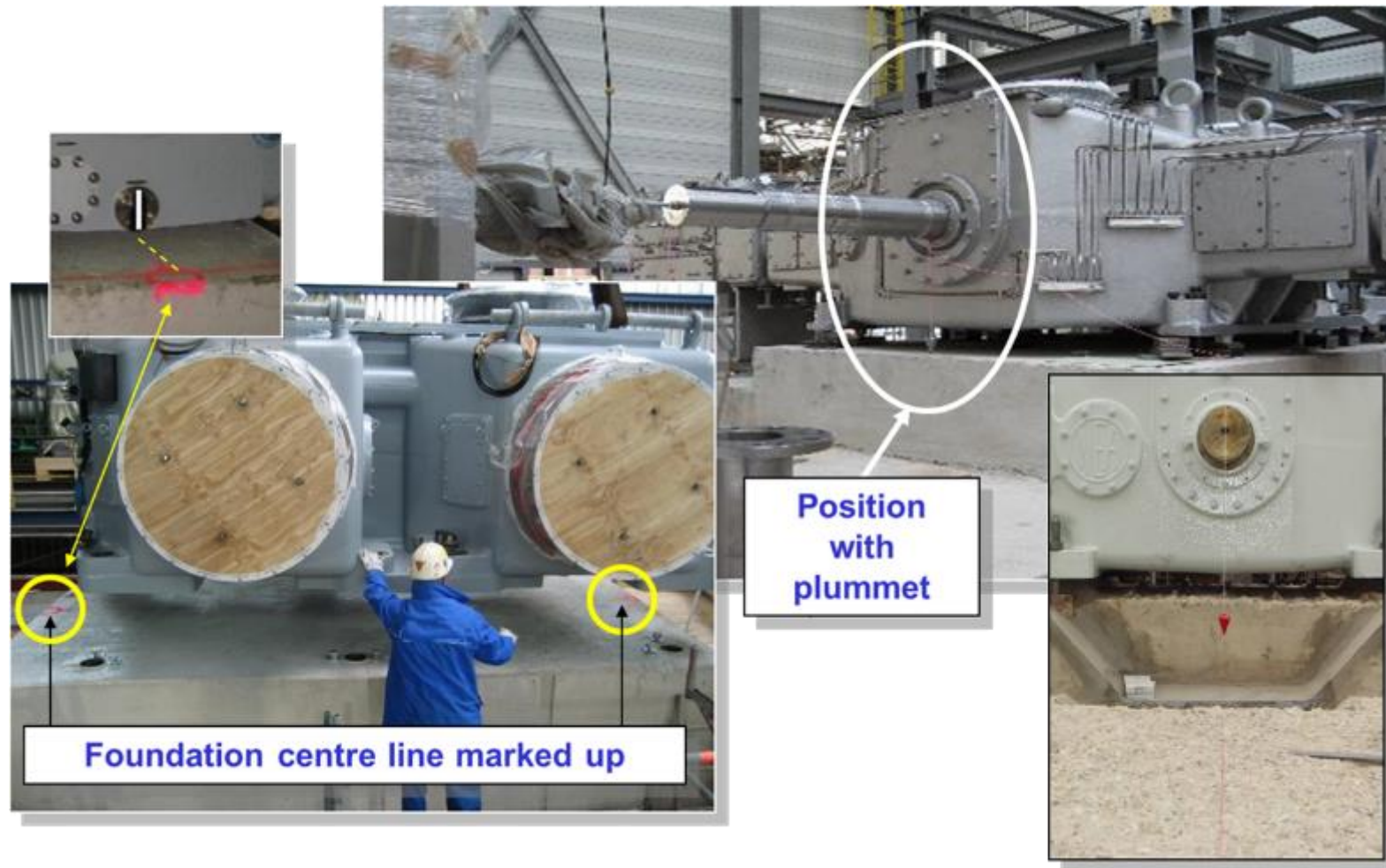
Make sure - prior to the compressor set-up - that anchor holes for anchor bolts are in correct position. The same applies for foundation bolts or similar to take up a skid with pre-fabricated holes and re-inforcements.

Put jacking spindles in place and check proper level.



Foundation with pre-arrangement of levelling spindles prepared

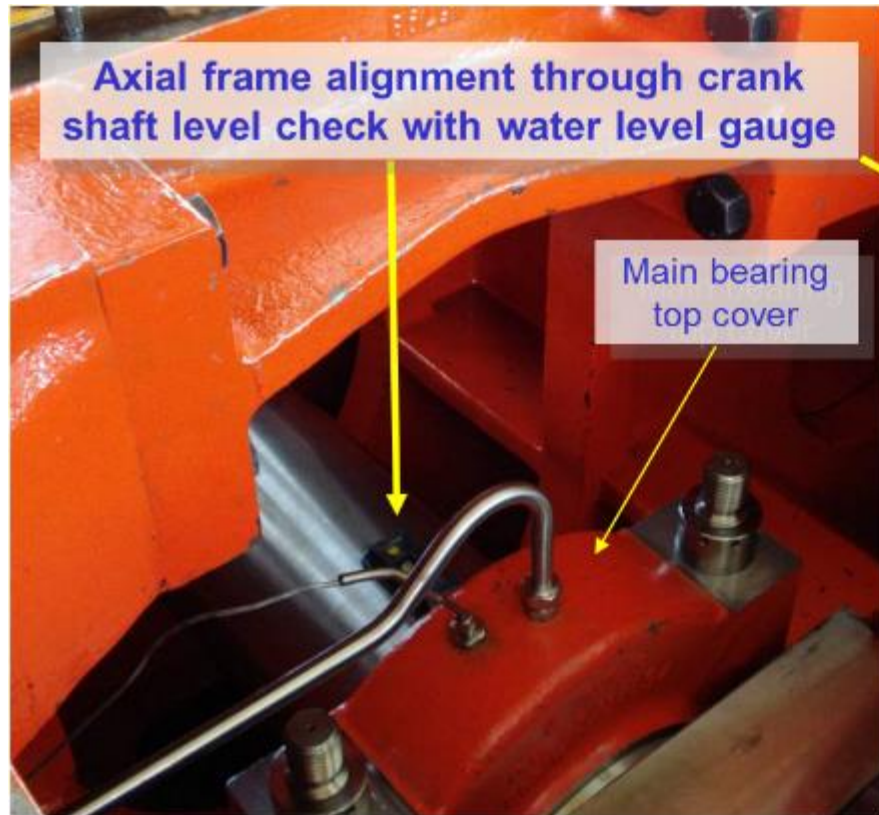
Installation, Operation & Maintenance



Installation, Operation & Maintenance



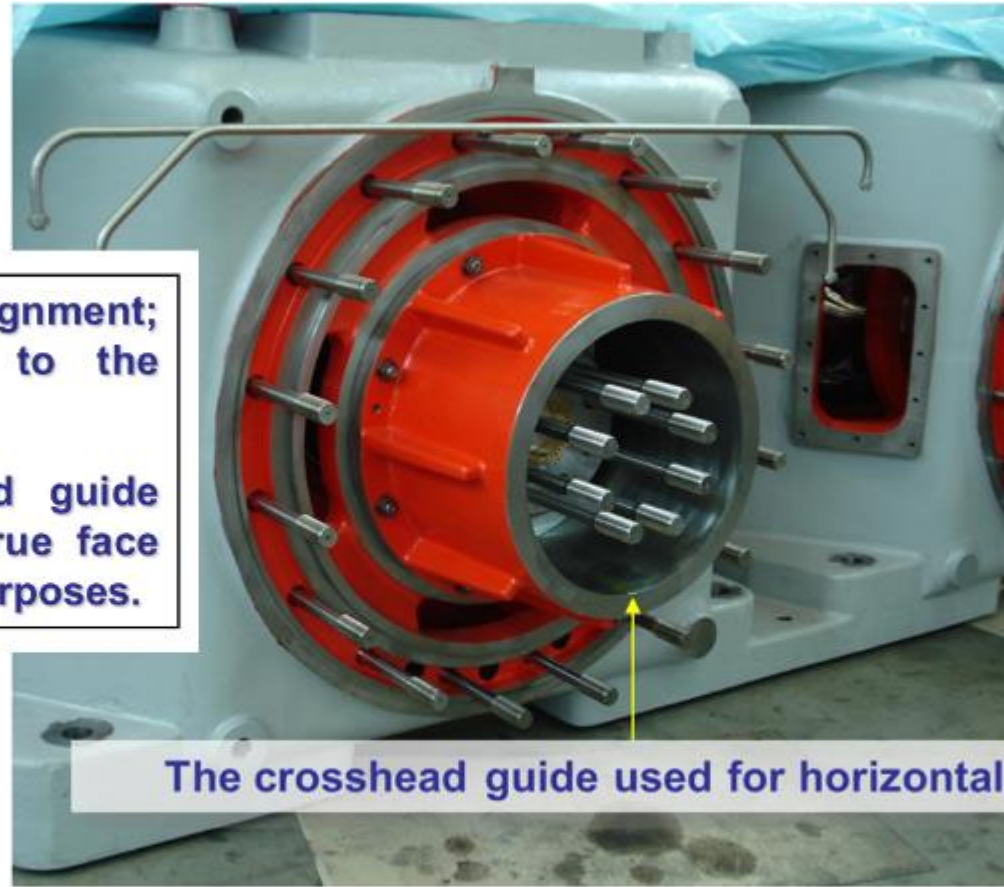
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**Horizontal alignment;
perpendicular to the
shaft axis:**

**The crosshead guide
surface is a true face
for levelling purposes.**



The crosshead guide used for horizontal levelling

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Axial alignment on frame top surface

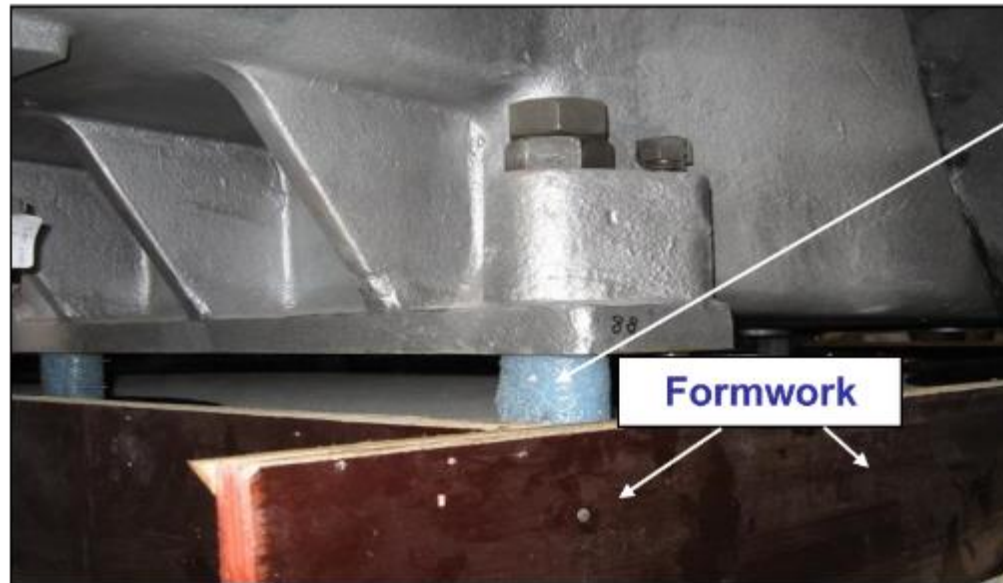


**Level check in horizontal orientation -
perpendicular to crank shaft axis**



Note: Frame top is not a true face referring to crank shaft and main bearing bore (but often good enough to utilize ...)

Installation, Operation & Maintenance



Wrapping of the anchor
bolt with plastic foam, rubber or
tape (*)

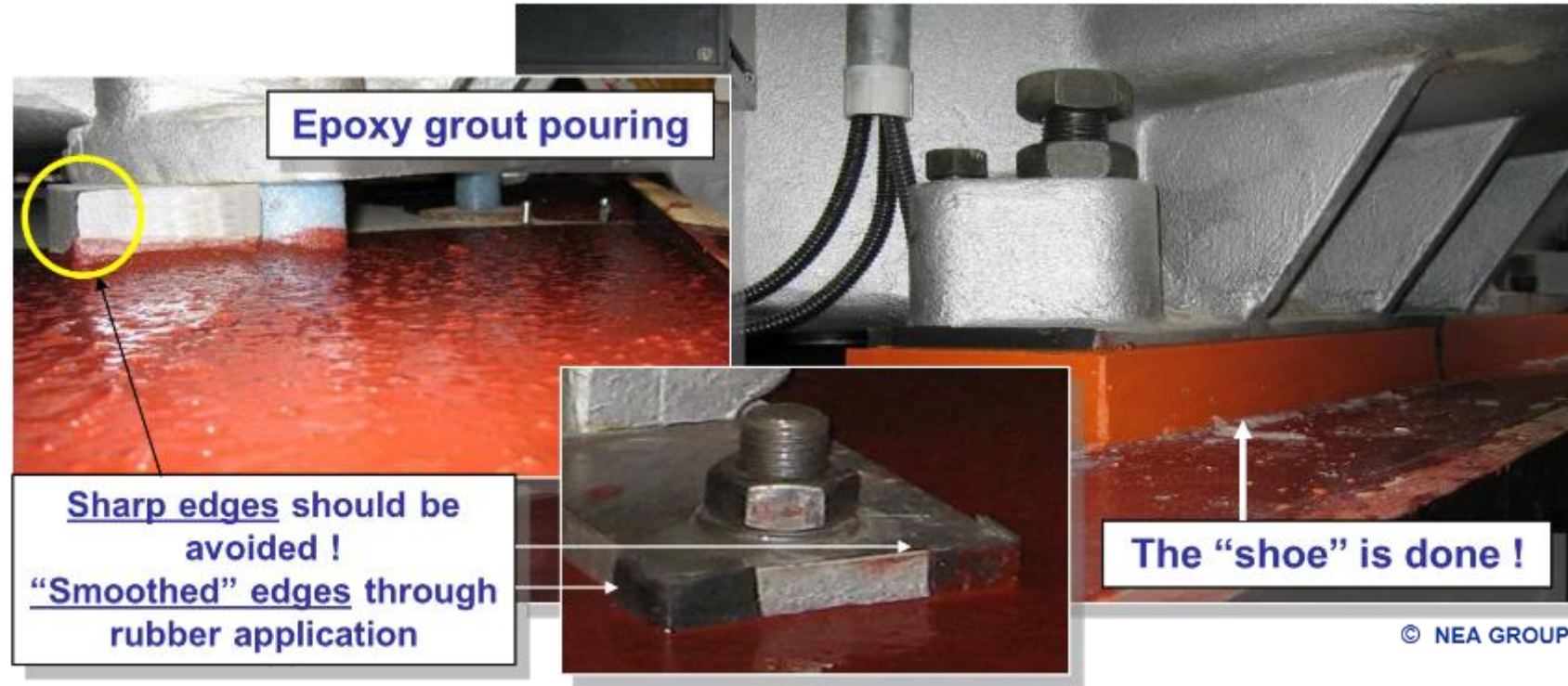
Anchor sleeve to be filled with :

- Glass Sand
- Polyurethane Foam



(*) In comparison with plastic foam or rubber the
tape has the advantage of being much thinner,
which enables easy fitting through the frame foot.


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2nd layer of epoxy grouting may be required in case of elevated temperatures.
Picture right: "Orange" quality on top of "Red" quality with better heat resistance

Maintenance

Compressor

The background of the slide is a collage of various industrial reciprocating compressors. Top left: A row of large, dark-colored compressors in a factory. Top center: A large industrial building with a curved roof. Top right: A smaller industrial machine. Middle left: A large, complex compressor assembly with multiple cylinders. Middle right: A large industrial machine with a prominent flywheel. Bottom left: A large industrial machine with a green component. Bottom center: A large industrial machine with a flywheel. Bottom right: A large industrial machine with a flywheel and a ladder.

***“A machine shall become
older than the engineer who
designed it”***

Unknown source

***... and a compressor being operated as per
specification does (theoretically) not wear***

- **Exception:** **Wear Parts**



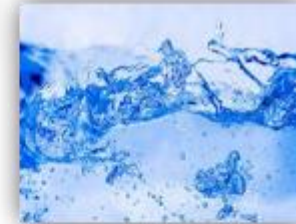
- **Requirements:** **Maintenance at regular Intervals
and consistent Overhaul**



- **Reality:** **Loads and Wear Phenomena
beyond Design Considerations**

Not assessable Loads and Wear Phenomena:

- **Debris**
 - Liquids and Abrasive Solid Particles in the Gas
- **Corrosion**
 - Rain, High Air Humidity, Aggressive Atmosphere
- **Foundation Deterioration**
 - Weathering, High Dynamic Loads, Oil Leaks
- **Material- Fatigue**
- Bearings, Fasteners, Mating Contact Surfaces etc.
- **Vibrations**
 - Gas Dynamic and/or Mechanical Resonances



Installation, Operation & Maintenance



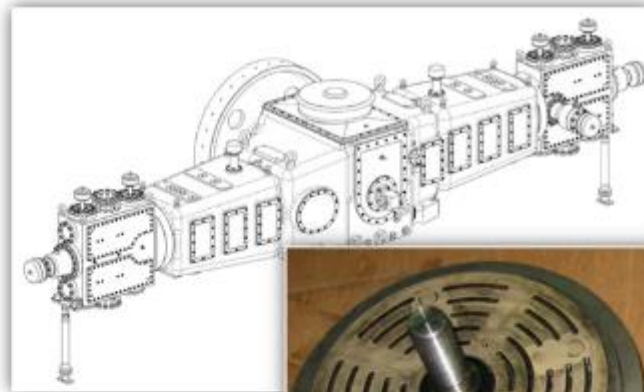
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Piston compressor foundation and frame fixation suffer long term deterioration from:

- Unbalanced mass loads
- Oil penetration into the concrete
- Unfavourable ambient conditions (leading to ice formation and/or corrosion)
- Loose or cracked foundation bolts

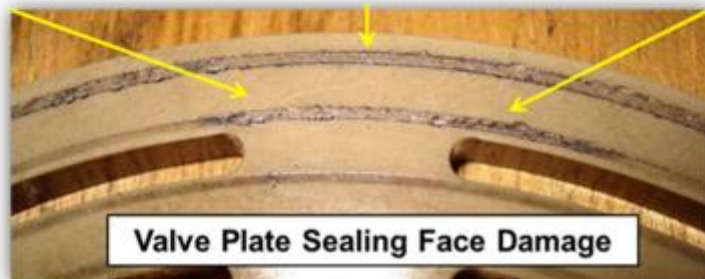


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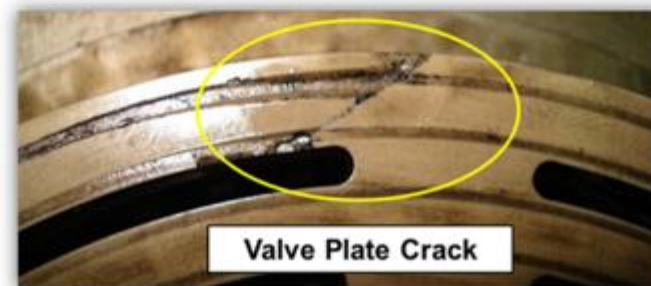


Hydrogen Recycle Compressor
Pressure in/out: 120 → 150 bar
Lubricated Service

Valve Failure



Valve Plate Sealing Face Damage

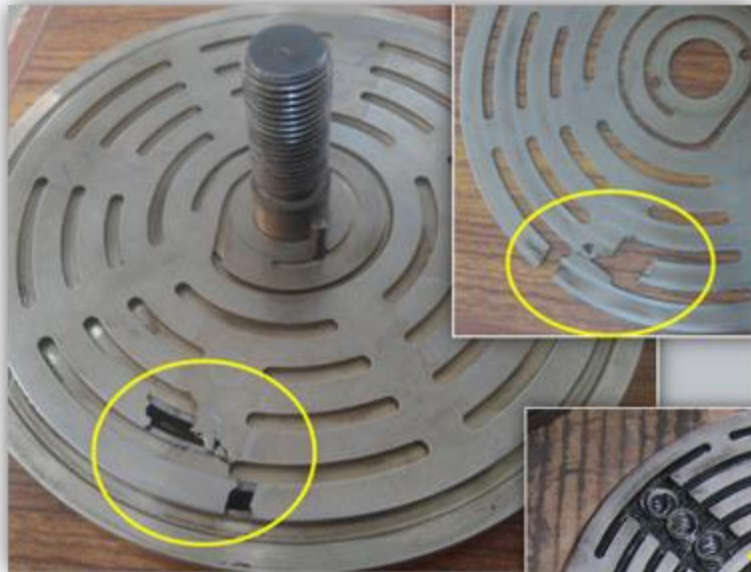


Valve Plate Crack

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Broken Valve Plates

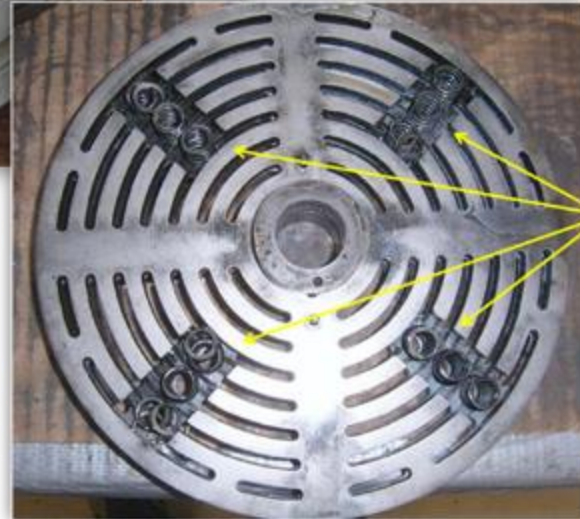
Valve Failure



Valve Housing Wear



Worn & Broken Unloader Fingers



Slack and/or broken Valve Springs

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**Condition found when
removed from machine and
opened**



**Cleaned for Photo Shooting
Some Rings broken in various
Pieces**



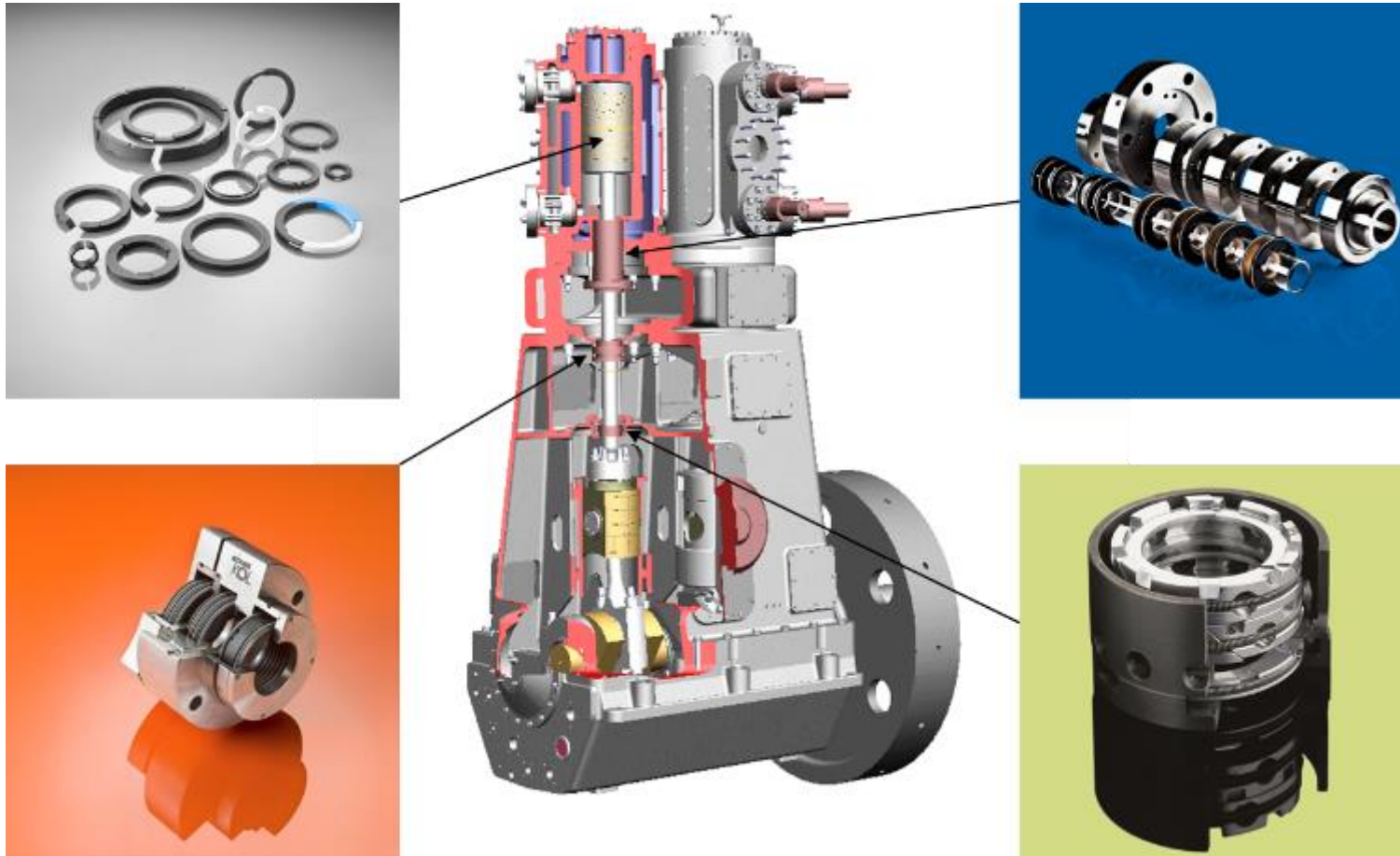
Missing Ring Pieces

Suction Valve 2nd Stage: Water trapped in valve pocket. Valve cage is wet

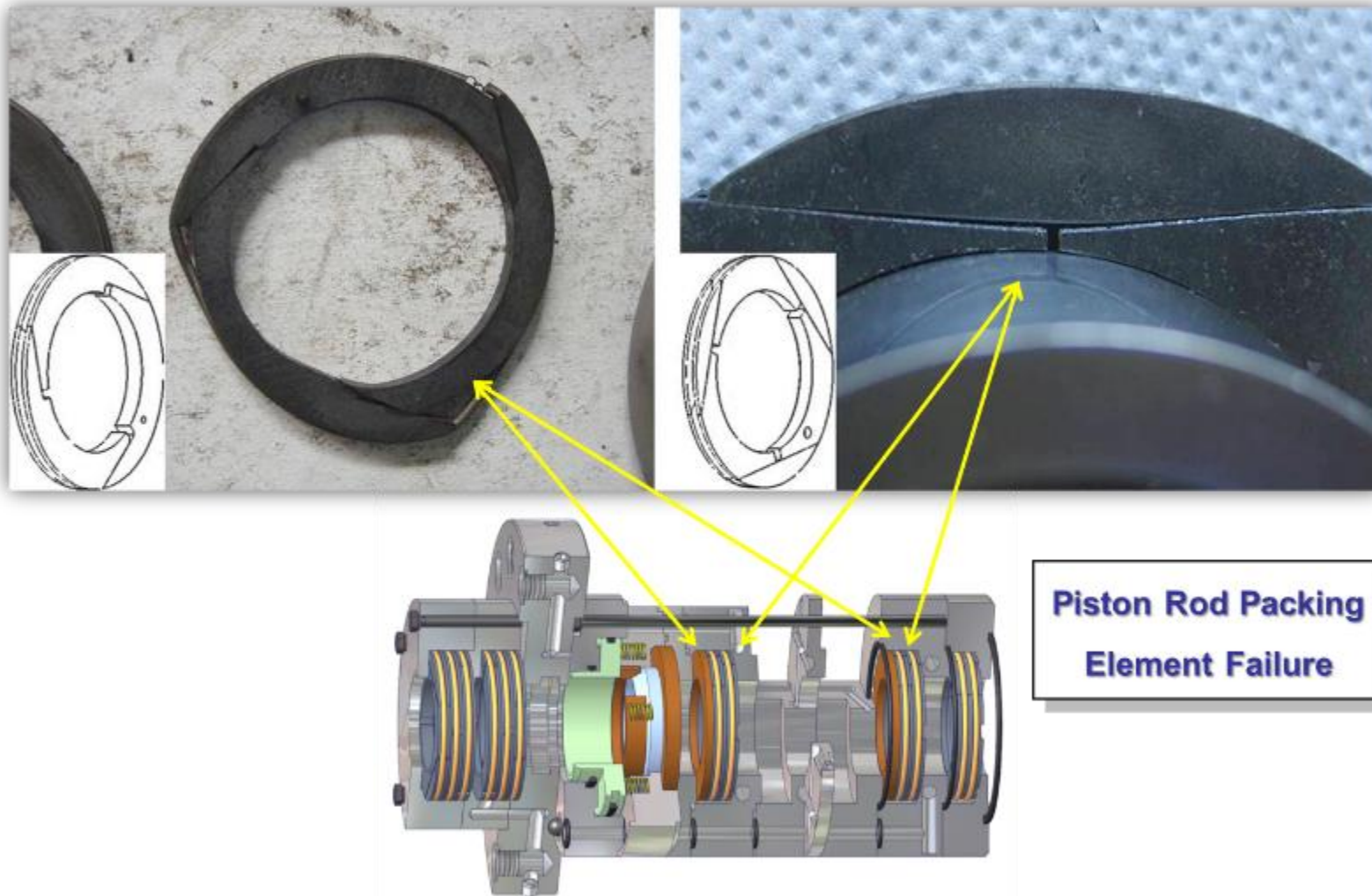


Indication of poor water separation and/or insufficient condensate drain

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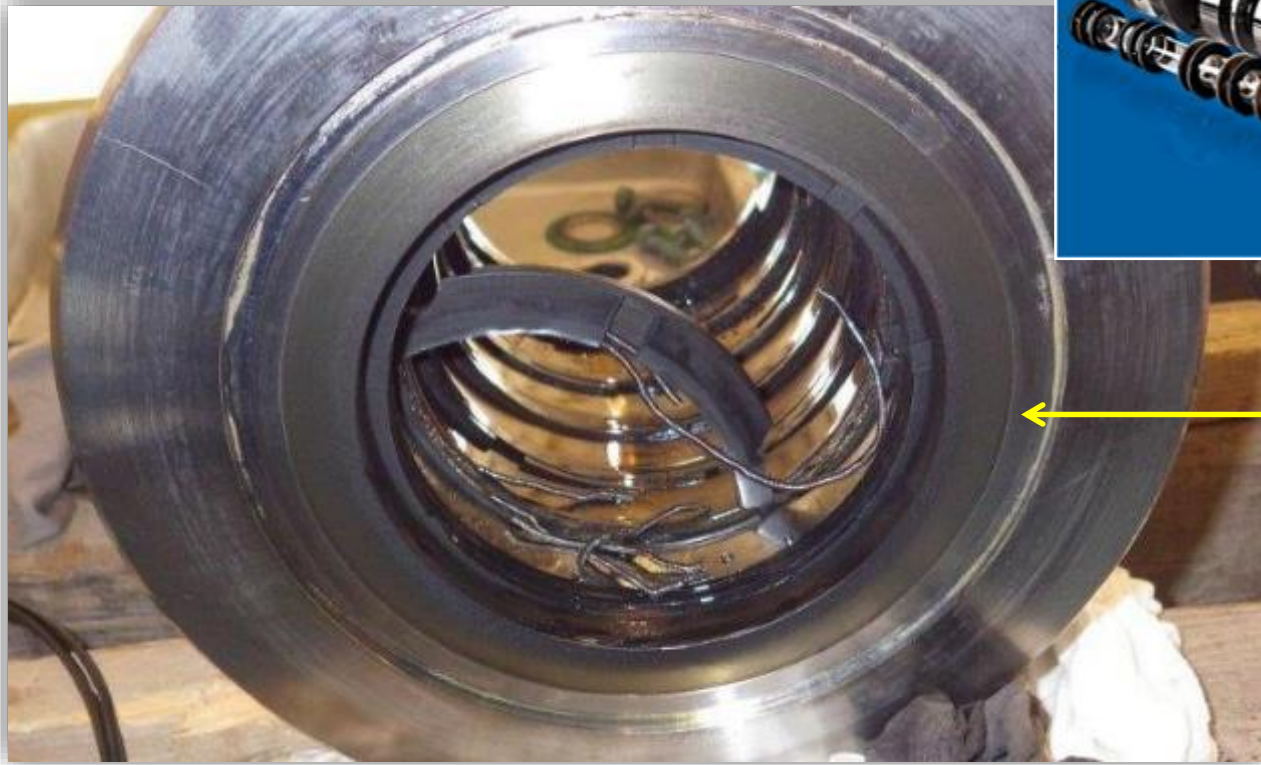


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**Piston Rod Packing
Element Failure**

Piston Rod Packing Spring Failure



View

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Excessive
Piston Ring
Wear

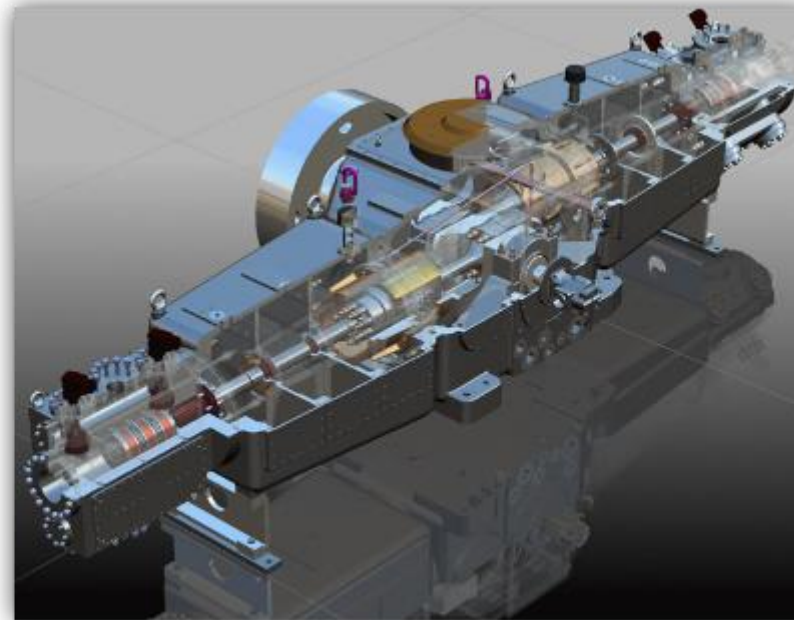


Piston Ring
Wear "Mud"
On Inside
Valve Cover
Surface



Parts that are not regarded as typical “Wear Parts”:

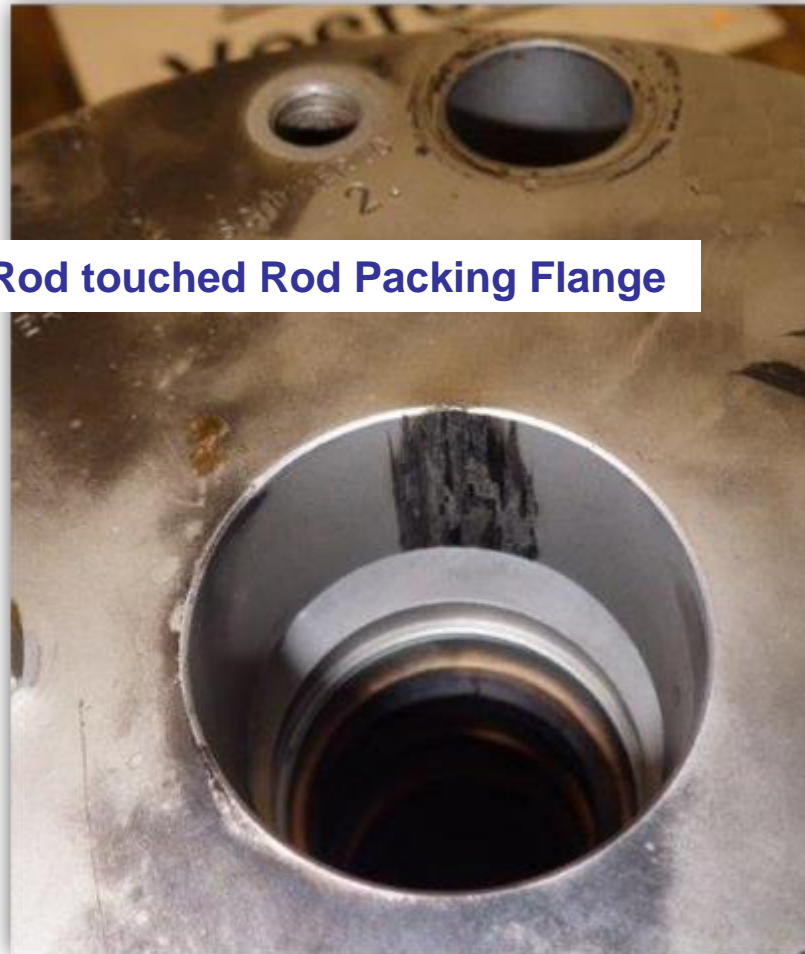
- Piston Rods
- Pistons
- Cylinder Liners
- Bearings and Crankshaft Journals
- Crossheads, with Liner and Pin
- Fasteners (Bolts & Nuts)



Installation, Operation & Maintenance



Piston Rod touched Rod Packing Flange



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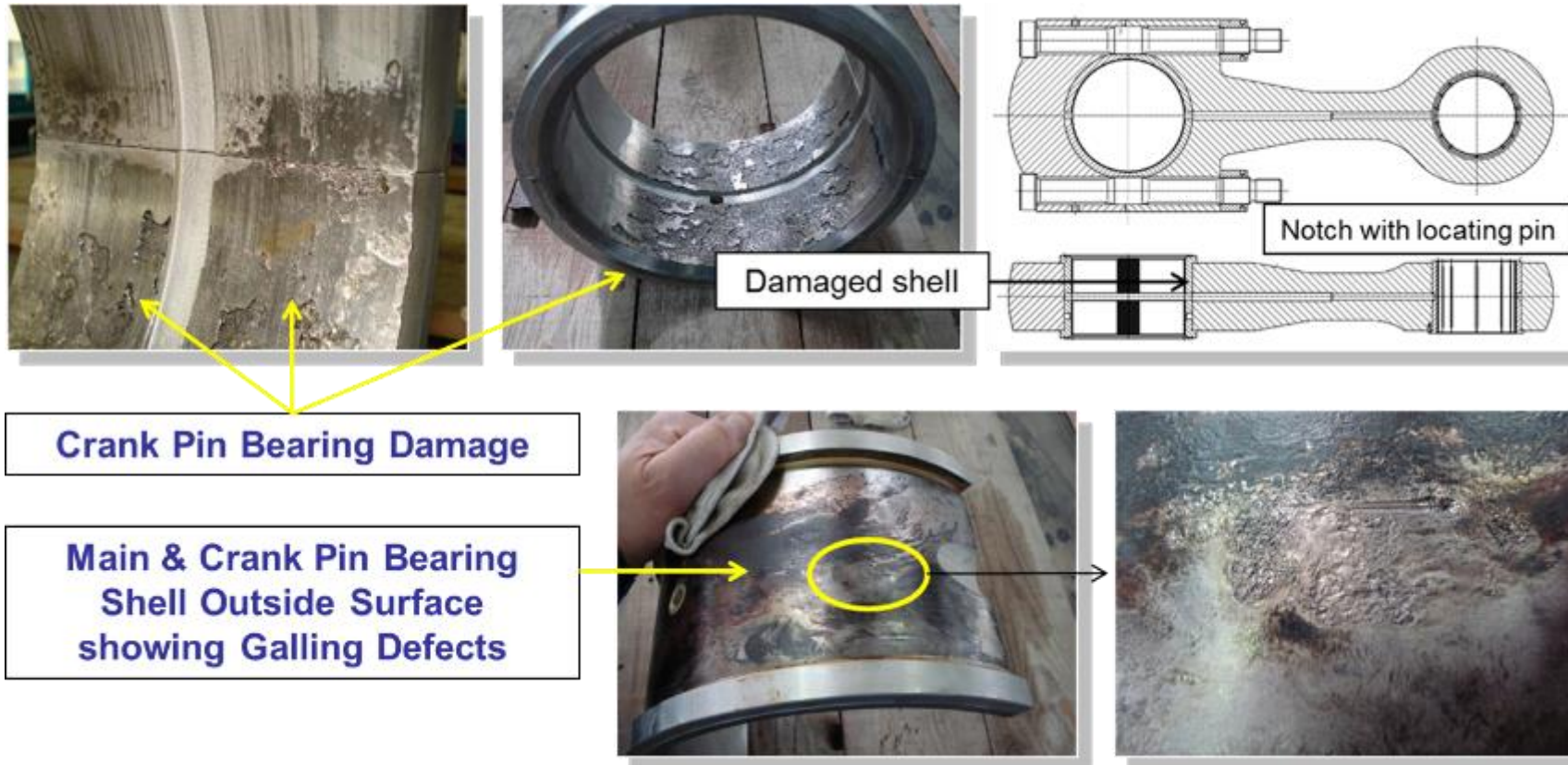
- Abrasive Material imbedded in Ring Surface →



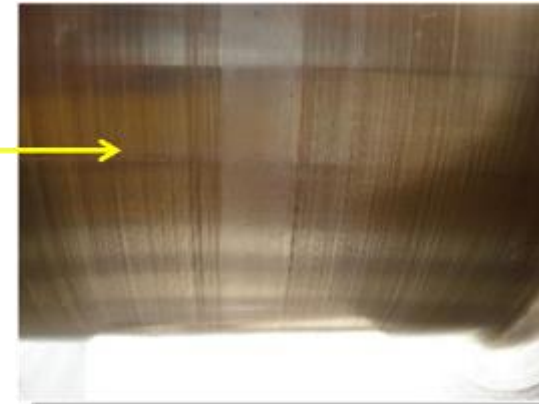
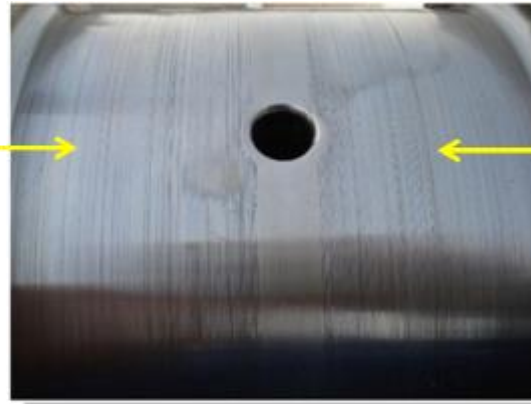
- Piston Groove Quality (Coating; Hardness) →



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**Crank Pin
Bearing Journal
Damage**



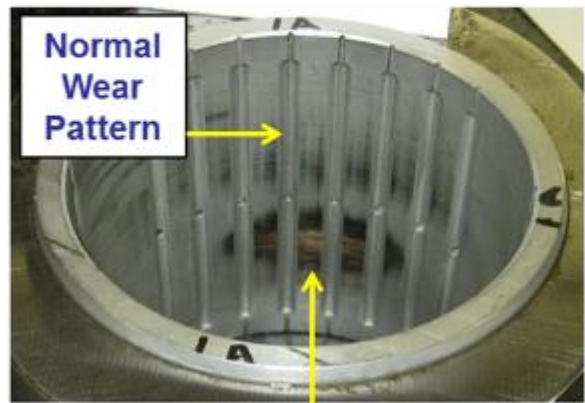
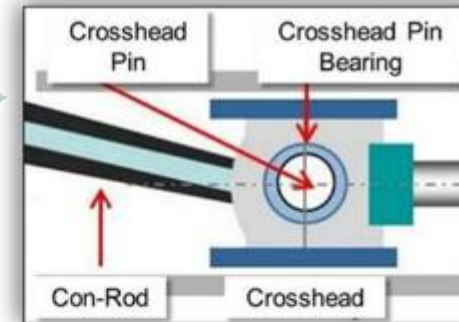
**Main Bearing
Journal Damage**



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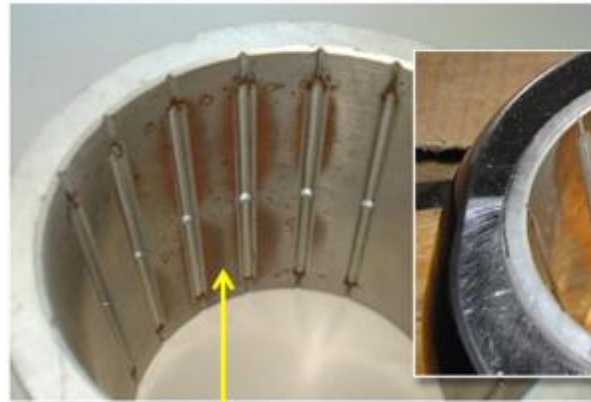
Key Parameters for Xhead Pin Bushing Endurance vs. Wear:

- Rod Reversal vs. Bearing Load
- Oil Filling Time as a Function of Speed
- Number of Oil Grooves vs. Load Carrying Area
- Oil Viscosity



Normal
Wear
Pattern

Local Wear
Pattern



Obvious Wear Pattern;
Still o.k. if Surface is smooth and
Bearing ID within Spec.



Bearing "Gone"
Replacement !

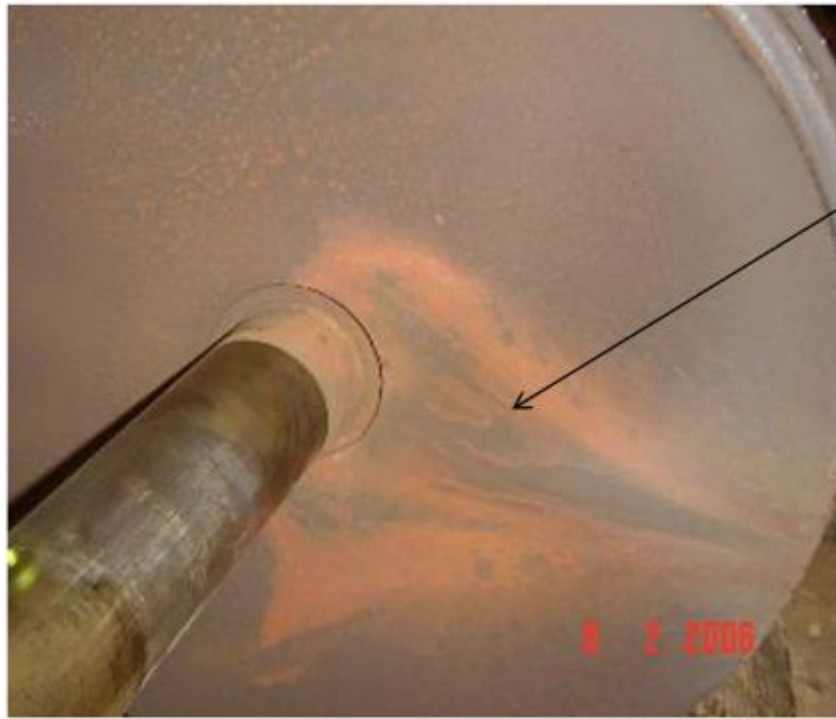
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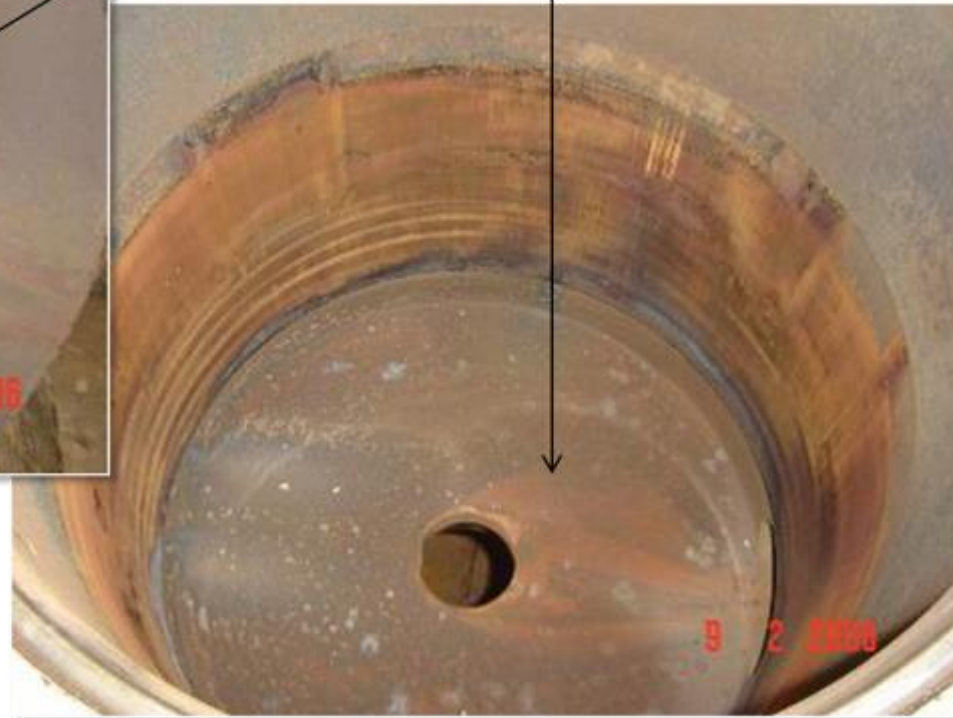
Some of the studs presumably cracked quite a while before the actual catastrophic failure occurred - because bolt crack surfaces were corroded.

When > 50% of the bolts had failed the cylinder disintegrated from the frame with significant consequential damage.

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Signs of a Darting Flame indicating
Liquid being pushed – usually towards
the Discharge Valve

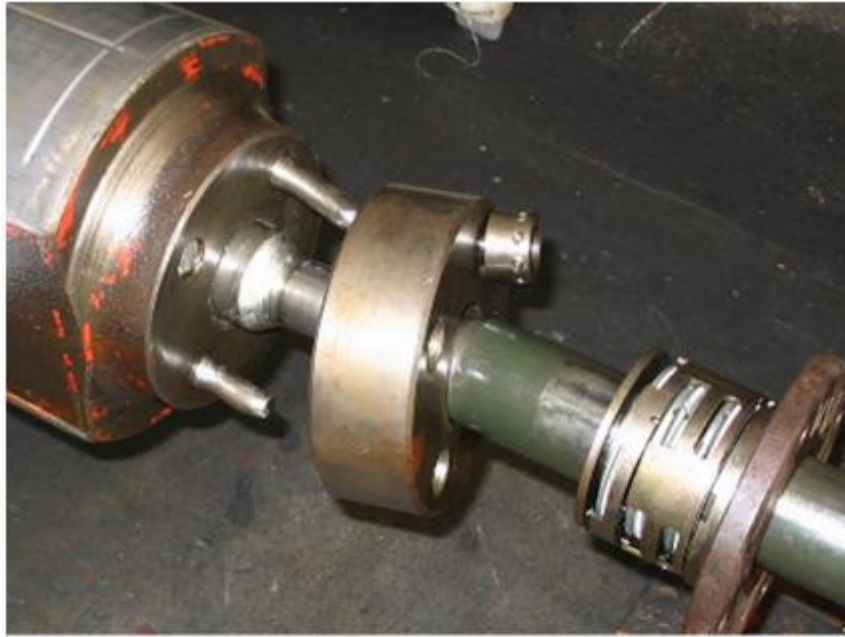


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Piston dis-integrated from water which had been forwarded into cylinder – due to poor condensate removal

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Piston rod to crosshead connection pulled apart from water that had been trapped inside cylinder – with consequential damage from continued rod back and forth movement

Maintenance

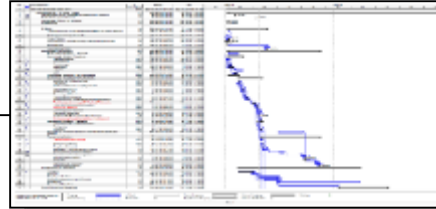
Organisation

Installation, Operation & Maintenance



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- **Job Schedule**
- **Human Resources Plan**
- **Site Coordination**
- **Documentation**
- **Cost Assessment and Controlling**
- **Internal Project Follow-up**
- **Reporting**

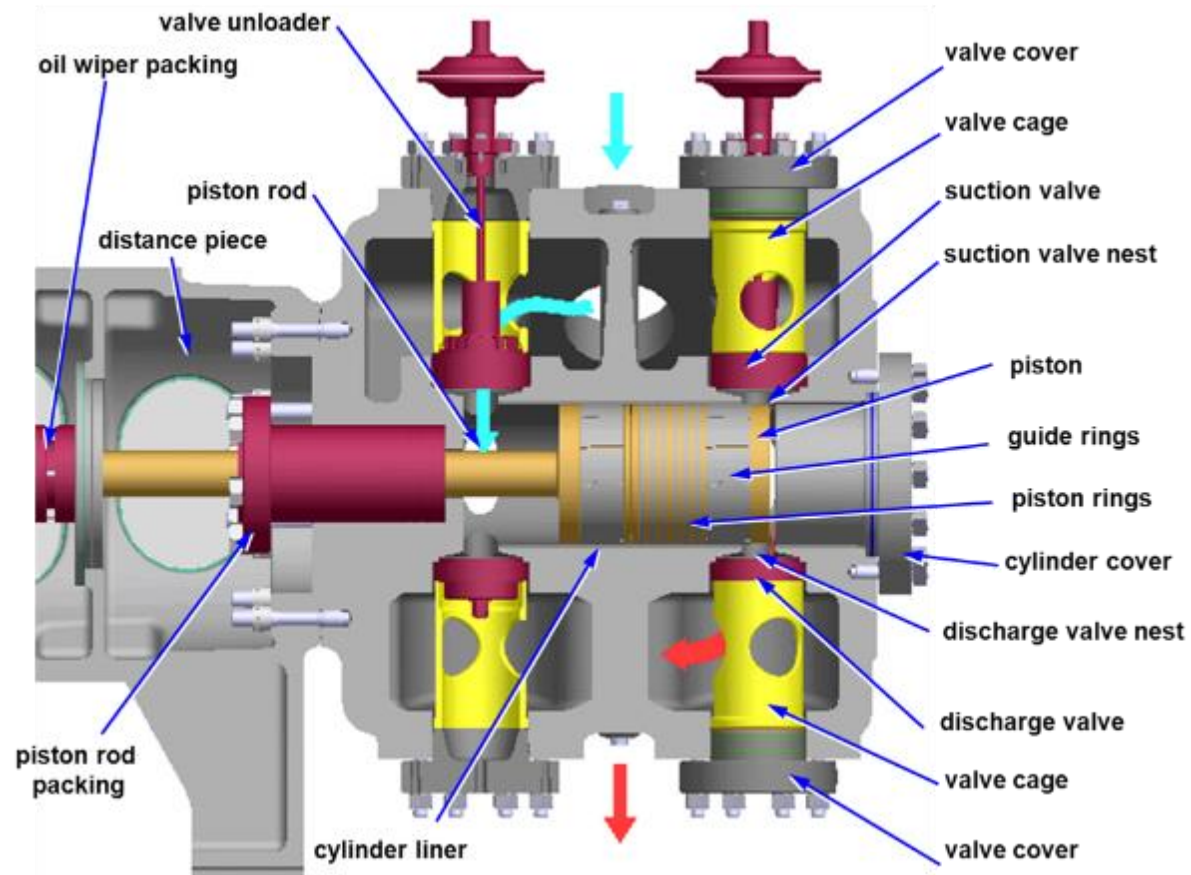


A screenshot of a personnel planning table. The title is 'Personnelplanung Projektion V20-5'. The table has columns for months (Jan to Dec) and rows for different personnel or tasks. It shows a detailed schedule with various colored blocks indicating different activities or resource allocations over time.



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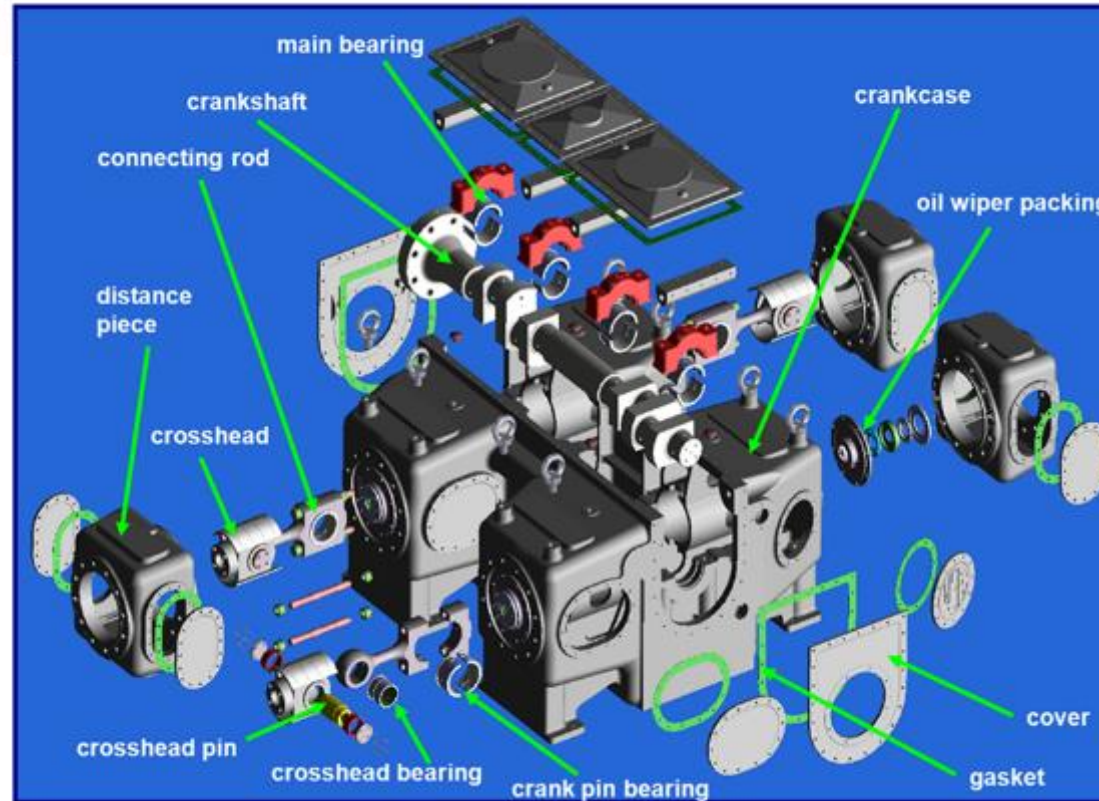
**!!! Make sure all
required Spare Parts
are in Stock !!!**
**And be prepared that
more Spare Parts
may be needed than
expected and
scheduled !
Plan "B" ?**



... and DO NOT forget Gaskets and O-Rings !

!!! Make sure all Technical Documentation is available; particularly:

- 1. Clearances, Gaps & Tolerances (e. g. for Bearings and Cylinder End Gaps)**
- 2. Torque Values for all major Fasteners**



Valve & Packing Replacement

Two Options:

1. Remove; take apart; clean; check; install new internals; take the risk of assembly error; finally put back into machine after ? Days.
2. Remove; install refurbished complete and refurbished spare immediately; have machine closed asap; send used/worn parts to OEM for refurbishment; without any time shortage. Investment for spares vs. time saving is often neglectable

**Note: In case of frequent and/or
abnormal wear/damage:
Contact OEM for remedy options !**



Exclusive Stock (Consignment Stock)

- **Stocking of parts**
 - Through OEM / Service Provider at customers site
 - At OEM / Service Provider premises
- **In Time Stock Refilling and Follow-up**
- **Overhaul and Repair Management**
 - Improvement Projects on Wear Parts
 - Extended “Pro Rata” Warranty



!!! Consignment Stock avoids Spare Part Shortage !!!

**Careful treatment, thorough observation
and regular or in-time maintenance
of the machine and its accessories
are the best preconditions
for cost efficient
and trouble free
operation**

Why does everyday practice often try to tell us differently ... ?

Also lautet ein Beschrift,
Daß der Mensch was lernen muß.



Daß dies mit Verstand geschah,
War Herr Lehrer Lämpel da.



Thank you for your attention

**Now it is time for
Questions**

?