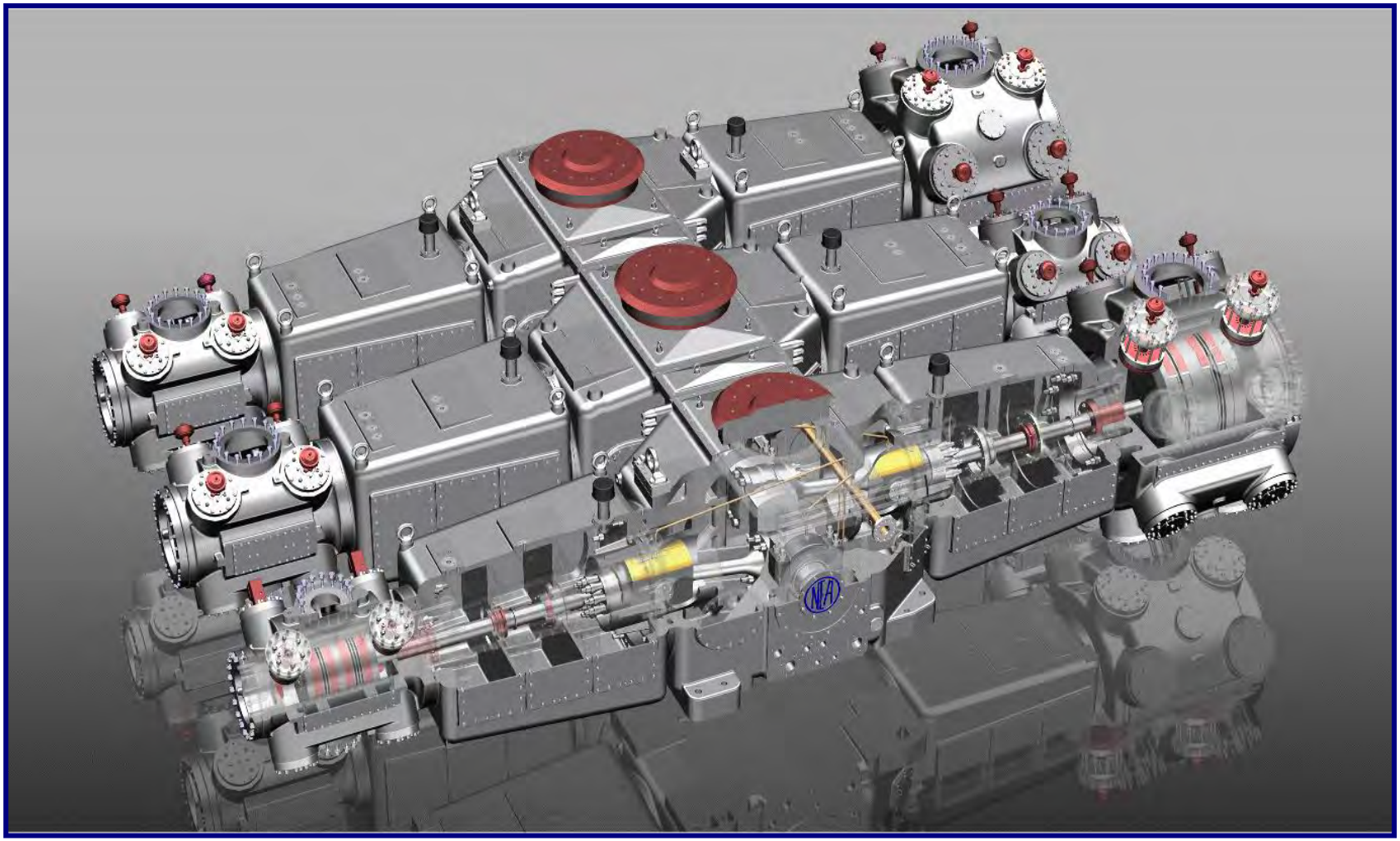
EFRC Training Workshop

Basic Training

Installation and Maintenance

Harry Lankenau – NEAC Compressor Service



Installation

Installation / Solid Footware for the Compressor

When the compressor is dispatched from the workshop it is practically "barefooted".

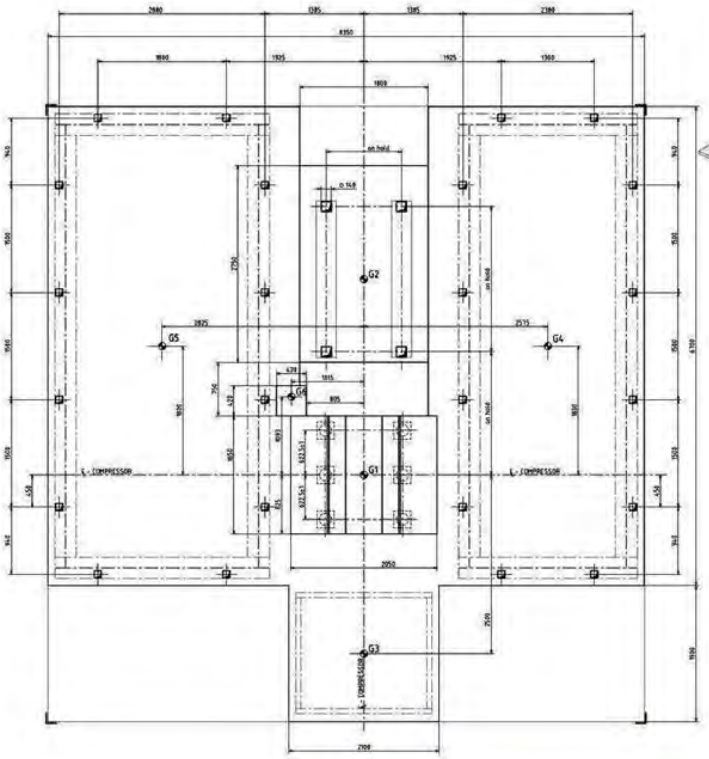
At site the "shoes" are fitted to "run" well.

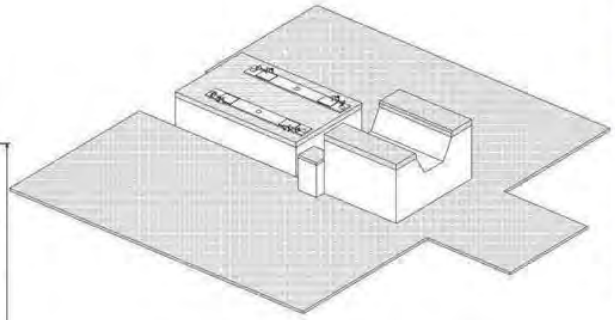
The "footwear" of the compressor is that what links it to the foundation:

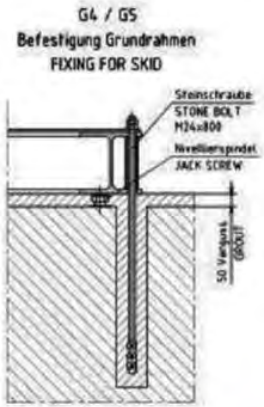
1. Skid or
2. Anchorage and
3. Grouting

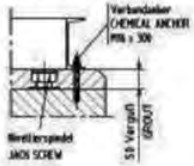
... and underneath is the foundation which shall be designed and built such to be a solid "walkway" !

Installation / Foundation Check – vs. Plan



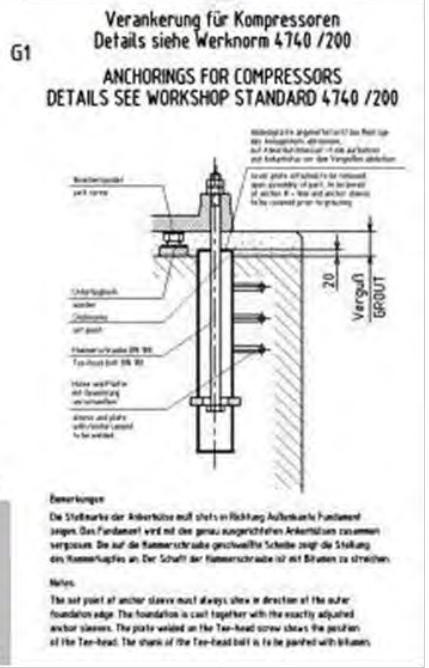






Check:

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



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

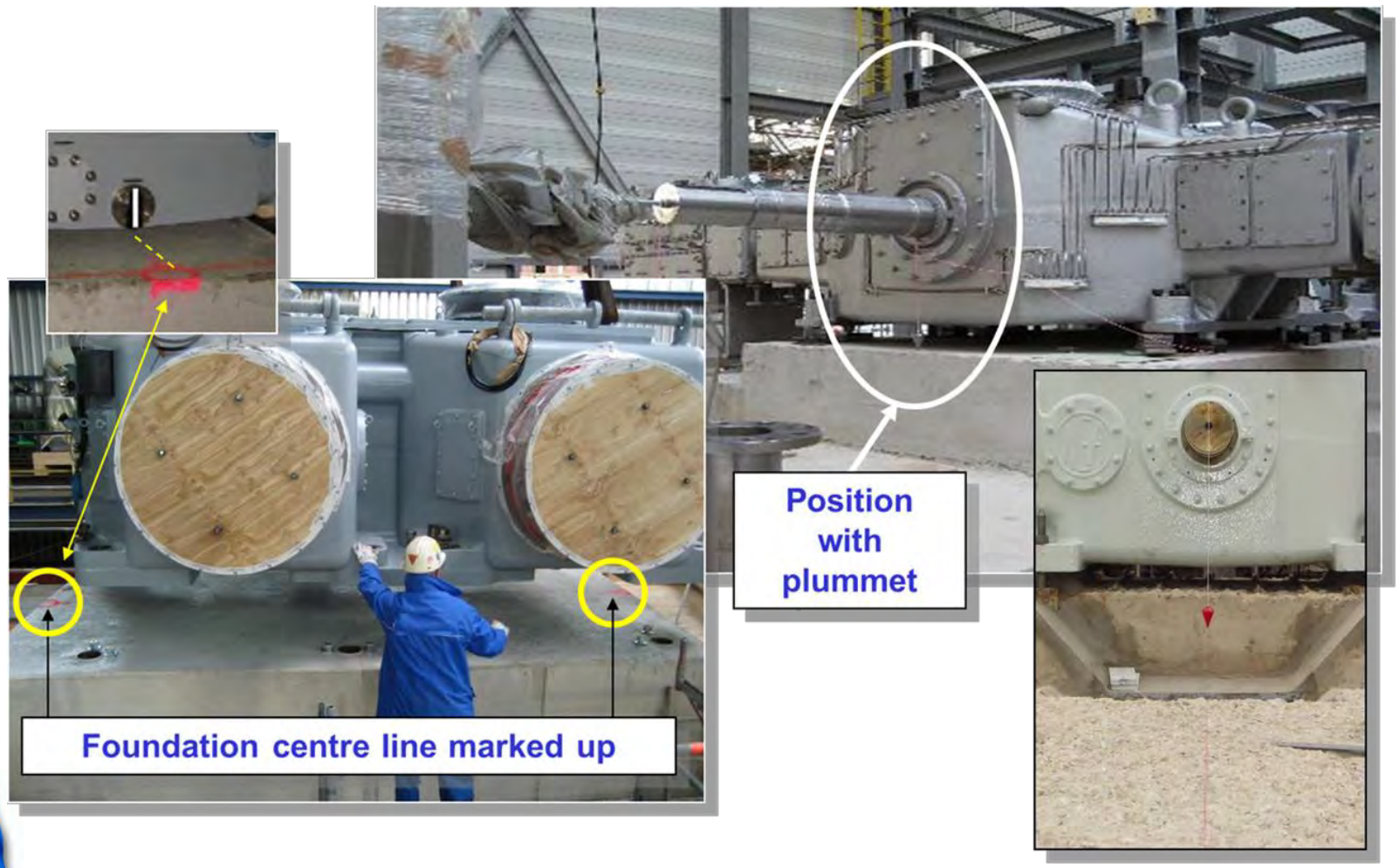
Installation / Foundation Check & Spindle Position

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.

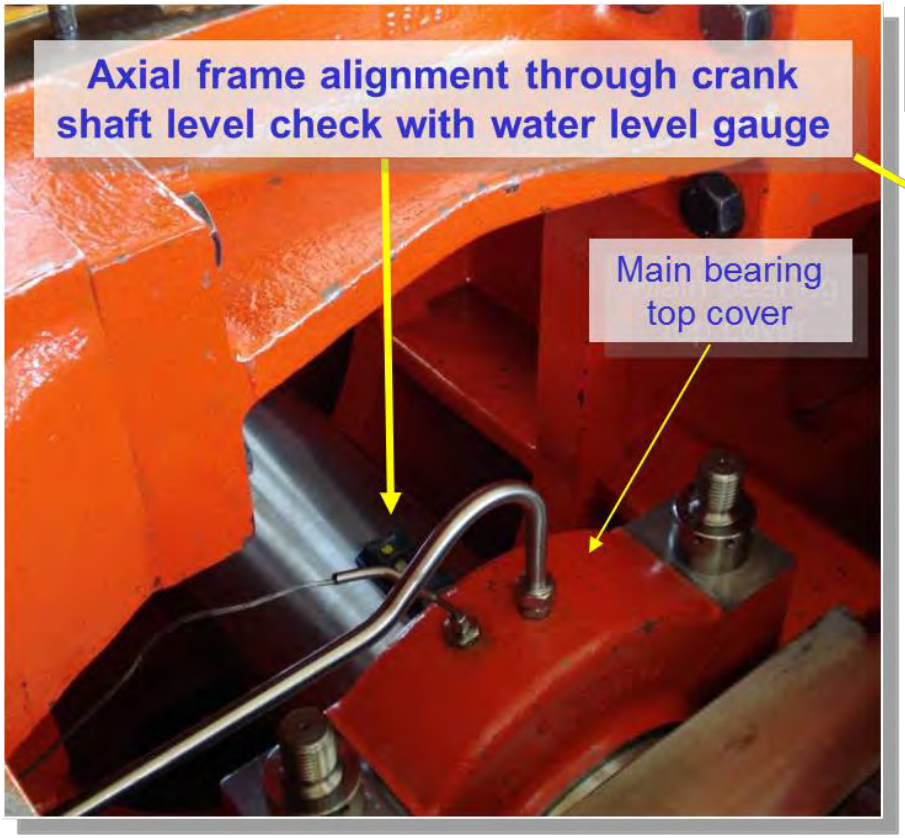
Put jacking spindles in place and check proper level.

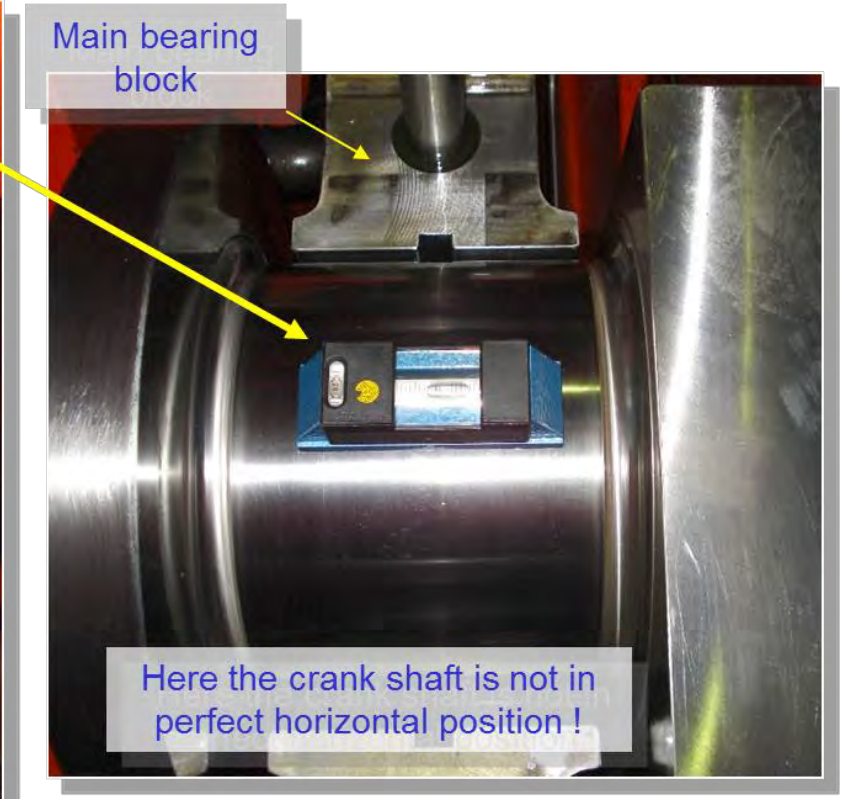
Foundation with pre-arrangement of levelling spindles prepared

Installation / Frame Flying-in and Positioning



Installation / Frame Level Check – Crankshaft

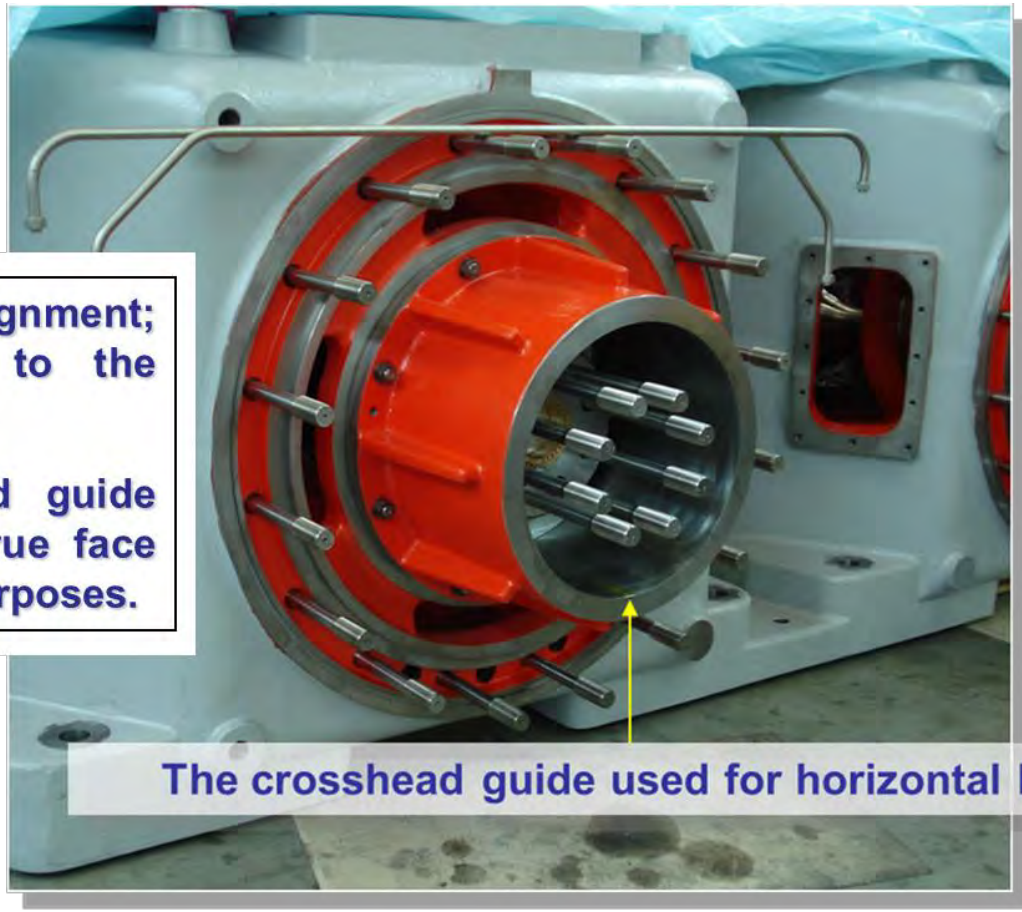




Installation / Frame Level Check – Crosshead Guide

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

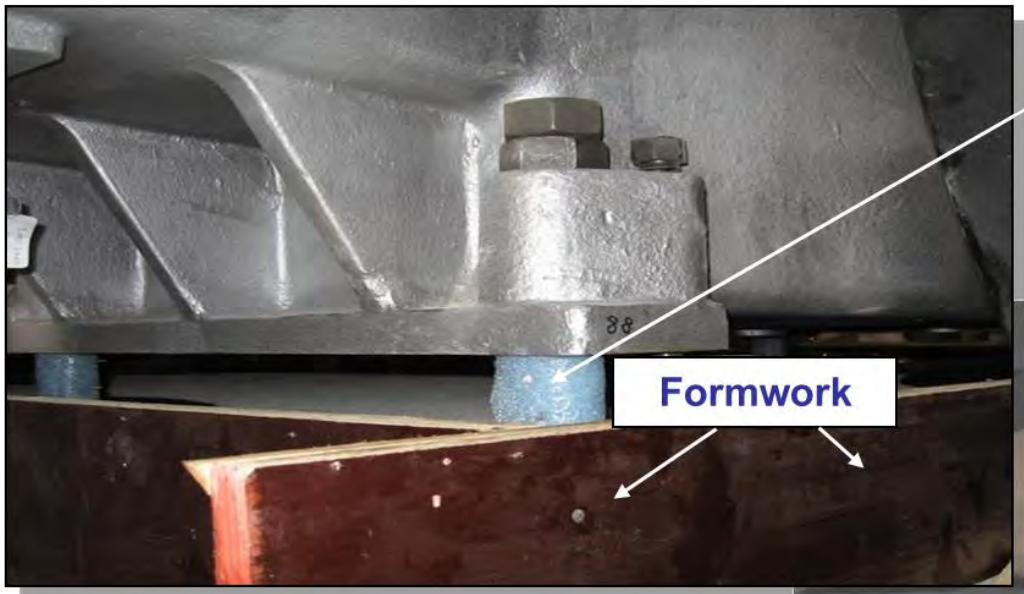
Installation / Frame Level Check – Frame Top

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 / Grouting Preparations



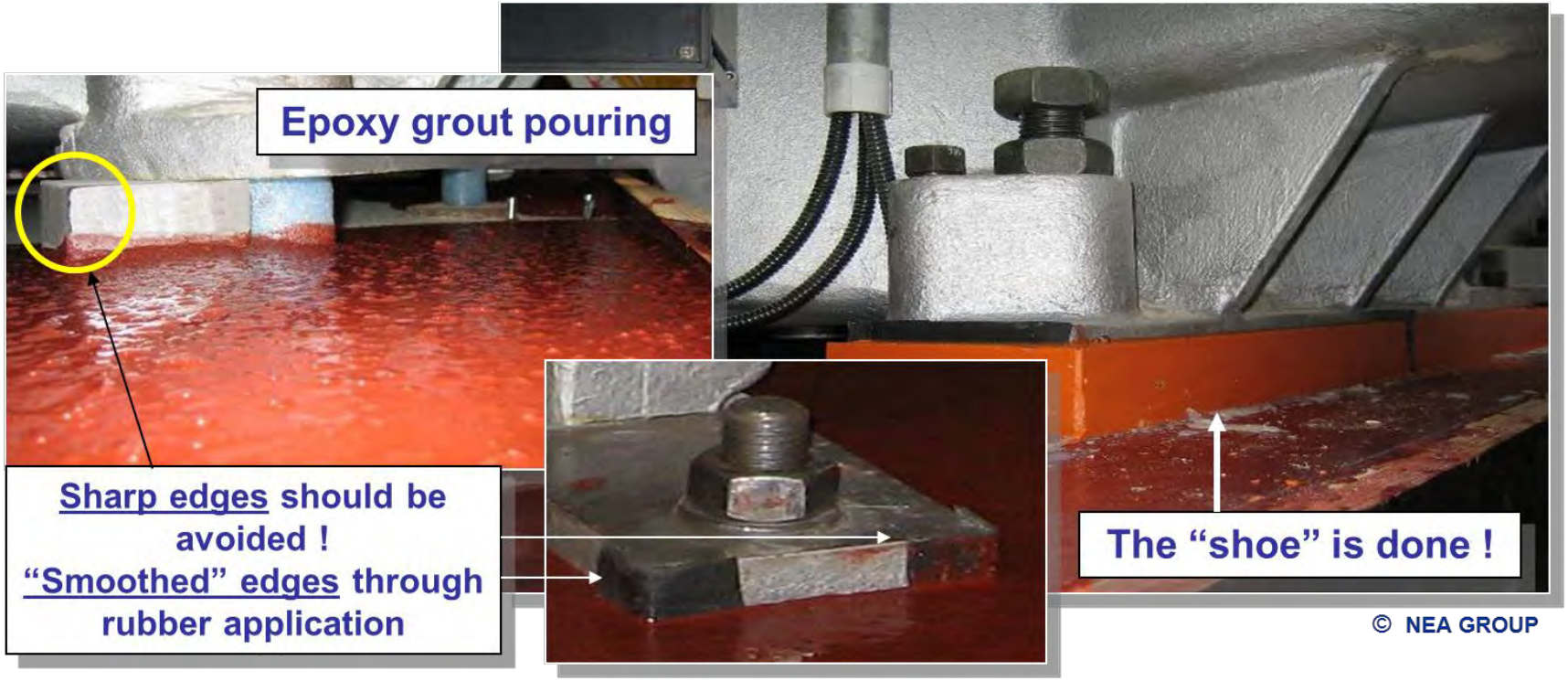
Wrapping of the anchor bolt with plastic foam, rubber or tape (*)

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.

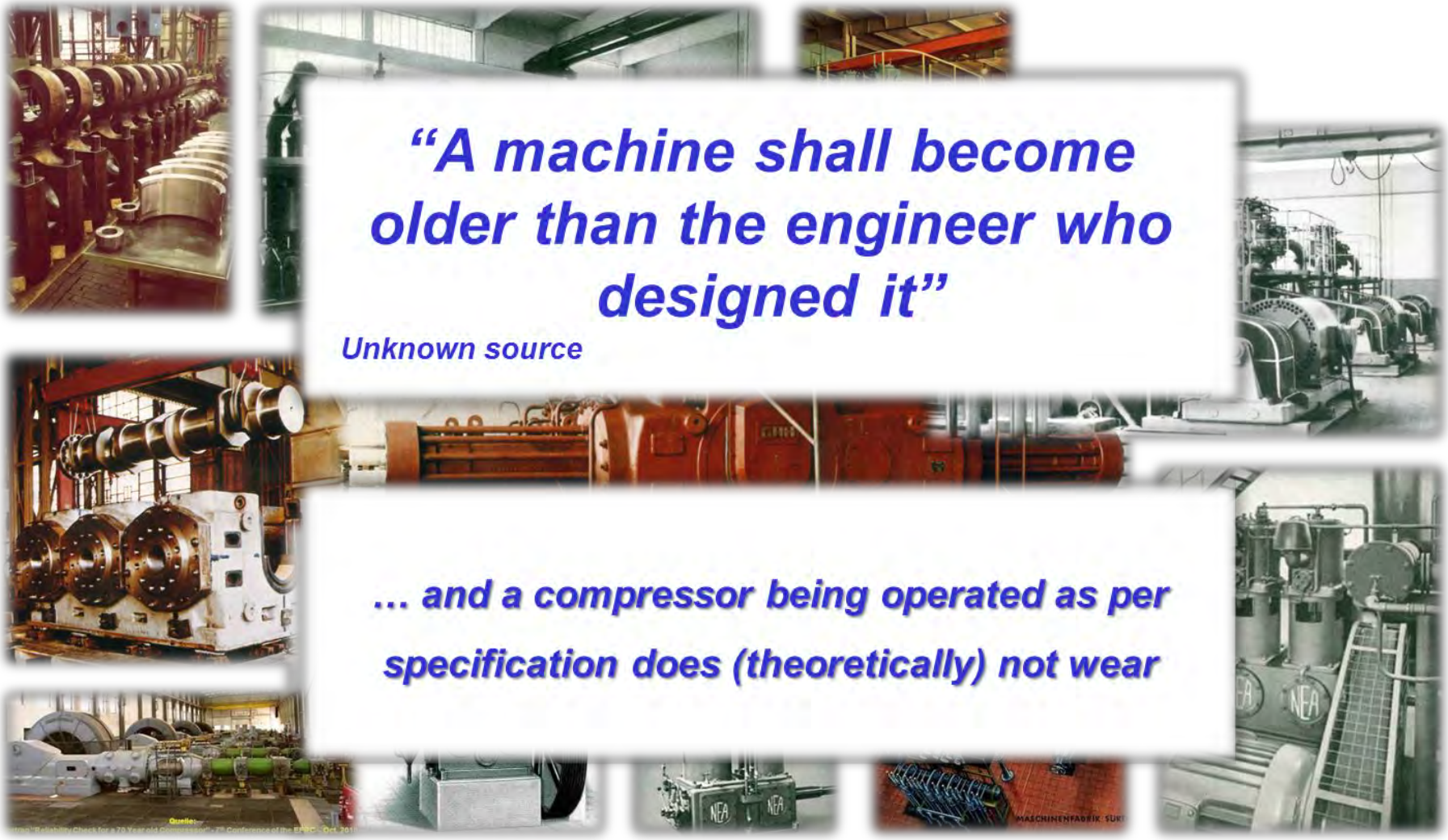
Installation / Grouting Procedure & Final "Shoe"



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



"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

Maintenance / General Aspects

- **Exception:** Wear Parts





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

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

Maintenance / Unpredictable Phenomena

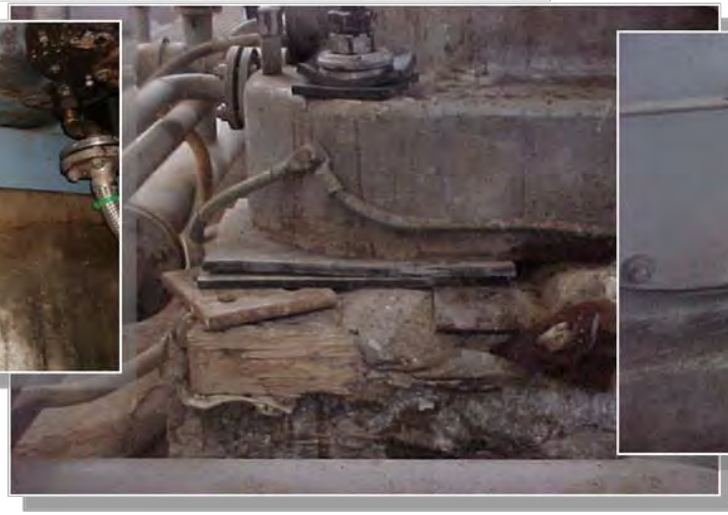
Not assessable Loads and Wear Phenomena:

- **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

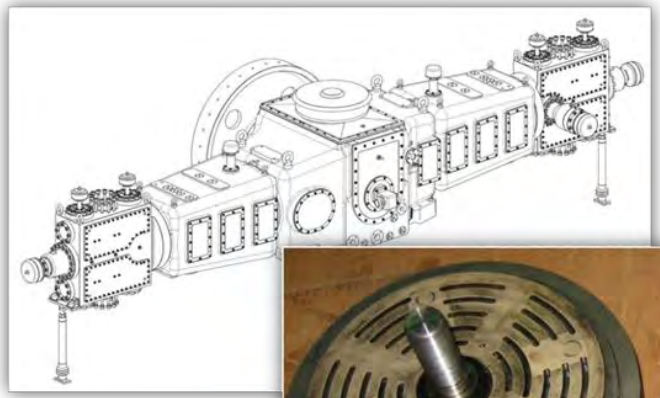
Maintenance / Foundation "Wear and Tear"

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



Maintenance / Wear Parts
Valves

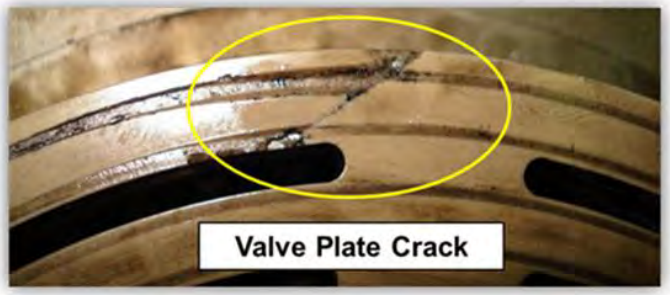


Hydrogen Recycle Compressor

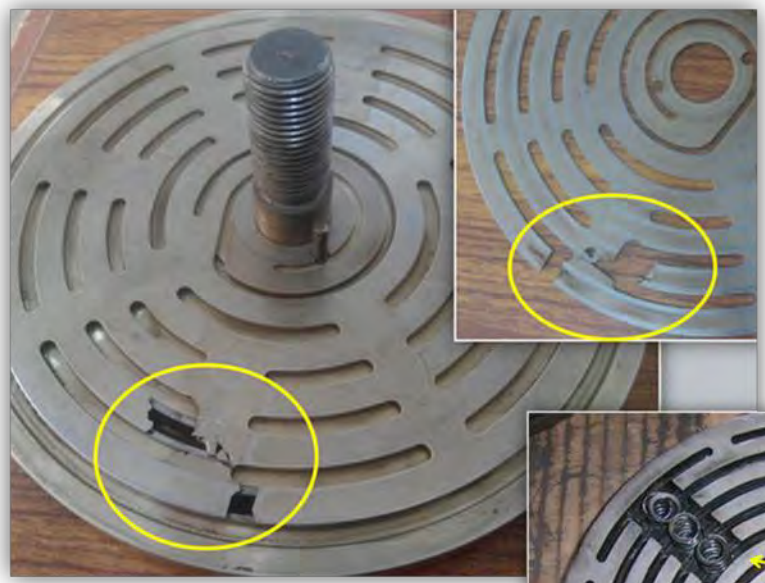
Pressure in/out: 120 → 150 bar

Lubricated Service

Valve Failure



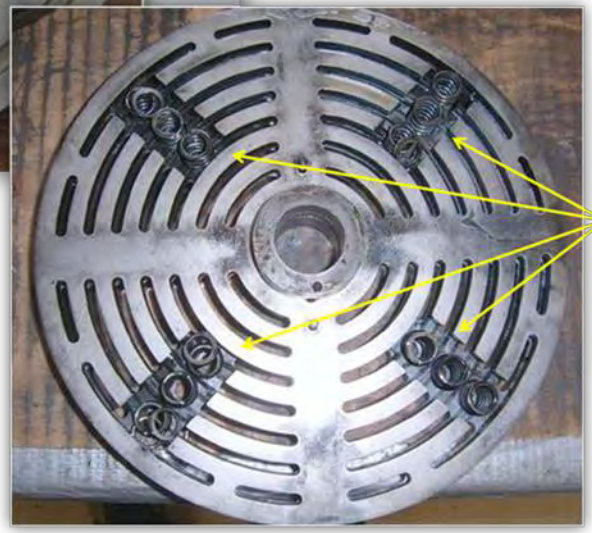
Maintenance / Wear Parts
Valves



Broken Valve Plates

Valve Housing Wear

Worn & Broken Unloader Fingers



Slack and/or broken Valve Springs

Valve Failure

Maintenance / Wear Parts
Valves

Valve Failure

Condition found when removed from machine and opened

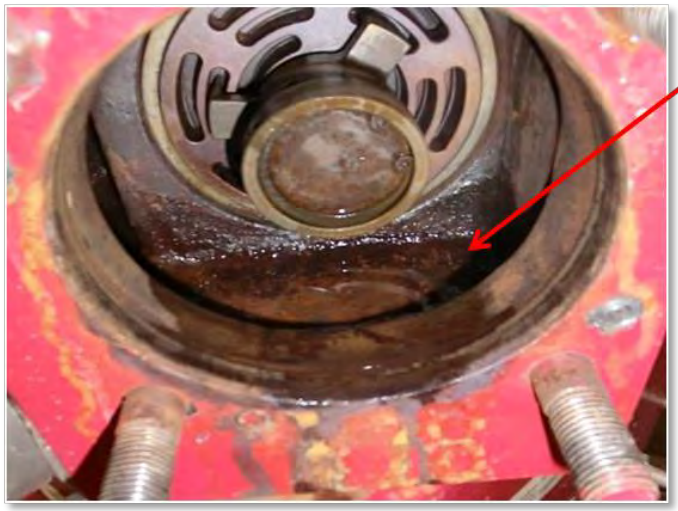
Cleaned for Photo Shooting
Some Rings broken in various Pieces

Missing Ring Pieces

Maintenance / Wear Parts
Valves

Wet Air & CO_2 Application Valve Failure

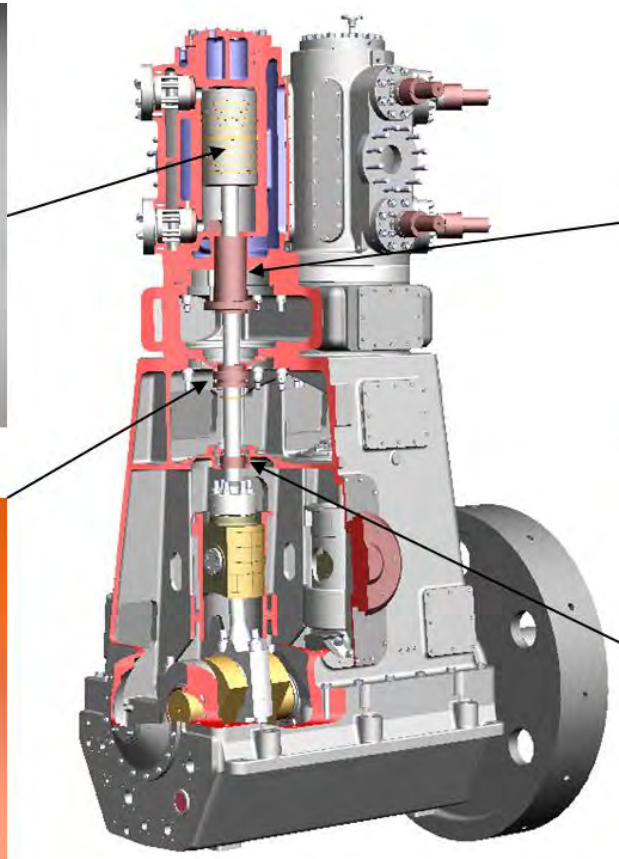
Suction Valve 2nd Stage: Water trapped in valve pocket. Valve cage is wet



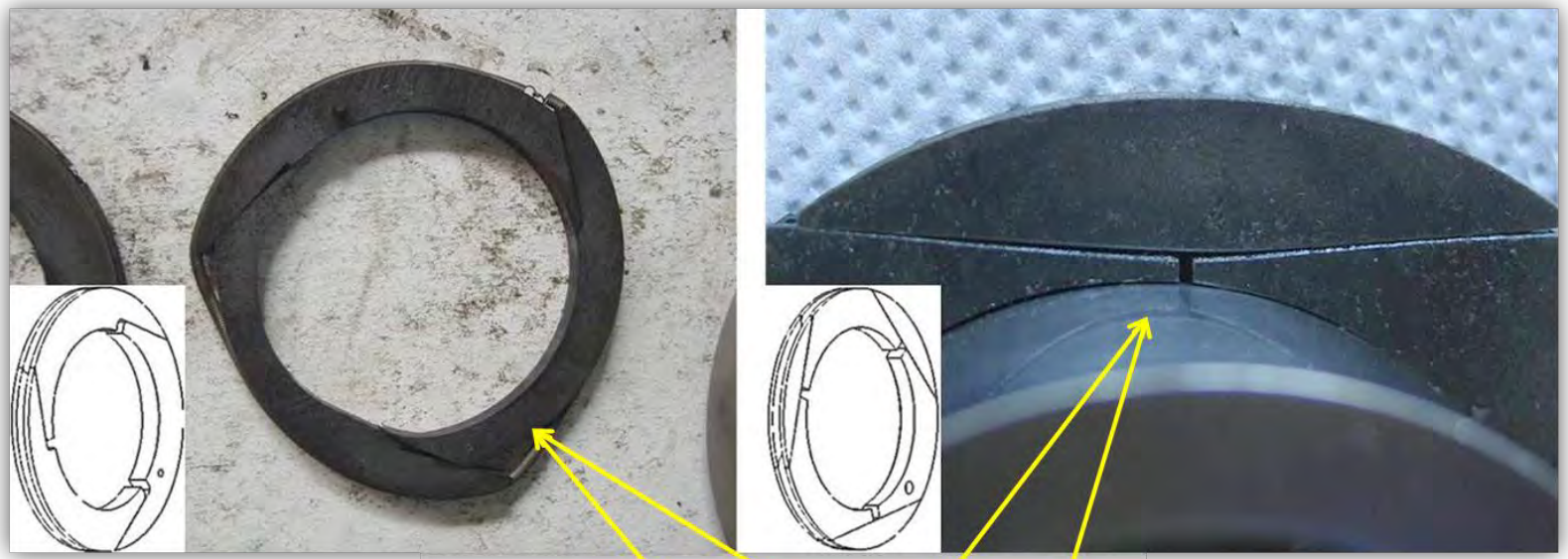
Indication of poor water separation and/or insufficient condensate drain

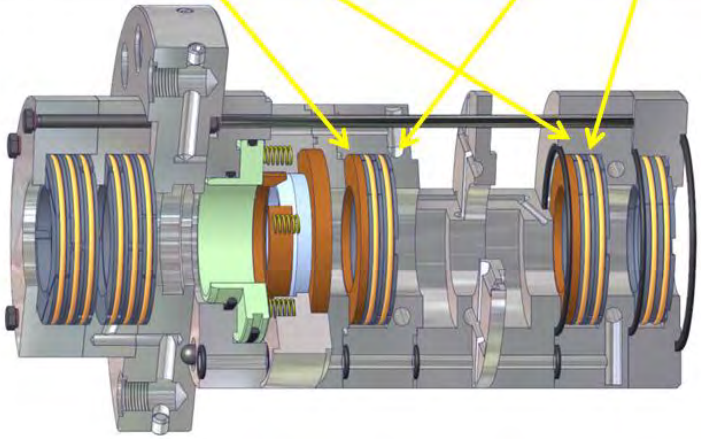
Maintenance / Wear Parts

Rings & Packings



Maintenance / Wear Parts
Piston Rod Packings





Piston Rod Packing Element Failure

Maintenance / Wear Parts
Packings

Piston Rod Packing Spring Failure

View

Maintenance / Wear Parts
Piston Rings

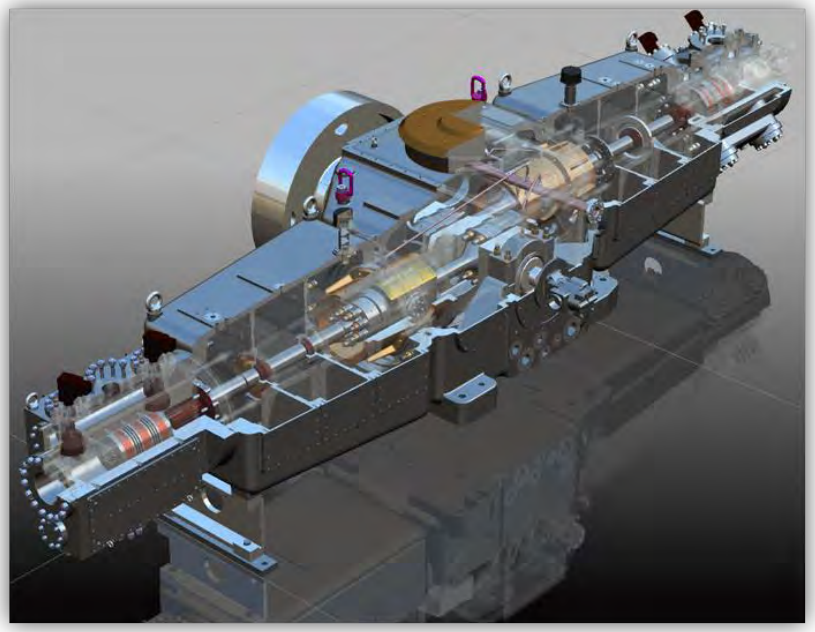
Excessive Piston Ring Wear

Piston Ring Wear "Mud" On Inside Valve Cover Surface

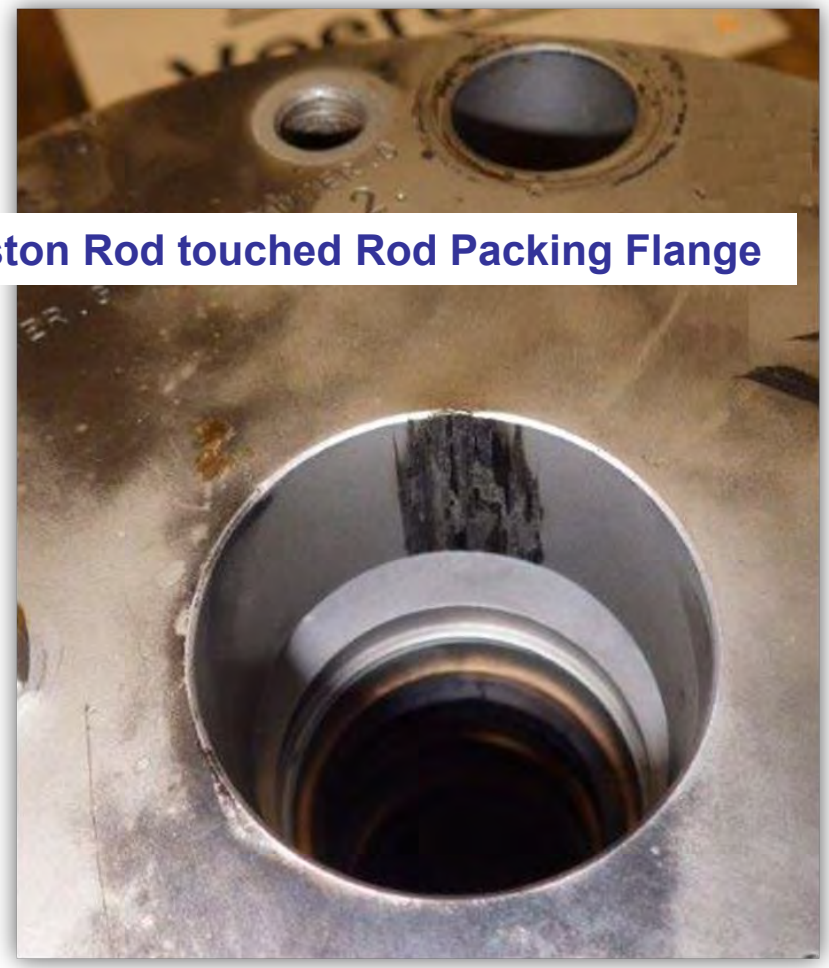
Maintenance / None Regular Wear Parts

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)



Maintenance / None Regular Wear Parts
Piston Rods



Piston Rod touched Rod Packing Flange

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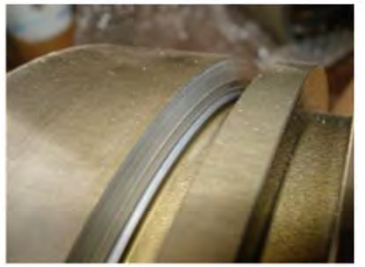
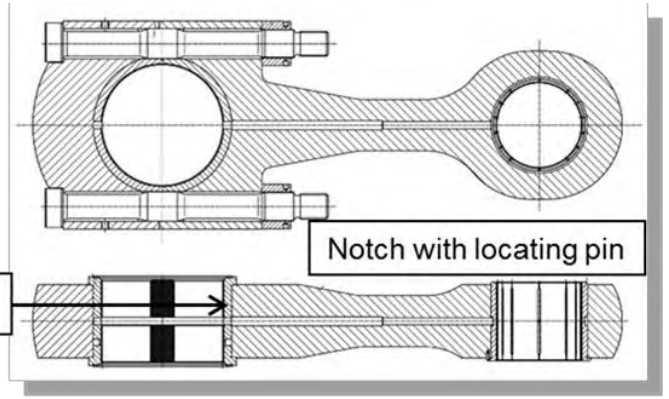
Maintenance / None Regular Wear Parts
Pistons

- Abrasive Material imbedded in Ring Surface →

- Piston Groove Quality (Coating; Hardness) ⟶

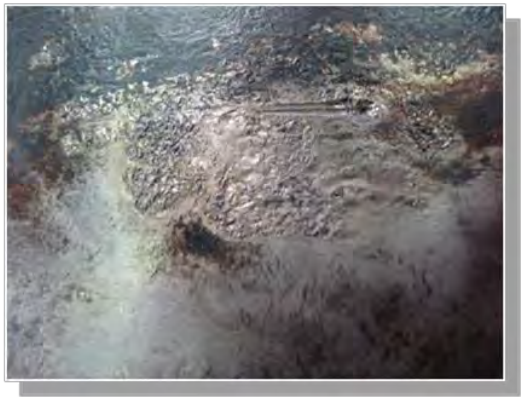


Maintenance / None Regular Wear Parts
Bearings & Crankshaft Journals

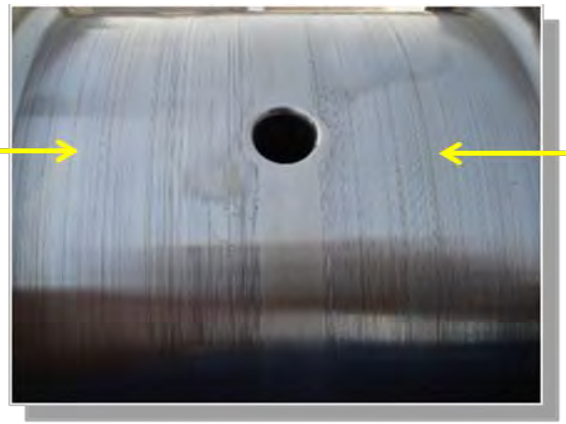


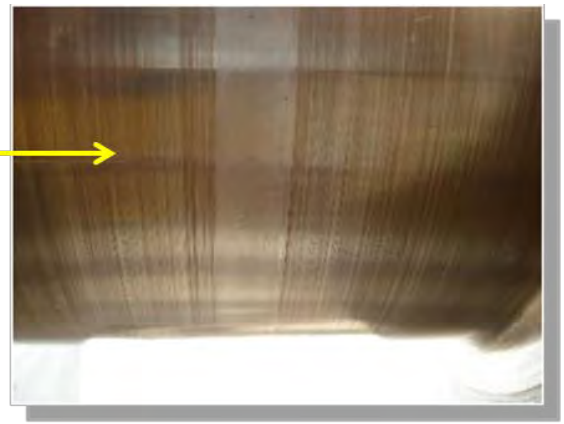
Crank Pin Bearing Damage

Main & Crank Pin Bearing Shell Outside Surface showing Galling Defects



Maintenance / None Regular Wear Parts
Bearings & Crankshaft Journals





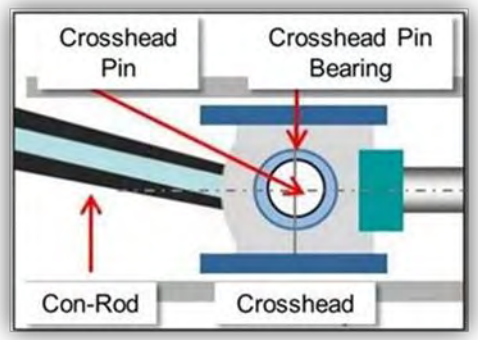
Crank Pin Bearing Journal Damage

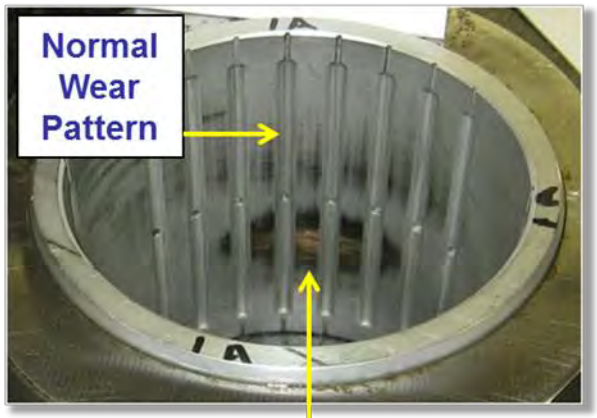
Main Bearing Journal Damage

Maintenance / None Regular Wear Parts
Crosshead Pin Bushing (Bearing)

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



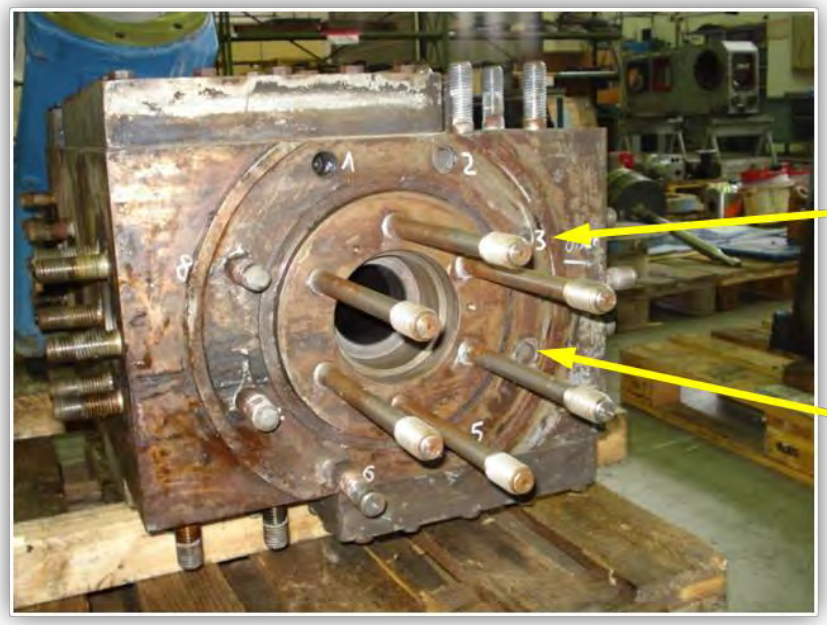


Local Wear Pattern

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

Bearing "Gone" Replacement !

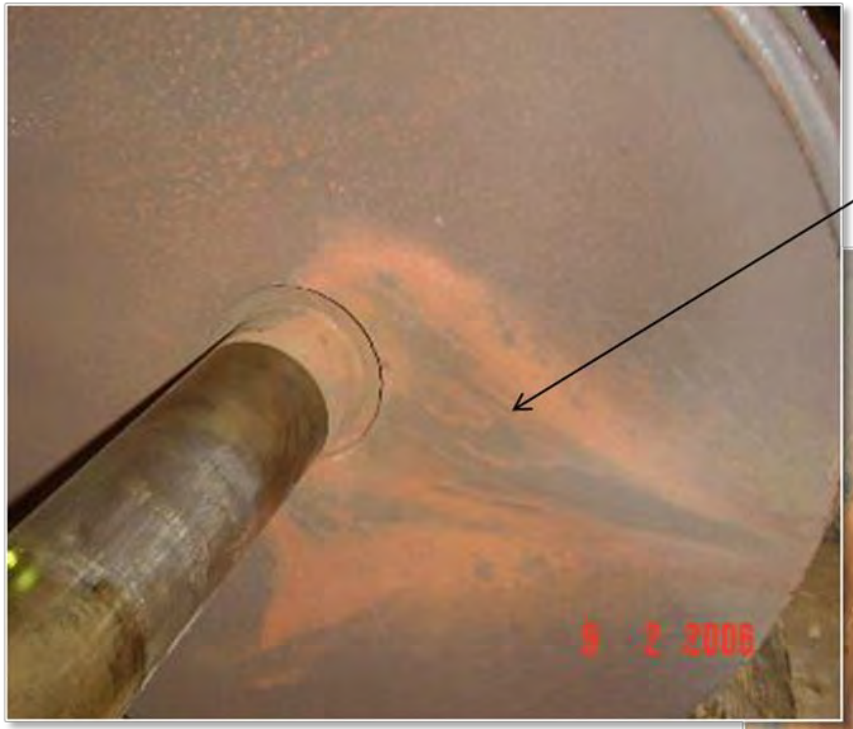
Maintenance / None Regular Wear Parts
Bolt Cracks



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

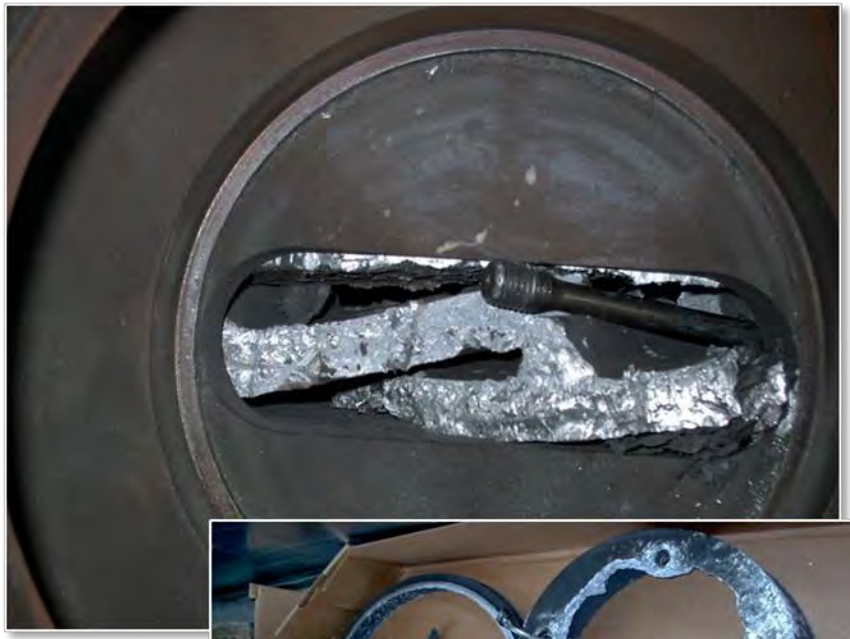
When > 50% of the bolts had failed the cylinder disintegrated from the frame with significant consequential damage.

Maintenance / Unusual Occurrences
Liquid Slugging



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

Maintenance / Unusual Occurrences
Damage from Liquid Slugging

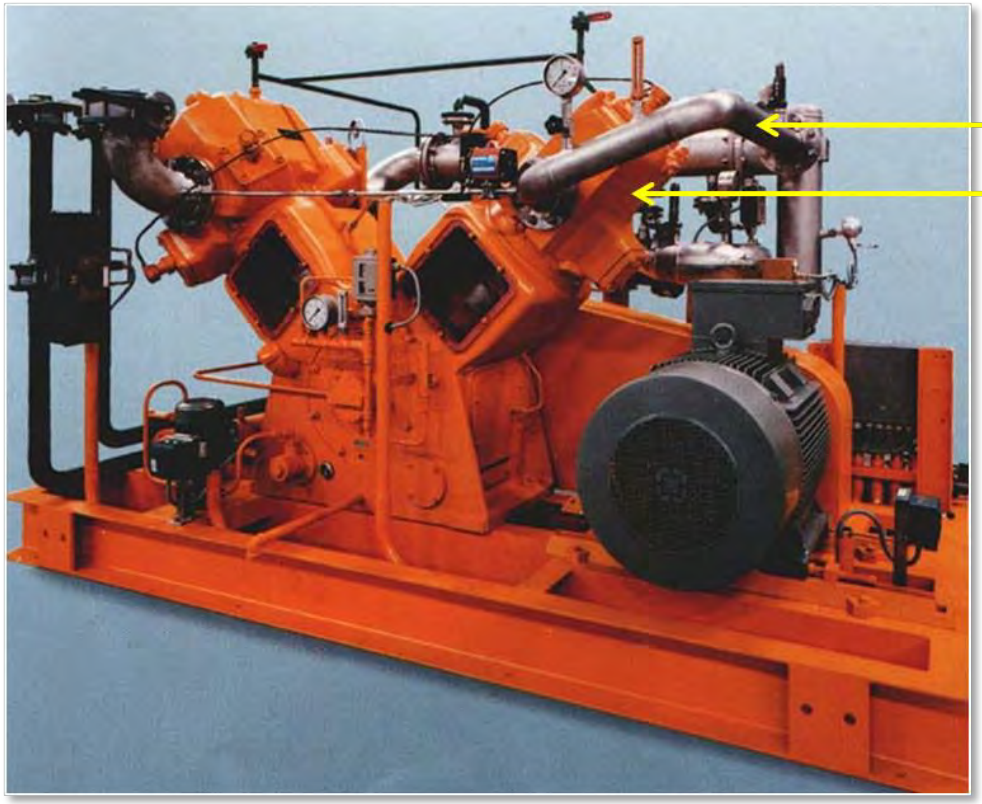


Piston dis-integrated from water which had been forwarded into cylinder – due to poor condensate removal

Maintenance / Unusual Occurrences
Damage from Liquid Slugging

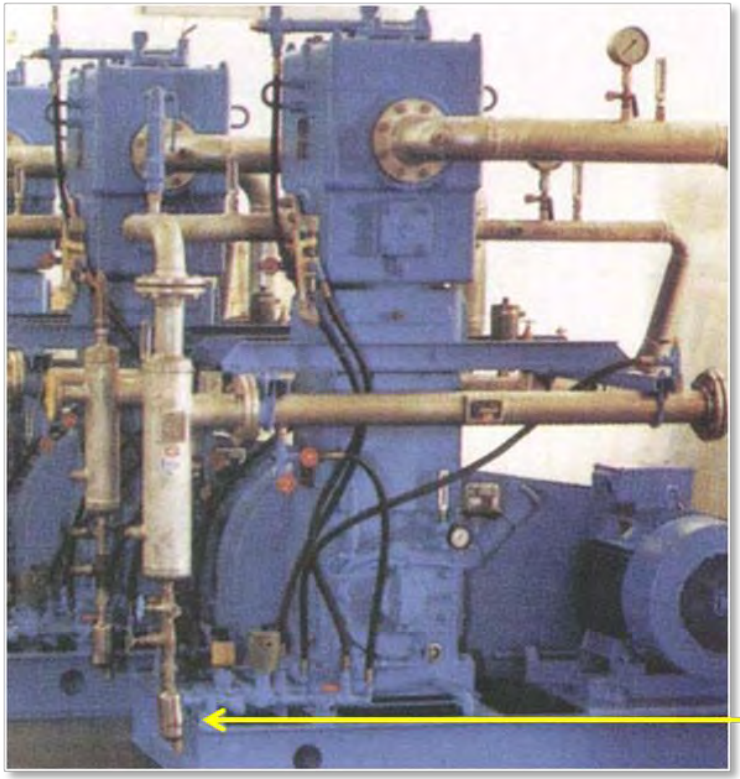
Piston rod to crosshead connection pulled apart from water that had been trapped inside cylinder – with consequential damage from continued rod back and forth movement

Maintenance / Unusual Occurrences
Potential "Secondary" Condensation



- Between separator outlet and next stage cylinder inlet – e. g. through cold wind or low ambient temperature
- Inside cylinder, through cooling water temperature being lower than the gas inlet temperature

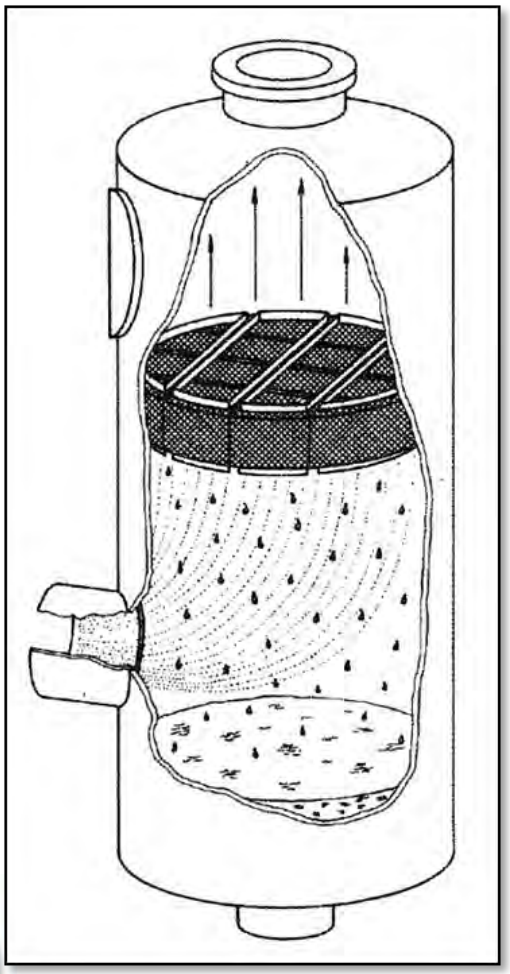
Maintenance / Compressor Units with Separators



➢ Drain Valves – important !

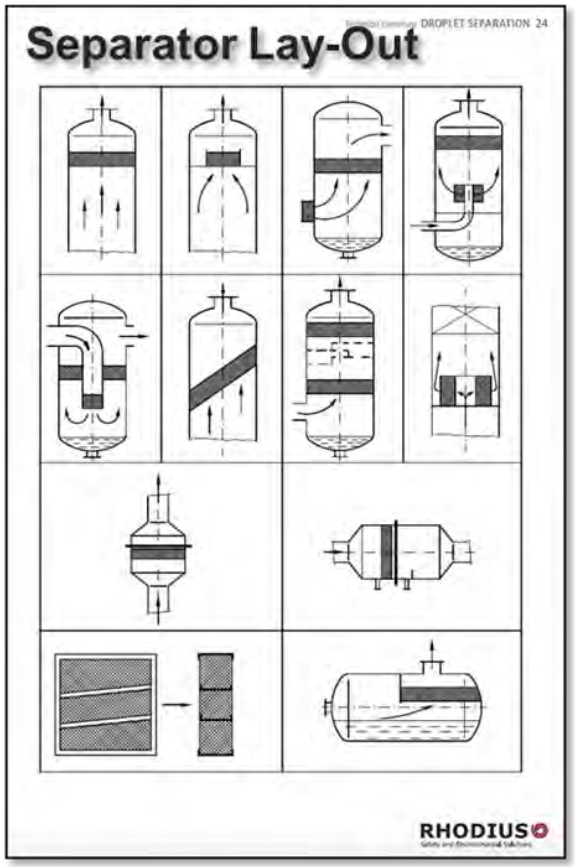
Drain valves and condensate traps at the far end of small tubing may be subject to elevated vibration – and damage – unless properly supported !

Maintenance / Separator Tasks



- Water Condensate Knock-Out
- Gas Condensate Separation
- Oil Mist Removal
- Special Applications
  - Gas Dryer (Humidity Removal)
  - Gas Washer + Separator

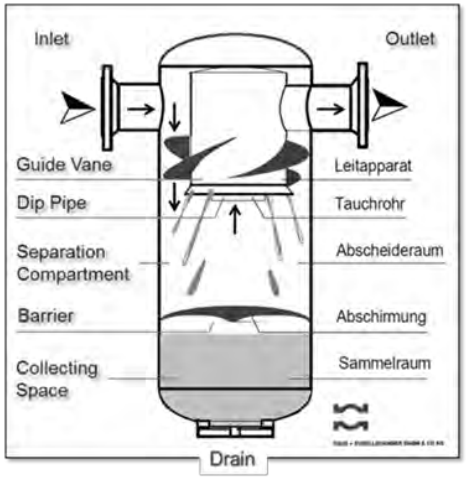
Maintenance / Separator Types



Typical Demister Type

Technical Terms:

- Separator
- Knock-out Drum
- Scrubber
- Mist Eliminator



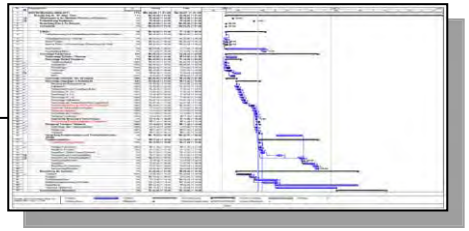
Cyclone Separator

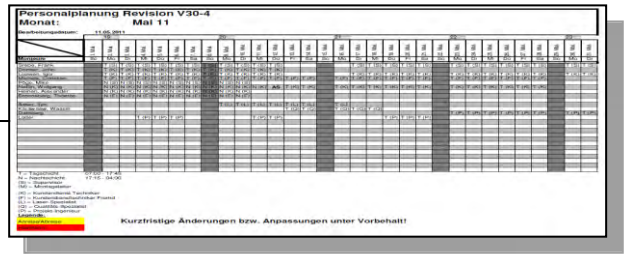
Maintenance

Organisation

Maintenance / Project Management

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



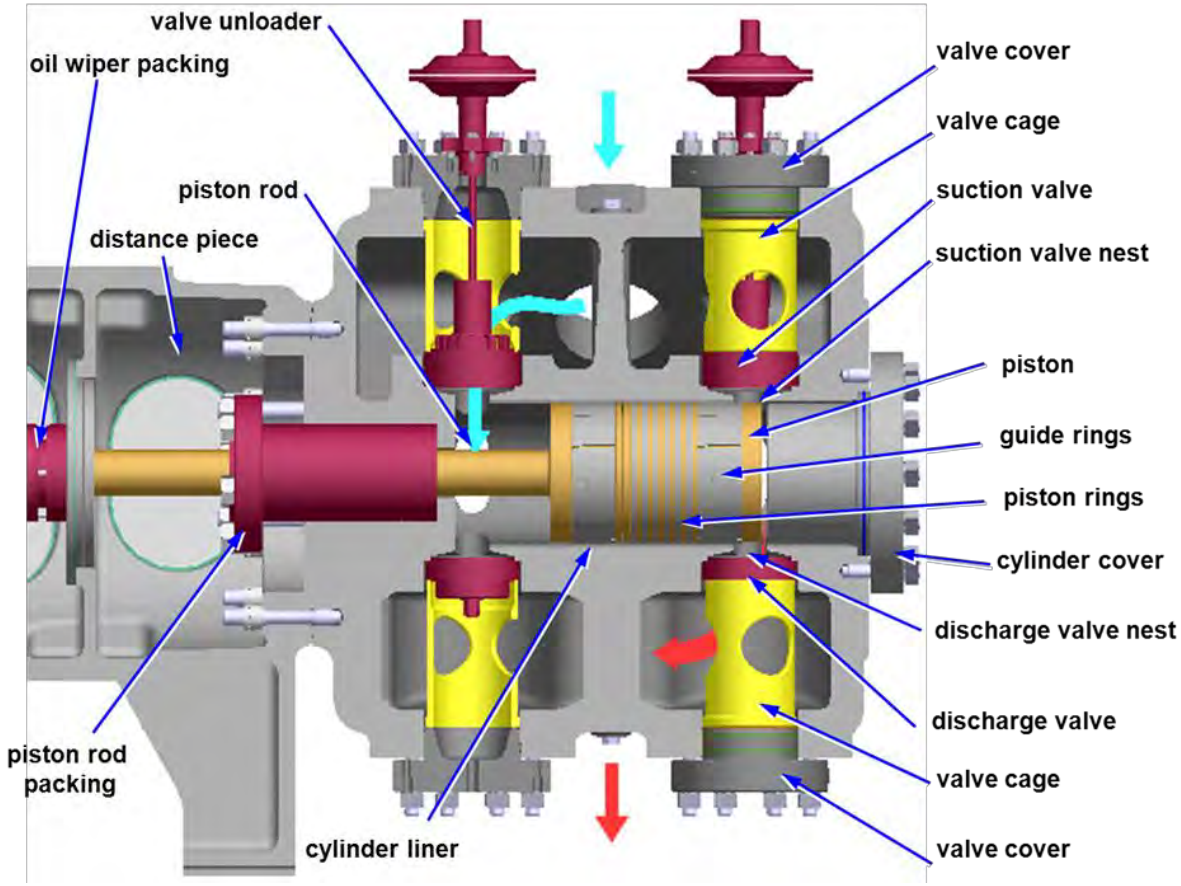


Maintenance / Spare Part Availability

!!! 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" ?



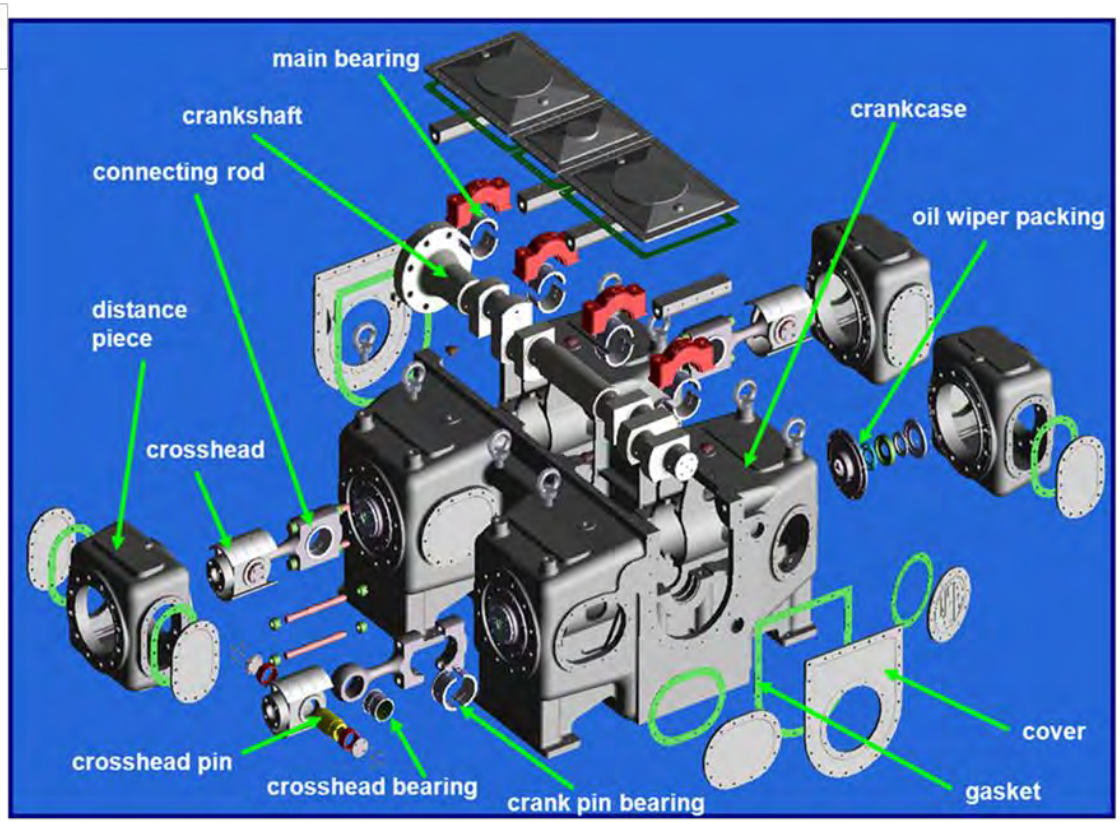
... and DO NOT forget Gaskets and O-Rings !

Maintenance / Technical Documentation

!!! 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**



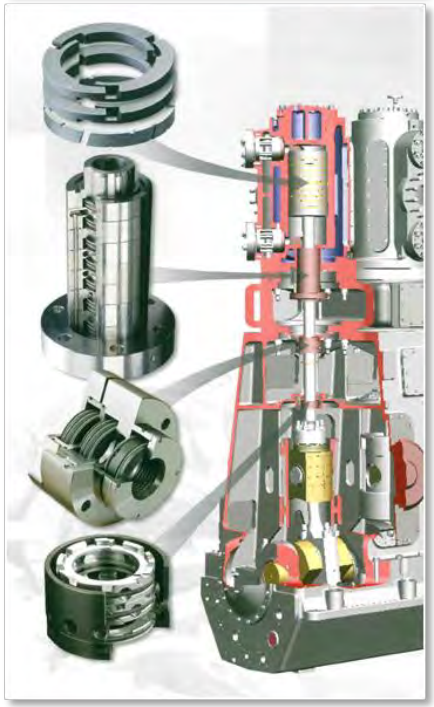
Maintenance / Quick & Safe Replacement

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 !

Maintenance / Consignment Stock

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 … ?

Thank you for your attention