EFRC Training Workshop

Design of Compressor Foundations

Foundation Repair and General Overhaul

Harry Lankenau – NEAC Compressor Service

Foundation Repair

Foundation Repair / Frame Foot Movement Check

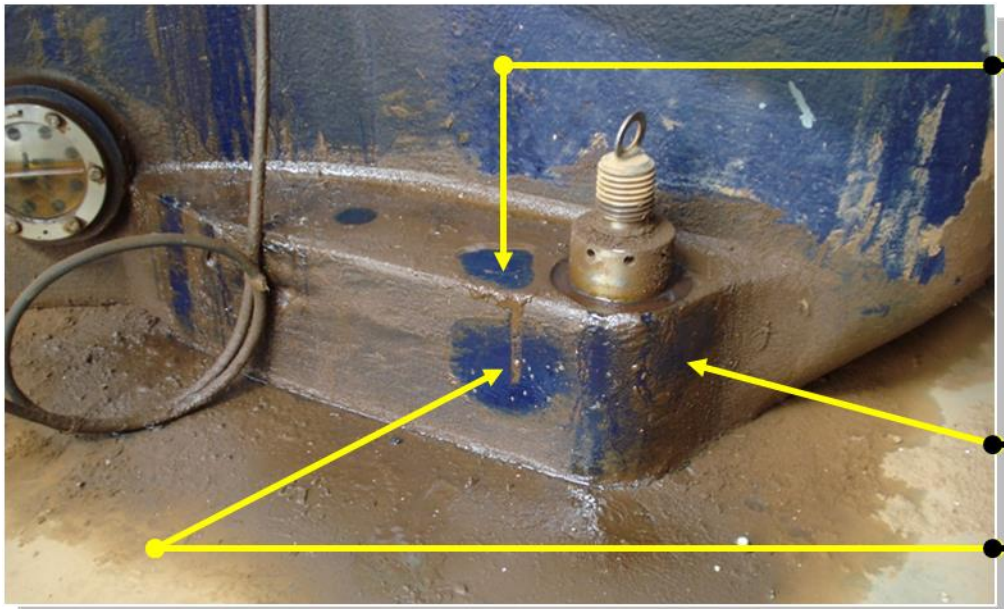
Example No. 1

Sometimes oil or water bubbles indicate slight relative movement ("Winking")

Some very small winking is normal or of no concern (due to the none infinite material stiffness)
Mobile vibration survey and monitoring may show if increasing

Foundation Repair / Frame Foot Movement Check

Frame foot oil contamination and relative movement

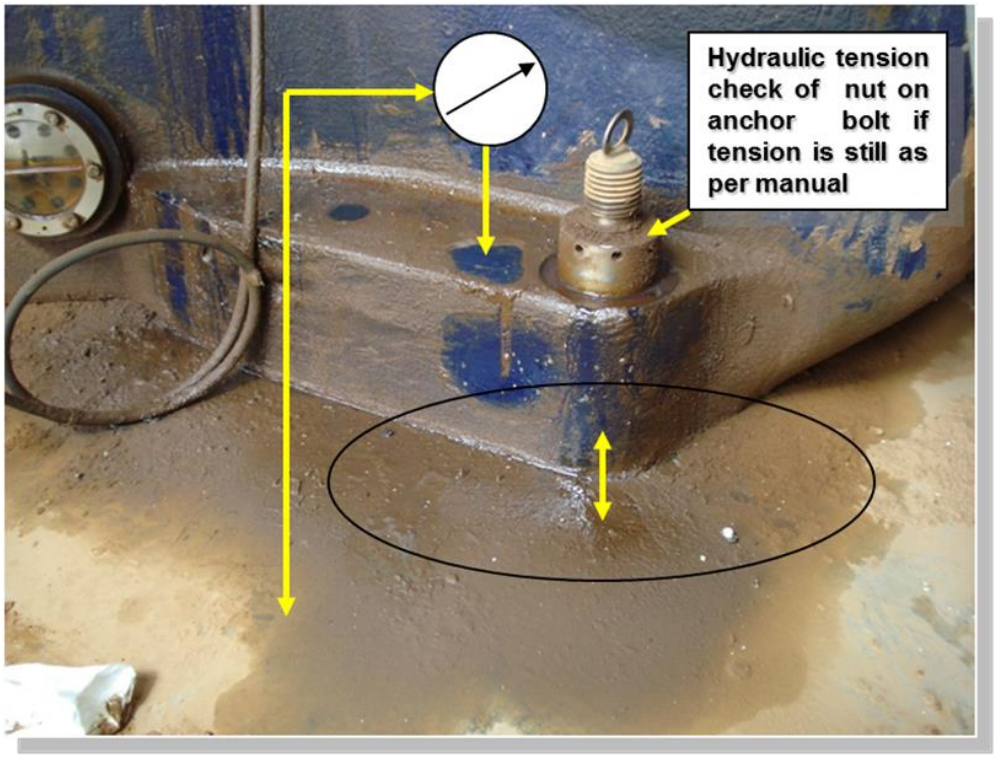


Mobile vibration measurement in 3 axes applied here to verify situation

Future checks recommended to monitor development

If oil penetrated between foot and shims (frame support) it is difficult to regain full strength to keep machine properly fixed on the foundation

Foundation Repair / Frame Foot Movement Check



Application of dial gauge to identify foot movement in vertical direction when hydraulic pump pressure of the nuts on the anchor bolts is checked and – in case of lost tension – brought back to specified level.

In case of major dial gauge off-set the ground / frame foot support has become soft.

Oil contamination long term deteriorates concrete quality.

Foundation Repair / Partial Foundation Repair

Example No. 2

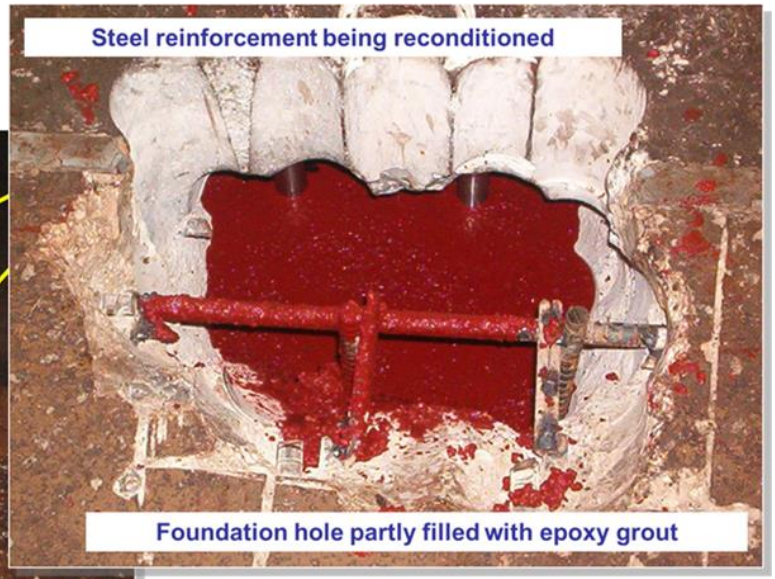
Foundation Repair / Partial Foundation Repair

Foundation Repair / New Anchor Bolt Installation (In Situ)

Example No. 3

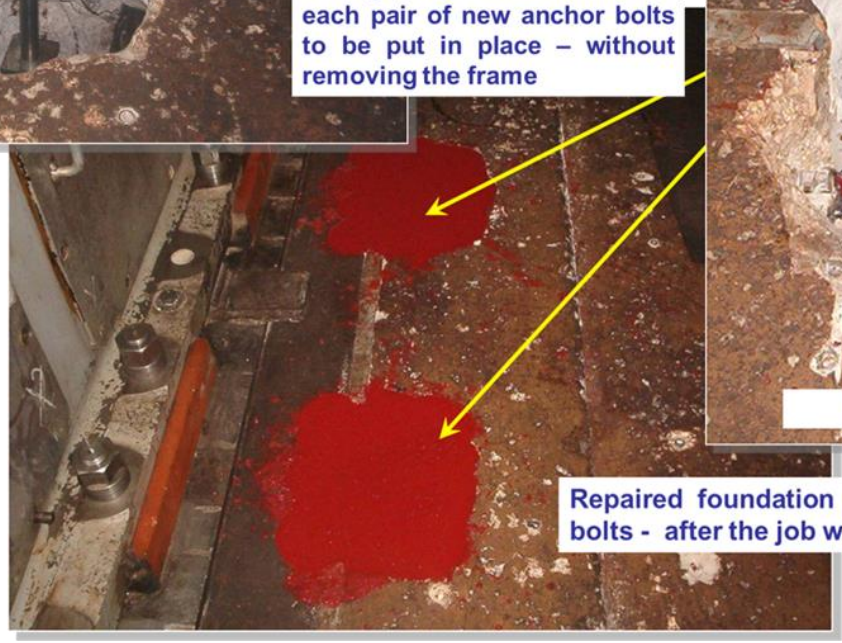
Machine frame anchor bolts had come loose and had no longer been able to hold the frame tight on the foundation

A large hole was drilled for each pair of new anchor bolts to be put in place – without removing the frame



Steel reinforcement being reconditioned

Foundation hole partly filled with epoxy grout

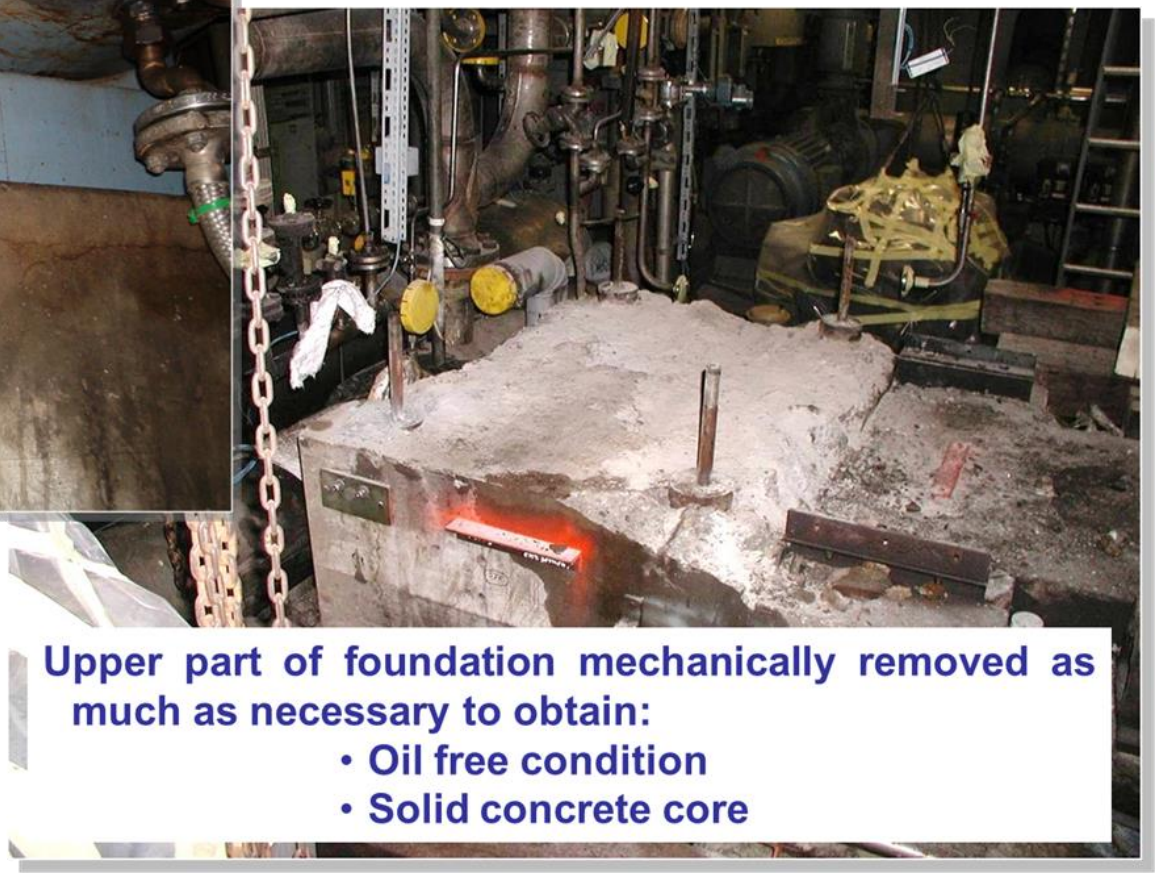


Repaired foundation with new anchor bolts - after the job was completed

Foundation Repair / Complete Revamp

Example No. 4

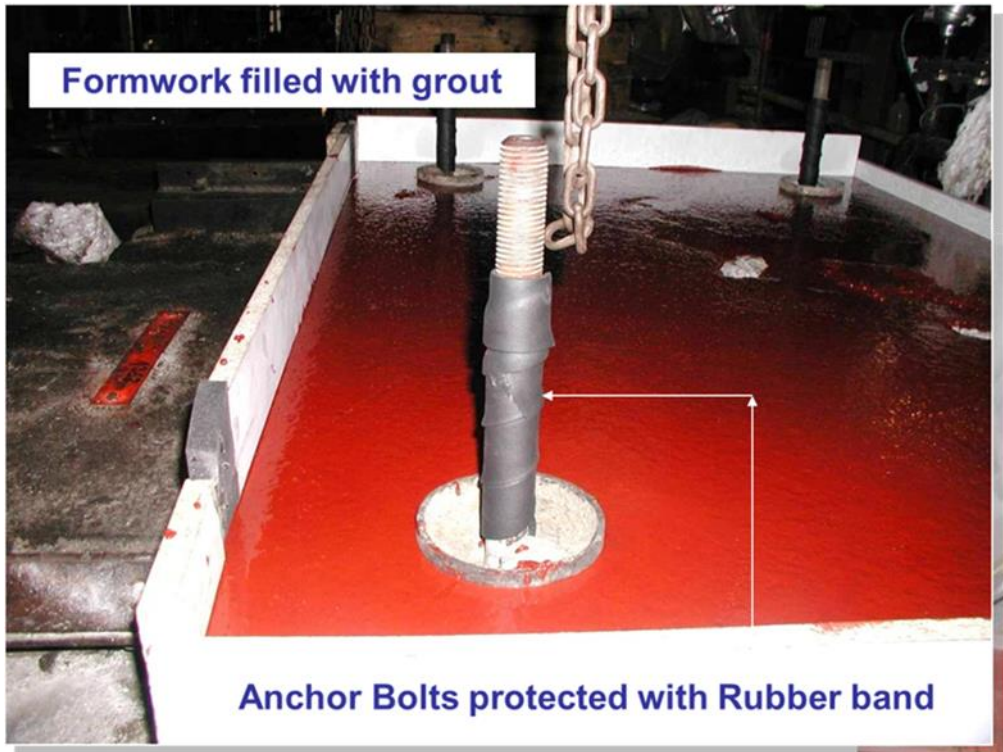
Oil emerging from lower section of the concrete foundation



Upper part of foundation mechanically removed as much as necessary to obtain:

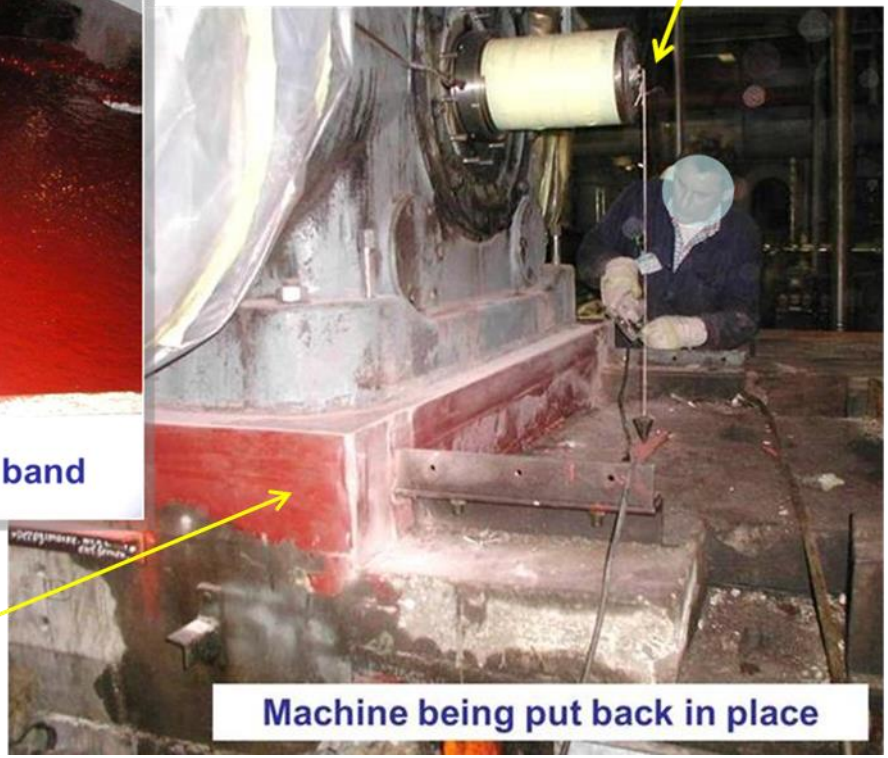
- Oil free condition
- Solid concrete core

Foundation Repair / Complete Revamp



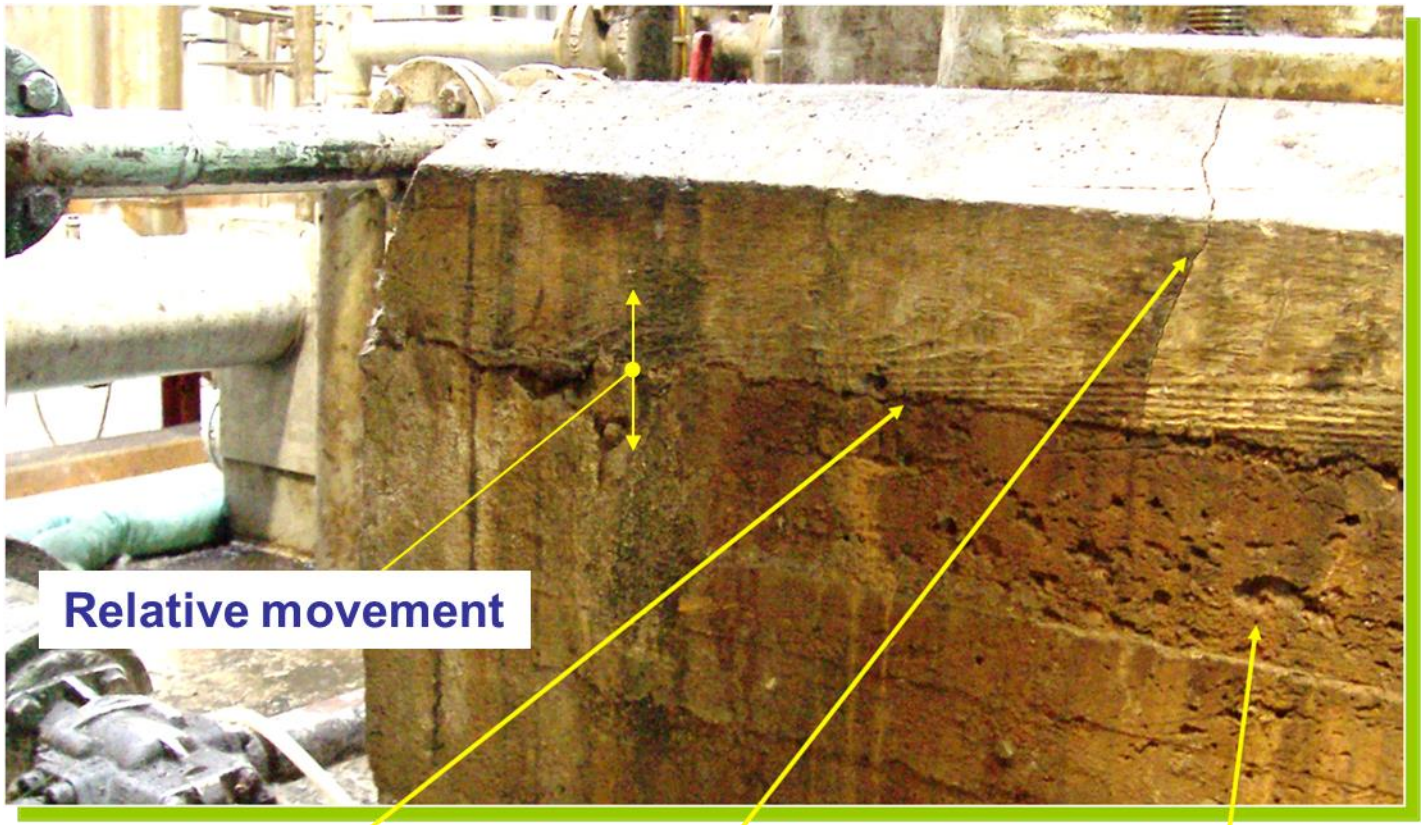
Frame position check with plummet

Epoxy compound applied as grout



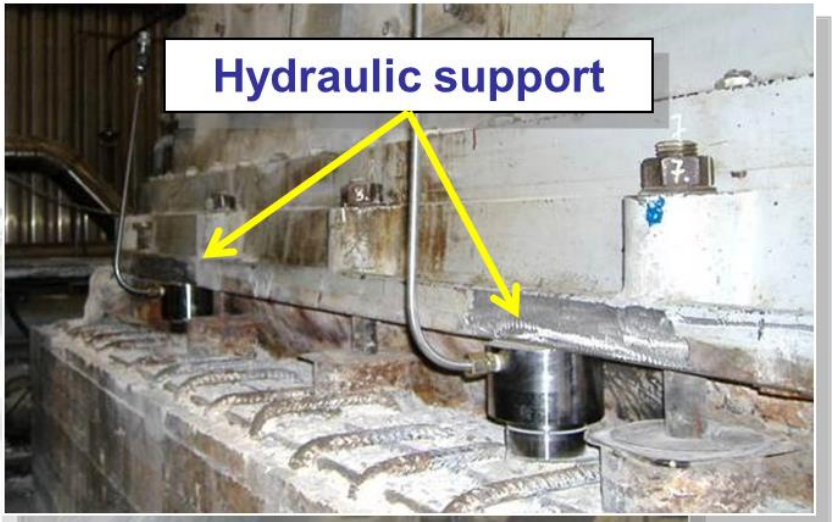
Foundation Repair / Complete Foundation Repair (In Situ)

Example No. 5



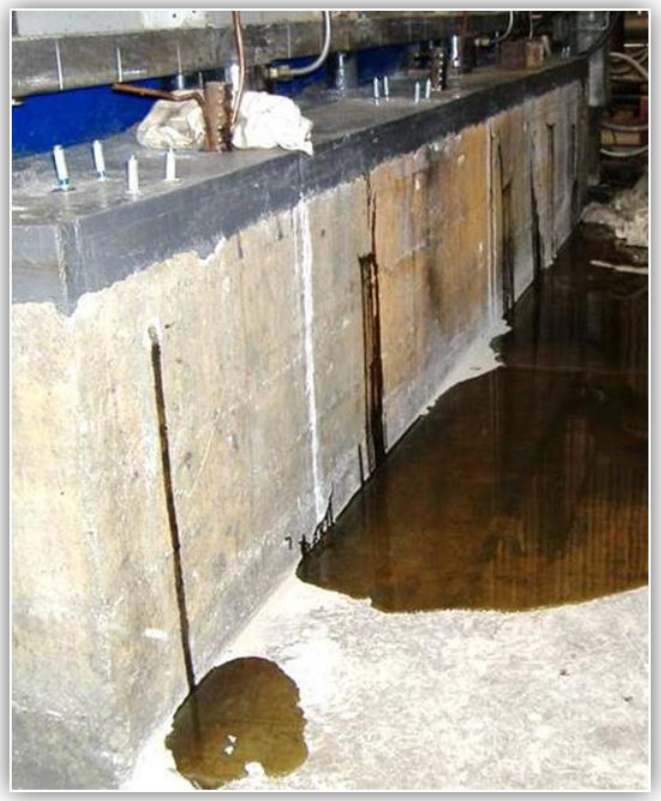
Foundation Repair / Complete Foundation Repair (In Situ)

Chipping off the old grouting and concrete



Form work and new epoxy grout

Foundation Repair / Complete Foundation Repair (In Situ)



Foundation Crack Repair by High Pressure Epoxy Injection

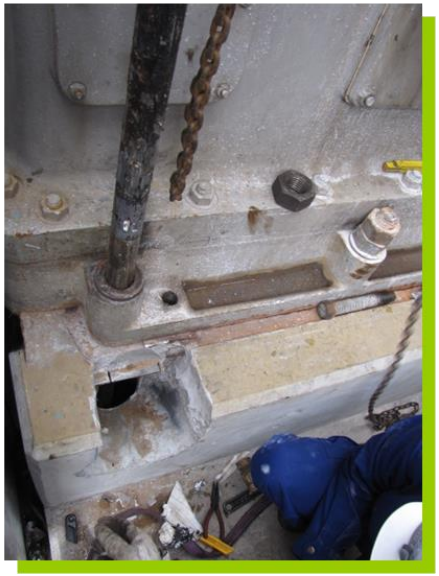
Refurbished Foundation with new Epoxy Grouting – Fit for Purpose

Foundation Repair / Anchor Bolt Crack

Example No. 6

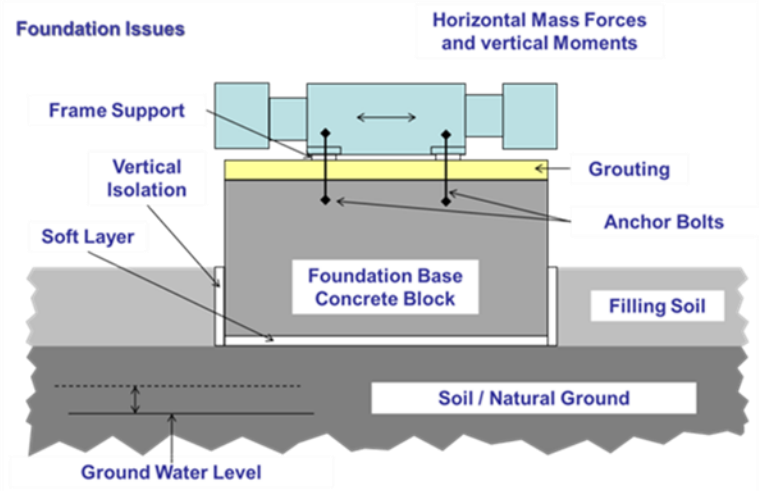
Anchor Bolt Check

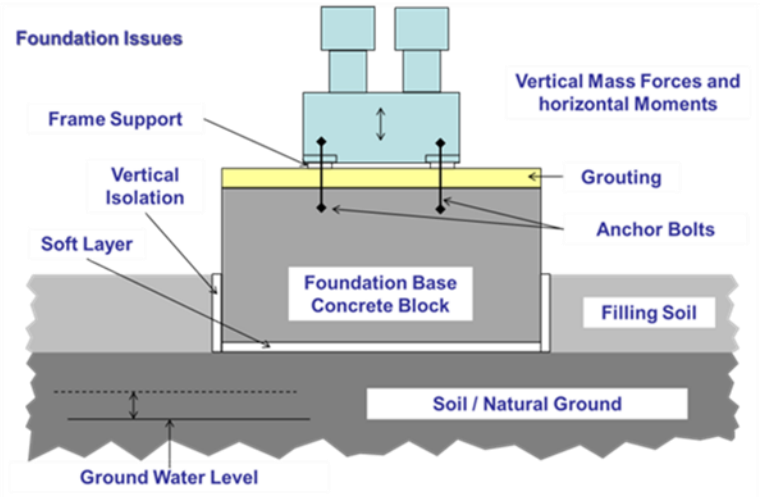
1. Partially cut off grouting and concrete
2. Open anchor sleeve
3. Pull anchor bolt



Foundation Repair / Items which require Remedy

1. Oil contaminated grouting and concrete
2. Cracks in concrete foundation («Cold Joints»)
3. Soft layer below concrete block
4. Varying ground water level
5. Ice formation
6. «Sandy» foundation concrete (poor quality)
7. Poor grouting quality (soft and/or cracked)
8. Soft link between compressor frame and foundation ⇔ cracking bolts
9. High dynamic loads and moments
10. Anchor bolt corrosion
11. Poor or damaged (corroded or bent) anchor bolt support at the bottom of the anchor sleeve





General Overhaul

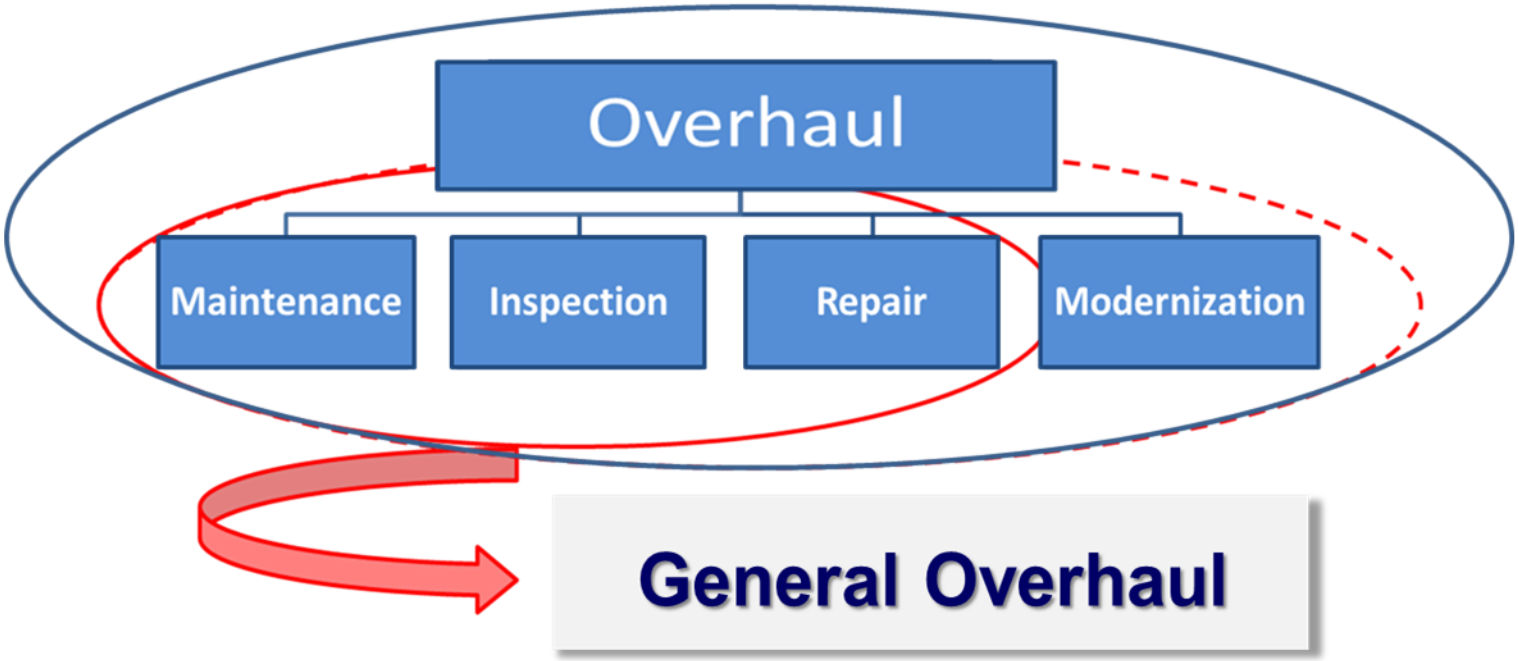
General Overhaul
Frame Removal with Overhaul & Foundation Repair

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

General Overhaul
Frame Removal with Overhaul & Foundation Repair

- The day will come when a General Overhaul is due



- Maintenance beyond the Scope of a Normal Revision or Repair

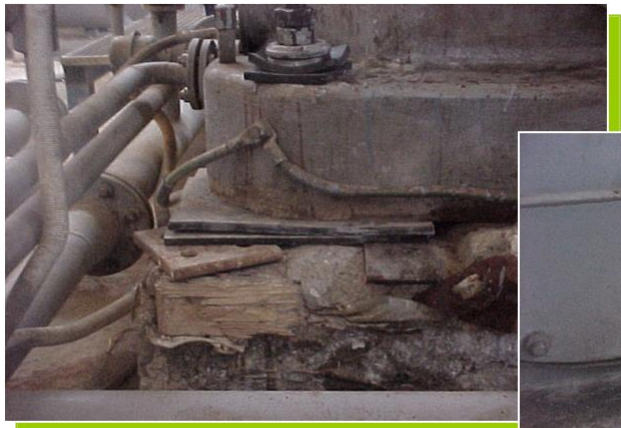
General Overhaul

Frame Removal with Overhaul & Foundation Repair

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

- Unbalanced mass loads
- Oil penetration into the concrete
- Unfavourable ambient conditions

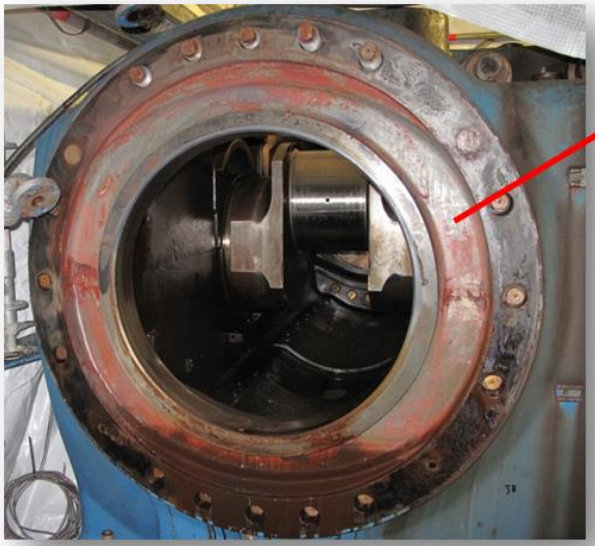
  (leading to ice formation and/or corrosion)
- Loose or cracked foundation bolts

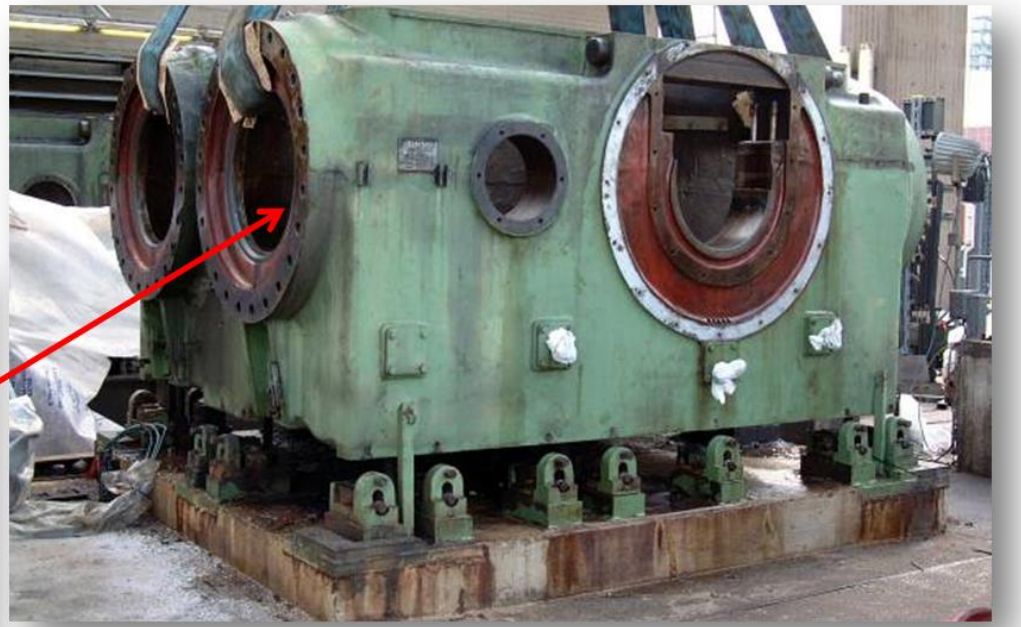


General Overhaul

Frame Removal with Overhaul & Foundation Repair

Example for Long Term "Wear & Tear"





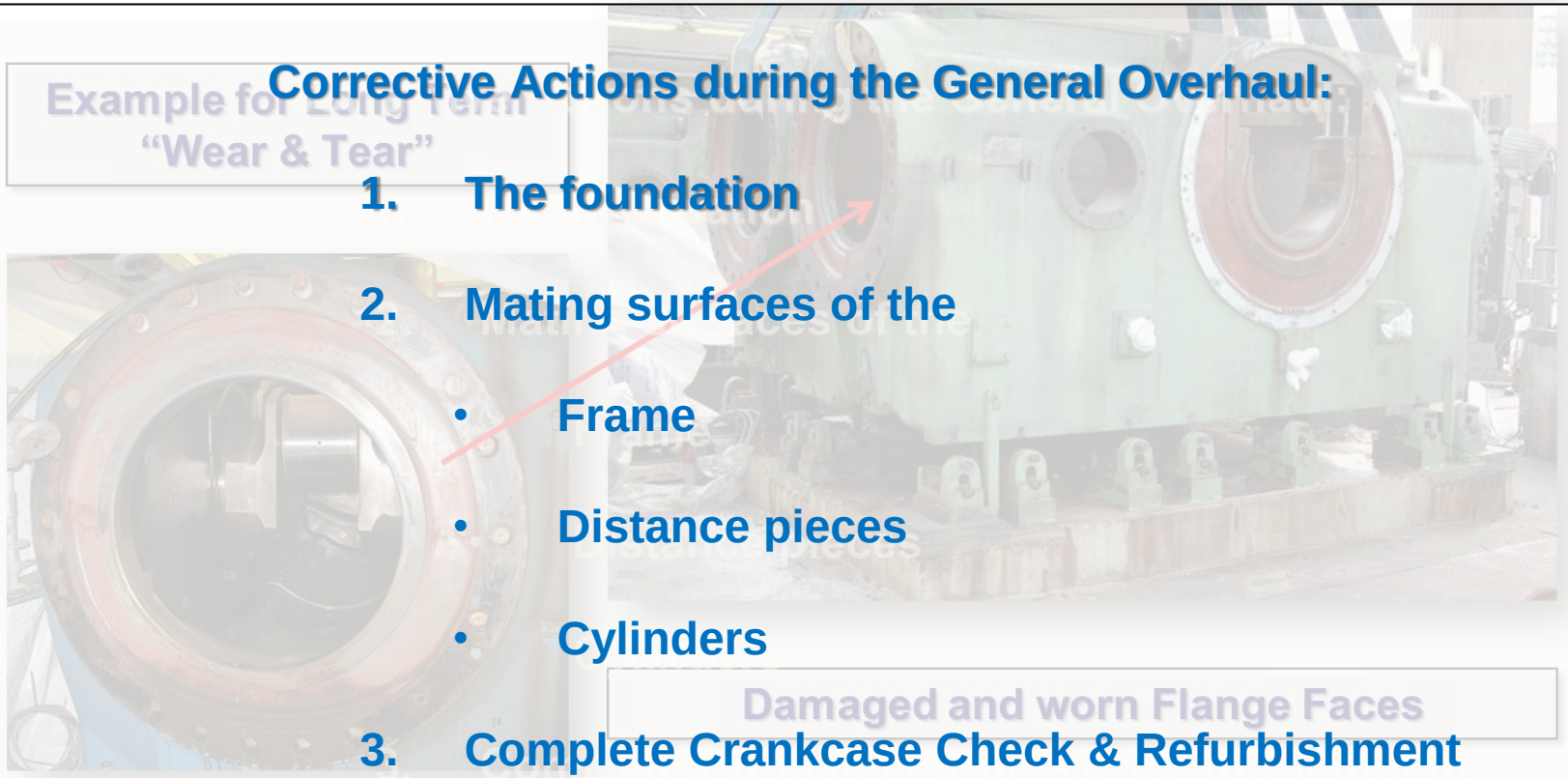
Damaged and worn Flange Faces

General Overhaul

Frame Removal with Overhaul & Foundation Repair

Corrective Actions during the General Overhaul:

1. The foundation
2. Mating surfaces of the
   - Frame
   - Distance pieces
   - Cylinders
3. Complete Crankcase Check & Refurbishment



General Overhaul

Frame Removal with Overhaul & Foundation Repair

Various Parts were shipped to the Workshop for:

- Condition and dimension checks
- Repair and/or machining
- Replacement where necessary

1. Frame Reconditioning

Crank Cased being reworked

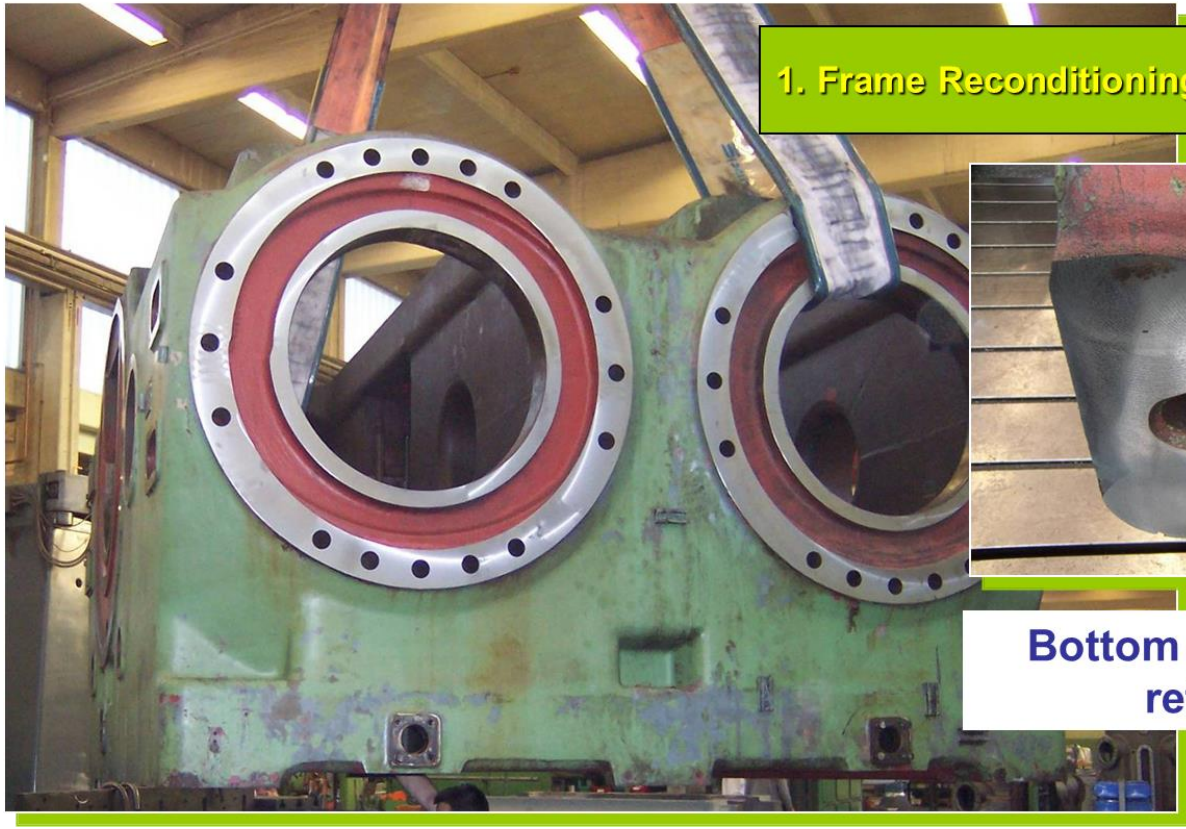
Hyper Frame set up on Milling Machine

Milling head at work

General Overhaul

Frame Removal with Overhaul & Foundation Repair

Crank Case after Machining



1. Frame Reconditioning

Bottom of Frame being refurbished

General Overhaul

Frame Removal with Overhaul & Foundation Repair

2. Foundation Repair

Most of the old concrete had to be removed …

… and reconditioned by application of Epoxy Resin

General Overhaul

Frame Removal with Overhaul & Foundation Repair

3. New Frame Support

Service Technicians guiding the Anchor Bolts into their Foundation Sleeves

General Overhaul

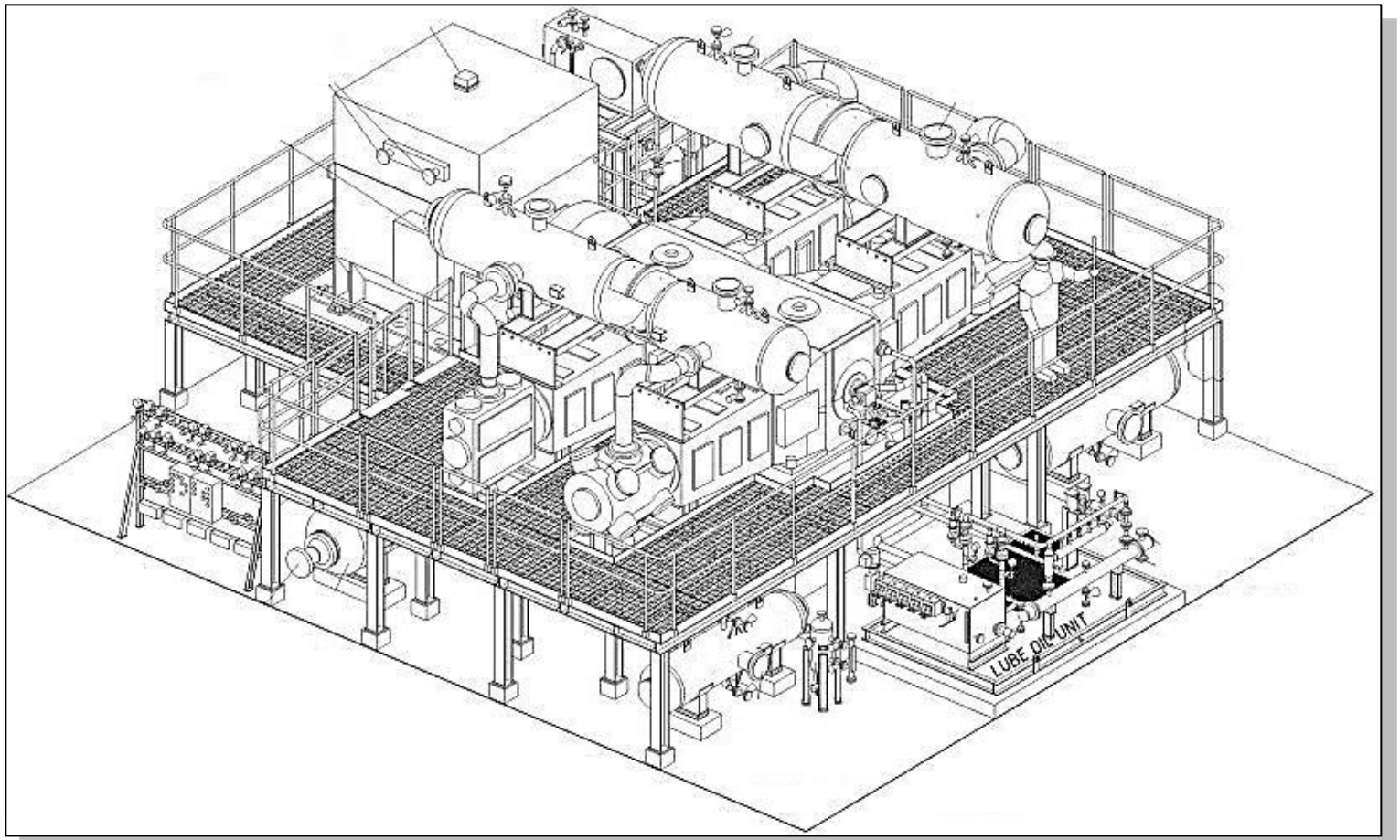
Frame Removal with Overhaul & Foundation Repair

Frame close to touch base …

… to get settled on its new bed

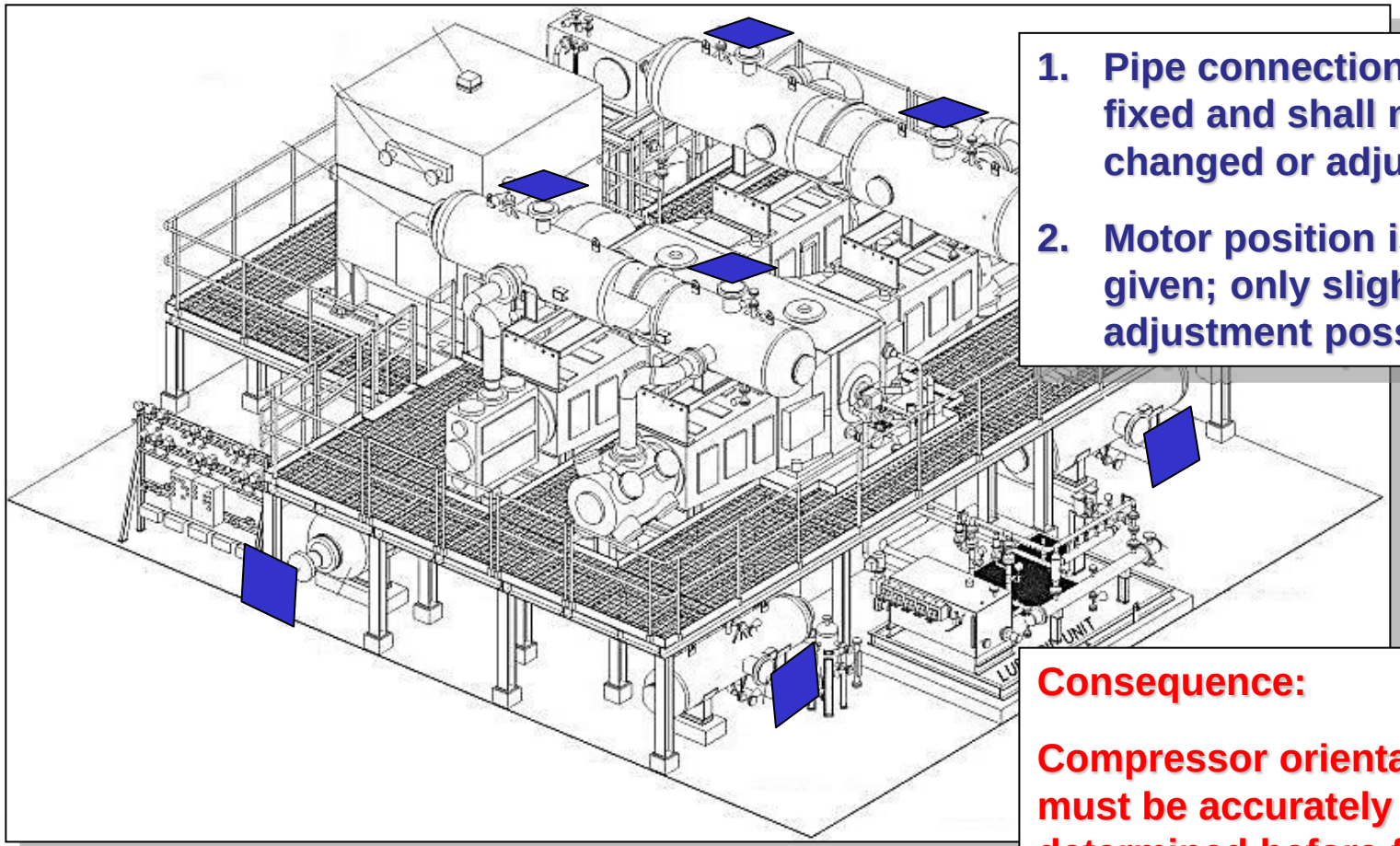
General Overhaul

Frame Removal with Overhaul & Foundation Repair



General Overhaul

Frame Removal with Overhaul & Foundation Repair



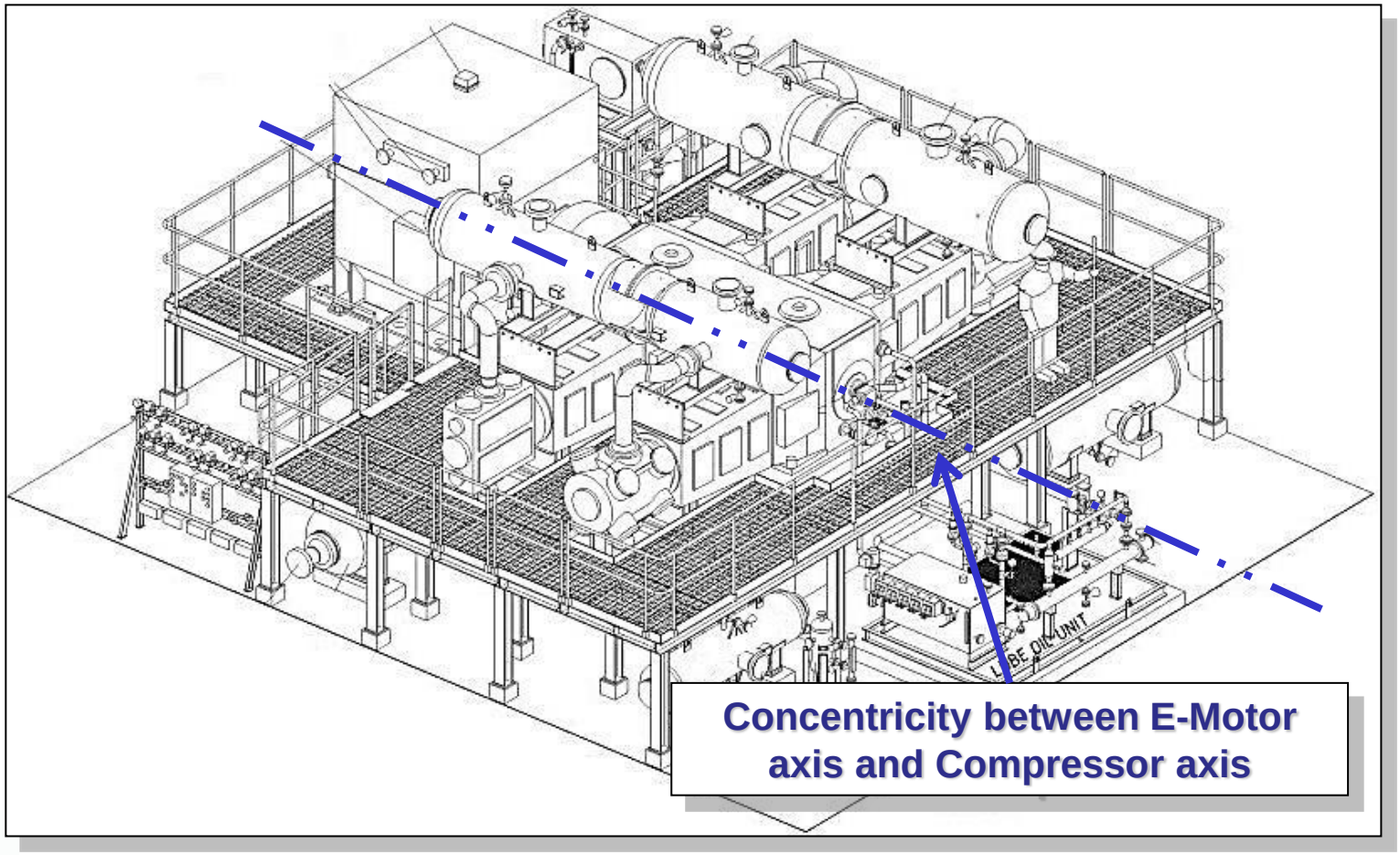
1. Pipe connections are fixed and shall not be changed or adjusted
2. Motor position is given; only slight adjustment possible

Consequence:

Compressor orientation must be accurately determined before frame lifting or movement !

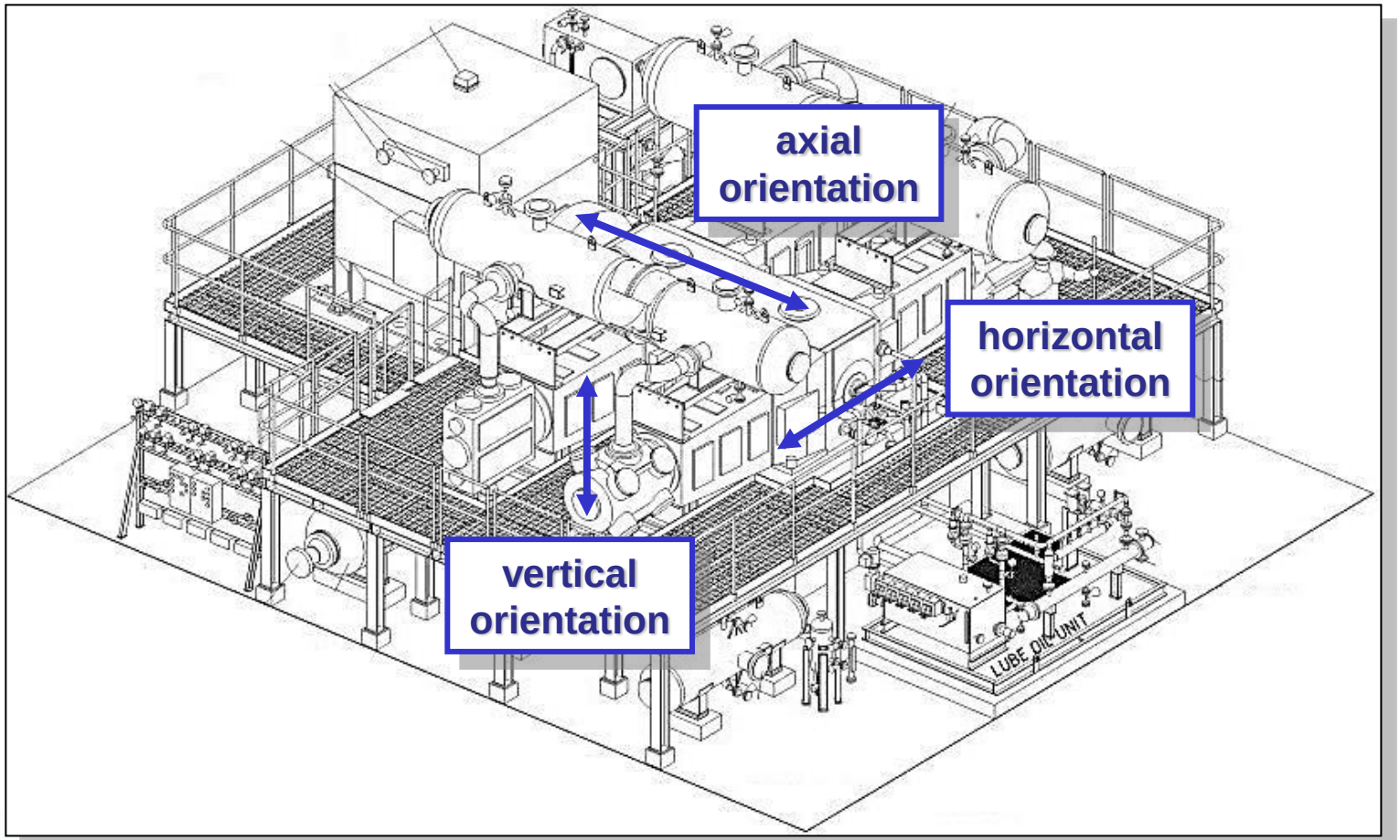
General Overhaul

Frame Removal with Overhaul & Foundation Repair



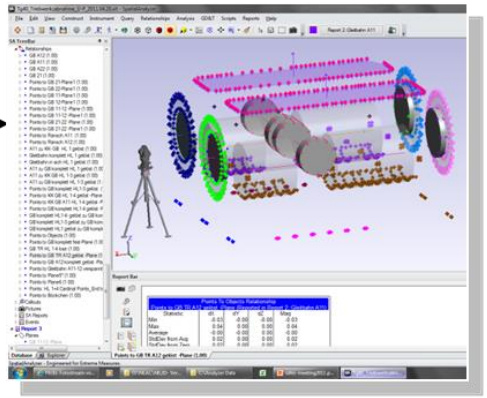
General Overhaul

Frame Removal with Overhaul & Foundation Repair



General Overhaul
Frame Removal with Overhaul & Foundation Repair

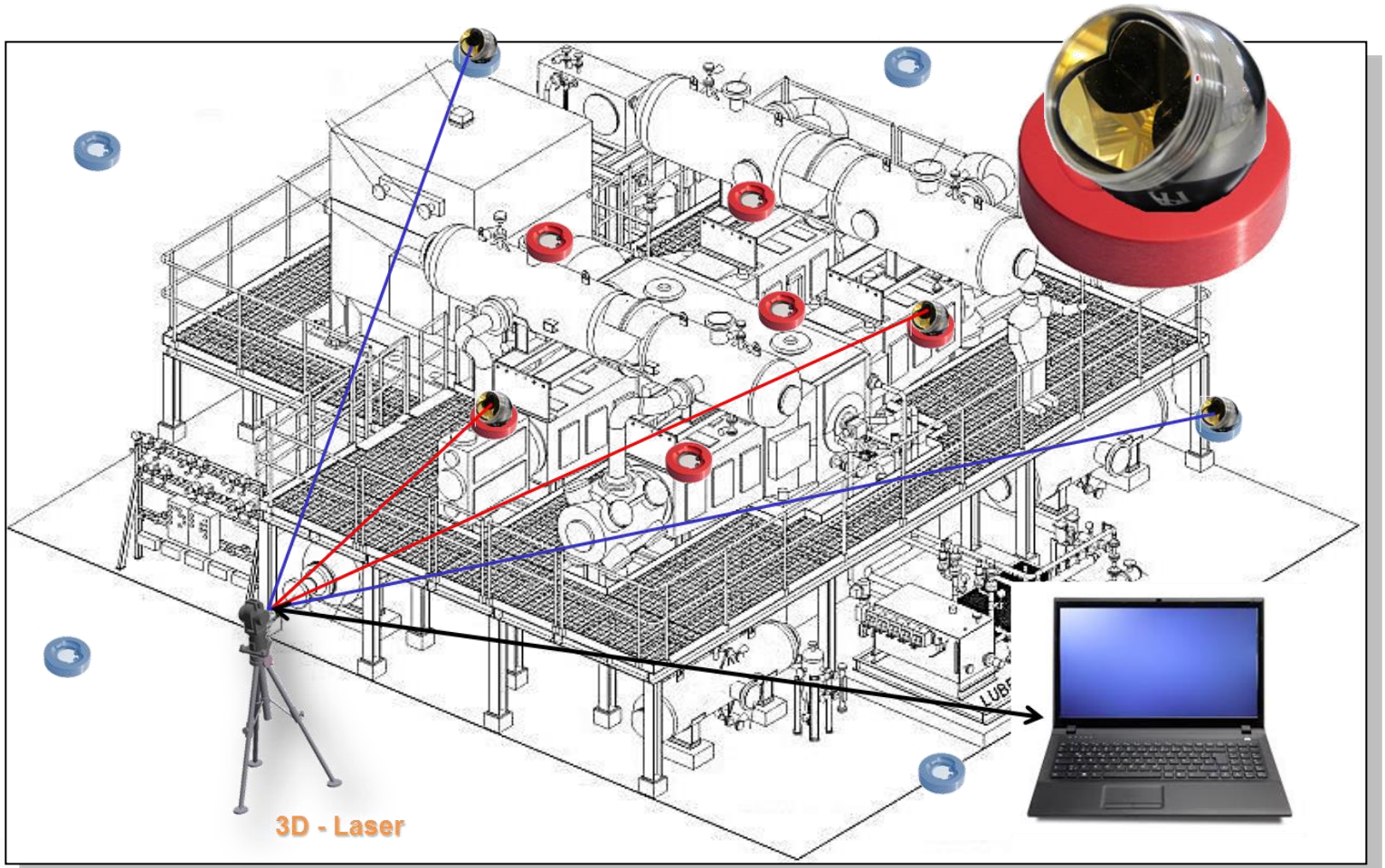
Laser-Technology



Detector (SMR) Mobile "Magic Eye"	Transmitter (Laser Tracker) Fixed	Notebook Computer
… is held towards the object to be measured; it receives the laser beam from the tracker and reflects it back	The tracker sends the laser beam to the reflective target – the "Magic Eye" prism mirror	… collects the coordinates of each point for data acquisition and evaluation through relevant software

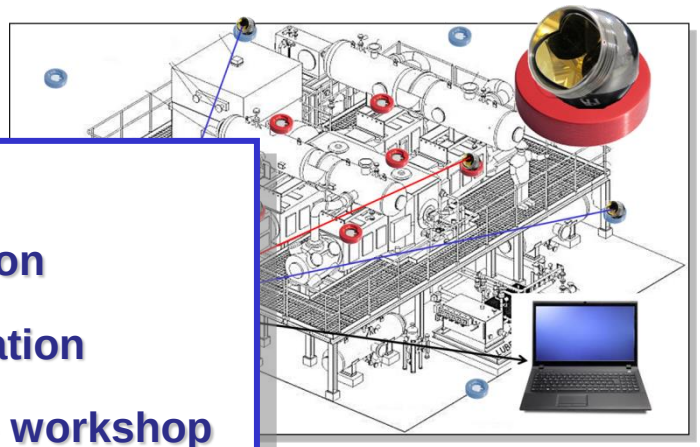
General Overhaul

Frame Removal with Overhaul & Foundation Repair



General Overhaul

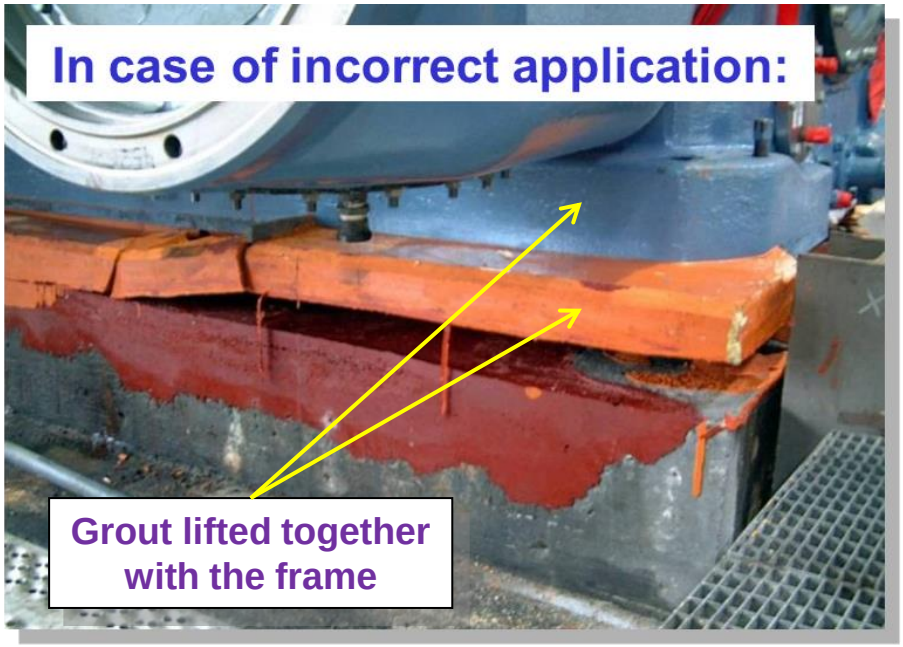
Frame Removal with Overhaul & Foundation Repair



Game Plan

1. Determination of “as-build” condition
2. Removal of crank case from foundation
3. Transportation of crank case to the workshop
4. Refurbishment of crank case and another parts
5. Foundation repair
6. Assembly of the crank case back on repaired foundation
7. Adjustment of compressor frame to match E-motor axis and pipe flanges

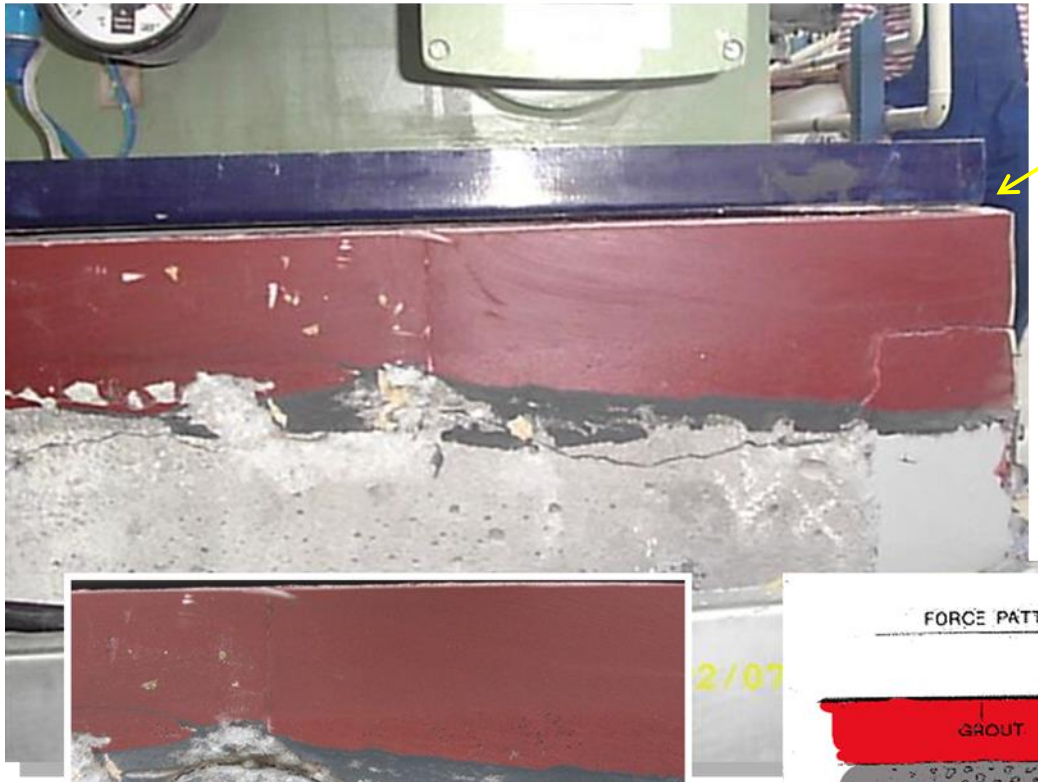
Foundation Repair / Epoxy Grout Issues

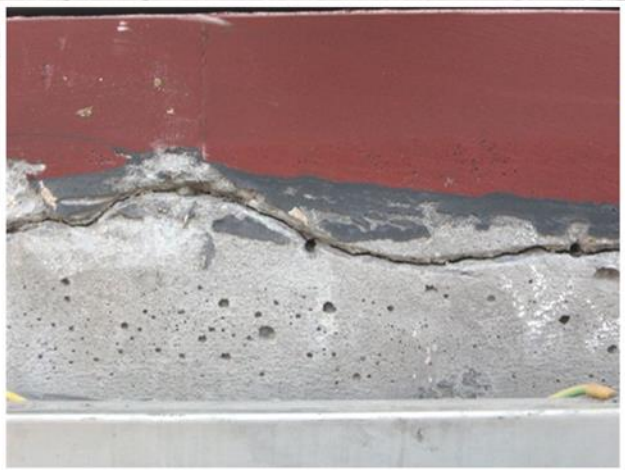


Possible causes:

- Too high temperature
- Wrong mixing
- Poor bonding – presumably due to inadequate surface treatment

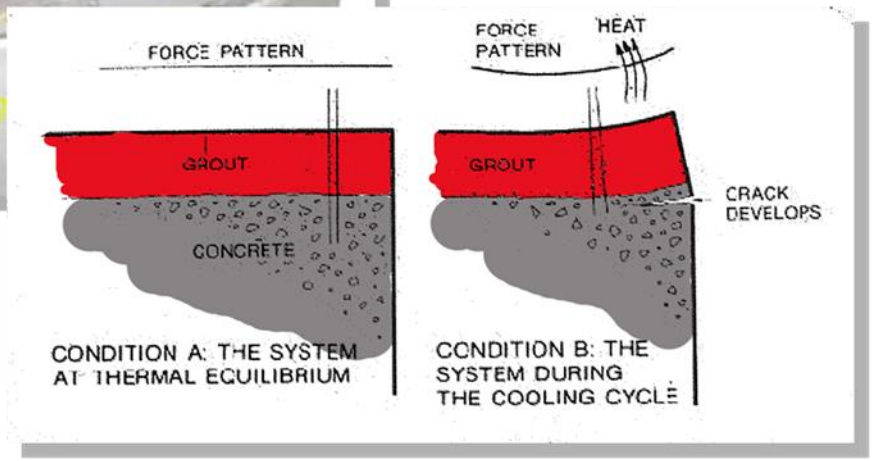
Foundation Repair / Epoxy Grout Issues





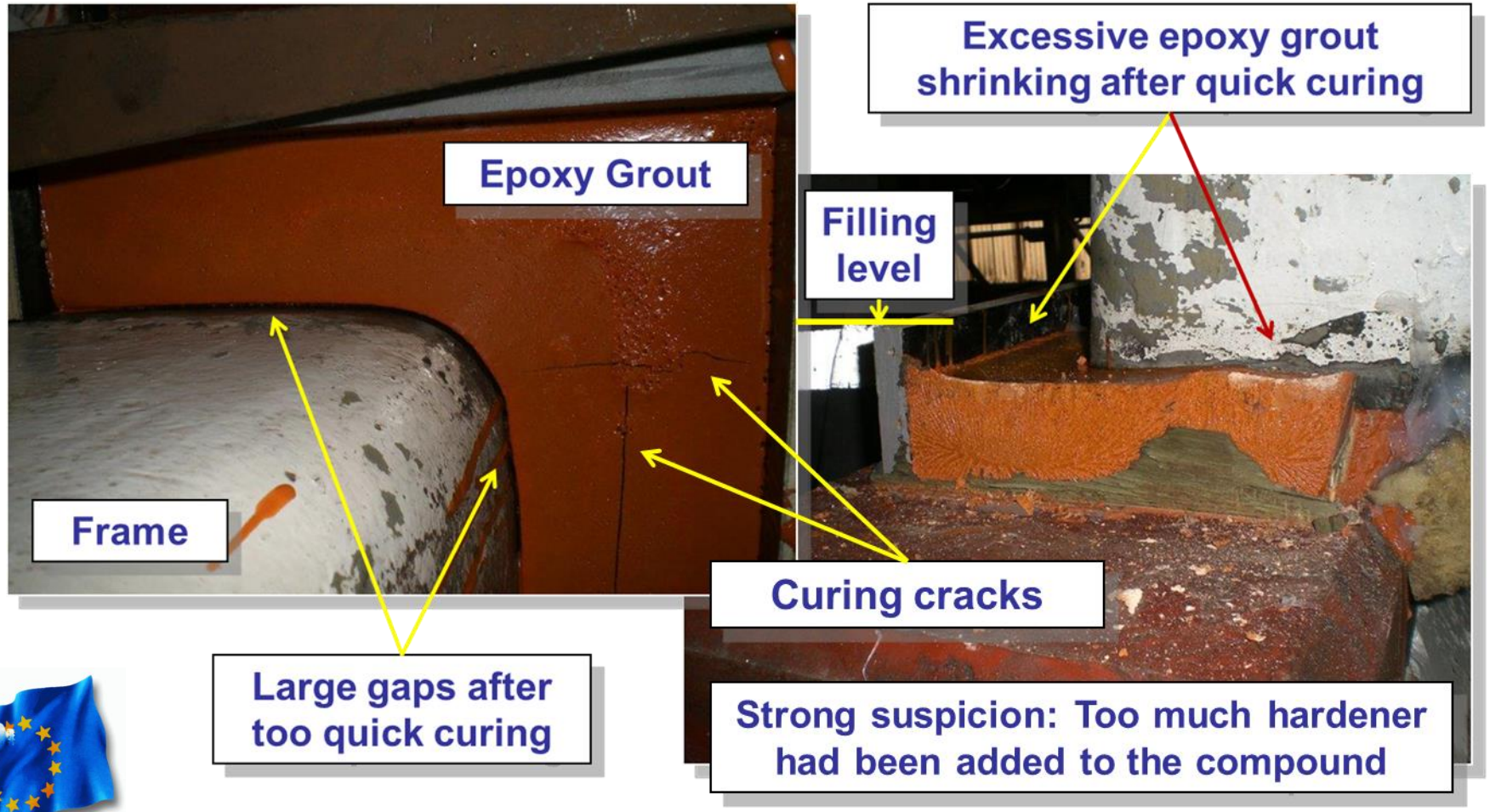
Potential reasons for grout lift up:

- Missing top weight (gap)
- Poor heat transfer from bad/no (top) contact
- High local grout temperature with partially fast curing and uneven expansion/contraction
- High temperature differential between grout and base



Foundation Repair / Epoxy Grout Issues

Here – as in many cases – epoxy compound was applied as grouting material; with wide pours; much larger than for typical chocks



Message “for the Road”

Your compressor deserves “Solid Footwear“ … !

Make sure it is comfortable for the machine to run smoothly

I hope you enjoyed the presentation

Questions and Comments ?