Case Study

Solving a Coupling Unbalance Problem in the Field

Author: **Quraisy A. Shatri P.E.**
Maintenance Superintendent – Machinery and Reliability
RasGas Company Limited
PO Box 24200, Doha, State of Qatar
Tel: (+974) 4492 3209
Mobile: (+974) 5583 8706
e-mail: qashatri@rasgas.com.qa

Author: **Joseph P. (Joe) Corcoran**
Manager, Global Services and Training
Kop-Flex Emerson Industrial Automation
7565 Harmans Road
Hanover, MD USA 21076
Tel: (+1) 410 787 8522
Mobile (+1) 443 831 1811
e-mail: j.corcoran@emerson.com

Abstract

When a large (3.4 meters long) diaphragm coupling was suspected of causing excessive (120 microns p-p) 1X unbalance vibration between a 90+ Megawatt Gas Turbine and a Propane Compressor in an LNG plant, there was not time to ship the coupling back to a distant factory or service center for troubleshooting. Simple field diagnostic techniques were used to discover the problem, which then led to a field correction and repair so that the unit was able to be quickly restarted with minimum downtime.

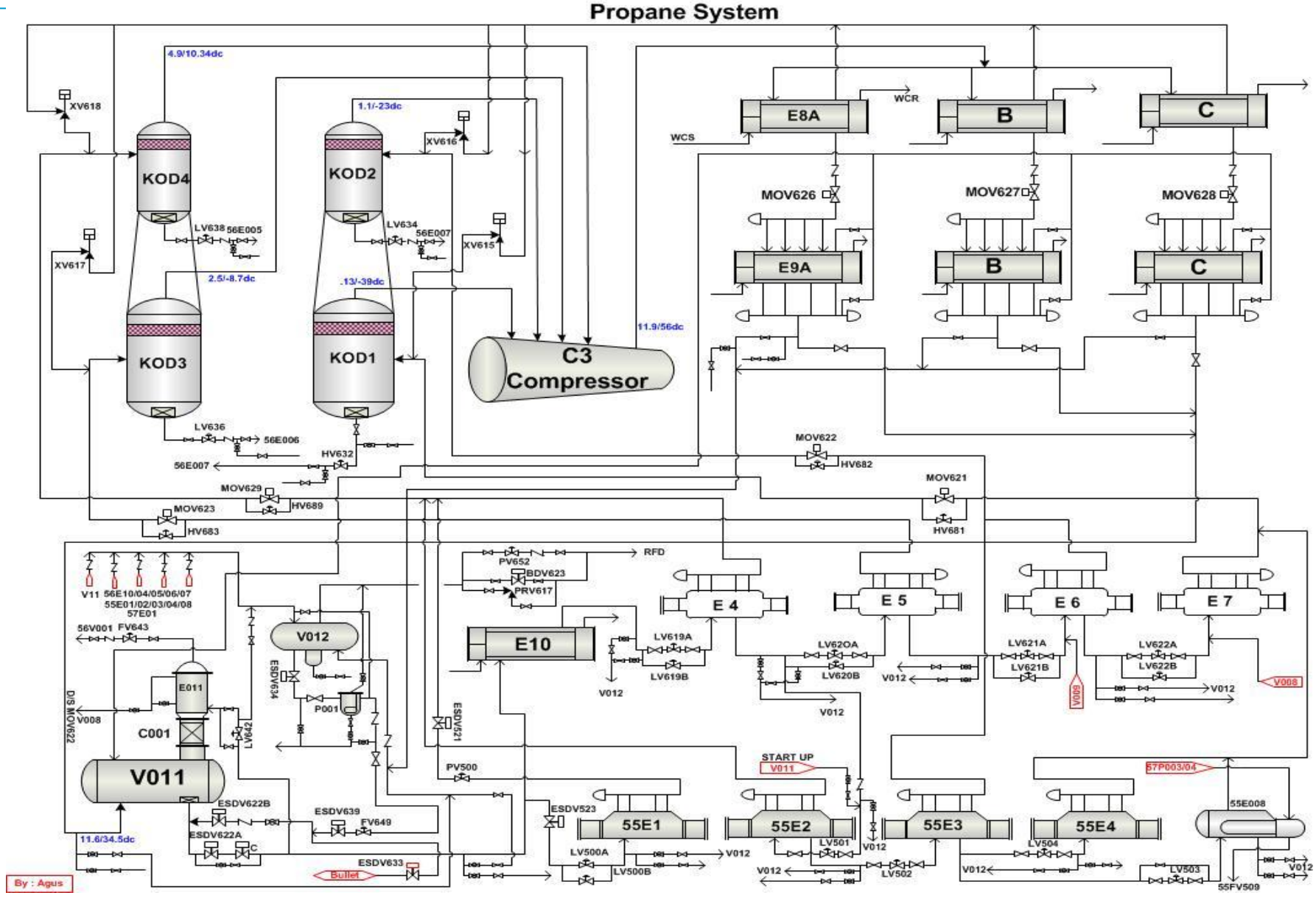
Process Background

- In an LNG Plant, After all impurities such as Hg, H2S,H2O are removed in upstream units, sweet feed gas enters the *gas chilling & liquefaction unit*.
- Two major pieces of equipment in *this* unit are the Scrub Column (SC) & the APCI Main Cryogenic Heat Exchanger
- SC is a distillation column, steam re-boiled, to remove C5+ and provide streams for producing refrigerants (C2 and C3).
- OH gas of the SC goes in to MCHE mid-bundle for liquefaction. The medium to cool is MR or Multi Component Refrigerant (MCR - ***C1+C2+C3+N2***)

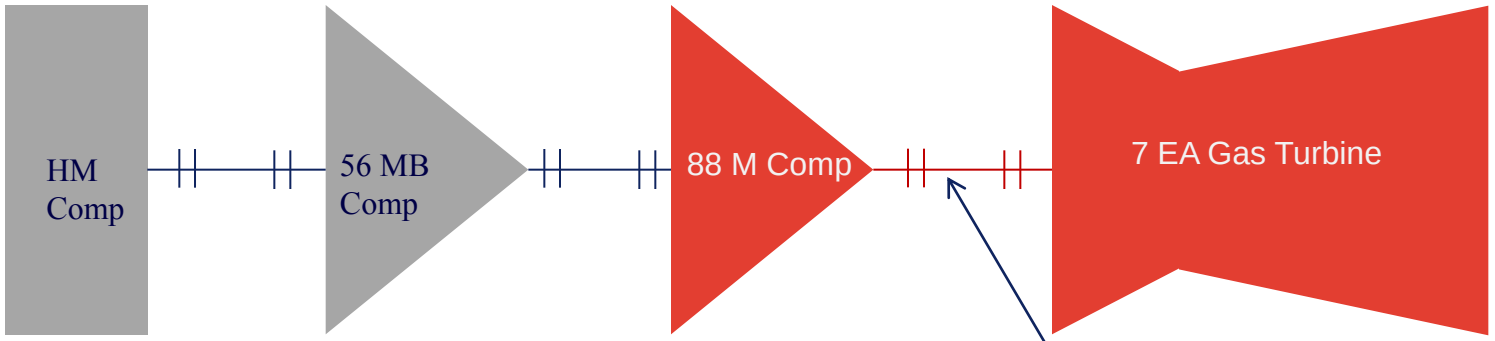
Process Background

- The *MR circuit* is cooled (and partially liquefied) by Propane. The *Propane refrigeration circuit* is also tasked to cool Feed Gas in the gas chilling section, De-C2 condenser and the reinjection stream from the refrigerant preparation unit.
- The two (2) main refrigeration compression circuits – MR & Propane – are illustrated in the next page.
- If either of these 2 strings are down, there'll be no production from the *gas chilling & liquefaction unit*, and no LNG is produced.

Simplified schematics

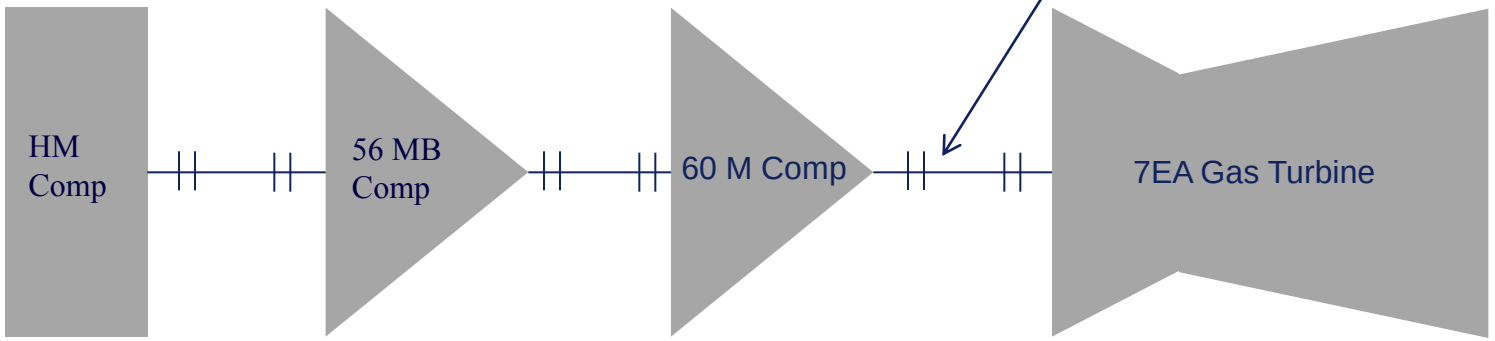


Main Refrigeration Compression Strings



PROPANE

#5.5 MSMH-J, Diaphragm coupling rated power≅ 92MW; 3,352.8 mm (Nominal cold shaft separation)



MR

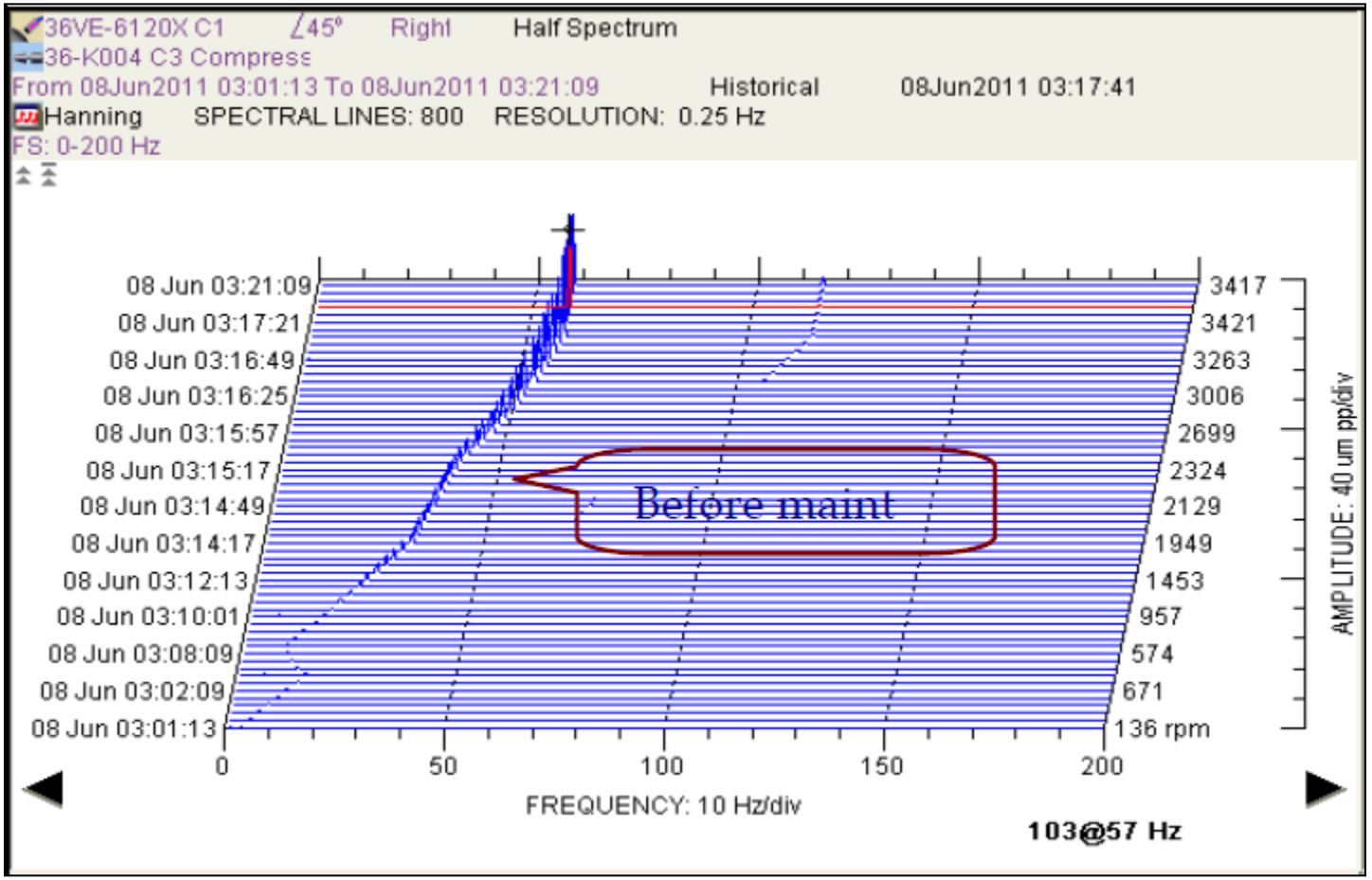
RCA

- The string comprises of 4 coupled rotors: 7EA GT rotor, 88M and 56MB compressor rotors – HM rotor
- Bearings: 3 radial bearings for a single shaft 7EA rotor, 2 radial bearings each of 88M and 56MB rotors, and 2 radial bearings of the HM.
- Only DE radial vibration of the 88M rotor was extremely high – increasing rapidly with increasing speed / load; other bearings-vibe readings were normal.
- Refurbished 7EA rotor and upgraded (new) 88M rotor were installed during the turn-around. The GT operating data indicated “perfect”; factory dimensional and high-speed balance data of the 88M rotor and as-installed records indicated everything was acceptable.
- Strong suspect was load coupling #5.5 MSMH-J based on possible coupling imbalance as seen via 88M DE vibe plots: new spools & adapter but *old coupling-hub* were assembled; wrong pre-stretch gap; and poor run-out. Coupling components individual balance records observed to be “perfect”.
- On attending the unit, installed couplings run-out checks clearly showed the coupling straightness was grossly out-of- straightness (0.018”) in mid-span point.
- Plans to index, change-out of coupling hub was cancelled; previously-installed spacers were re-installed after all necessary checks were done and certified acceptable. Run-out checks of the installed coupling was then checked and certified acceptable for services.
- The whole string was started-up, sent in to normal operations satisfactorily.

High Vibration – Coupling Suspected

Location	Before coupling spacer replacement (At 70% Load on 09-Jun-11, 07:28 hrs)		
	Overall Vibration (Microns, Pk-Pk)	1X Amplitude (Microns, Pk-Pk)	Phase (Degrees)
36VI6120X	165	163	174
36VI6120Y	67	64	233
36VI6121X	46	35	59
36VI6121Y	24	16	202
Speed	3421 RPM (95 % Speed)		

High Vibration – Coupling Suspected



Before Disassembling Coupling Installed Runout was Checked

-This is Not Normally Done but Can Provide Important Information

-Sometimes Difficult to Turn Over Machines

-Many Ways to Overcome

-Jog Motor (If Motor)

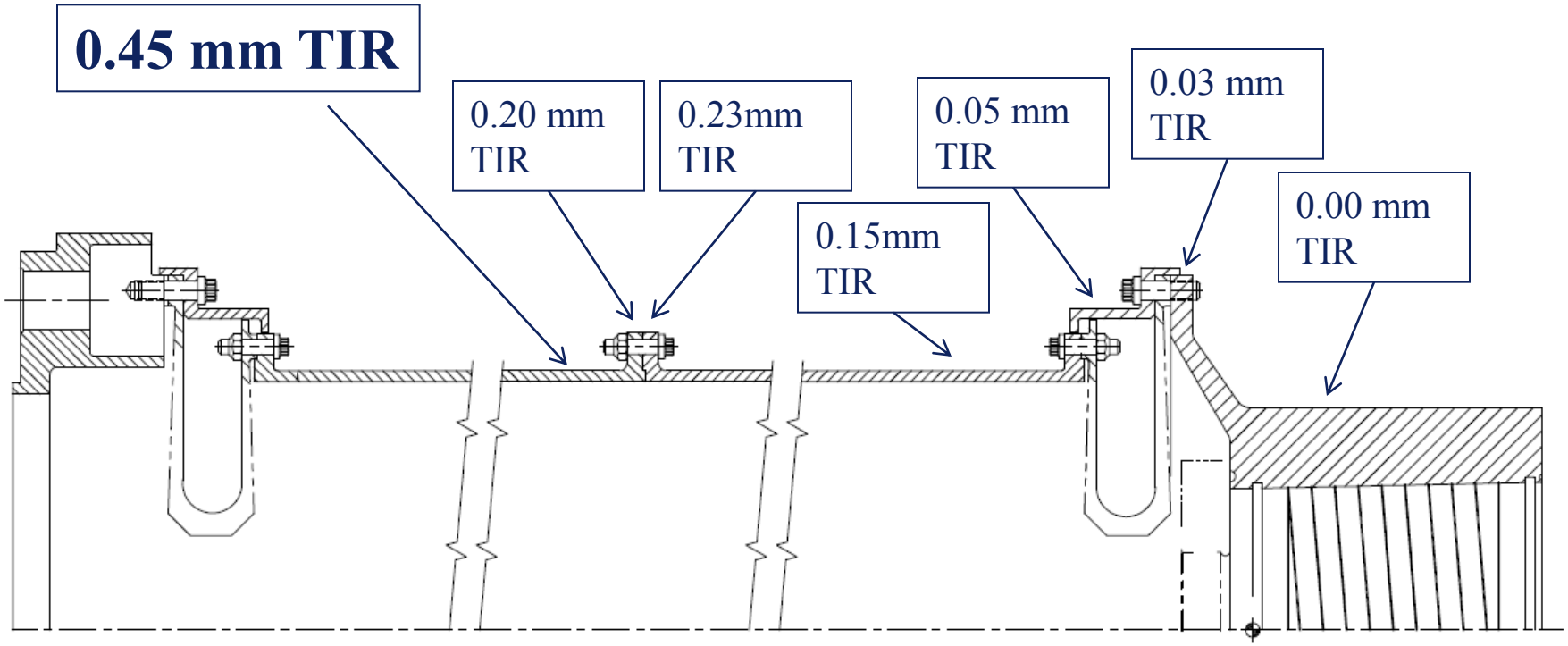
-Use Turning Gear

-Even Overhead Crane can be Used with Long Strap Wound Around Coupling or Shaft

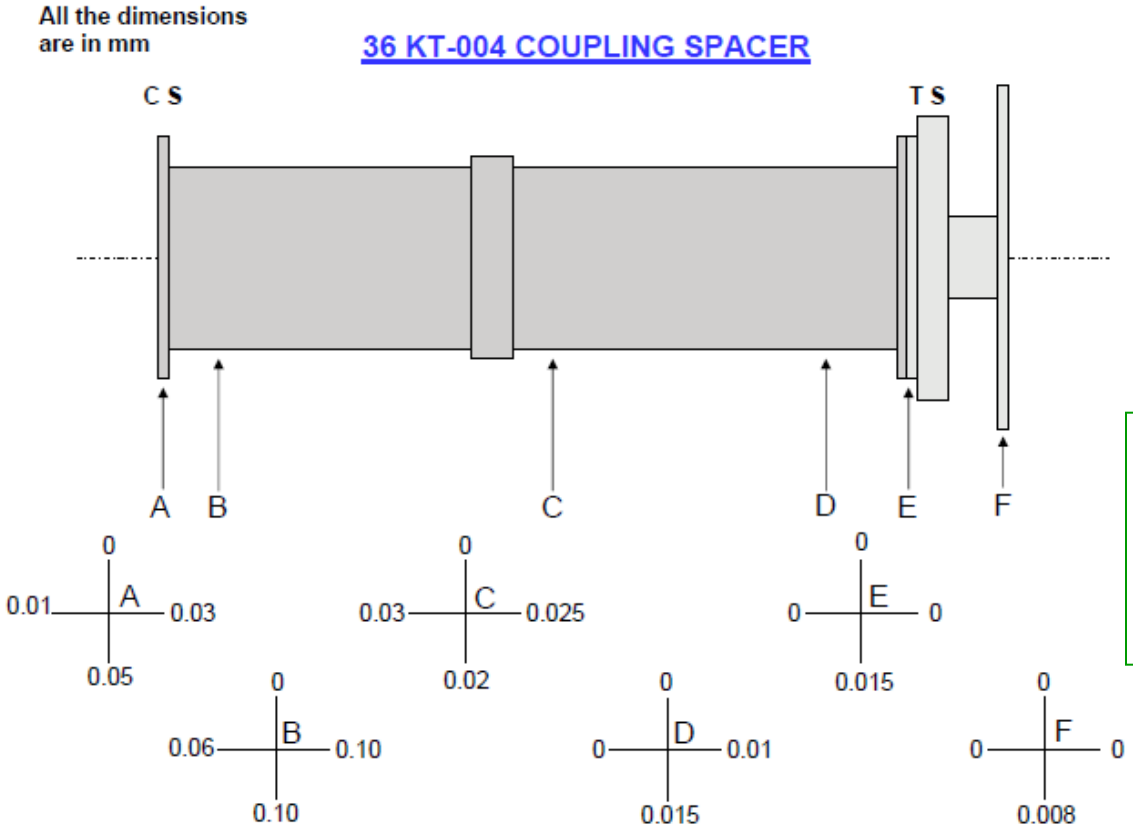
Run Out Should Typically be No Greater Than 0.002” TIR at Flange Connections

0.001” TIR at Hub Bodies

Field Installed Run Out Check of Coupling Confirm a Problem



Next, Previously Installed Coupling was Checked to Reinstall to Get Train Running



Is the Available Field Repair Equipment Acceptable?

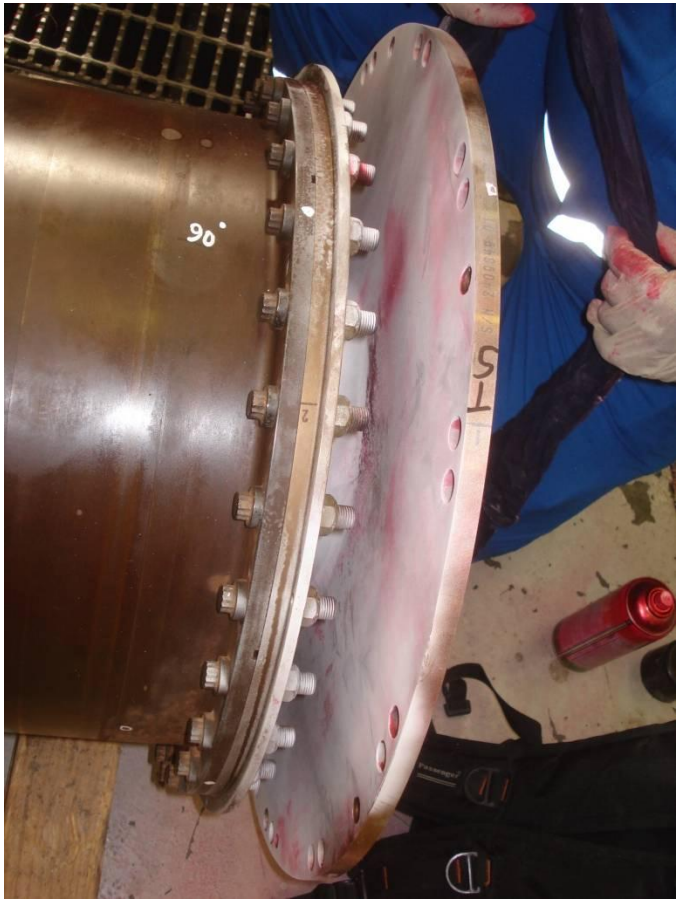
Checked on Calibrated Acceptable Balance Machine

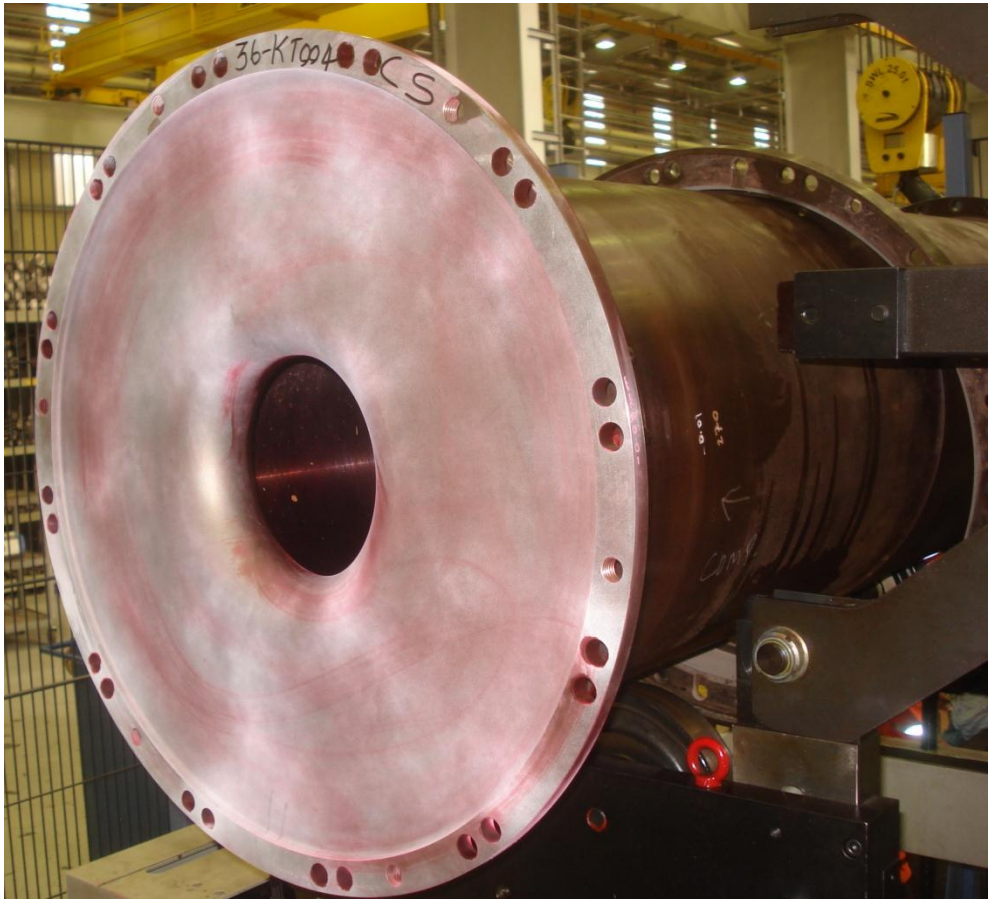
Minor Issue w/ Length Capacity of Available Balance Machine

Run Outs O K

Then Dye Penetrant Checks of Diaphragms

Important Check On Used Diaphragms After Handling

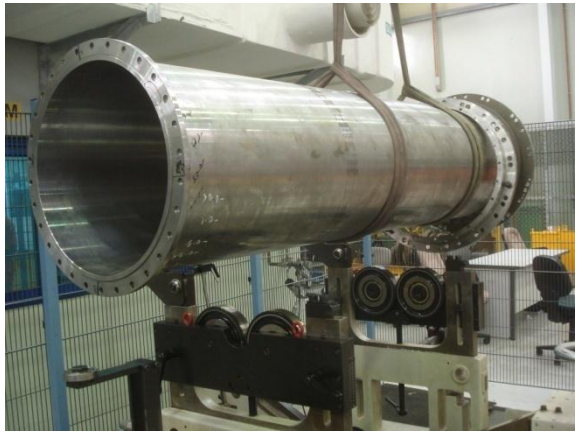


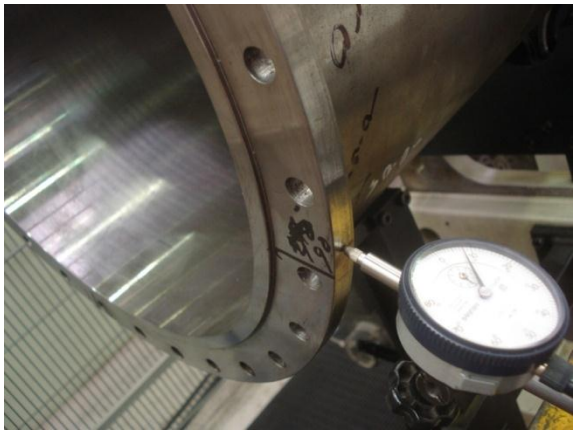


No Indications, Cracks, or Unacceptable Scratches

Install Replacement Coupling Center Section

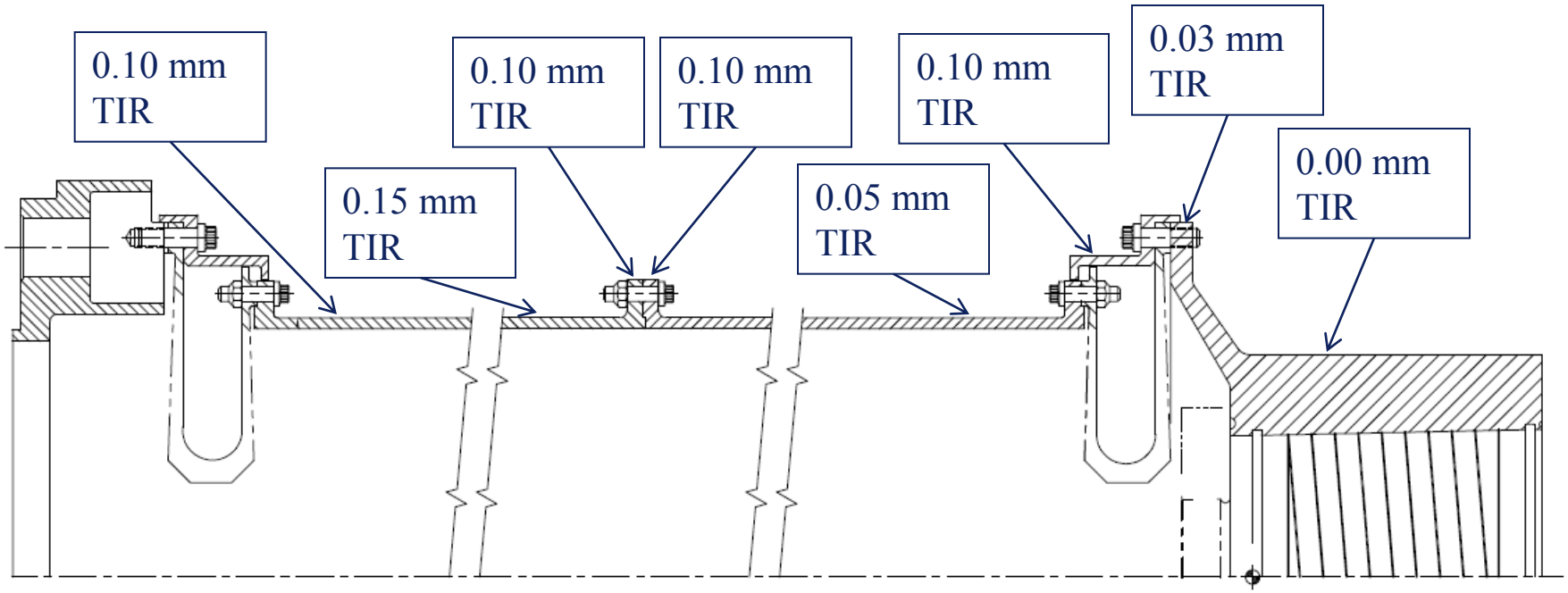
- Use Existing Turbine Adapter and Compressor Rigid from the First Coupling
- Do a High Spot Check
- Line Up High Spots of Male and Female Pilots
- Remember that “High Spot” Definition is the Spot Furthest from the Center of Rotation





This Guarantees the Best Balance Condition From a Concentricity to Center of Rotation Perspective

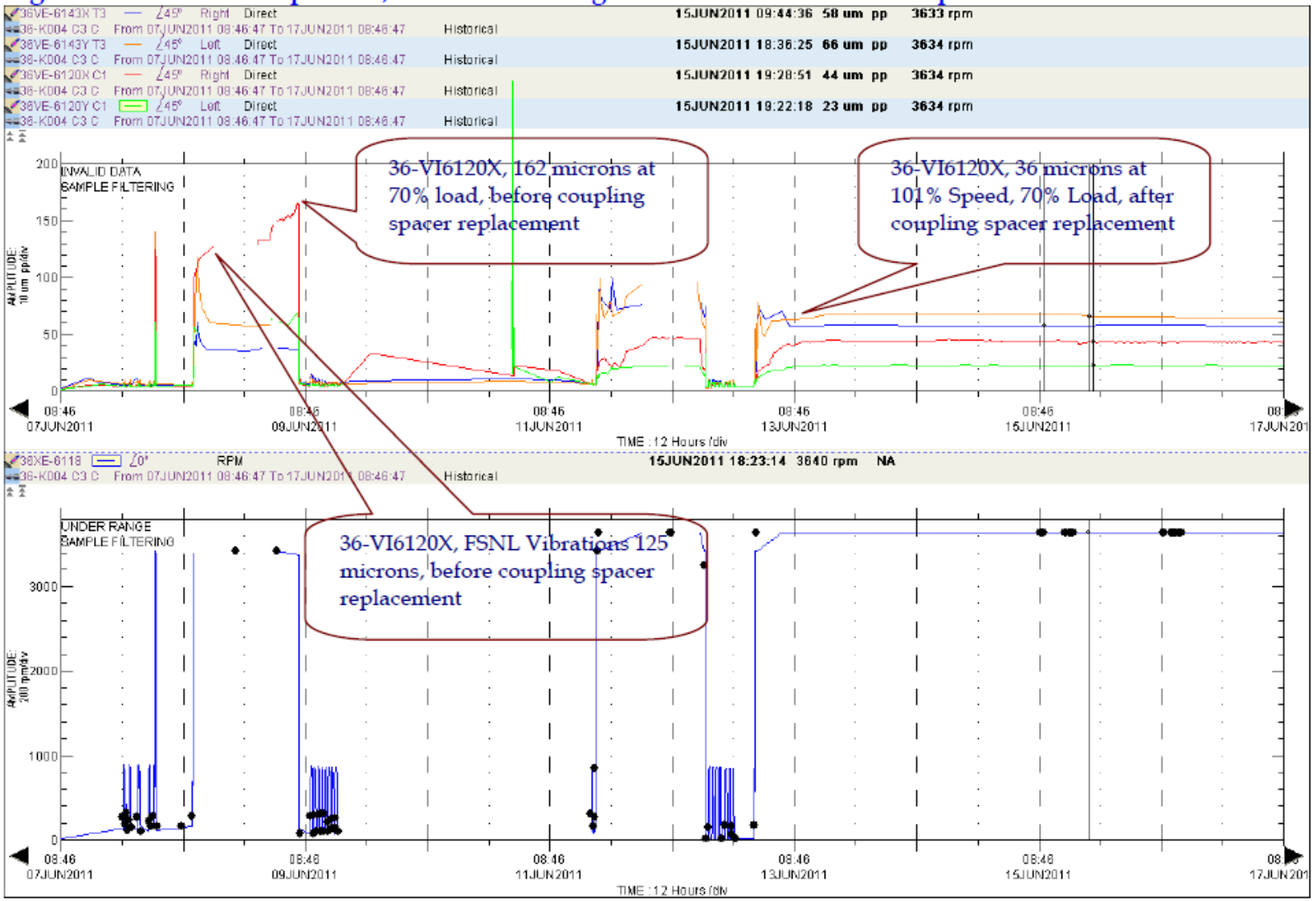
Installed Replacement Coupling Run Out Checks



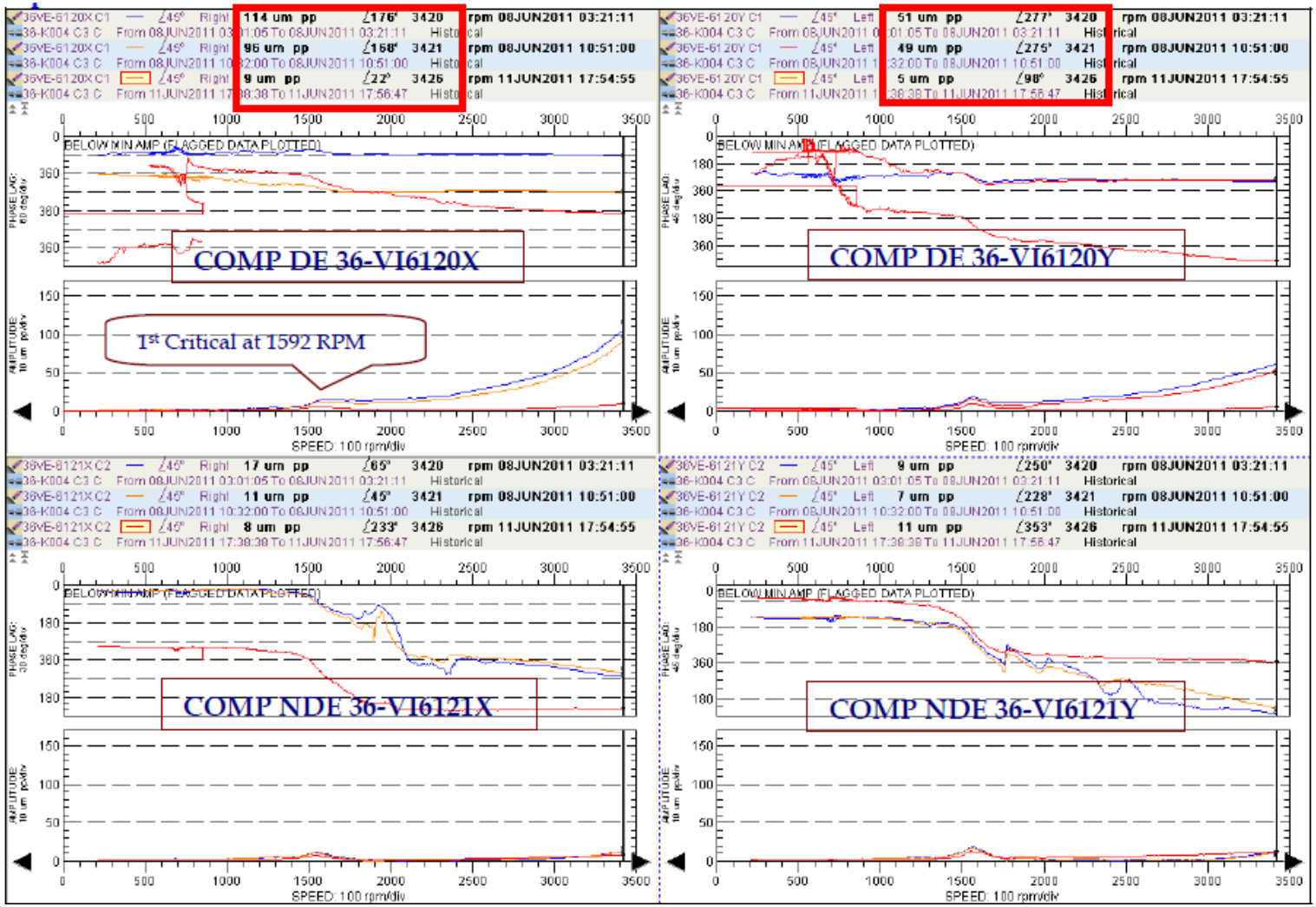
No Problem

Runout Checks are Good and New Vibration Plots are Good

Figure 1: 36-K004 Compressor, Turbine Bearing # 3 radial vibration and Speed trend



Proof: Vibration Plots are Good



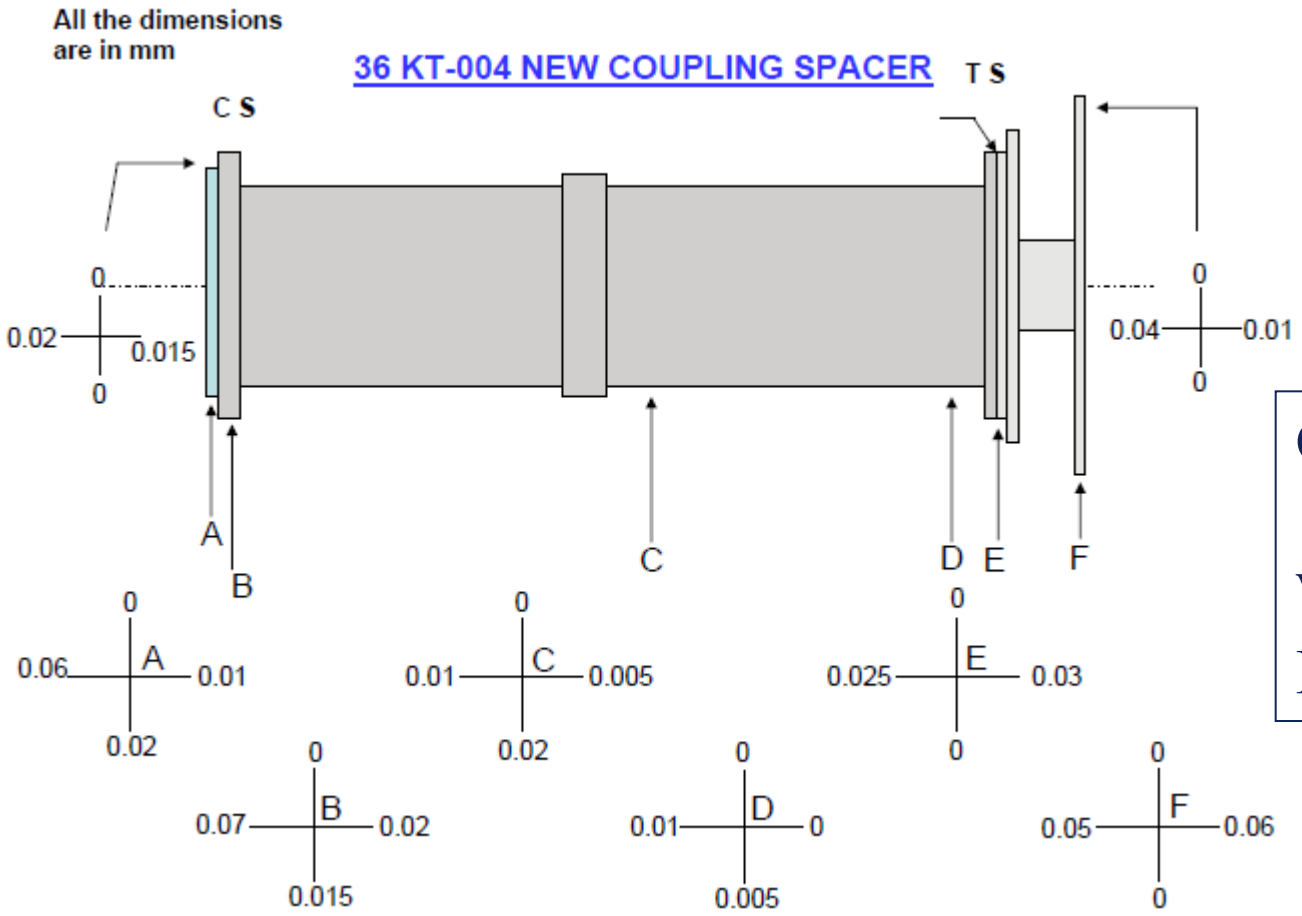
Before and After

Proof: Vibration Plots are Good

Table-1: 36-K004 Vibration levels before and after coupling spacer replacement:

Location	Before coupling spacer replacement (At 70% Load on 09-Jun-11, 07:28 hrs)			After coupling spacer replacement (At 90% Load on 17-Jun-11, 09:00hrs)		
	Overall Vibration (Microns, Pk-Pk)	1X Amplitude (Microns, Pk-Pk)	Phase (Degrees)	Overall Vibration (Microns, Pk-Pk)	1X Amplitude (Microns, Pk-Pk)	Phase (Degrees)
36VI6120X	165	163	174	43	28	14
36VI6120Y	67	64	233	21	11	179
36VI6121X	46	35	59	25	15	291
36VI6121Y	24	16	202	20	8	50
Speed	3421 RPM (95 % Speed)			3636 RPM (101 % Speed)		

Next - Check of Problem Coupling



OK Too !!

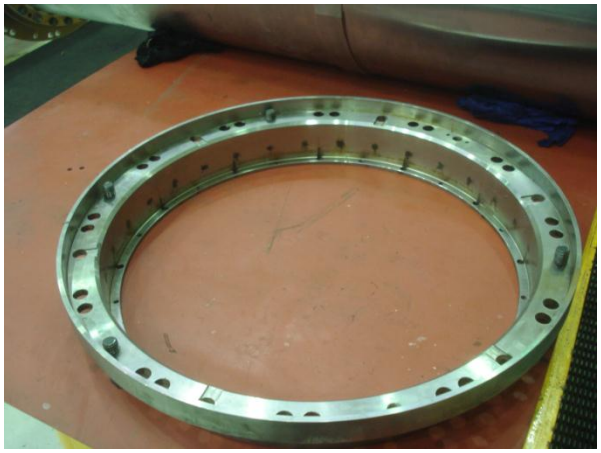
What is the Problem ??

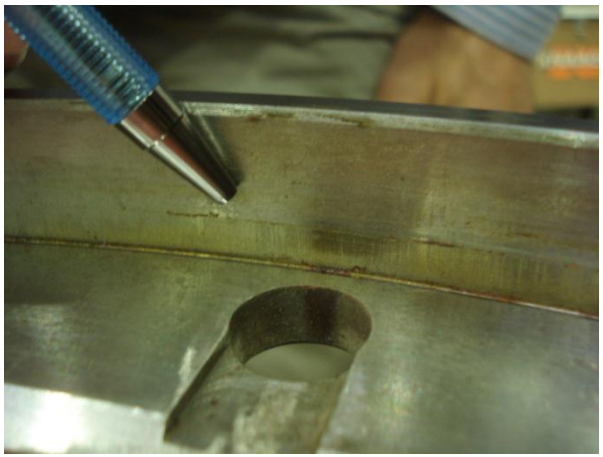
What Could Have Been the Problem?

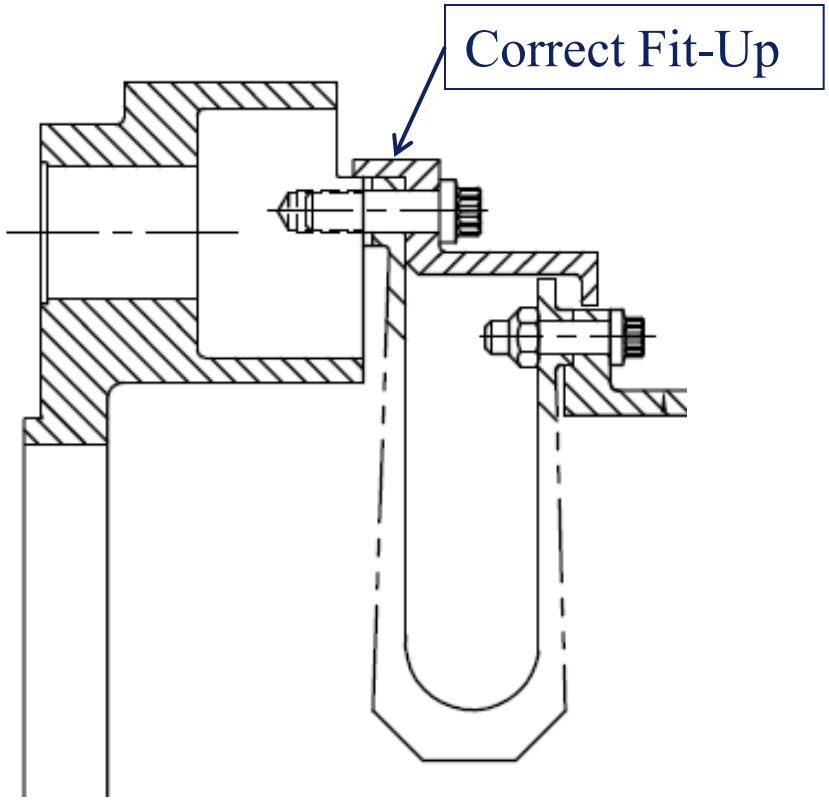
-Installed Run Outs at Positions Other Than Spacer - OK
-Mounting Flange and Adapter - OK
-Hub Mounting Surfaces - OK
-*Then* we remembered a comment about the difficulty of connecting to the Turbine flange
-Re-look at Coupling/Turbine Mounting Surfaces

Aha !! ; Clear Evidence of a Mounting Problem

Connecting Flanges were not Contacting and were out of Square Even Though Bolts Were Tightened Properly



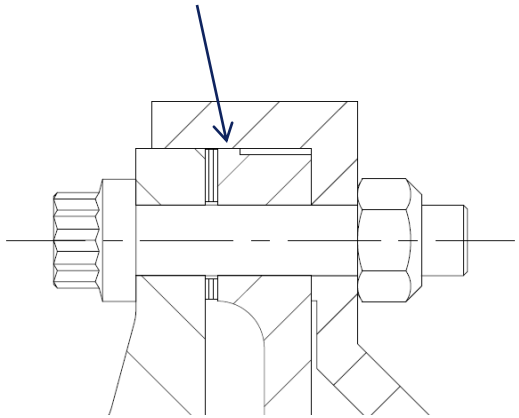




This out of Square caused the Mounted Center Flange High Runout

Recommendations

-Improve Existing Turbine Flange Connection for Ease of Assembly
    -Reduce Width of Guard Pilot
    -Reduce Amount of Interference at Pilot



-Improve Overall Flange Connection Design
    -Use Standard Design Bolting

-Improve Procedure
    -Leave Coupling Adapter in Place

-Handle Diaphragms “Gingerly”

Lessons Learned

-If Coupling Balance is Suspected, Check Installed Run-outs
-If Replacing Non-Match Marked Components, Find "High Spots" and Match Them
-Dye Check or MPI used and/or handled Coupling Diaphragms
-Carefully Handle any Diaphragm
- Do not lay face down on rough surface
-Understand Installation Potential Difficulties When Designing Coupling