WELCOME TO

2014 - MRO
Technical Conference and Workshops
Best Practices in Compressor Mounting

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A Compressor In Slow Motion

Courtesy of Beta Machinery Analysis
http://www.betamachinery.com/
Introduction

The purpose of the mounting system on a reciprocating gas compressor is simple:

Position and support the compressor, its driver and related equipment.

Effectively transmit the vibration produced by dynamic forces down through the foundation while reducing or eliminating the harmful effects of those vibrations.

Accomplish items #1 and #2 above for 30 years or more.
There is Only One Problem

Reciprocating compressors have very high operational forces that act in all directions.

Diagram showing forces in various directions:
- Vertical
- Torsional (Yawing)
- Lateral
- Pitching
- Rocking
- Longitudinal
Solution = FEA + Experience

http://www.swri.org/default.htm
Best Practices Related To...
Foundation Construction
Frame, Rail, Sole Plate and Foundation Preparation
Anchor Bolts, Nuts and Washers
Anchor Bolt Holes / Sleeves / Covering / Sealing
Expansion Joints
Epoxy Grout & Chocks
Coating and Sealing the Foundation
Compressor & Its Foundation

Are a series of interacting structures that move and vibrate.

Objective is to make them into a tightly integrated structure.
Straight vs. Skid Mount
Construction of the Foundation
Foundation Weight = 4 to 8 times Compressor Wt
Foundation Width = > 1.5 times Foundation Height.

- Foundation/Mat CG (FCG) of the block < 15-20 cm (6-8") from the crankshaft’s vertical centerline (CVC)
- Minimize the elevation difference between the MDF and MFCG
- Mechanically isolate the foundation block from
Construction of the Foundation

- Dense rebar in the upper third of block
- #6 Rebar on 6" Centers
- #6 Rebar on 12" centers in lower 2/3's of foundation
- Extra reinforcement around anchor bolts
- Anchor bolts terminating half way into the mat
- Heavy rebar into the mat
- Diagonal rebar at all re-entrant angles
Foundation Design & Installation

High quality concrete with crushed stone

Increase tensile strength with steel fibers

Allow concrete to fully cure

Avoid cold joints

NO sharp internal corners

Avoid vertical connections

Avoid edge lifting

Option 2 - Round Edge of Concrete
Frame, Rail, Sole Plate and Foundation Preparation

Clean, Clean, Clean

Sandblast metal to a minimum SP6 & Solvent Wash

Chip concrete exposing 50% chipped & broken aggregate

NO coatings

COF = 0.7

Coefficient of Friction = Normal Force / Resistive Force
Anchor Bolts

Grade: 4140 ASTM A193 B7 Grade 8.8
Length: 1.2 m (48 inches)
Terminate anchor bolts in the mat
Allow 12 times the diameter or 40% to 50% of the length of the bolt to free-stretch
Allow 10 times the bolt diameter to be embedded
Nuts and Washers

Nuts

Grade: ASTM A194
2H - High Strength

Washers

Spherical Washers
Tensioning

Nuts Hand-Tool tight until grout hardens

Tension Bolts with Hydraulic Bolt Tension

Design for a maximum epoxy chock / grout loading is 6.9 MPa (1,000 psi)

Tension bolts to maximum of 65% to 70% of their yield strength

Re-tighten after compressor & driver have come up to temperature
The Benefits of Bolt Tension

Stored Energy
High Pretension

Stress
Tension in the Bolt

2x

x

Decompression Point - High Pretension

Decompression Point - Low Pretension

Stored Energy Increases as the Square of the Tension

Strain
Change in Length
Tension Applied to the Mounting Flange

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Types of Anchor Bolts
SuperBolts & MagBolts

Other types of bolting options offer more accurate bolt tension.
Anchor Bolt Holes / Sleeves / Covering / Sealing

Rule of Thumb –

12 x Bolt Diameter for Free
10 x Bolt Diameter installed

Upper portion

PVC bolt sleeve
Corrugated plastic
Metal pipe

Lower portion in concrete or epoxy grout
Other Bolting Arrangements
Skid Mounting Methods
Expansion Joints

Proper Layout based on…

Grout manufacturer’s recommendation
Differences in seasonal temperatures

Install Grout Holes
Correct Joint Materials
Well Sealed
Alignment Tools

Many different types

Should have round landing plates with round edges

NEVER leave them inside the grout
Epoxy Grout

3- Component, Non-shrink Grout

Epoxy Grout is Best

Best Practice – full bed of epoxy grout with individual epoxy chocks for anchor bolts

Install without stress risers
Preparation and Pouring
Poured-in-Place Epoxy Chocks

2 Component Epoxy Chocking Compound is Best
NO Stress Risers in Chock
MUST Manage Epoxy Temperature
Overpour is important – use a metal dam
Foam Strip
Depth above bottom of mounting foot
Individual Chocks

- Compressor mounting foot
- Jacking Screw
- Seal bottom edge of metal dam with sealant, putty or clay
- Coat threads of joining screw with non-melt grease
- Tack weld flat bar metal dam on 3 sides
- 2 mm Gap between metal dam and sole plate on 3 sides
- Sole plate
- Wrap threads with tape, apply grease or cover with Armalox Pipe Insulation
- Angle iron used to create the overpour area
- Must have water-tight seal here
- 1-beam may need to be spot faced to ensure bolt is perpendicular to face of nut
- 260mm
- 740mm
- 14mm
- 20mm
- Wrap threads with tape, apply grease or cover with Armalox Pipe Insulation
- Tack weld flat bar metal dam on 4 sides
- 15mm
Vibratherm Chocks
Coating and Sealing the Foundation

After Grouting – Seal Surrounding Concrete

Prepare surface
Address cracks & expansion joints
Epoxy Primer & Epoxy Top Coat

Seal Mounting feet & Sole Plates

Seal Expansion Joints

Install Drip Pan
Precise equipment alignment –
- Positioning critical to efficient performance

Increased stiffness, damping natural frequency of the fabricated equipment platform.

Superior connection with the foundation –
- Monolithic contact between equipment (dynamic) and foundation (absorbing) masses for efficient load transfer and dissipation
- Steadfast adhesive bond of epoxy grout to steel and concrete
- Enhanced vibration damping properties of epoxy grout

Chemical resistance –
- Extends the service longevity of the grout
- Can protect concrete to maintain integrity of the foundation mass
  - Achieving the above helps to provide key essential benefits –
    - Optimum Equipment Performance
    - Decreased Life-Cycle Costs
Best Practices

Follow standards, guidelines & recommendations...

Whatever standard(s) you choose to follow...follow them.

- **API 610** - Centrifugal Pumps for General Refinery Service
- **API 686** - Recommended Practices for Machinery Installation and Installation Design
- ACI 351 - Foundations for Dynamic Equipment
- PIP STS03601 - Epoxy Grout Specification
- In-house Standards - Your own established guidelines
- **Grout recommendations** - for storage, handling, mixing, placement, curing and testing of grouting materials
All components must be considered and properly engineered as a system when designing for optimum equipment performance.
Conclusion

Installation “Best Practices” should be…

Accumulated & Recorded
Confirmed and
Consistently Applied
Thank You

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