Case Histories

Screw Compressor Pulsation & Vibration

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The Whole Story

The Myths
• Screw compressors are pulsation & vibration free
• Screw compressors never need pulsation control
• Pulsation has no effect on component life

The Truths
• Screw compressors are positive displacement compressors which create fluctuating flow and, therefore, fluctuating pressure
• Many larger compressors have custom pulsation control devices
• Bearings, piping and fitting failures can be due to pulsation & vibration
• Field control of vibration can include orifice plates for pulsation control
Gas is captured between the male and female rotors at the suction port, transported down the rotors and released at the discharge port at lobe-passing frequency (rotor speed x number of lobes on rotor = PPF).

There is pulsating flow due to the opening and closing of the rotors to the suction and discharge ports.

With pulsating flow, there is pulsating pressure – Pulsation!

Note: Often the male is the driven rotor and it has 4 lobes, but configurations vary.
Over- or Under-Compressing

• A screw compressor has a built-in volume ratio $V_i$, which is the amount it compresses the suction gas just before reaches the discharge port.

$$V_i = V_s/V_d$$

• Ideal pressure ratio when internal pressure = discharge pressure when open to discharge port.

$$P_i = \frac{P_d}{P_s} = Vik$$

$$V_i = P_i^{1/k}$$

Ideal pressure and volume ratios based on line conditions and ratio of specific heats, $k$. Pressure units must be absolute.

• Efficiency decreases and pulsation levels increase with over- or under-compression.
Acoustical and Mechanical Resonance

• High frequency pulsation (PPF) in the order of 14,400 cpm (240 Hz) can excite acoustical resonance in piping and vessels.

• Large diameter, thin wall coalescing filter vessels – flexing of vessel walls amplify pulsation.
Symptoms

- Component Failures
  - Pipe and fittings
  - Instrumentation
  - Vessel internals
  - Compressor bearings
- Extreme Noise
  - Vessels make excellent “speakers”
- Damage to off-line equipment
Solutions

- Adjust Vi close to ideal
- Adjust speed away from resonance
- Modified or thicker wall vessels (rather costly)
- Orifice plate at compressor outlet flange

Notes:
- Size orifice plate for allowable pressure drop.
- Position hole at bottom if oil collection is a concern.
Case History #1
Refrigeration Compressor

- New package
- Propane Service
- Coalescing filter internal and external failures
  - Broken oil diverter caused excessive oil loss
### Extreme Pulsation Levels

- 95 psi pk-pk in 200 psi discharge line pressure!!!
Coalescing Vessel Shell Deformation

- 4 lobe deflected shape amplifies pulsation and unit vibration
- High vibration destroyed vessel internals

Field generated operating deflected shape of coalescing vessel. – Ethan Clark, March 2012
Case History #1 – Solution & Results

• Installed orifice plate at compressor discharge flange
• Repaired coalescing filter
• Pulsation and vibration reduced to acceptable levels
• It was so good, they didn’t need us to come back!
• No more reported failures.
Case History #2
CO$_2$ Compressor

- Spared process compressors
- Normal operation is one unit operating
- Premature bearing failures
High Vibration on Common Suction Piping

• High pulsation-induced vibration on shut down machine causes bearing damage.

• Very short bearing life
Case History #2 – Solution & Results

- Installed orifice plate at compressor discharge flange
- Suction piping vibration reduced by >90%
- Bearing life has increased from days to years
Case History #3
Coalbed Methane Field Booster

- New compressor with high bearing vibration.
- Not bearing faults – pulsation frequencies.
Case History #3 – Solution & Results

• Monitoring for bearing wear is impractical with high vibration from pulsation.
• Installed orifice plate at compressor discharge flange and reduced overall vibration by >70%.
• Still running!

![Before Orifice](image1.png)

![After Orifice](image2.png)
Conclusions

• Screw compressors produce pulsation that can be destructive.
• Discharge orifice plates can be a valuable solution.
• Orifice pressure drop should be well-understood!
  • Consider lube oil in pressure drop calculations
  • Consider hole location in orifice plate
Any questions?

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