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Innovative Remediation Techniques to Compressor Foundation Systems

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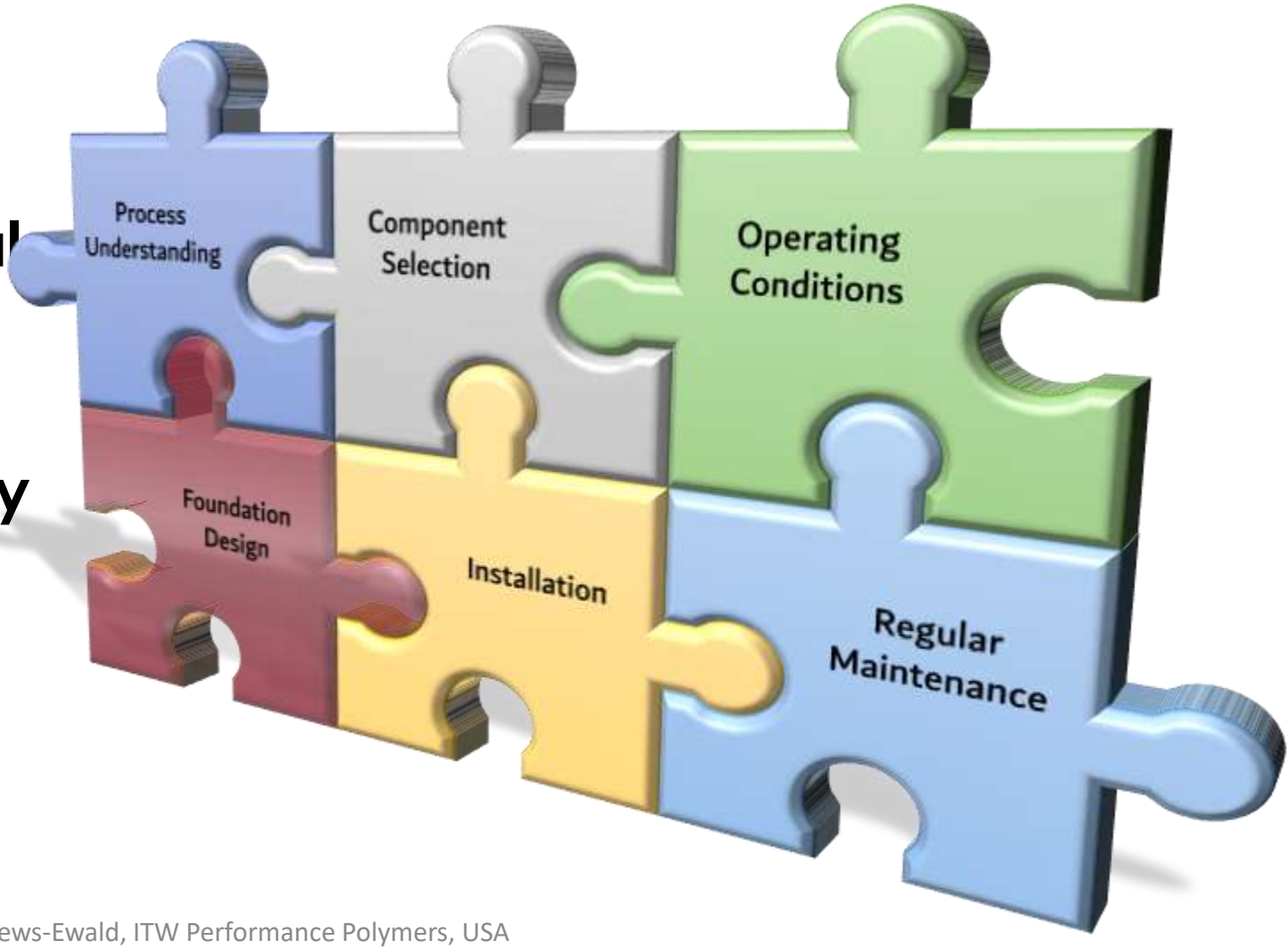
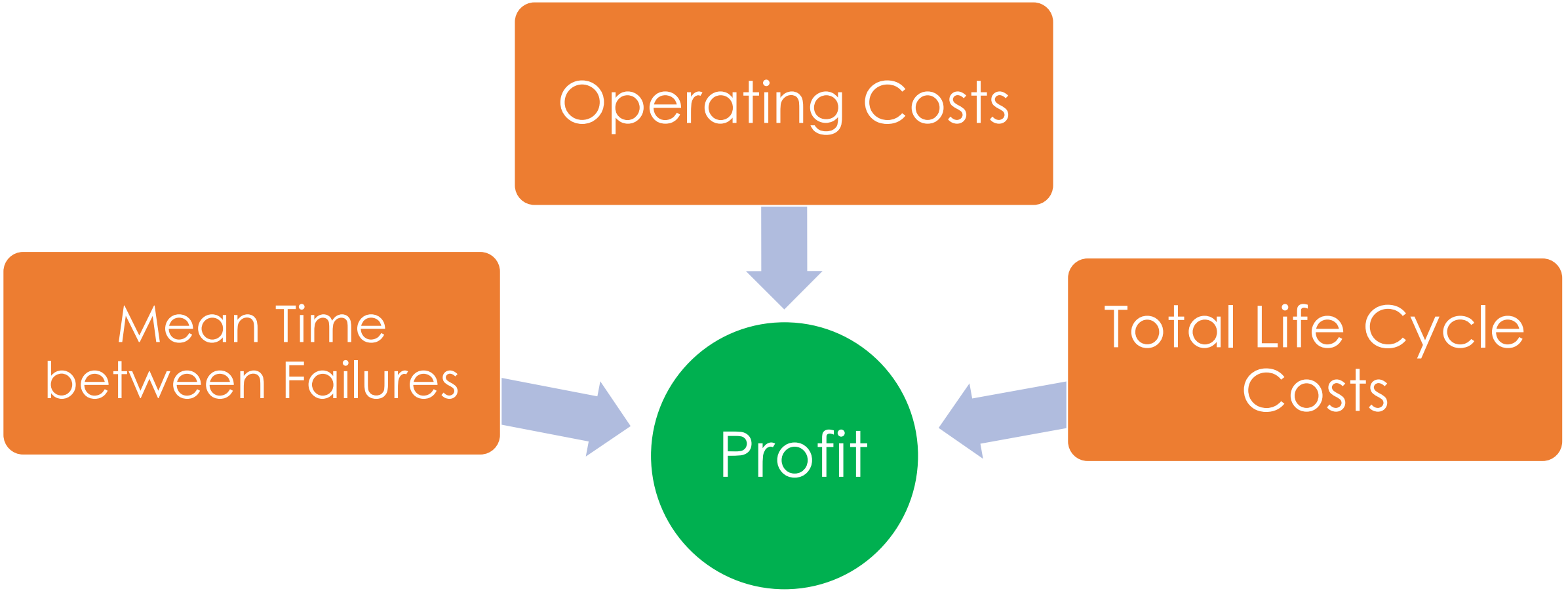
Introduction

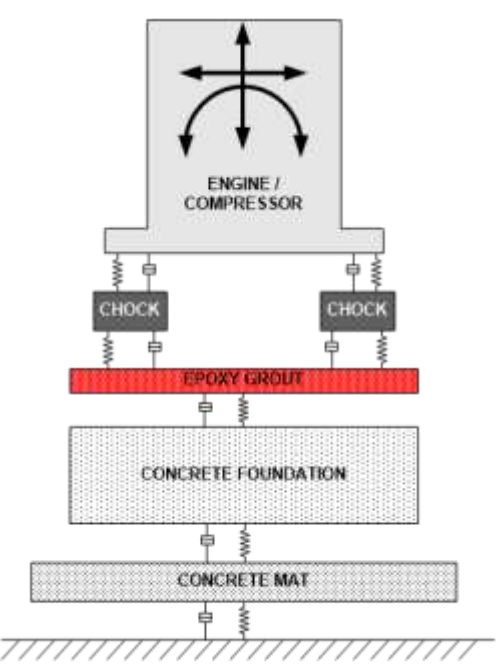
- Crtitical pieces of dynamic equipment, particularly compressors, receive especial focus when evaluating and assessing reliability
- Reduced operational reliability has a direct impact on asset profitability through:
  - Increased maintenance costs
  - Decreased up-time
  - Increased Operational Risks

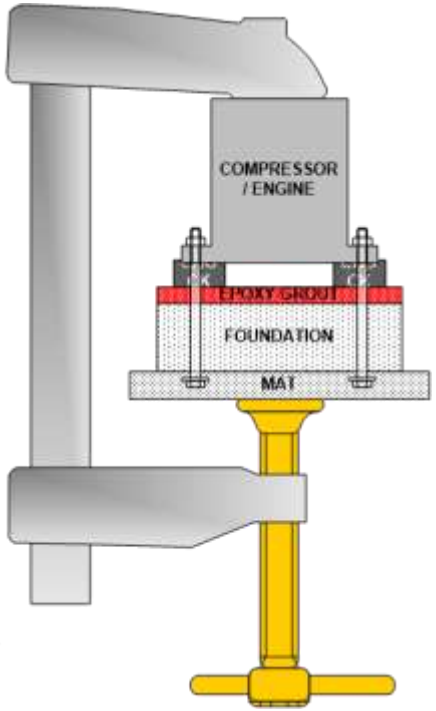


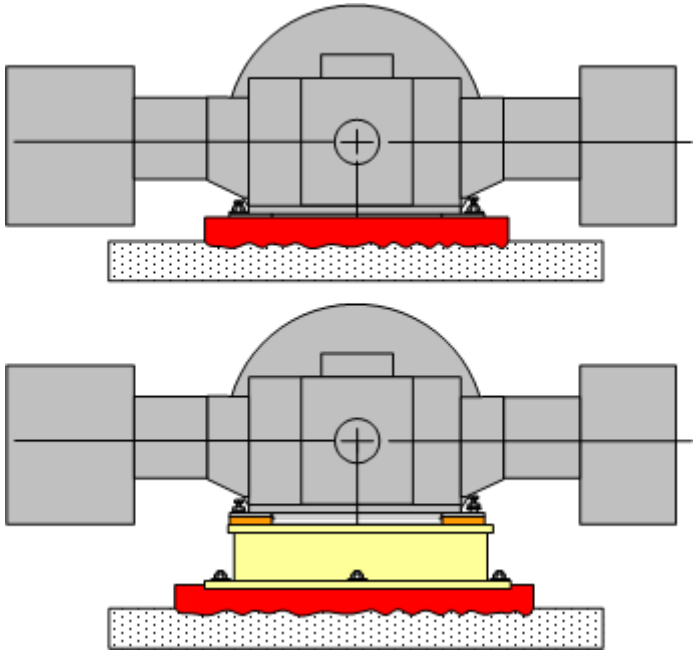
Introduction



Foundation Design for Compressor Reliability







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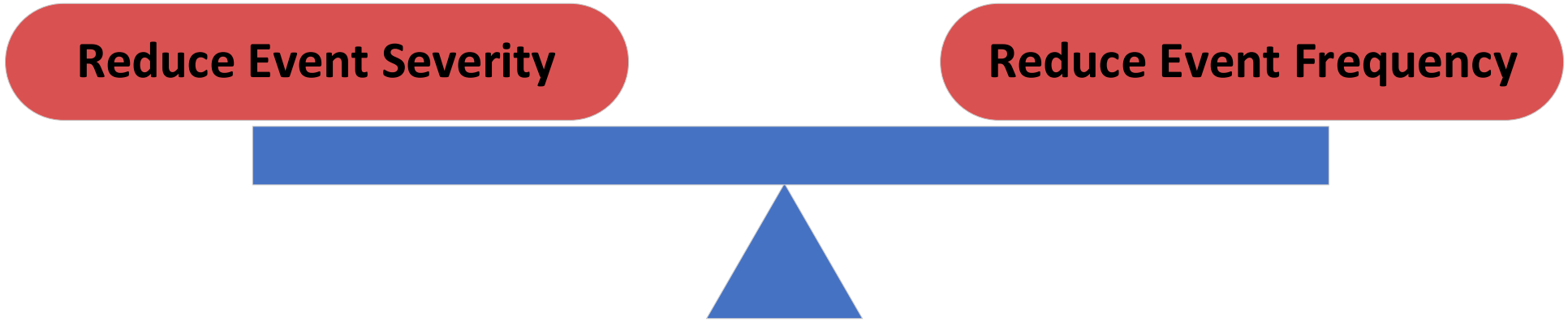


Risk ($/yr) = Consequence of Occurrence ($) x Frequency of Occurrence (/yr)[4]
Where Frequency of Occurrence =[Frequency of Event x Probability of Failure]

Foundation Design for Compressor Reliability

Ways to Reduce Event Frequency

Ways to Reduce Event Severity

Proper Planning and Execution

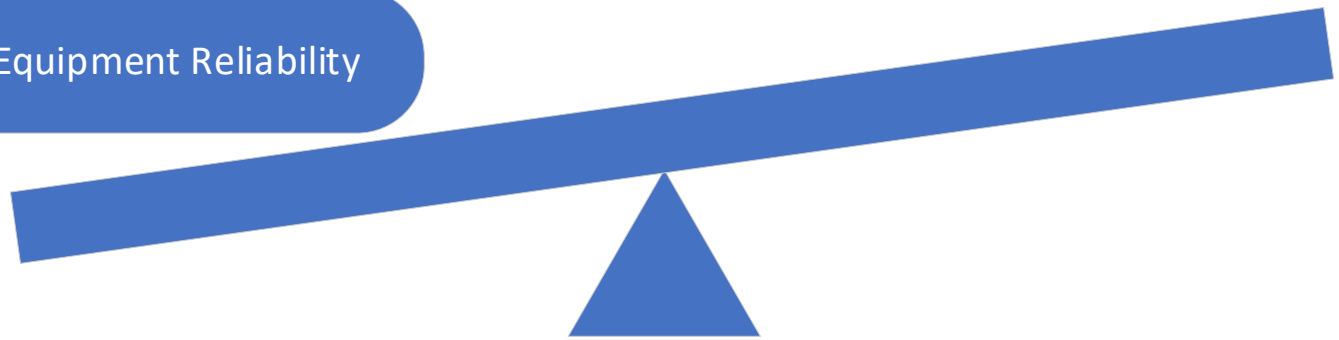
Stock of Spare Parts

Selection of Proper Components

Trained Maintenance Staff

Predictive Maintenance Culture

Improved Equipment Reliability



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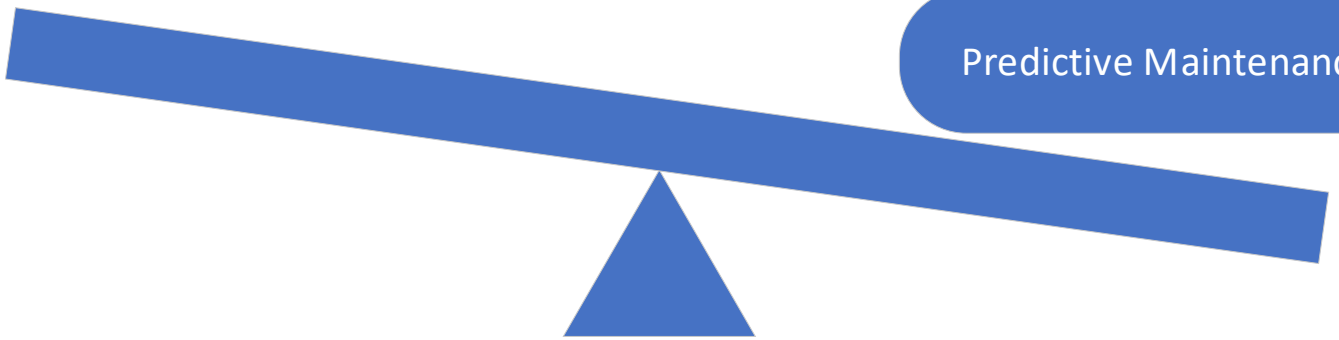

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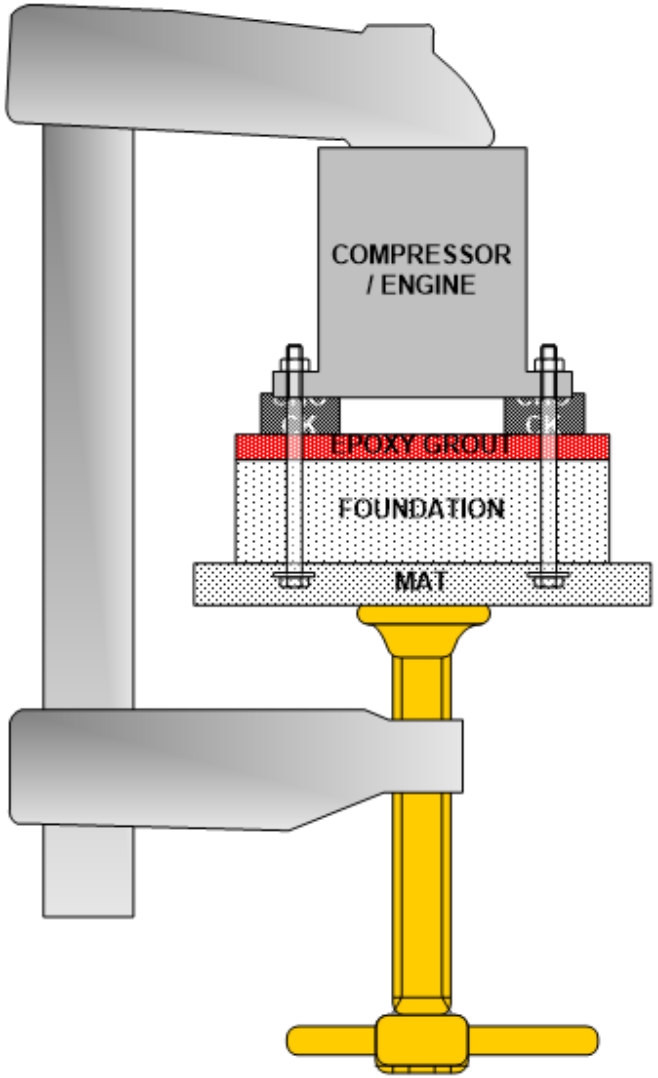


Case History – Equipment Removal and Foundation Rework

- A major operator of a petrochemical facility was experiencing ongoing performance and mechanical problems with a critical, one-stage, 4-cylinder reciprocating process gas compressor.
- Originally installed in 1978 on cementious grout.
- Overtime, vibrations increased to the point that the equipment could no longer be operated due to safety concerns.

Case History – Equipment Removal and Foundation Rework

- Asset owner contracted the original equipment manufacturer (OEM) to review, diagnose, and implement remediation.
- OEM partnered with a regional team of foundation experts to assess extent of damage and develop remediation plan.
- Vibrations resulted in extensive damage to foundation system.
  - Mechanical Damage to Compressor Components
  - Anchor Bolts no longer maintaining tension
  - Extensive cracks within foundation system

Case History – Equipment Removal and Foundation Rework

1st Step - Evaluate overall condition of foundation system

- Alignment verified by tensioning anchor bolts to recommended preload.
- Based on this assessment, determined that only the piston loaded areas would require foundation remediation.

Case History – Equipment Removal and Foundation Rework

1st Step - Evaluate overall condition of foundation system

A remediation design was created through effective collaboration between project stakeholders.

- **Remove and replace existing anchor bolts.**
- **A best-in-class, precision epoxy grout was selected to connect new anchor bolts and sole plates to existing concrete foundation.**

Case History – Equipment Removal and Foundation Rework

2nd Step- Remove Equipment Components

- Existing compressor removed from foundation and sent off-site for rework
- Allowed full access to the remaining foundation system

Case History – Equipment Removal and Foundation Rework

3rd Step – Remove Existing Foundation Components

- Sole plates were removed
- Existing cementious grout removed

Case History – Equipment Removal and Foundation Rework

3rd Step – Remove Existing Foundation Components

Prepare concrete surface for epoxy grouting

Case History – Equipment Removal and Foundation Rework

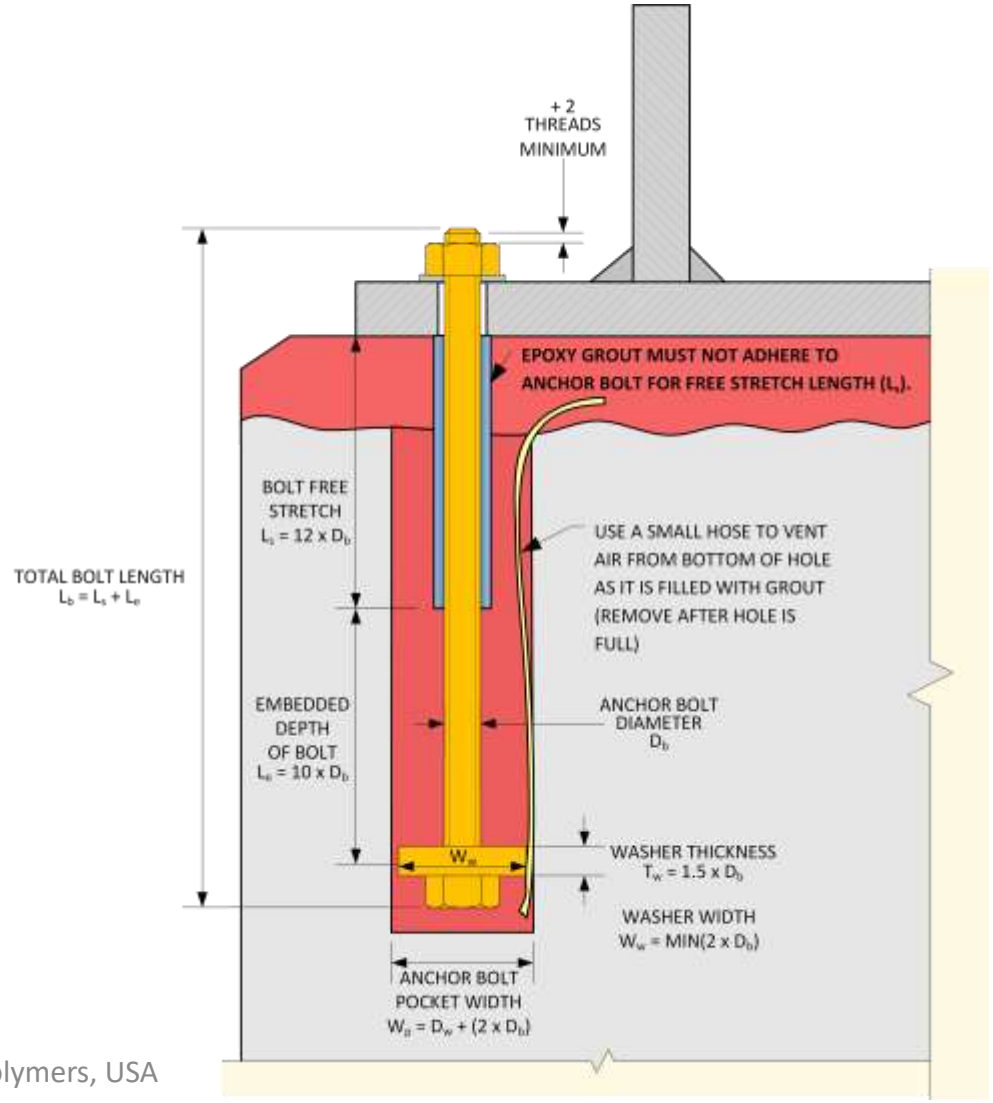
4th Step – Core Drill New Anchor Bolt Pockets

- Core drilling was performed using a 152-mm OD (6-in) core drill bit and were drilled down to a depth of 100-mm (39-in), to accommodate the new bolts with a length of 950-mm (37-in).
- A total of 4 support plates and 16 damaged bolts were removed.

Case History – Equipment Removal and Foundation Rework

5th Step – Reinstall Compressor after Overhaul

- Overhauled compressor aligned on foundation.
- The new anchor bolts installed.
  - Class 8.8 per ISO 898-1.
  - Anchor Bolts hung into newly drilled anchor bolt pockets.



Case History – Equipment Removal and Foundation Rework

6th Step – Clean Foundation

- Cleaned foundation in preparation for epoxy grout installation
- Removed all dust and debris
- Particular attention on anchor bolt pockets

Case History – Equipment Removal and Foundation Rework

7th Step – Prepare for Epoxy Grout Installation

Formwork was constructed to allow filling of the mounting area.

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Case History – Equipment Removal and Foundation Rework

8th Step – Install Epoxy Grout

- The mounting area under the compressor support rails were filled with precision epoxy grout, as recommended and installed by the regional foundation expert team.

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Case History – Equipment Removal and Foundation Rework

9th Step – Remove Formwork and Prepare for Startup

After sufficient time had elapsed, based on temperature during initial cure, the formwork was removed, the removable alignment devices were backed out, and the anchor bolts were properly tensioned per the recommendations of the OEM.

CURE TIME (APPROXIMATE)	54 hours @ 60°F (16°C) 36 hours @ 72°F (21°C) 24 hours @ 80°F (27°C) 18 hours @ 90°F (32°C)

Recommended Initial Cure Time for Precision, Non-Shrink Epoxy Grout, as found in Product Data Sheet.

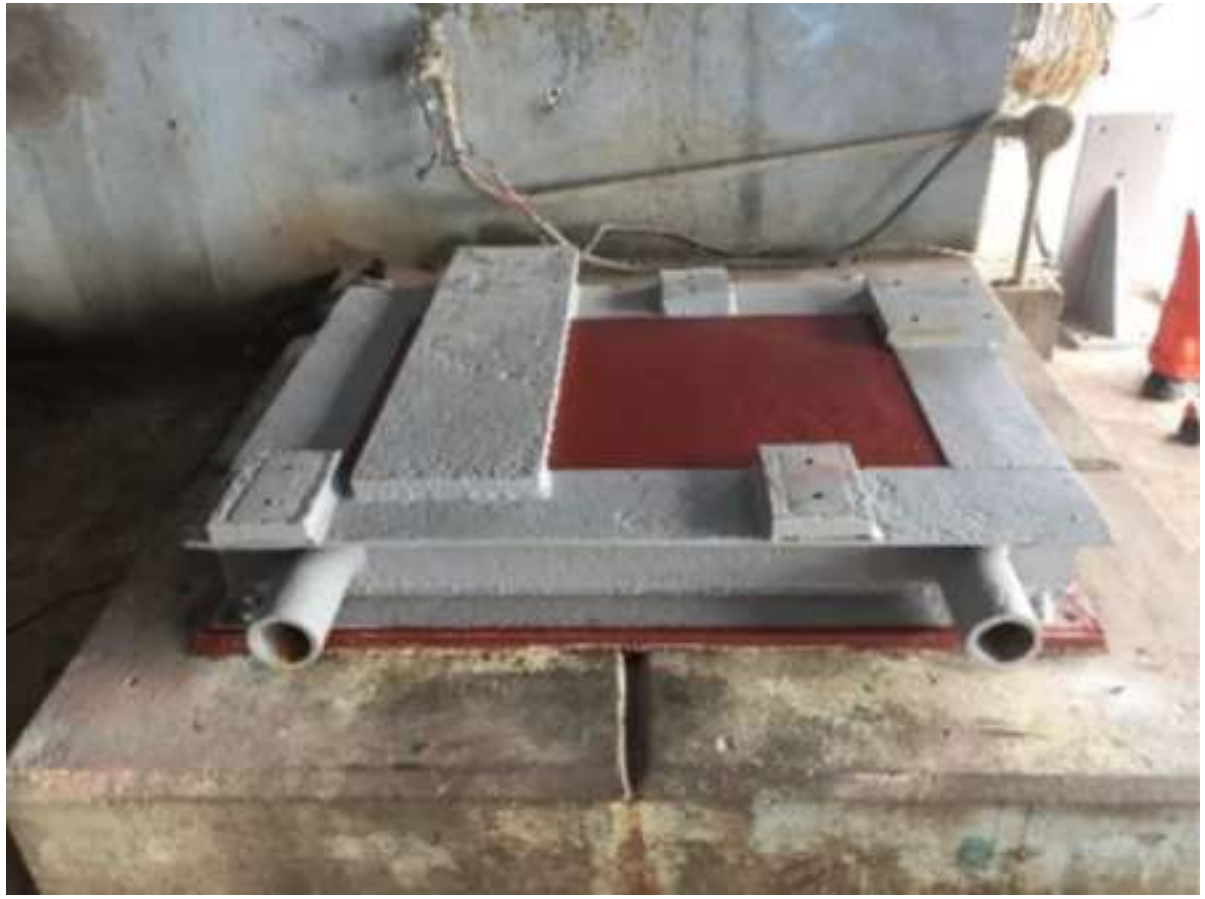
Case History – Equipment Removal and Foundation Rework

A follow up visit was conducted approximately 1 year after the initial installation. At that time, the anchor bolts were observed to be maintaining the proper tension without concern and the compressor was reported to have been operating very well. There were no concerns with excessive vibrations or wear to the mechanical components of the compressor. The remediation was considered a success.

Case History – Equipment Removal and Foundation Rework

Keys to Success

- Early engagement with teams of experts that understand local requirements & operating environments
- Effective collaboration between stakeholders (OEM, Asset Owner, Foundation Team)
- Thorough understanding of the operating environment & selection of best-in-class components to meet those needs.



Case History – Equipment Removal and Foundation Rework

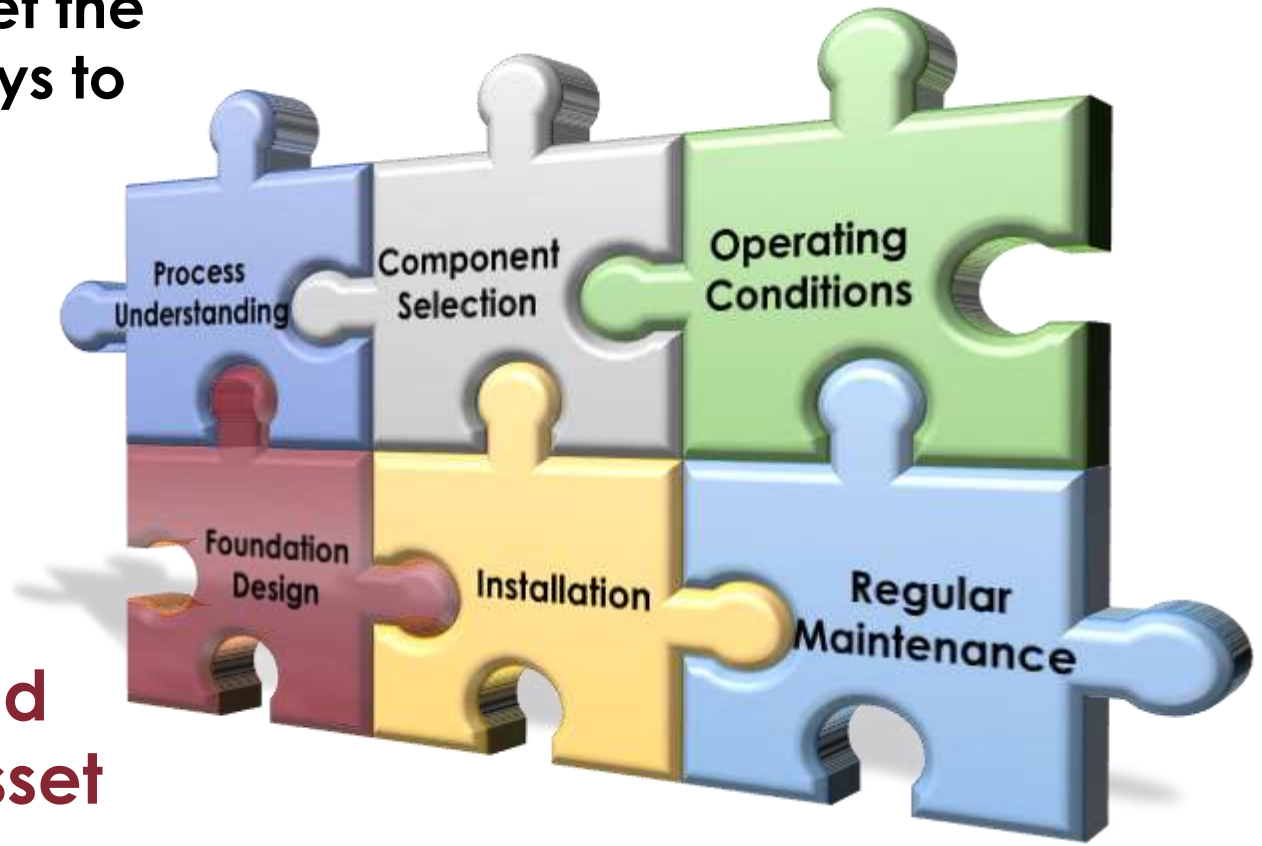
Lessons Learned

- Regular maintenance schedule would likely have identified compressor deficiencies prior to being non-operational and negatively impacting overall profitability of asset
- Early identification of high vibrations would likely have reduced overall cost of rehabilitation
- Selecting foundation components initially based on the operating environment would have likely extended service life and decreased total life cycle costs

Conclusion

Selection of best-in-class foundation components and partnering with regional experts to meet the operational needs of an application are keys to achieving long-term reliability of critical machinery, resulting in benefits including:

- **Increased equipment up-time**
- **Increased Mean Time Between Failures**
- **Decreased maintenance costs**
- **Decreased overall operating costs**



Increased predictability, reduced operational risk, and increased asset profitability.

Acknowledgements

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- **Timothy Barrington,** ITW Performance Polymers, Regional Sales Manager, Overland Park, Kansas, United States – tbarrington@itwpp.com

Thank you!

For any further questions or assistance, please contact me at:

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