MIDDLE EAST TURBOMACHINERY SYMPOSIUM

Reliability Improvement for Turboexpander-Compressor System

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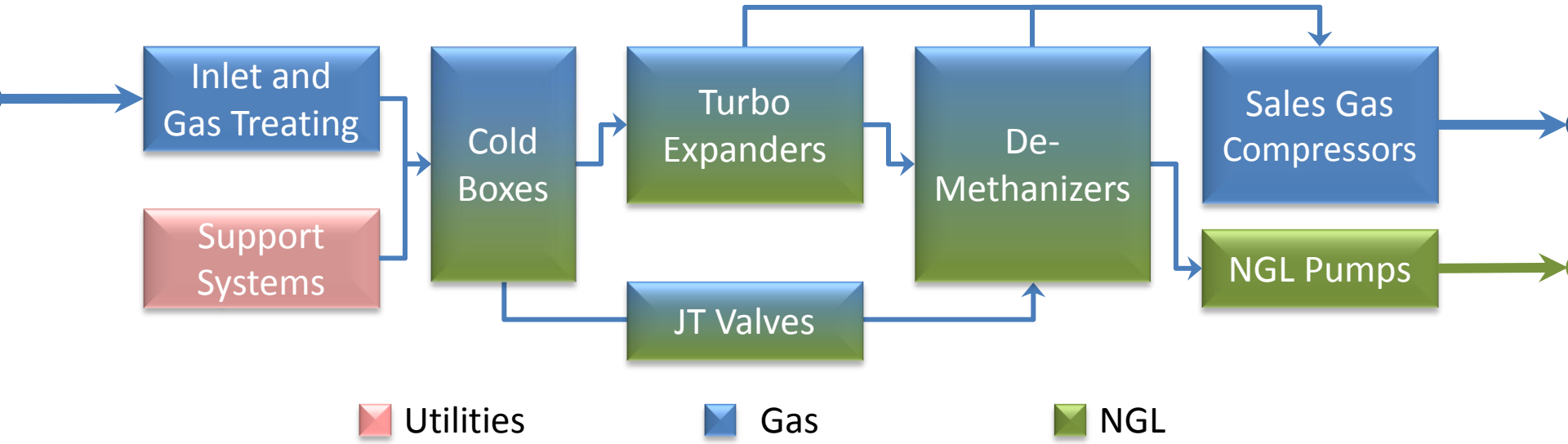
Outline

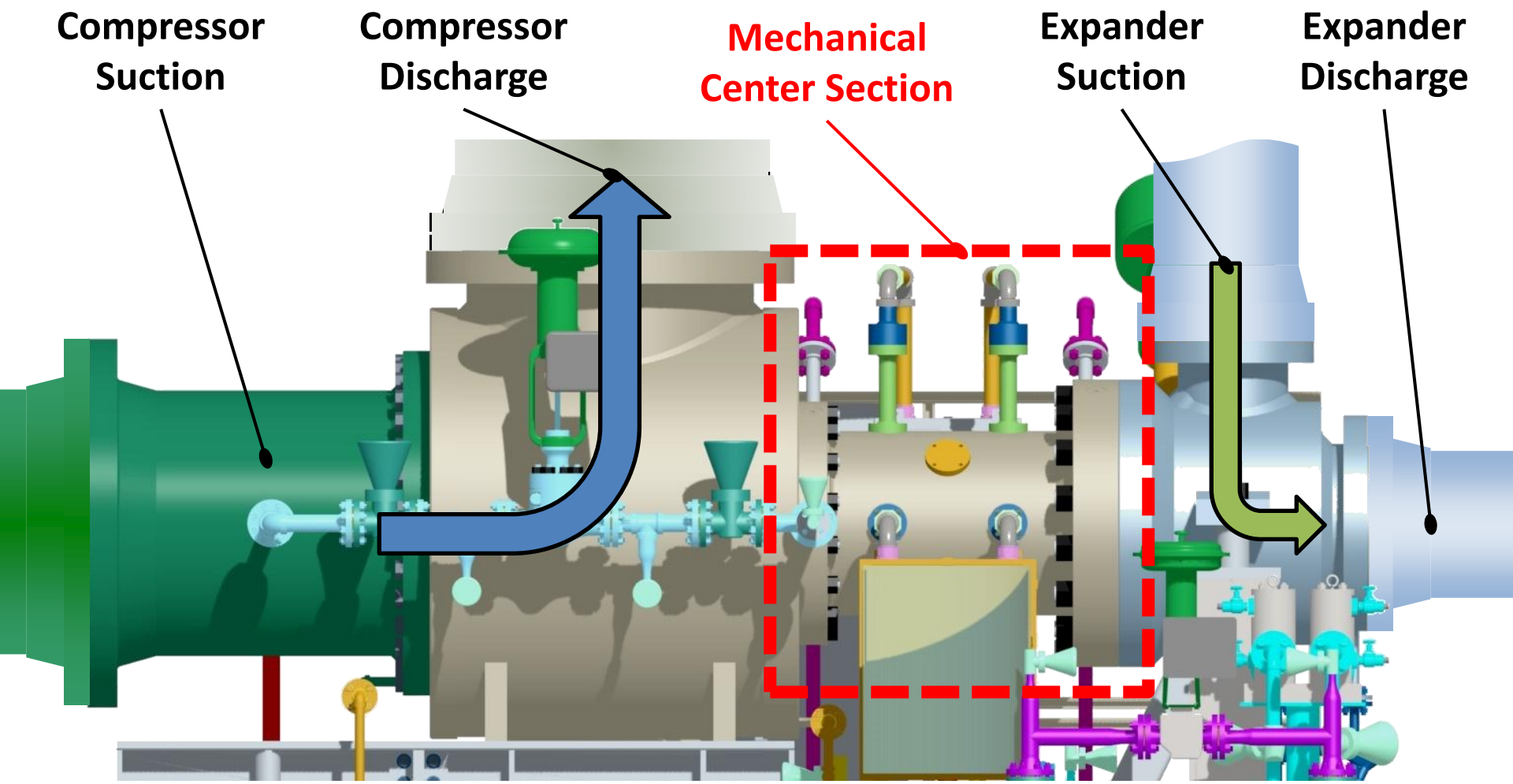
- Introduction
- Turboexpander-Compressor Challenges
  1. Buffer Gas Excessive Flow
  2. Expander Speed Limit
- Execution Optimization
- Lessons Learned
- Concluding Remarks

Hawiyah NGL Plant

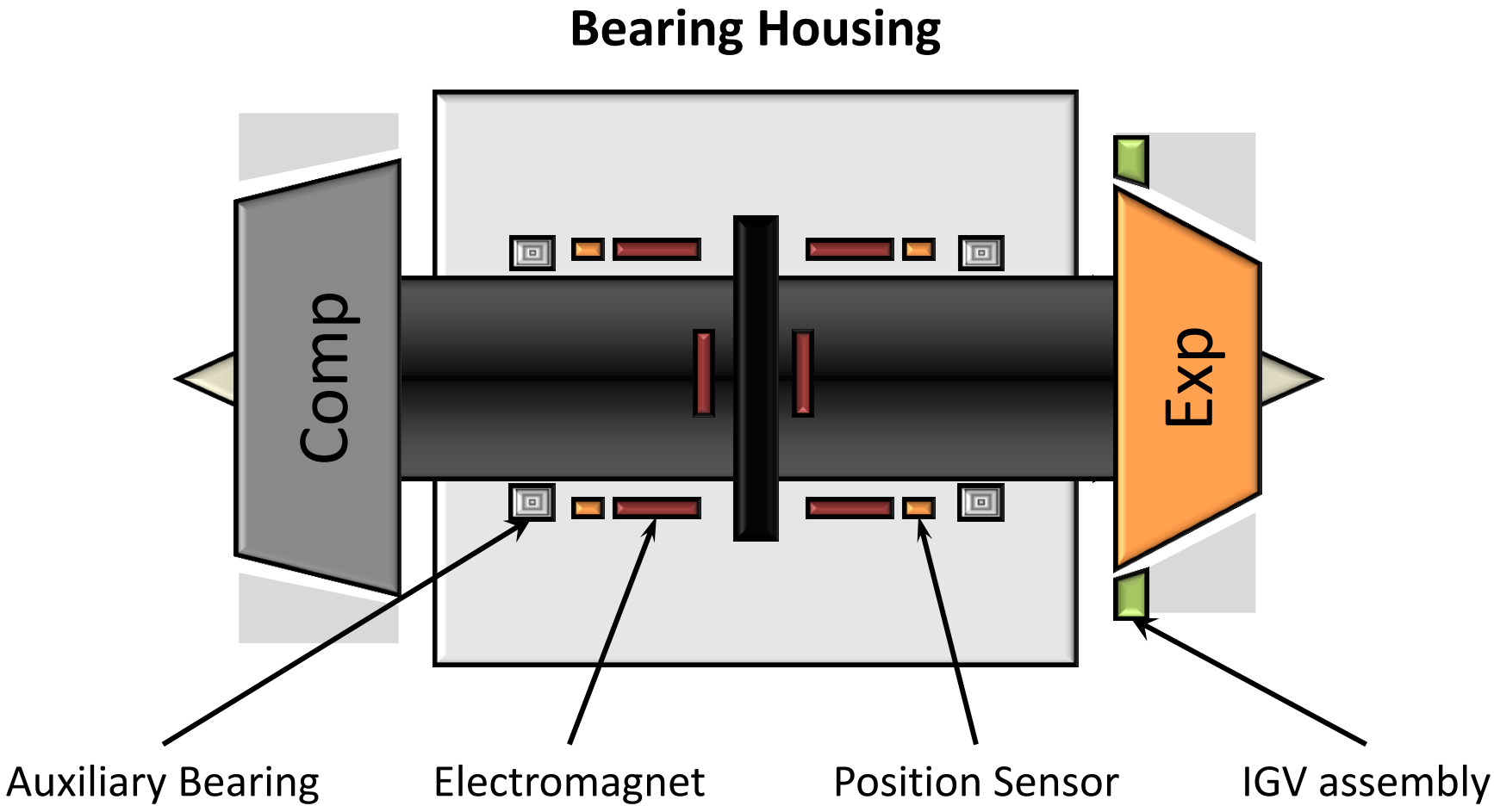
- Plant was commissioned in 2009.
- Three trains to recover Ethane-rich NGL.
- Each train has two 50% turboexpander-compressors.
- Reliability of EC system directly impacts production and operating economics.



Turboexpander-Compressor System



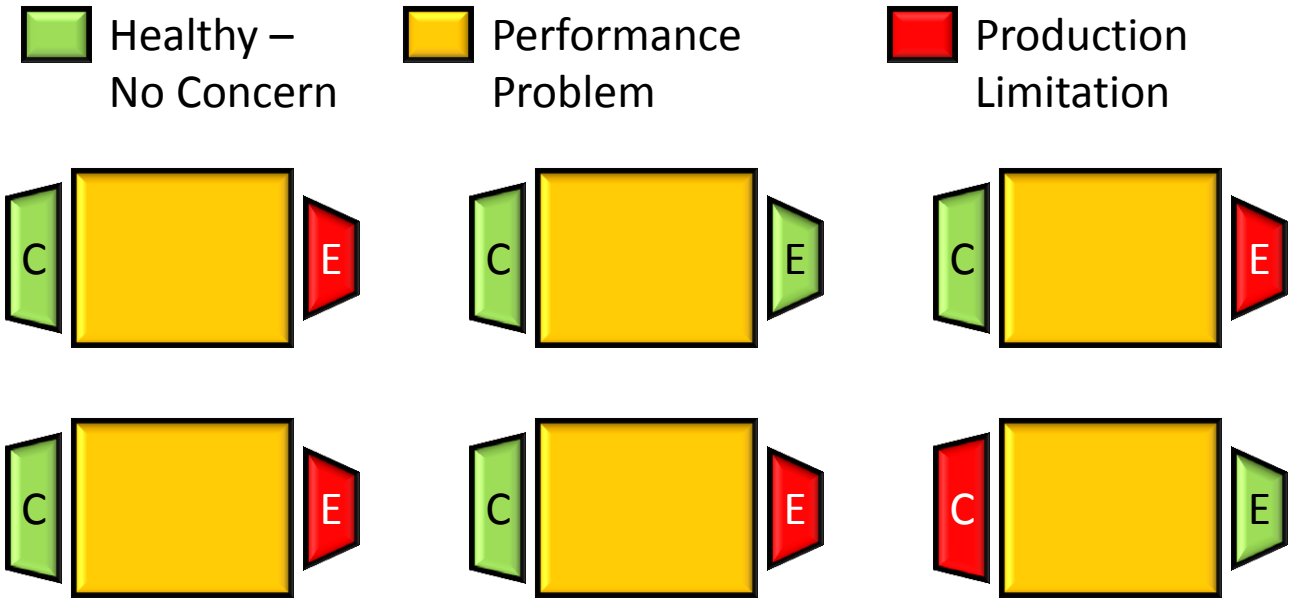
Mechanical Center Section



Performance Assessment Survey

The turboexpander exhibited three problems:

1. Buffer gas excessive flow (Bearing Housing)
2. Wheel imbalance (Compressor)
3. High magnetic bearing current (Expander)

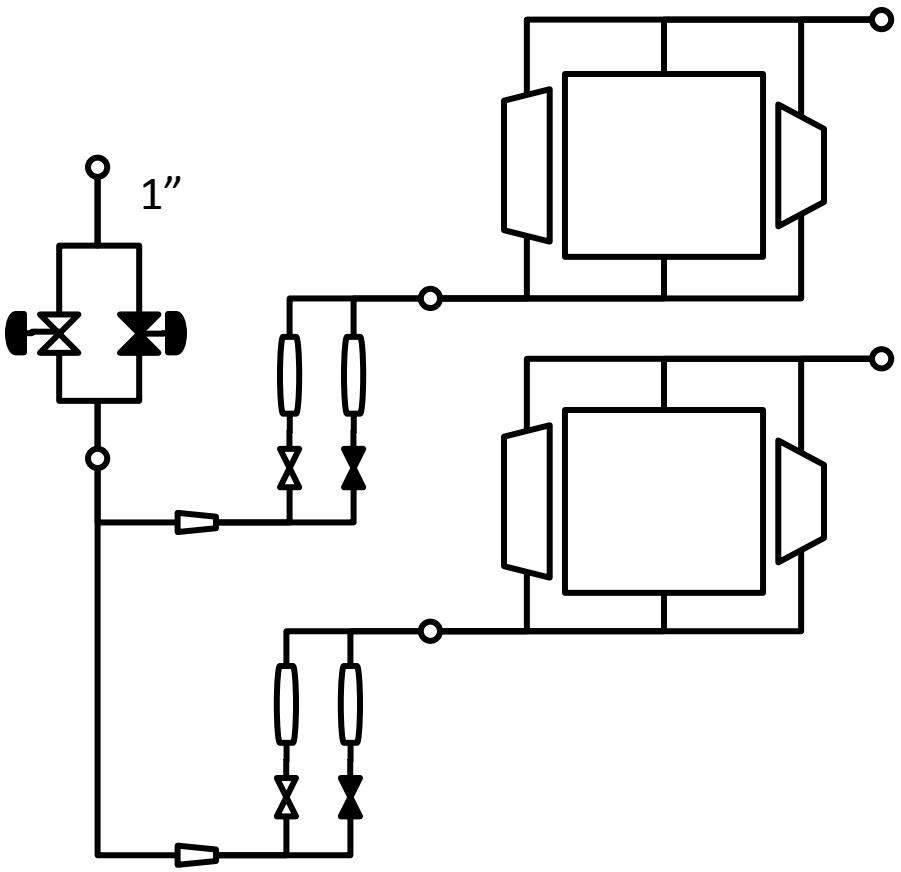


Challenge 1: Buffer Gas Performance

Buffer Gas Functions:

1. Rejects heat generated by magnetic bearings and shaft windage.
2. Protects auxiliary bearings from process gas.

Buffer Gas = Sealing Gas + Cooling Gas



Challenge 1: Description

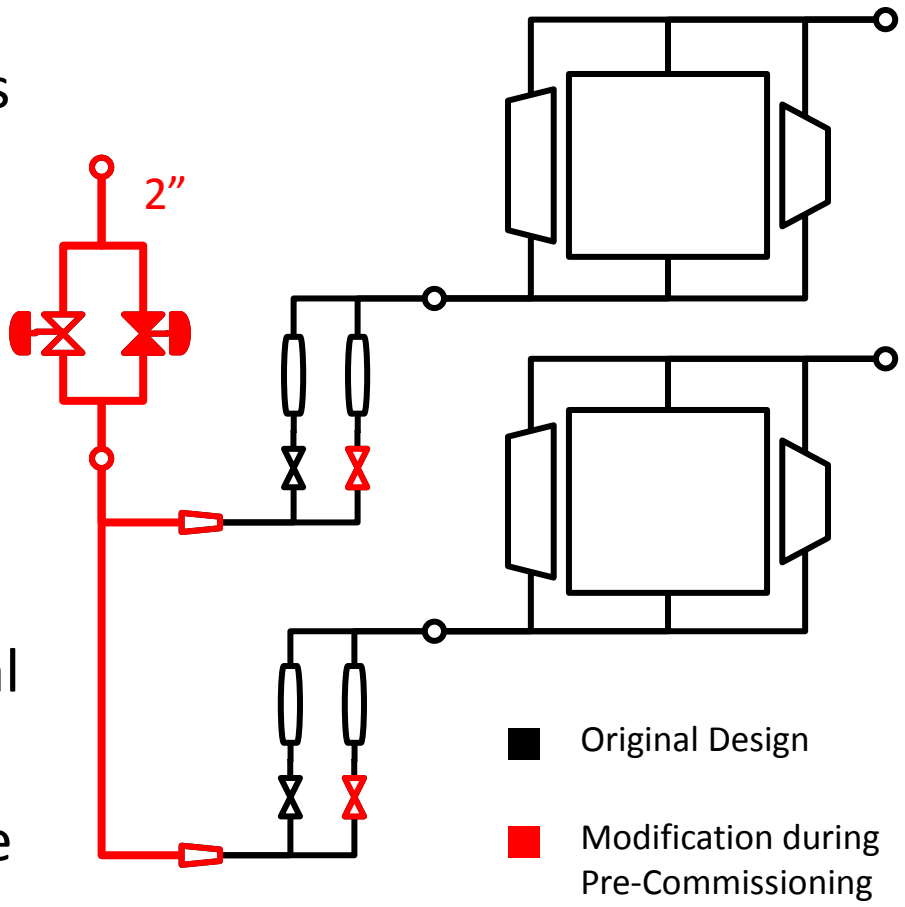
During Pre-Commissioning:

- Piping vibration at seal gas supply valves.

→ Increased valves and piping from 1” to 2” for stiffness.

Subsequent Performance Problems:

1. High dP across on-skid seal gas filters.
2. Potential machine trip due to low seal gas dP.



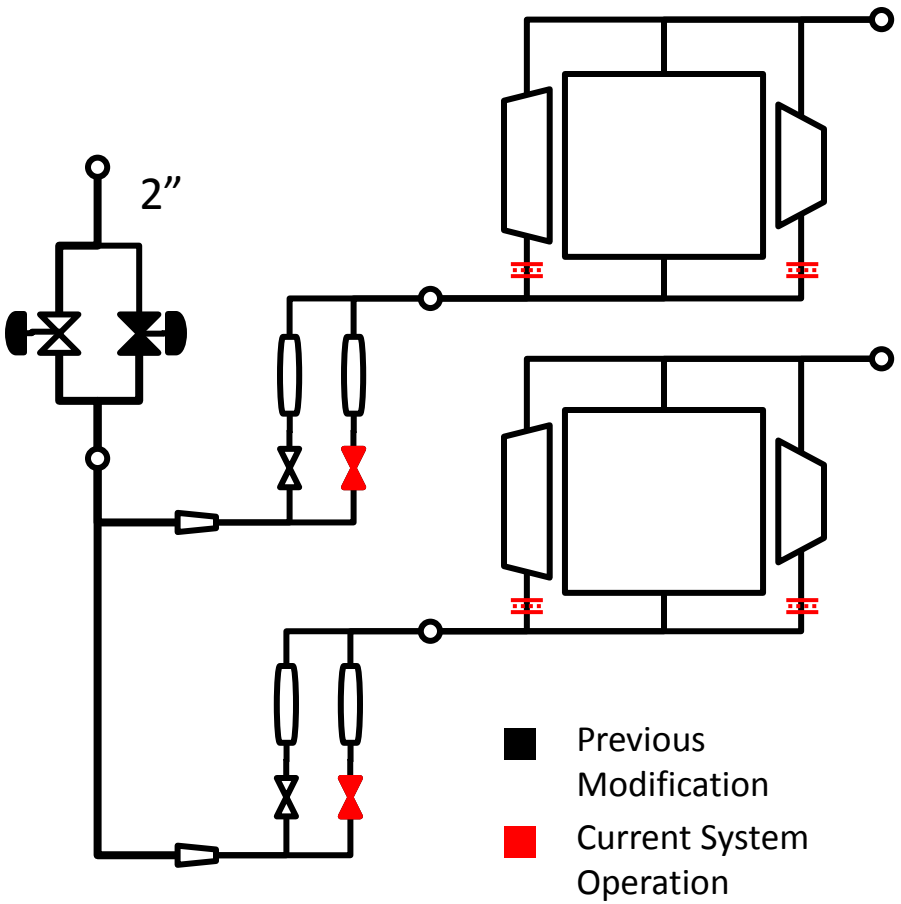
Challenge 1: Analysis and Solution

Problem Analysis:

- Cooling gas flow could be reduced, such that bearings temperatures remain < 230 °F.

Implemented Solution:

- Reduced the size of **internal** orifices to 1/8” to restrict the cooling gas flow.



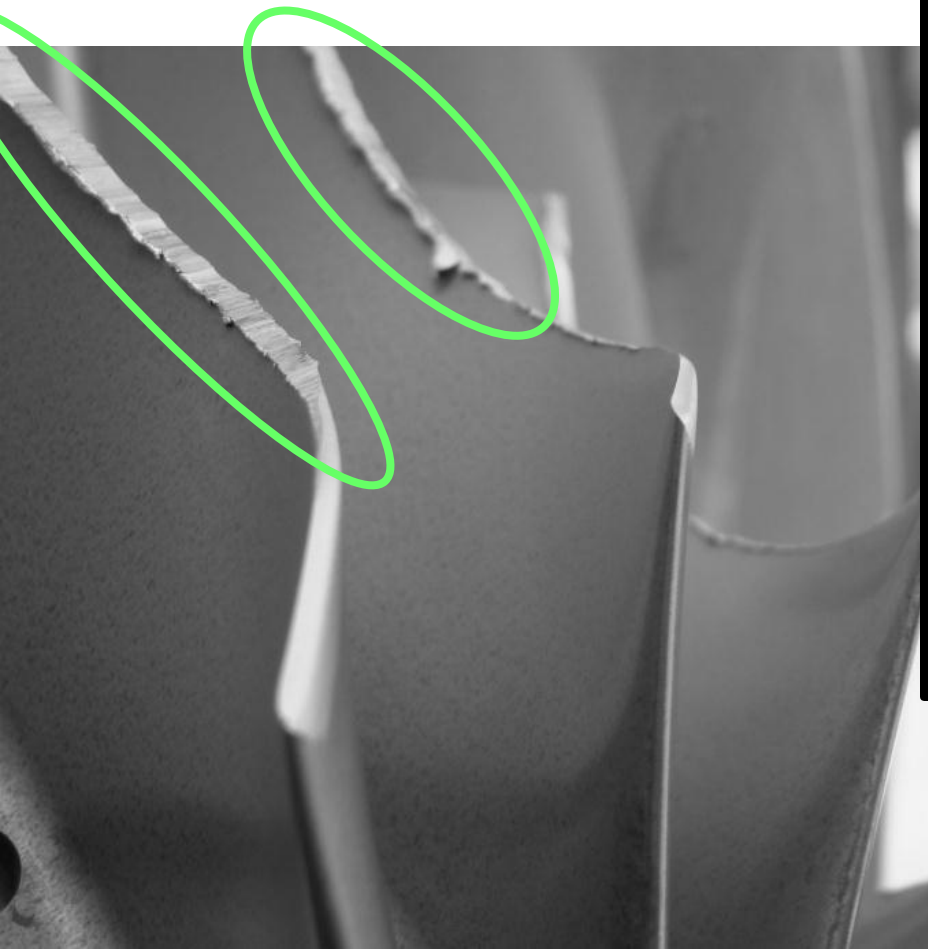
Challenge 1: Realized Enhancements

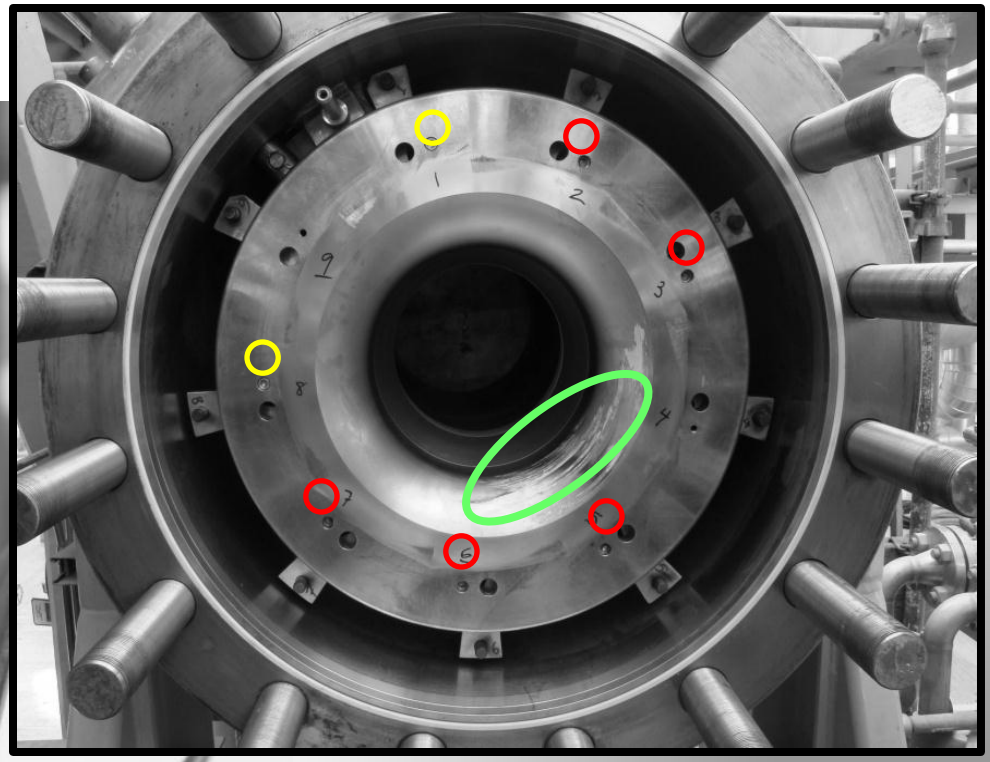
- Seal gas consumption was optimized by internally reducing orifice diameters.
- Filter cartridge life was increased due to reduced seal gas flow.
- Turboexpander trip due to low seal gas supply differential pressure was eliminated.

Challenge 2: Expander High Current

- Some machines could not be placed back online after planned shut down.
- Once started up, machines exhibited high magnetic bearing current on expander side.
- When the machine was shut down, high current still persisted.
- Lateral shaft translation by AMB control system was necessary to restore magnetic bearing parameters to acceptable levels.

Challenge 2: Internal Inspection



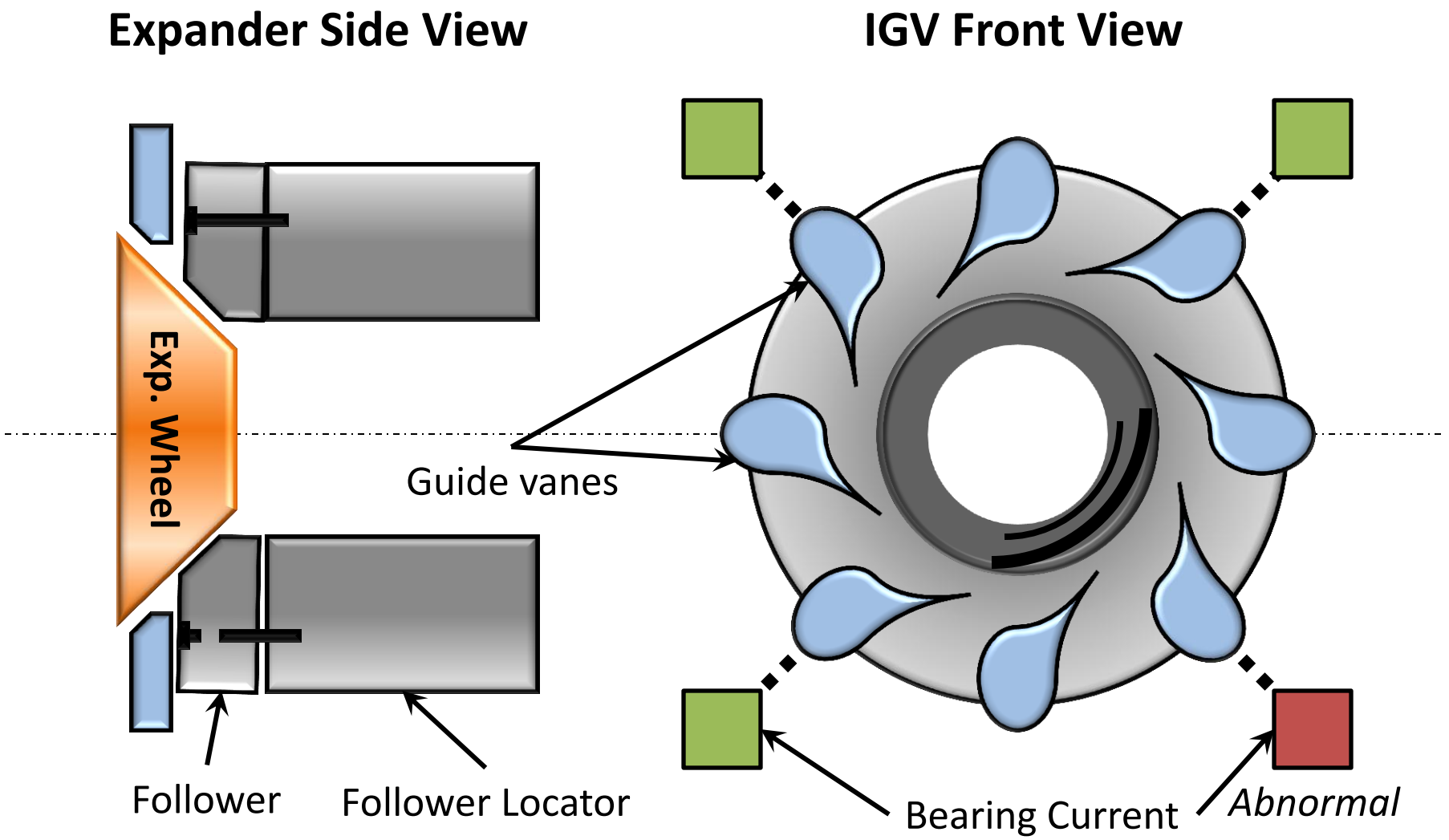


Failed Screw

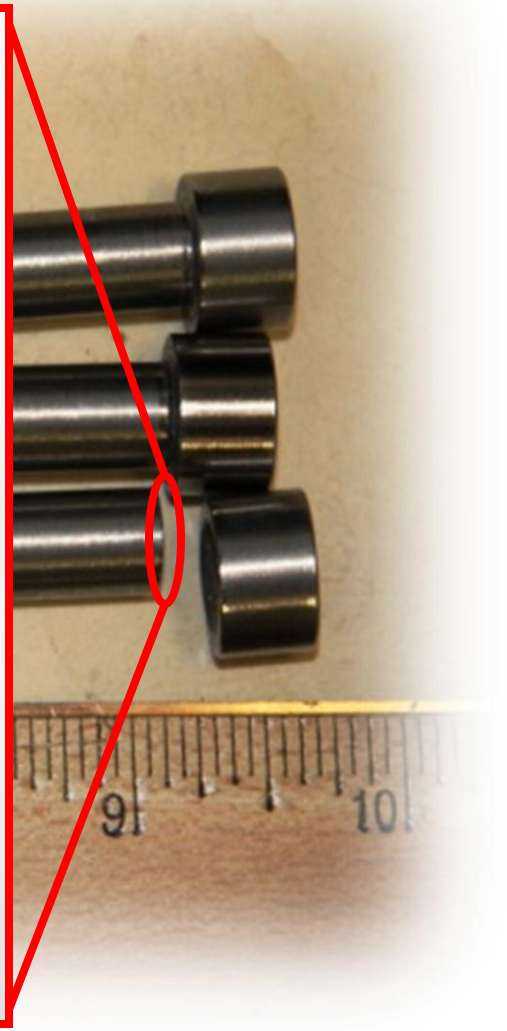
Non-failed Screw

Expander Rub

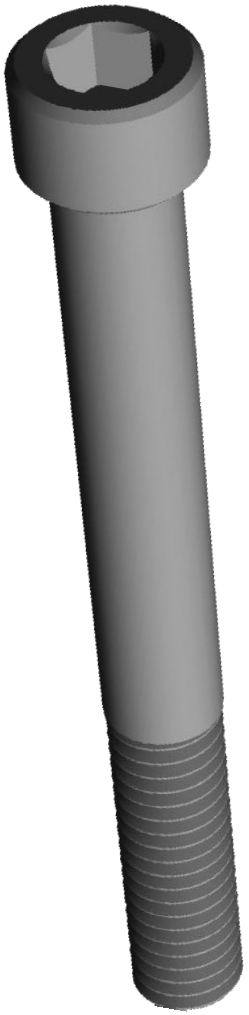
Challenge 2: Analysis



Challenge 2: Screw Failure Analysis



Old vs. New Screws



Cap Screw Design

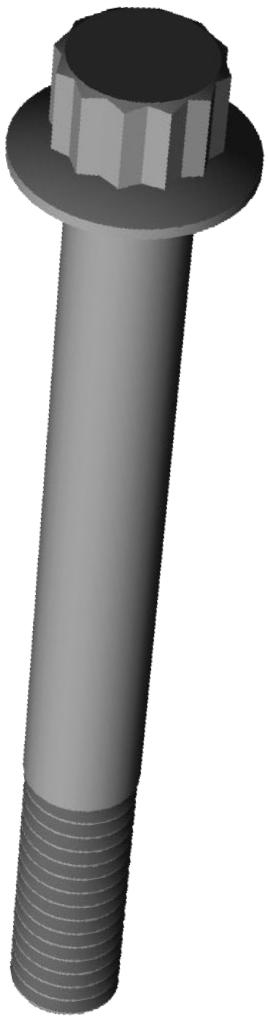
Socket-head	Flanged-head

Fillet between head and Shank

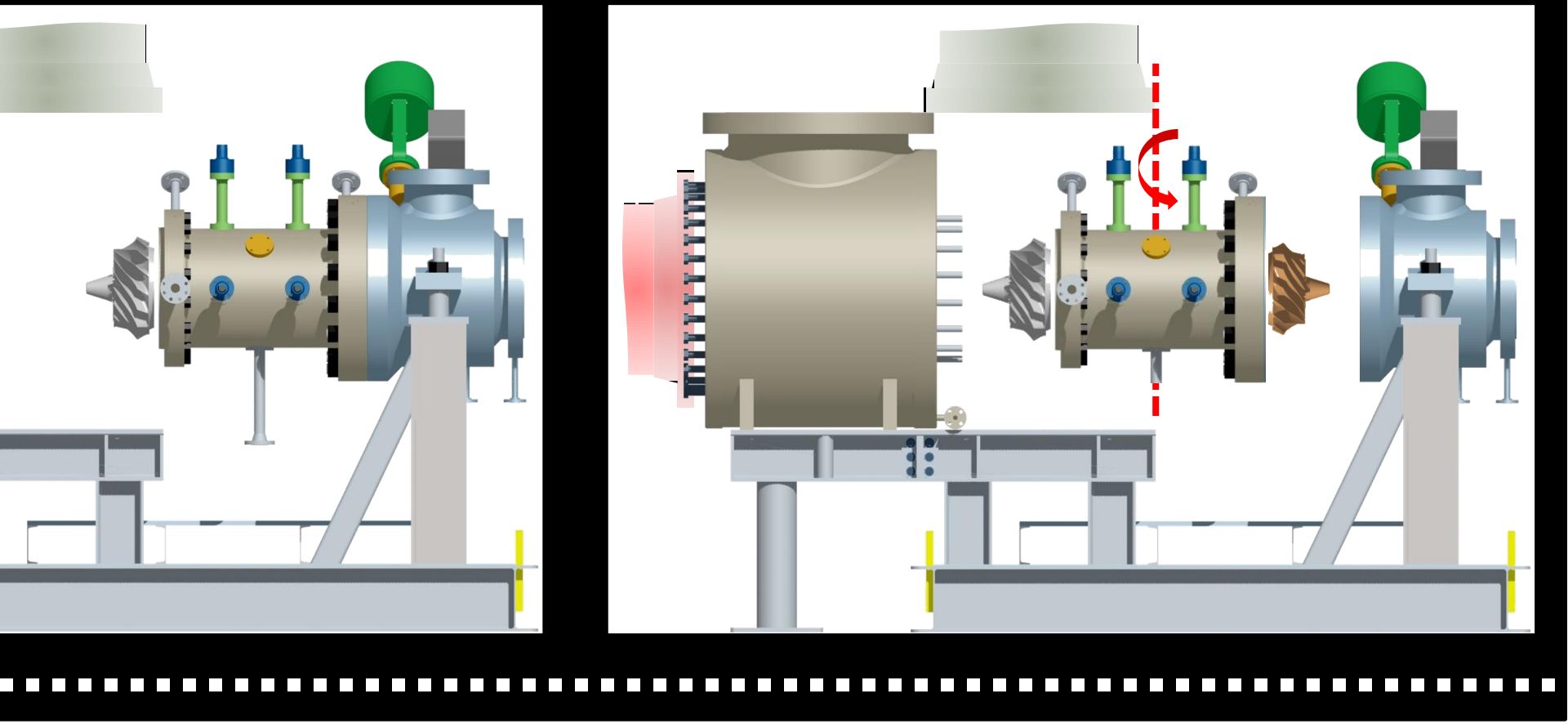
Small radius	Larger radius Beveled washer

Material

A320-L7	A286 ↑ 60% tensile ↑ 500% fatigue

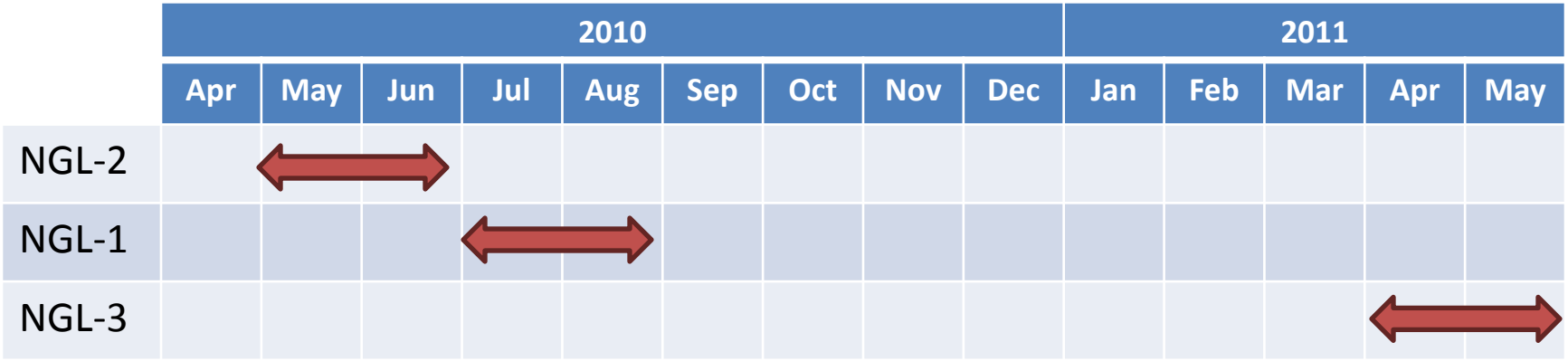


Safely Removed Rotating Assembly

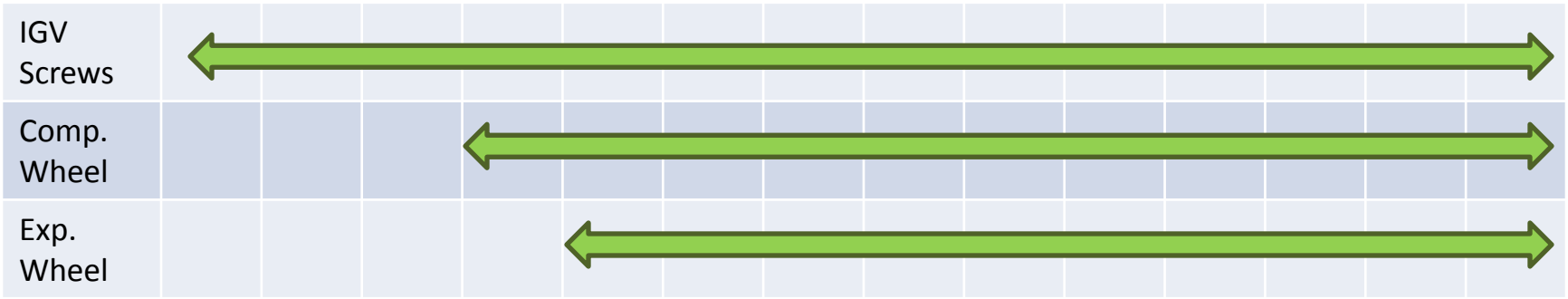


Readiness and Execution

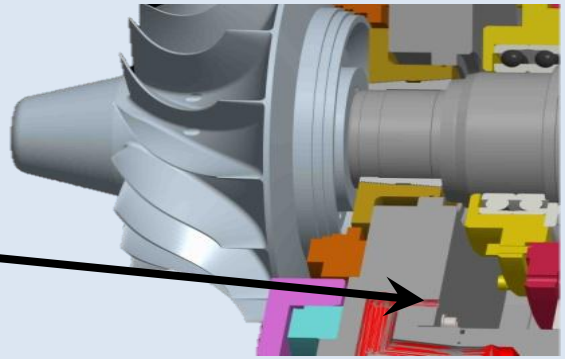
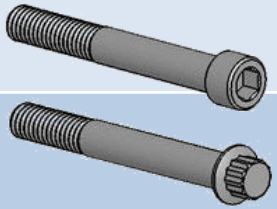
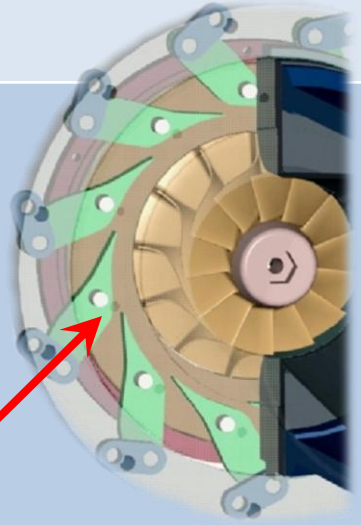
Secure shutdown windows and resources – **User Role**



Expedite material manufacturing/delivery – **Manufacturer Role**



Findings Summary

Finding/Cause	Corrective Action
Excessive seal gas flow ⇨ Oversized cooling-gas orifice. ⇨ Parameter difficult to estimate a priori.	• Reduced orifice size to 1/8”. 
Rubbed expander wheel ⇨ Failure of expander follower screws (IGV assembly). ⇨ Improper screws design and material selection.	 • Replaced damaged wheels. • Upgraded screw material and design. 

Lessons Learned

User's Perspective

- Conduct joint review of equipment/piping layout by manufacturer and user prior to construction approval.
- Implement Management of Change for modifications made at construction phase.

Manufacturer's Perspective

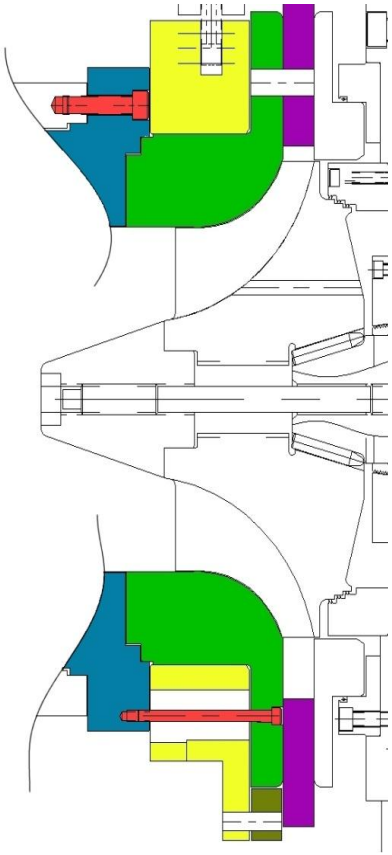
- Develop analytical tools to more accurately determine pressures acting on IGV components.
- Redefine fastener selection process to provide a better safety margin.

Lessons Learned - Continued

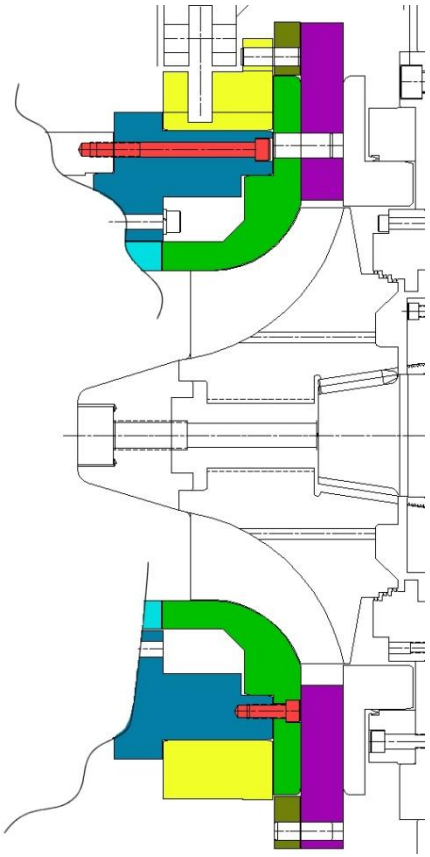
Manufacturer's Perspective

- Modified expander follower design:
  a) Adjusted component geometry to ensure mounting stability of IGV assembly members.
  b) Improved mounting screw material and geometry.

Original Design



Modified Design



Concluding Remarks

- Turboexpander availability was boosted from 65% to 98%
- Active magnetic bearings have outstanding resistance to major rotor imbalance events.
- Corrective actions effectiveness was confirmed based on inspection findings.
- The key to success was outstanding coordination for
  - Shutdown windows
  - Spare parts and material manufacturing
  - Technical and field support