

Variable Center of Gravity Lifting System

(Formerly Bi-directional Offset Lifting Bar)

Danfoss Turbocor

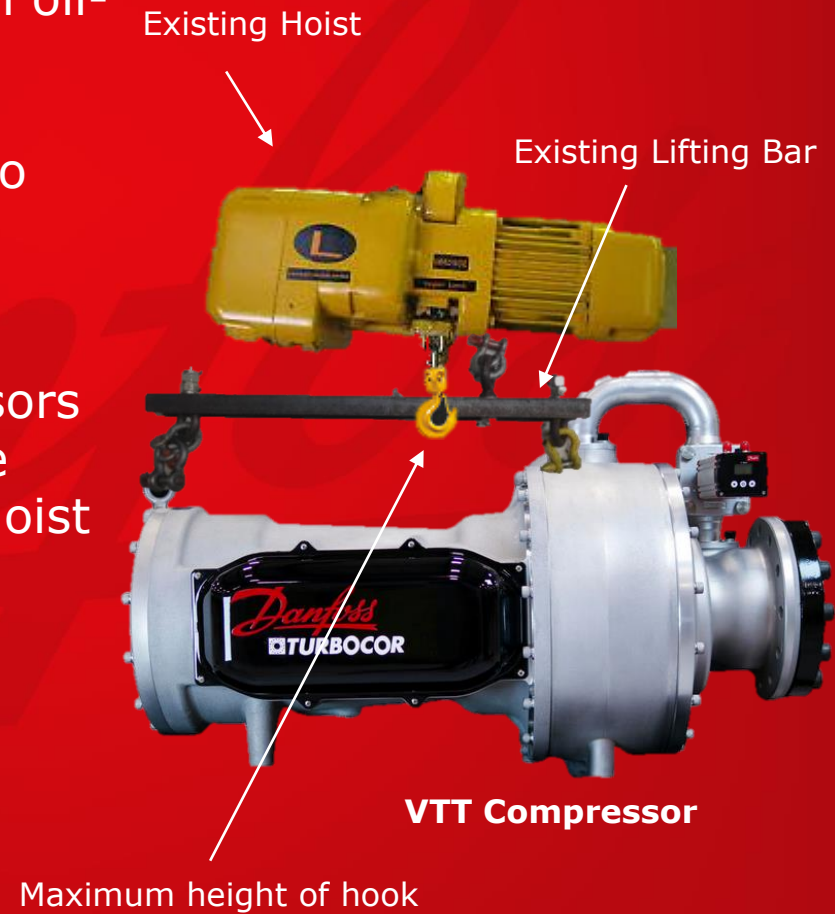
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Team 5

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Project Background

- Danfoss Turbocor is the world leader in oil-free centrifugal compressors
- All compressors must be tested prior to distribution for quality control
- Since Chiller 3 was built Turbocor has developed a new line of VTT Compressors that have a greater height than can be installed with the current gantry and hoist system

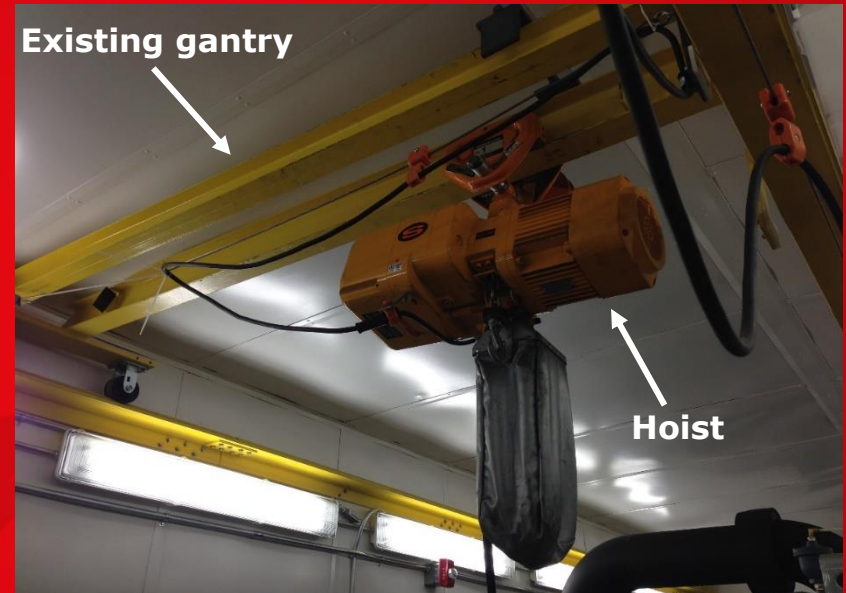


Project Description

- A better lifting system must be designed and implemented in order to conveniently install the compressor for testing
- Lifting bar to include:
 - Auto-leveling
 - Adjustable lifting positions
 - 1 Ton load capacity
 - Less than 500lb operating weight
 - OSHA Compliant

Issues with Current Setup

- Current Chiller:
 - Hoist hook lower than VTT compressor eyebolt
 - Hoist cannot be used to lift VTT Compressor
 - Manual Workaround
- Current Lifting Bar:
 - Non-adjustable lifting point for variable center of gravity
 - Suboptimal vertical height between lifting points

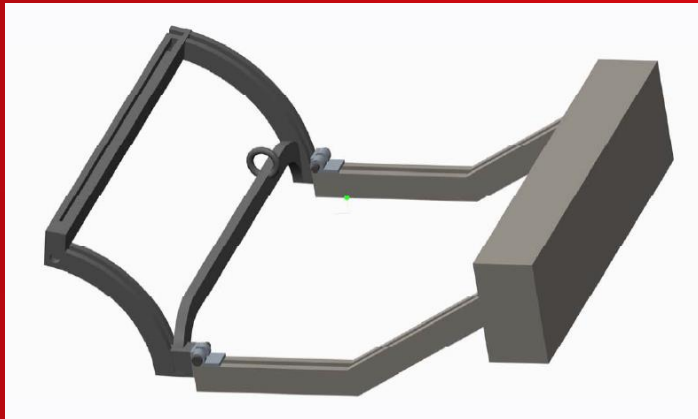


Current Gantry & Hoist

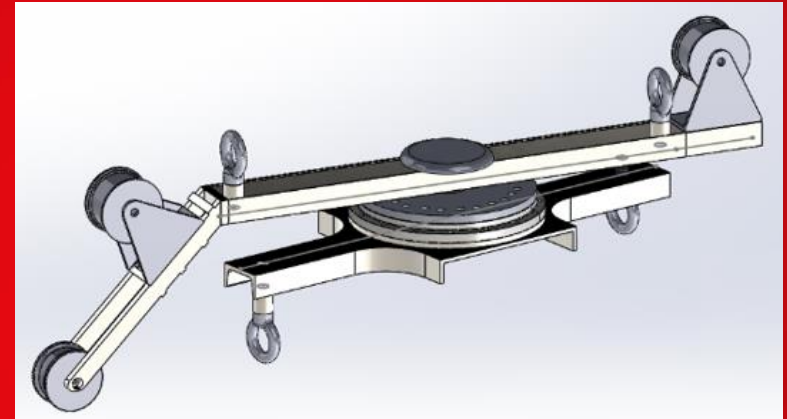


Current Lifting Bar

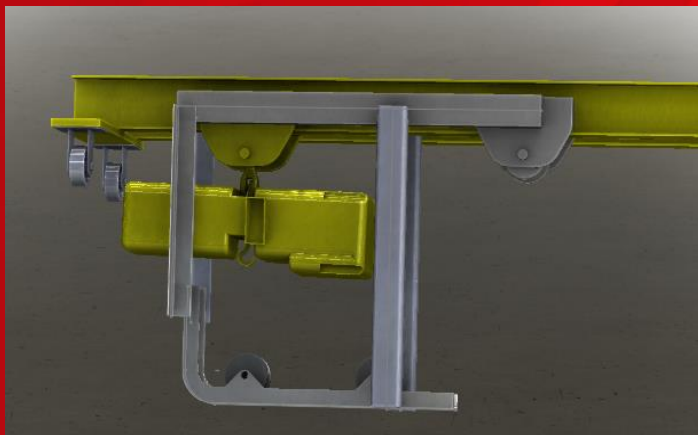
Concept Creation



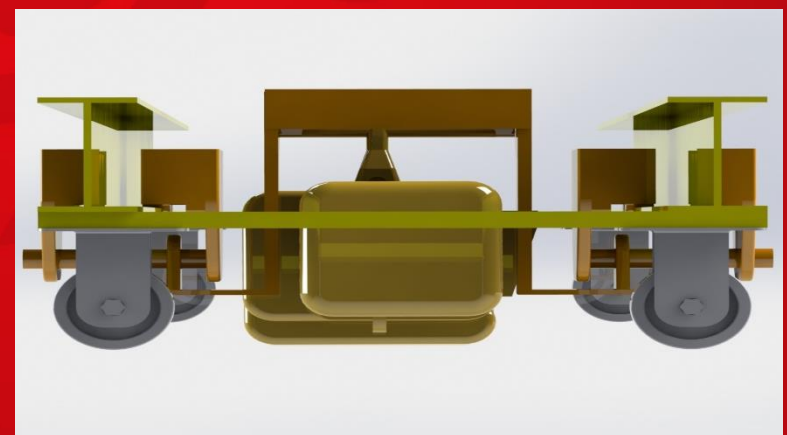
Counterweight lifting bar



Two Points of Lift with Turntable



Redirection of Lift by Pulleys



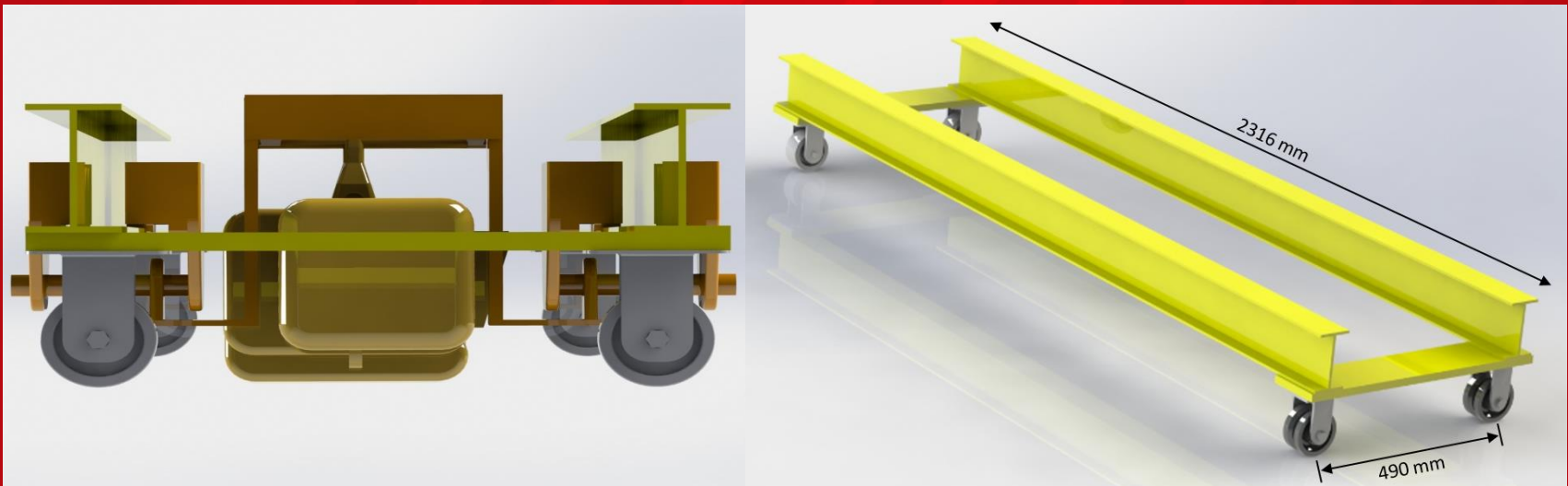
Redesigned Gantry System

Decision Matrix

Design	Safety (30%)	Performance (25%)	Cost (20%)	Implementation (15%)	Durability (10%)	Total
Counterweight	2	5	3	6	6	3.95
Two Points of Lift	4	6	3	3	5	4.25
Redirection of Lift	6	9	6	6	7	6.85
Redesigned Gantry & Lifting Bar	9	9	8	8	9	8.05

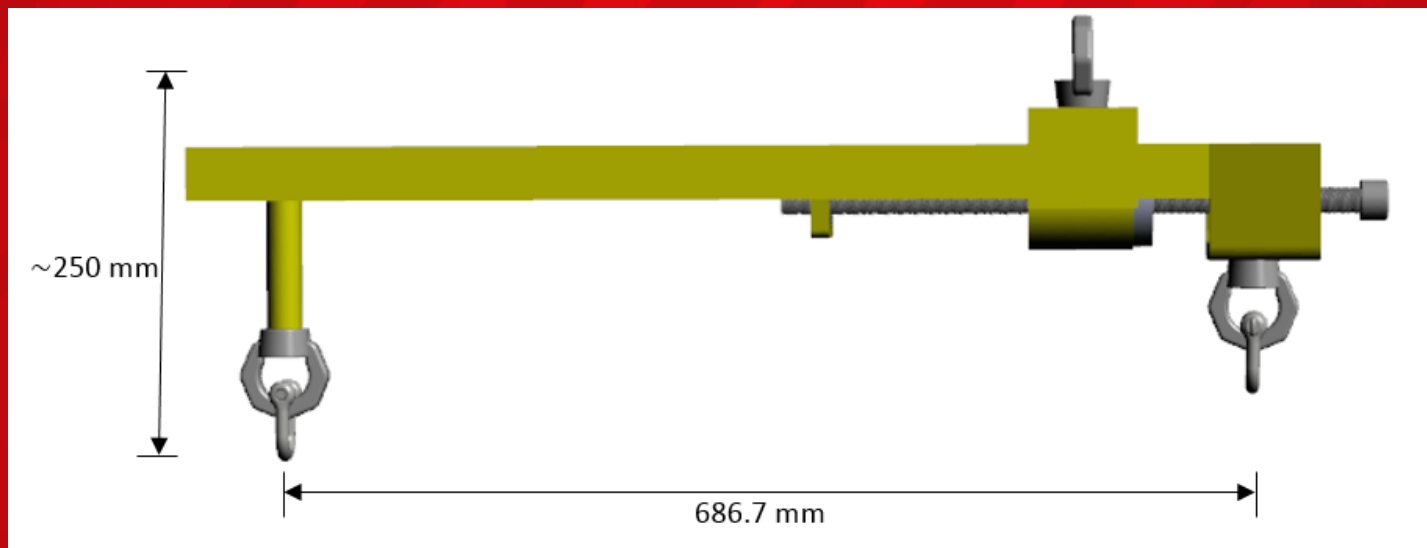
Concept Solution: Gantry & Trolley

- Redesign gantry with further spaced I-beams
- Designed trolley to suspend crane hoist between I-beams
- Increases available lifting height of VTT Compressor

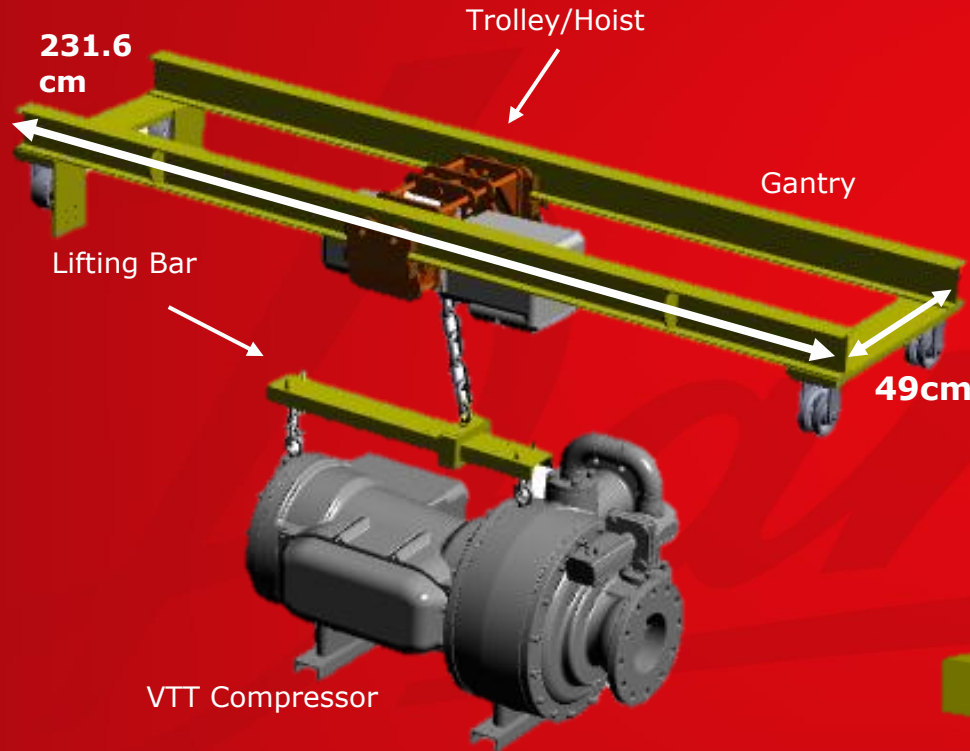


Concept Solution: Lifting Bar

- Redesigned lifting bar compliments redesigned gantry
- Power screw adjusts point of lift for variable center of gravity
- Adjustable position for lifting hooks
- Minimized vertical distance between lifting points



Final Design



- Approved by Turbocor
- Increase vertical height of hoist 8" (Approx. 200mm)
- Meets design requirements and OSHA standards

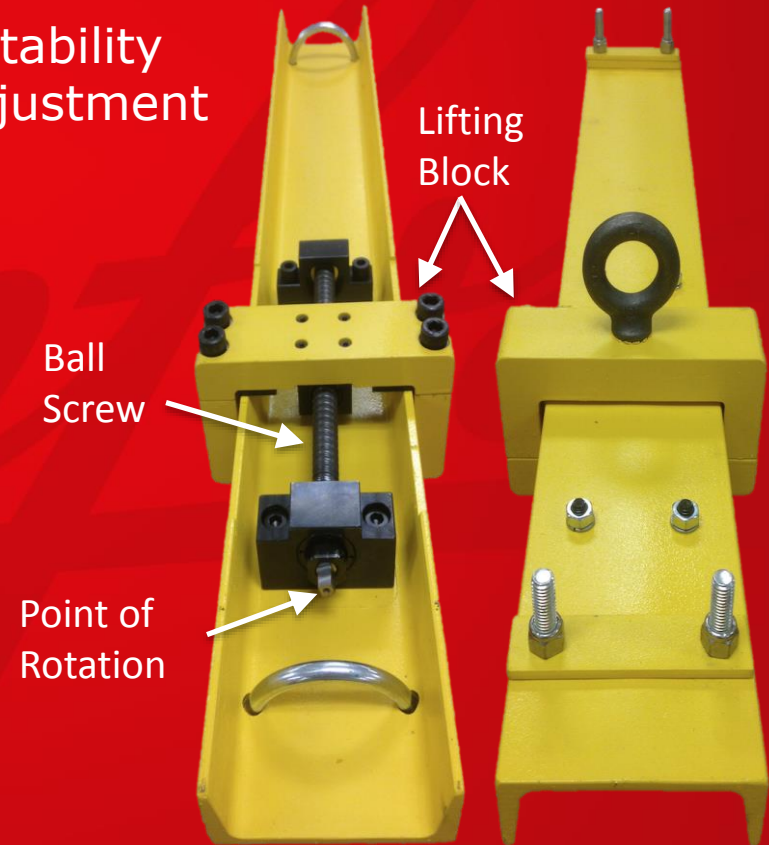


Lifting Bar

- C4x5.4 Channel for increased bending strength
- MISUMI ball screw for lifting point adjustability
 - 5mm lead allows for incremental adjustment
 - 11 kN static load rating
- 50 mm shorter than current lifting bar



Lifting bar final design



Trolley

- Initial design for trolley
- 1/2" steel plate and 1018 cold rolled 3/4" steel rod
- Water jet fabrication
- Welded assembly



Preliminary Load Testing

- Utilized Civil Engineering Department Strengths of Materials Lab
 - MTS Unit capable of applying 100 kip force
- Gantry and trolley tested at 2500 lb load



Trolley & Gantry Test Configuration

MTS Unit used for testing



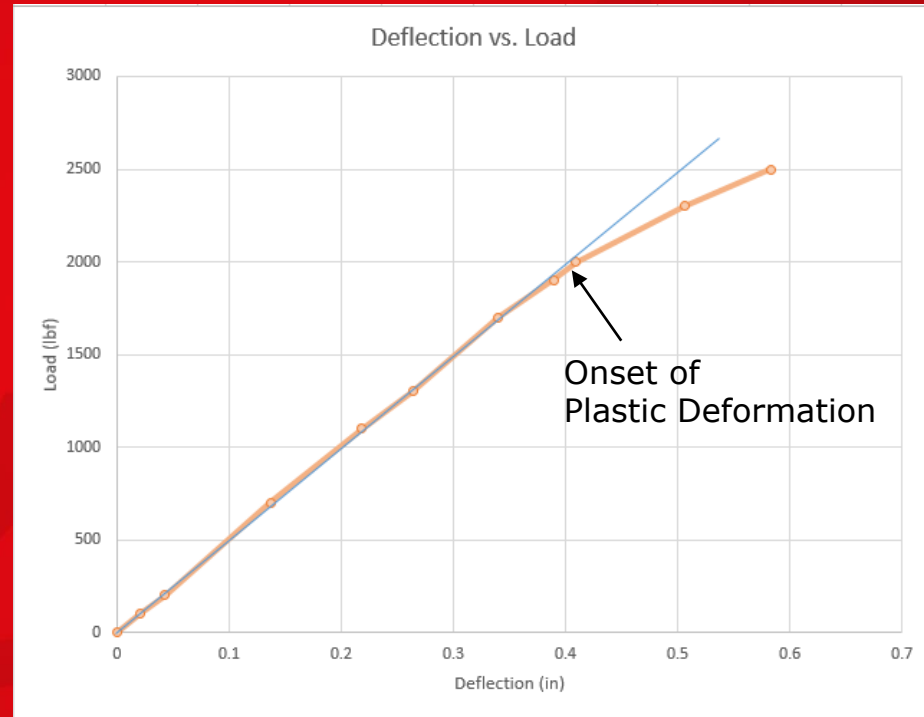
Extension arm

Strength of Materials Lab

Load Testing Results



Trolley + Gantry under 2500 lb. load



Load vs. Deflection

- Original FEA results did not match testing results
- Results call for design revision

Trolley Revision

- Additional gusset support
- Increased height of support bolt location
- Revised Trolley FEA
 - Stress < 250 MPa yield stress



Revised Trolley FEA
500:1 deformation scale



Original Trolley



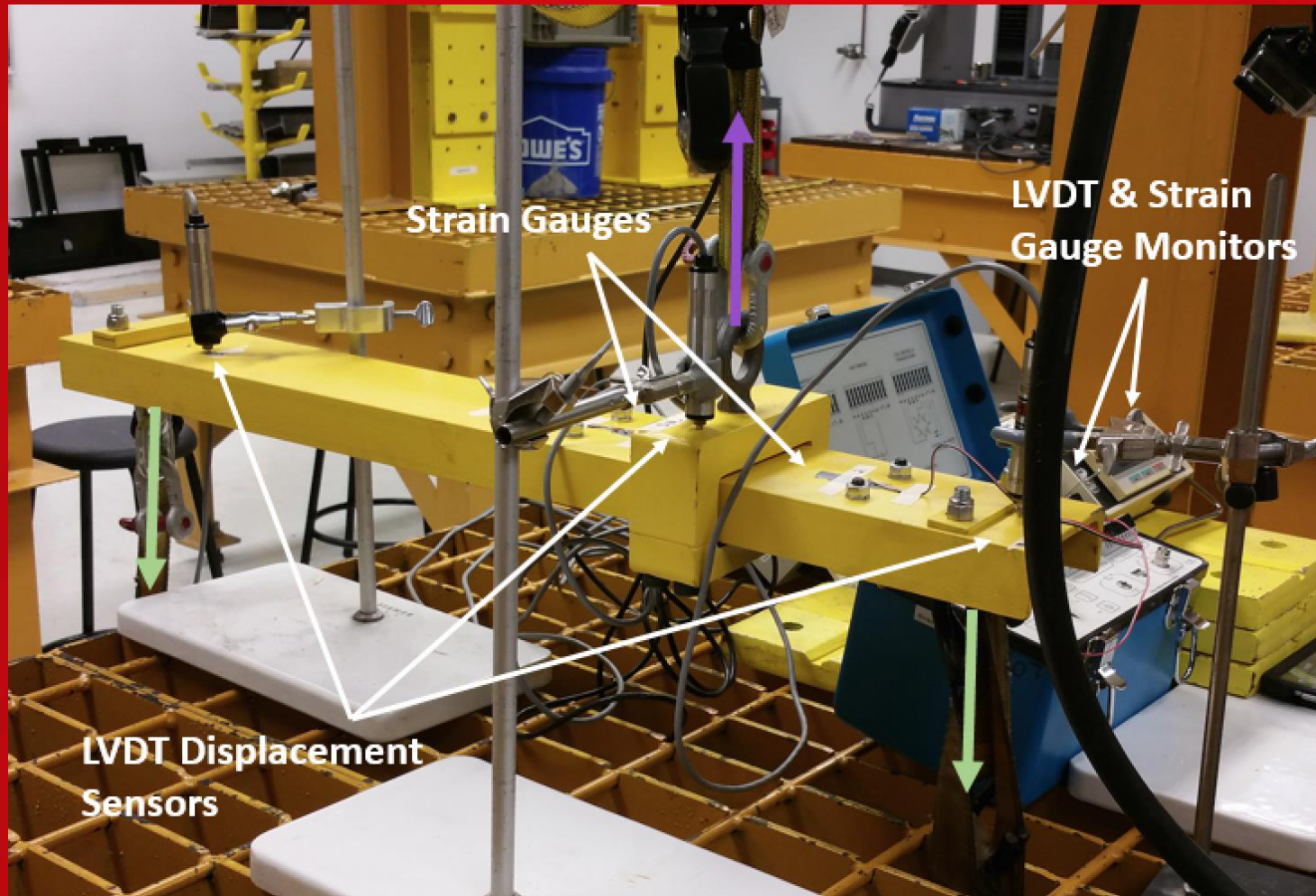
Additional Material

Raised Support Bolt



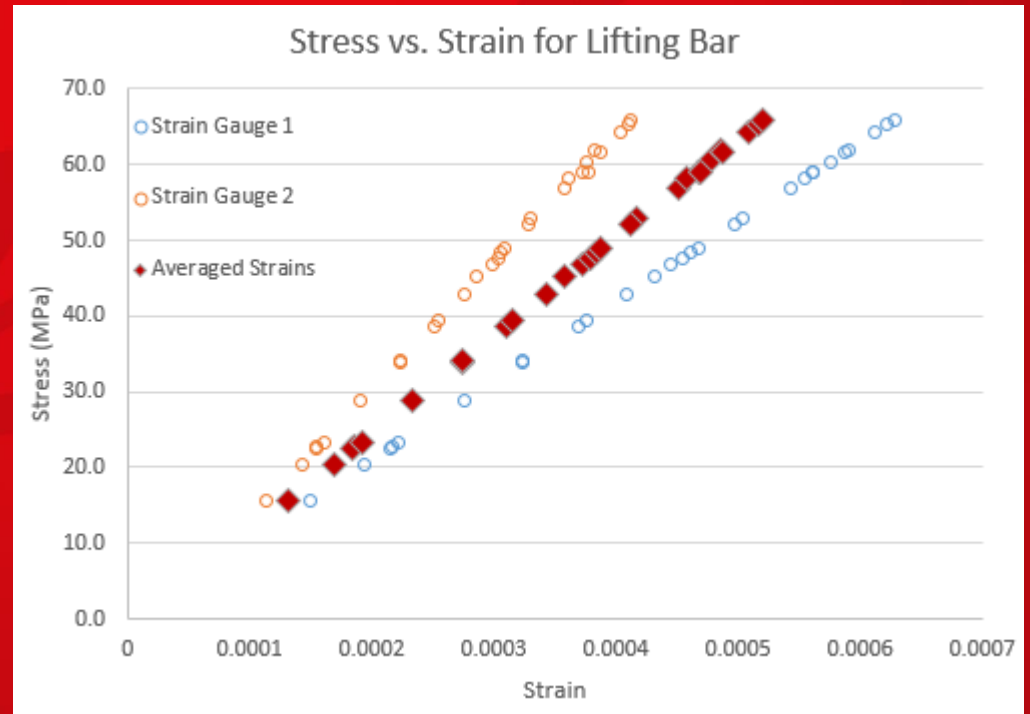
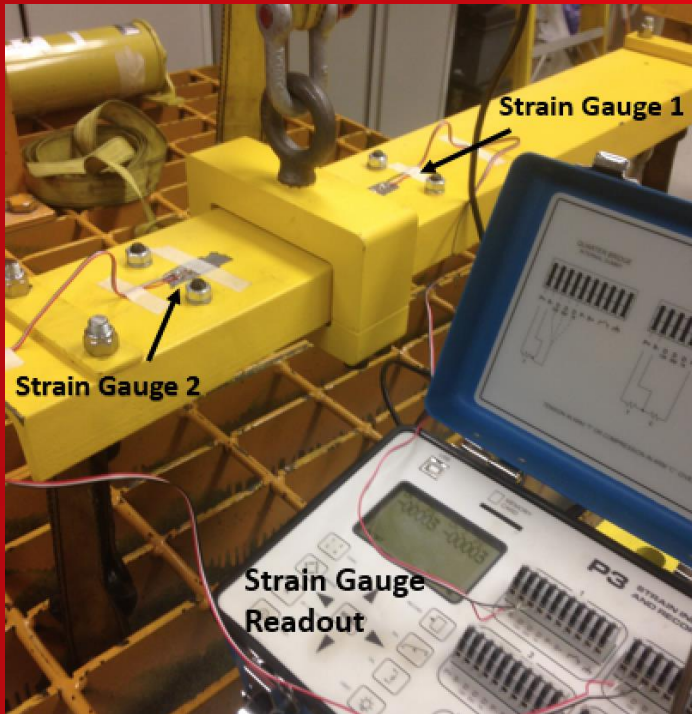
Revised Trolley

Final Load Testing: Lifting Bar



Final Test Results: Lifting Bar

- Test performed 3 times; maximum load at 2700 lbs
- Stress-Strain curve remains in linear, elastic region



Final Load Testing: Gantry

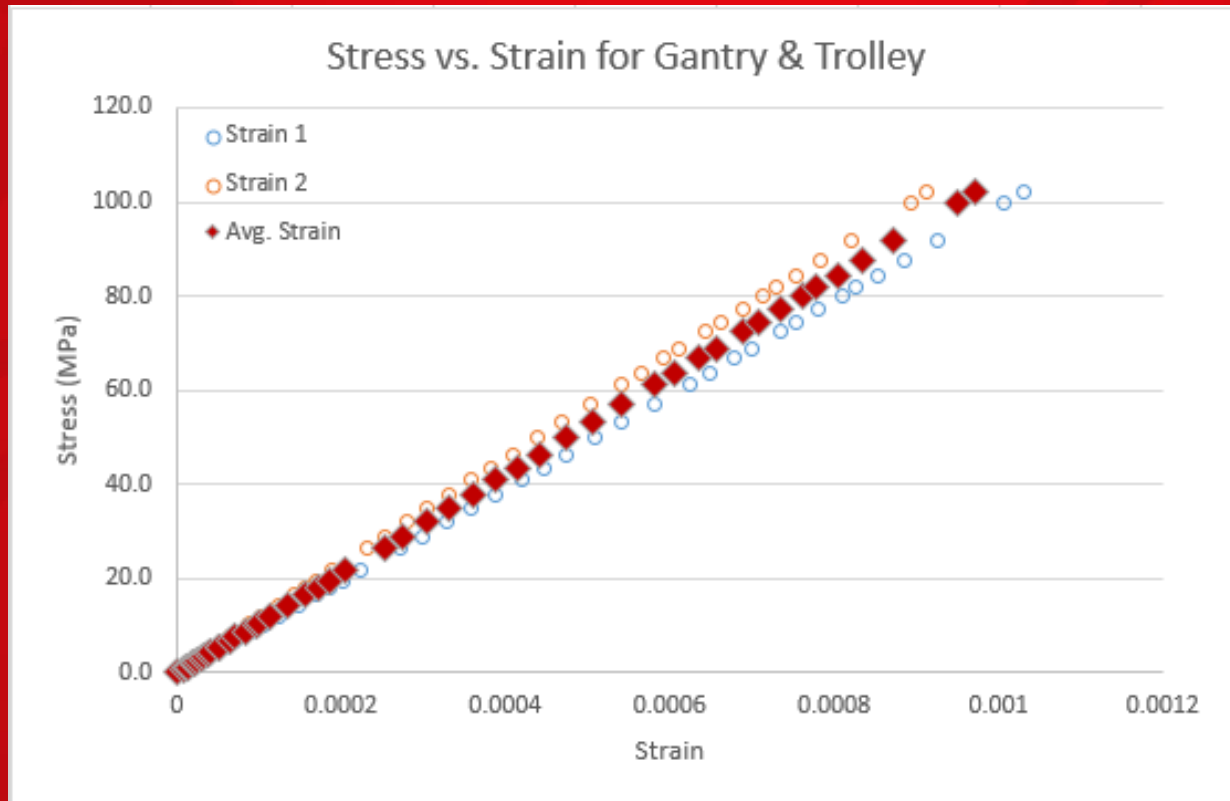
ENGINEERING
TOMORROW



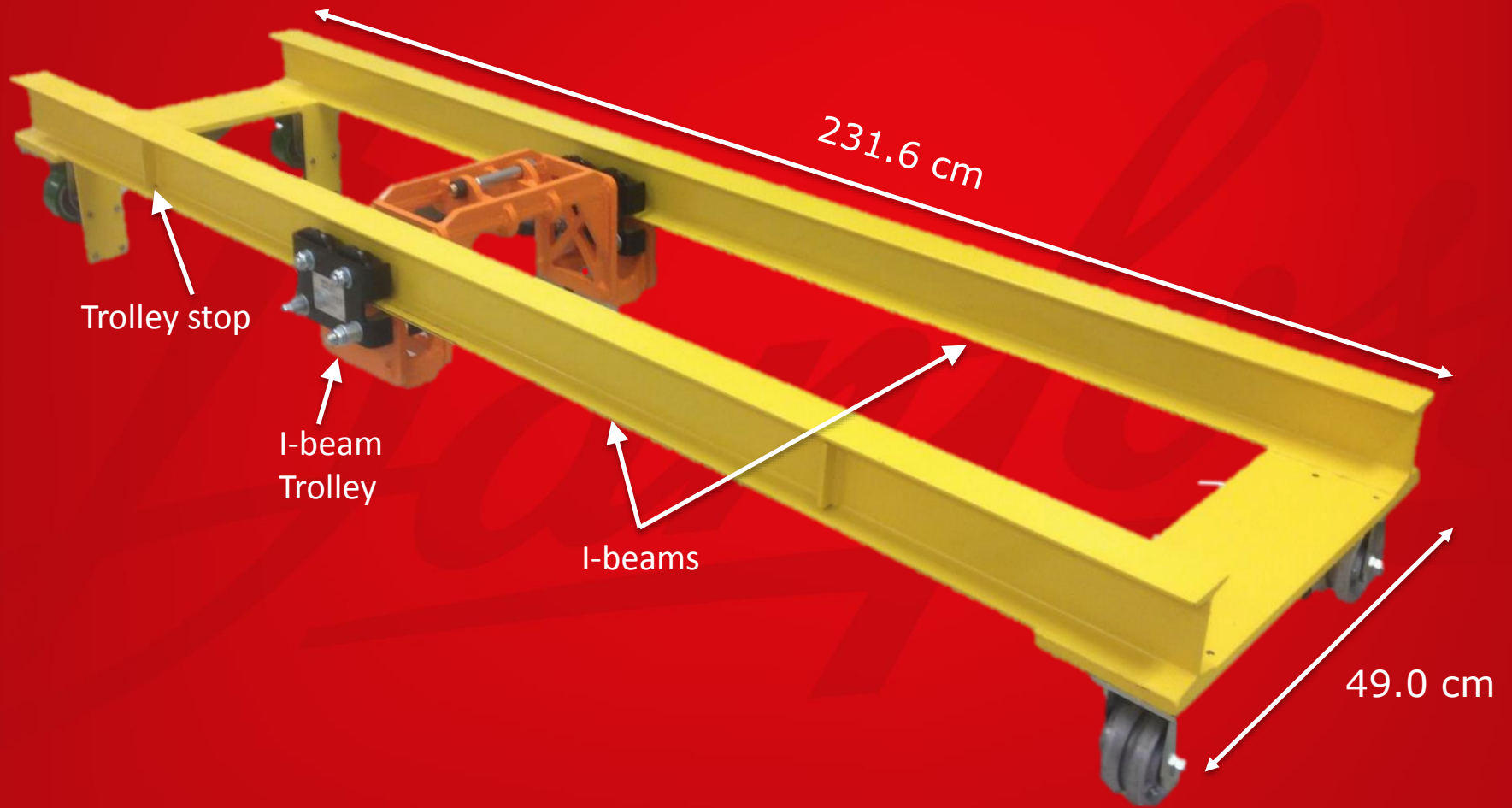
Load Test to 3675 lbs

Final Test Results: Gantry

- Test performed 3 times; maximum load at 3675 lbs
- Stress-Strain curve remains in linear, elastic region



Final Product



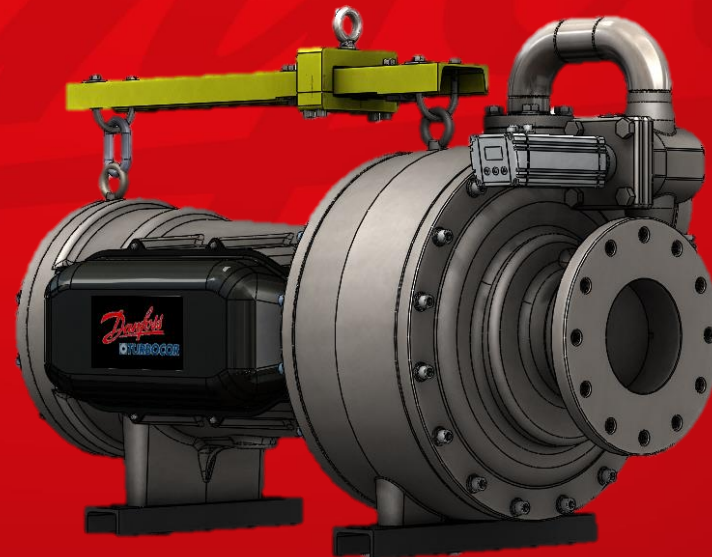
Final Gantry & Trolley Assembly

Final Product

ENGINEERING
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Final Lifting Bar



Lifting Bar & VTT Compressor

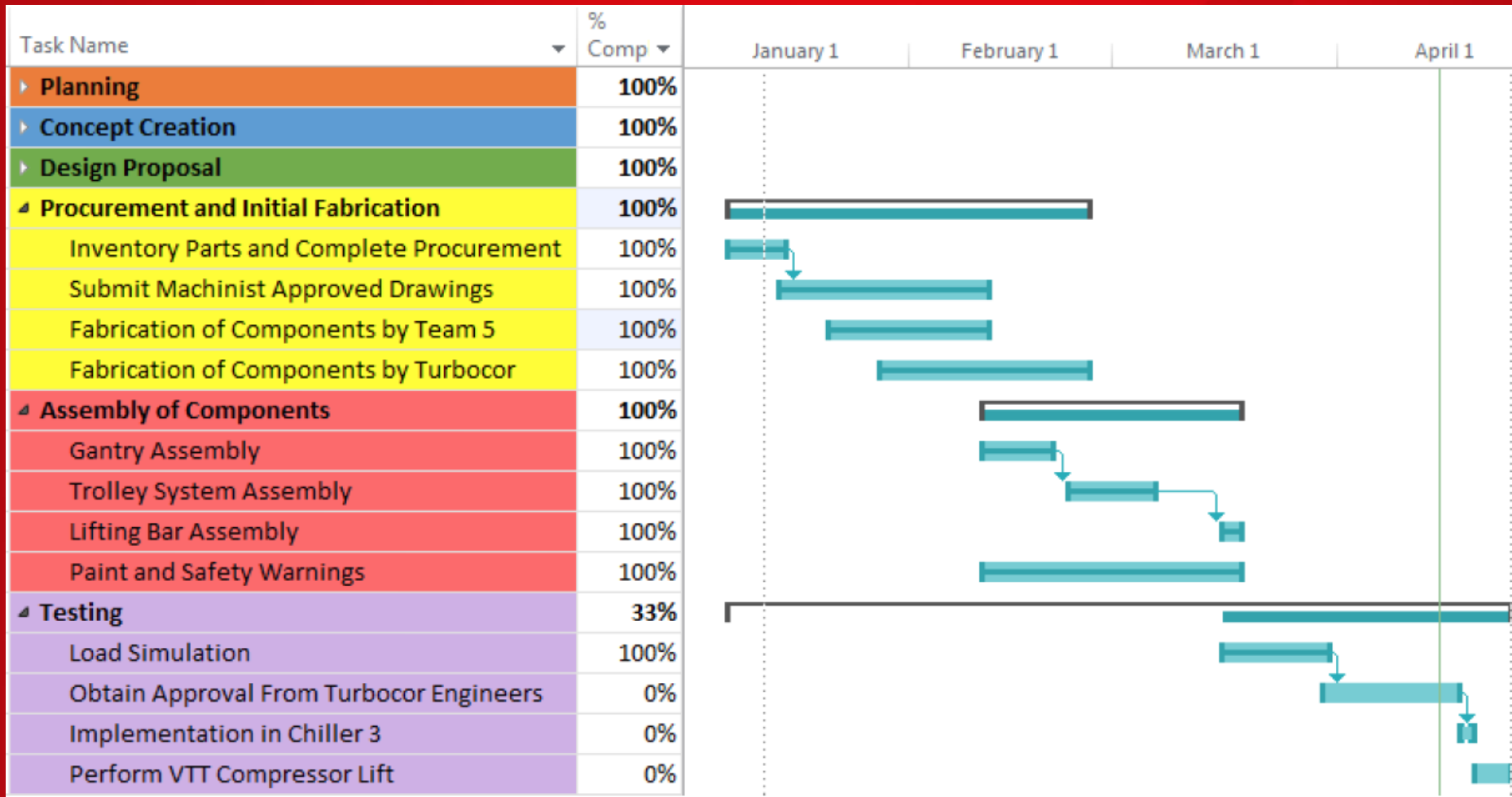
Challenges Faced

- Tight spatial constraints of test room
- Meeting OSHA regulations during design process
- Scheduling of load tests with certified supervisor
- Discrepancy between FEA and real world results
- Load testing results required trolley redesign

Lessons Learned

- Team communication key to success
- Easy to fall behind schedule
- Expectations and reality can't always coincide
- Real world results don't always match FEA
- Always listen to Murphy: what can go wrong will go wrong

Gantt Chart



Checklist

- ✓ Increased lifting height of compressor by over 200 mm
- ✓ Confirmed Load Rating of >2000 lb
- ✓ OSHA Compliant
- ✓ Less than 500 lb operating weight
- ✓ Lifting bar adjustable for multiple lifting positions
- Future Work
 - Turbocor approval of load testing results
 - Onsite implementation at Turbocor

Acknowledgements

Team 5 would like to personally thank:

- Turbocor Liaisons, Kevin Lohman and Bill Bilbow
- Dr. Nikhil Gupta
- Dr. Patrick Hollis
- Dr. Raphael Kampmann
- Jeremy Phillips & James Gillman

Questions?

More information available online at:

http://eng.fsu.edu/me/senior_design/2015/team05