



# High Speed Motor Test Stand

Virtual Design Review IV



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Charles Daher

# PROJECT RECAP



## ➤ Project Scope

- Design a system that can measure motor efficiency at standard operating speeds for various Danfoss Turboacor compressors

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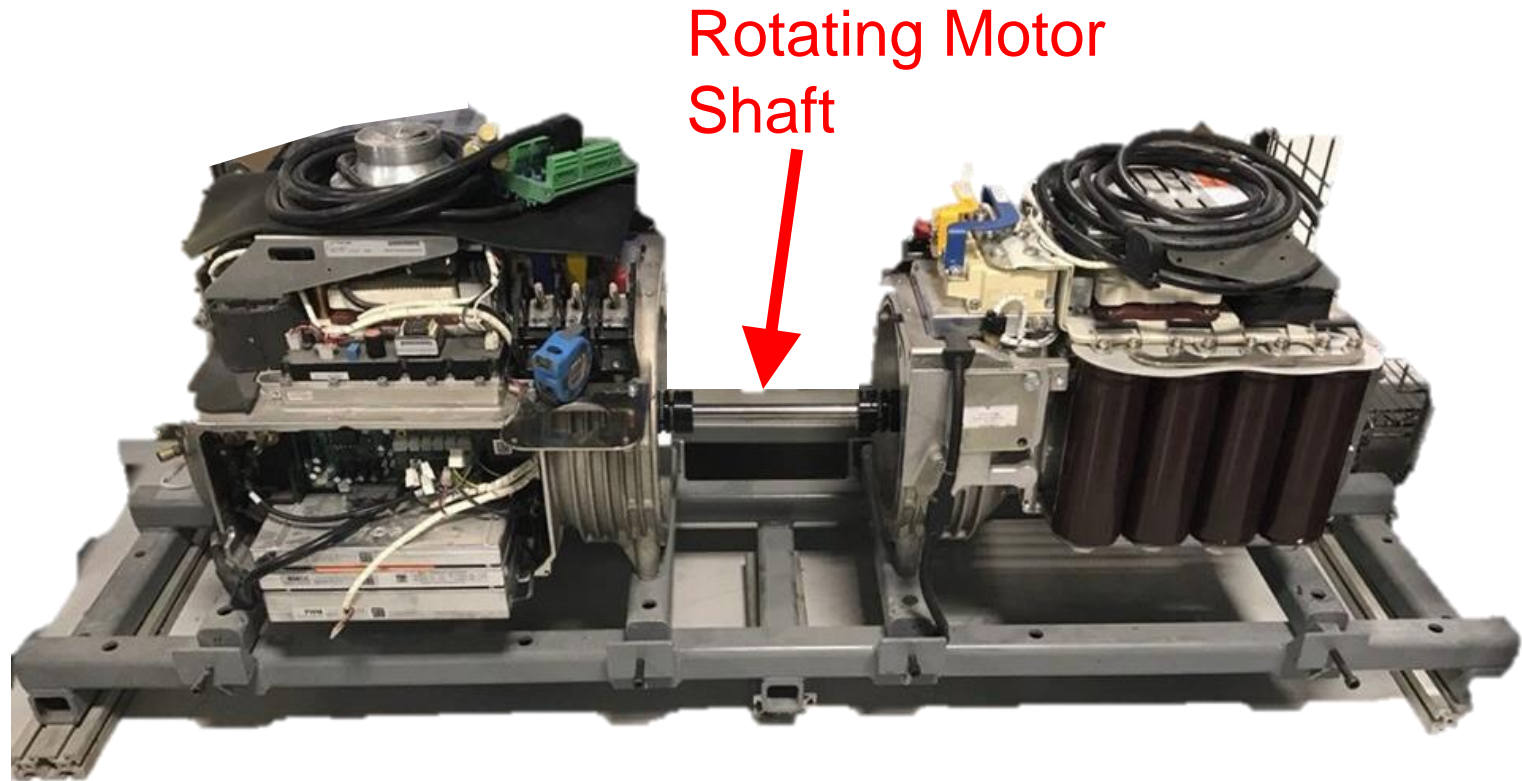
# Recap



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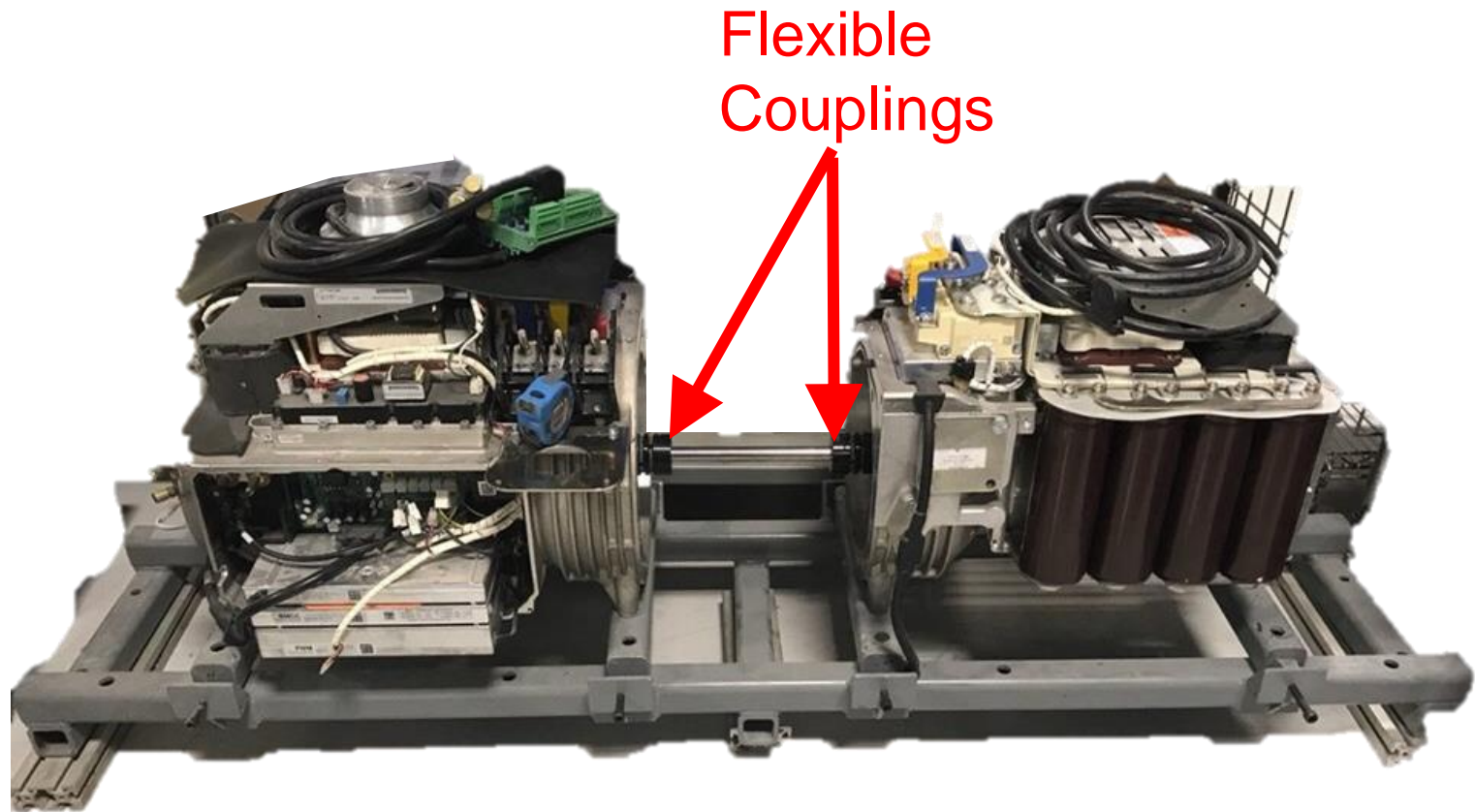
# Recap



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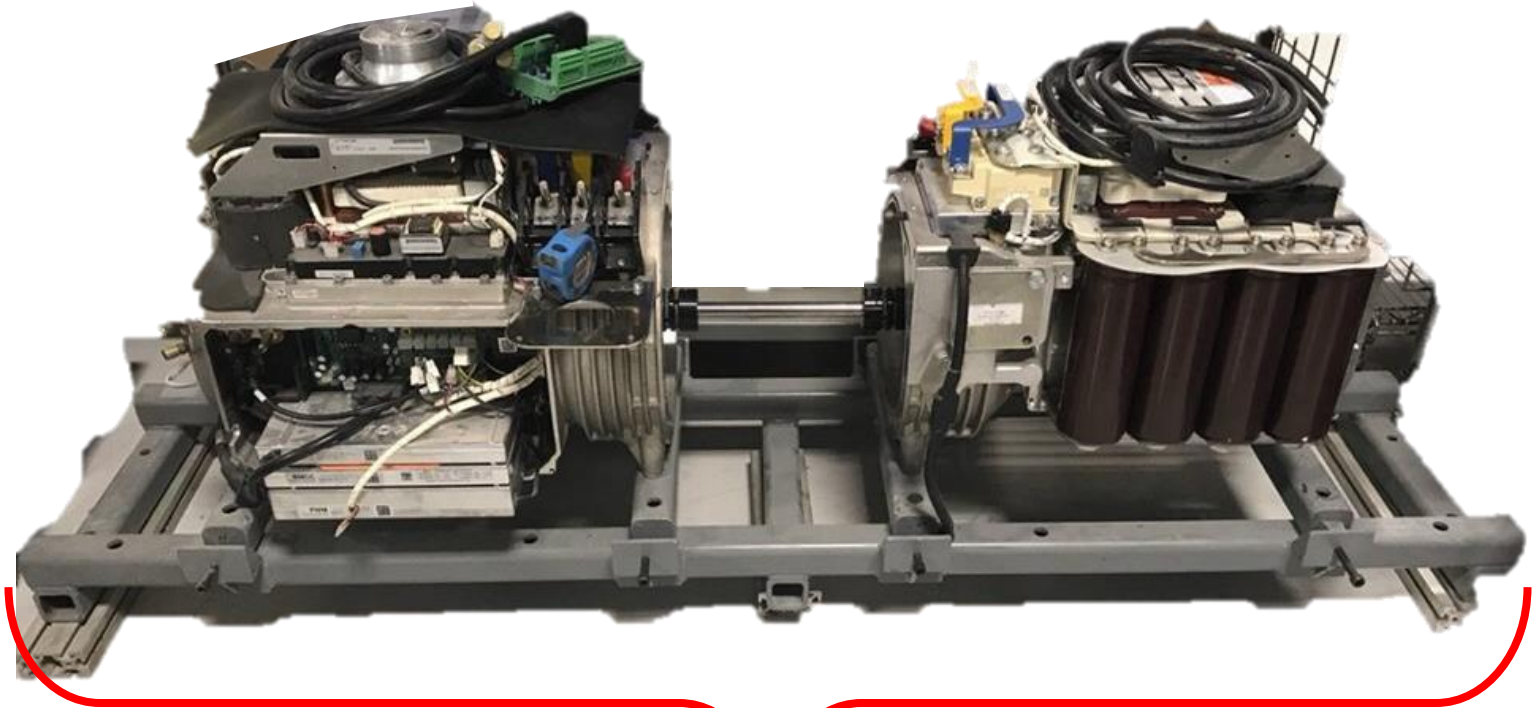
# Recap



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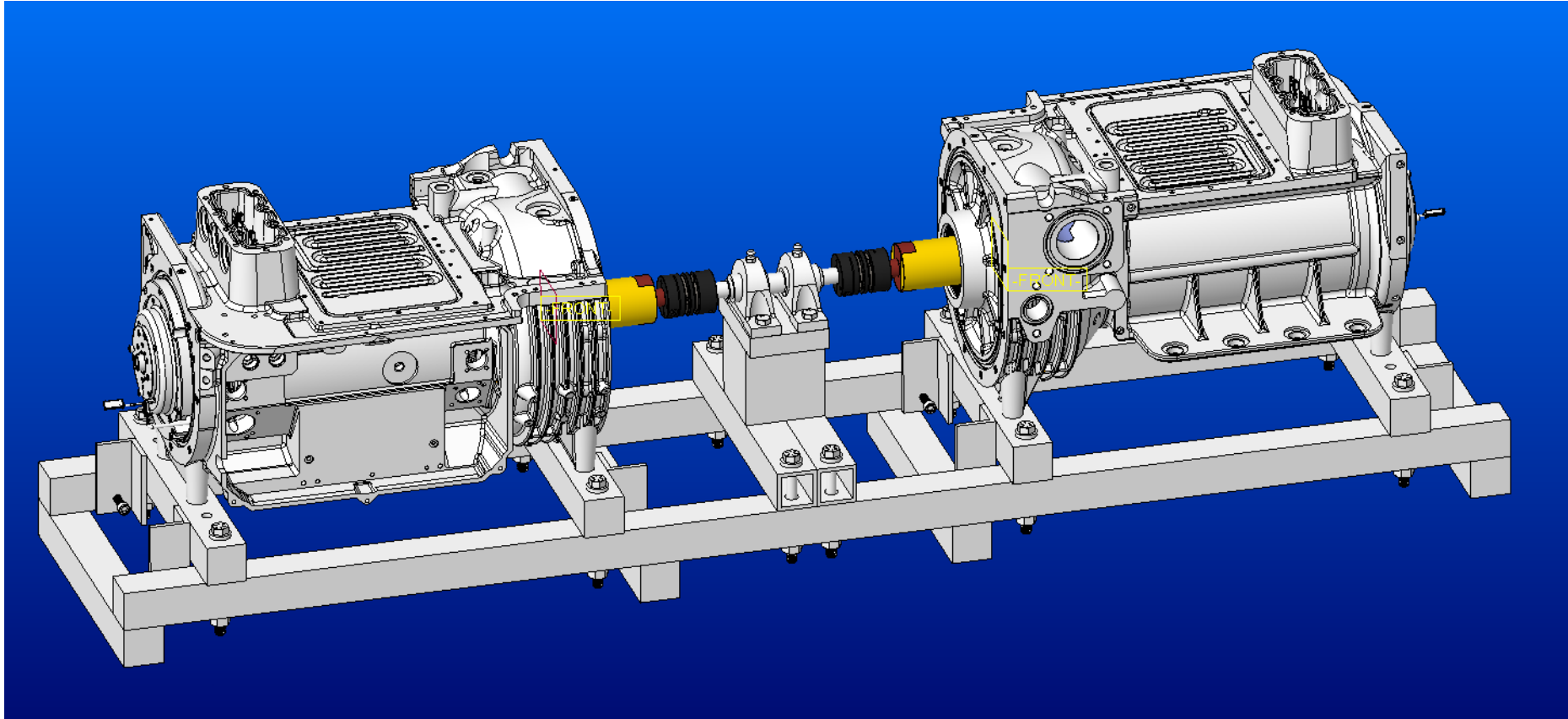
# Recap



Motor Frame

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# Recap



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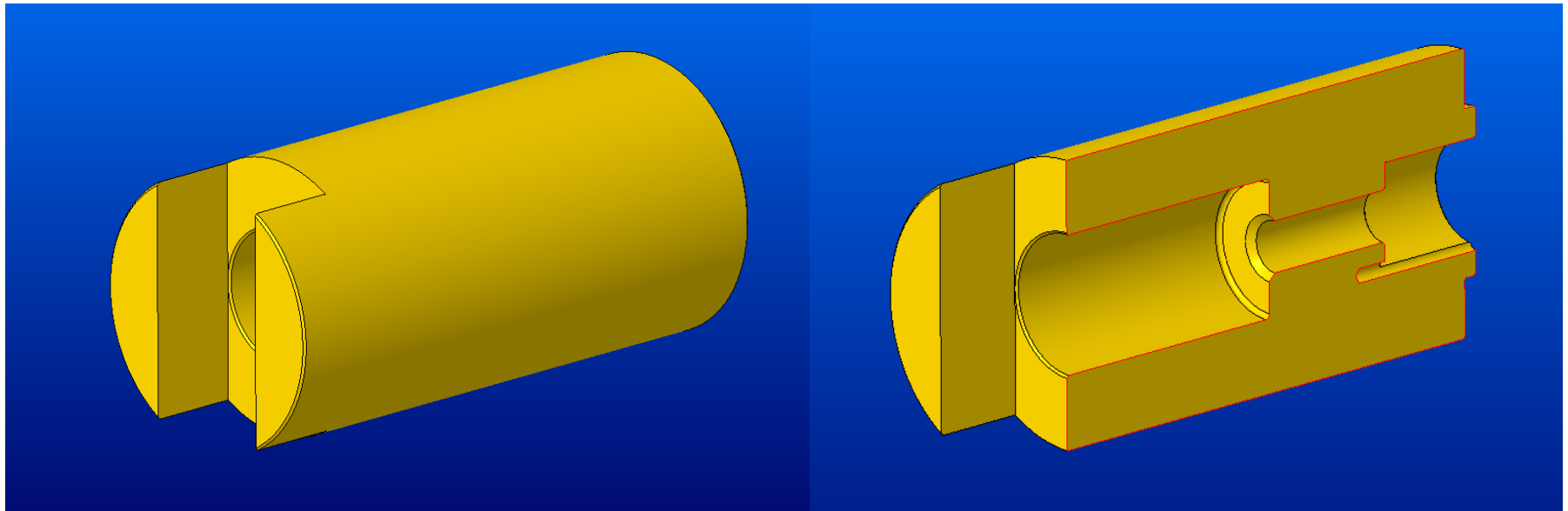
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# CUSTOM PARTS



# Shaft Extender

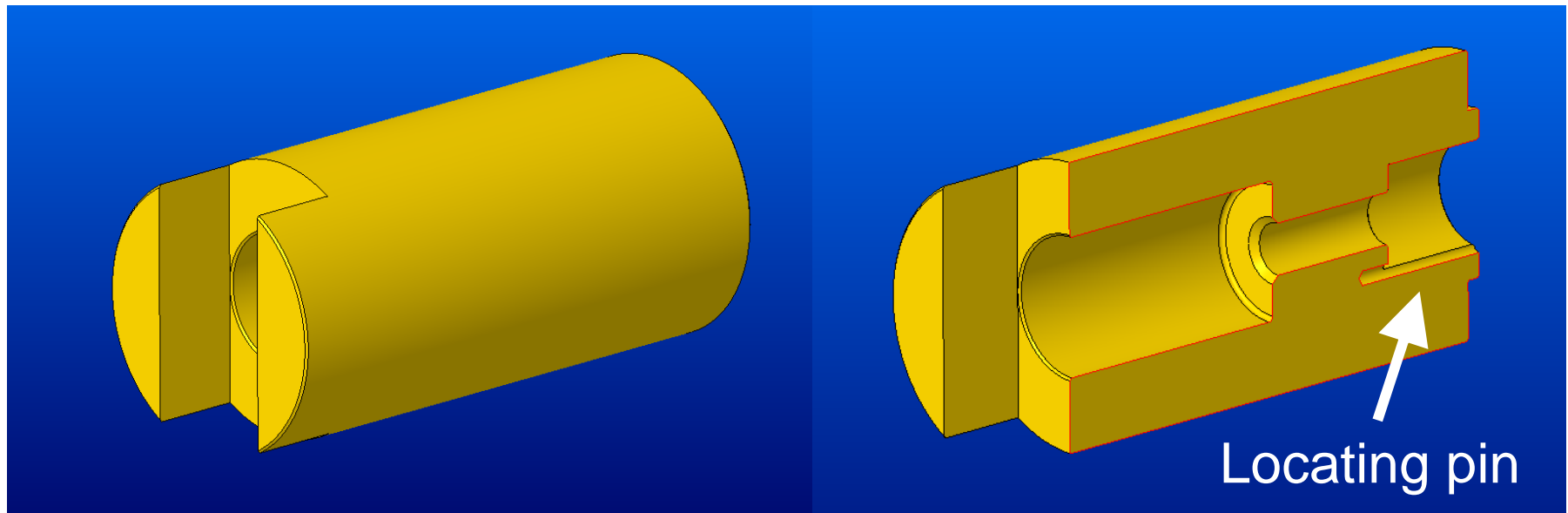
- Acts as modified 1st stage impeller
  - Allows for shaft to be in proper stack tolerance
  - Allows shaft to be balanced in the balancing cell at Danfoss



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# Shaft Extender

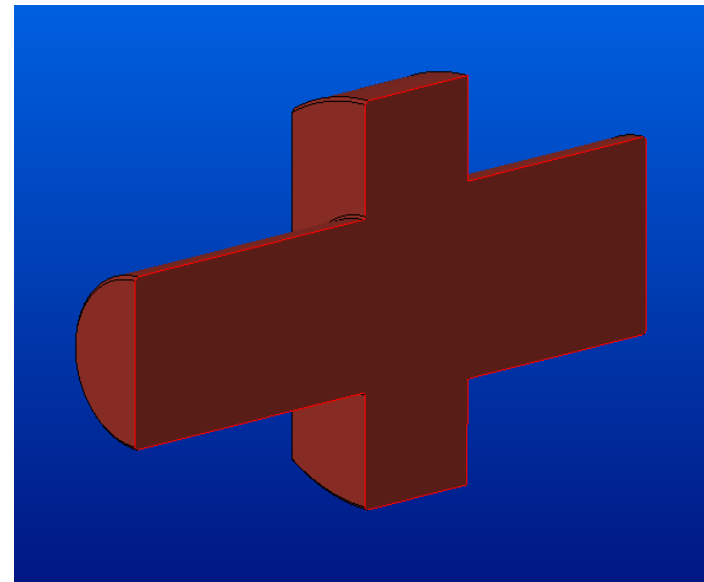
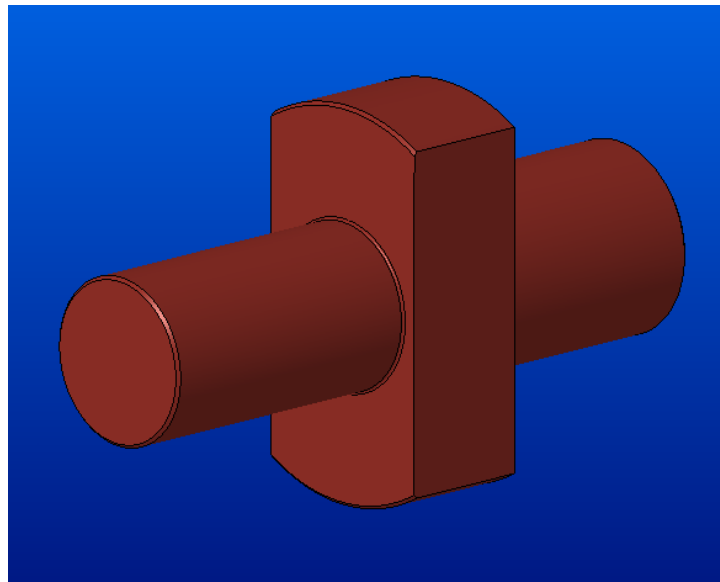
- Allows for laser alignment tool to be used properly
  - Original design was altered due to machinability of part



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# Coupler Connector

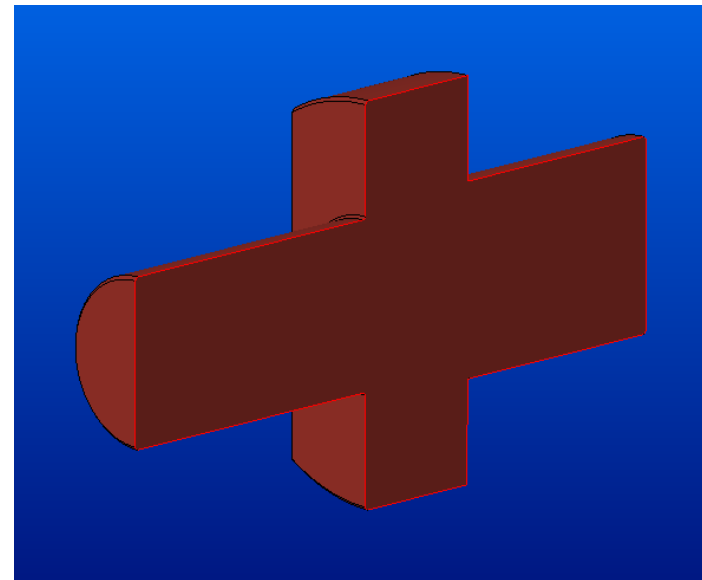
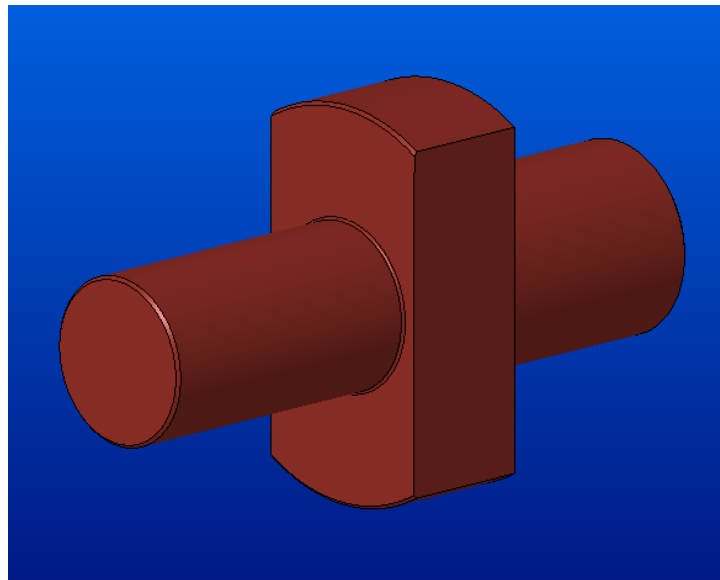
- Connects Shaft Extender to flexible coupling
  - Slip fits into Shaft Extender
  - Original spline design was altered due to machinability of parts



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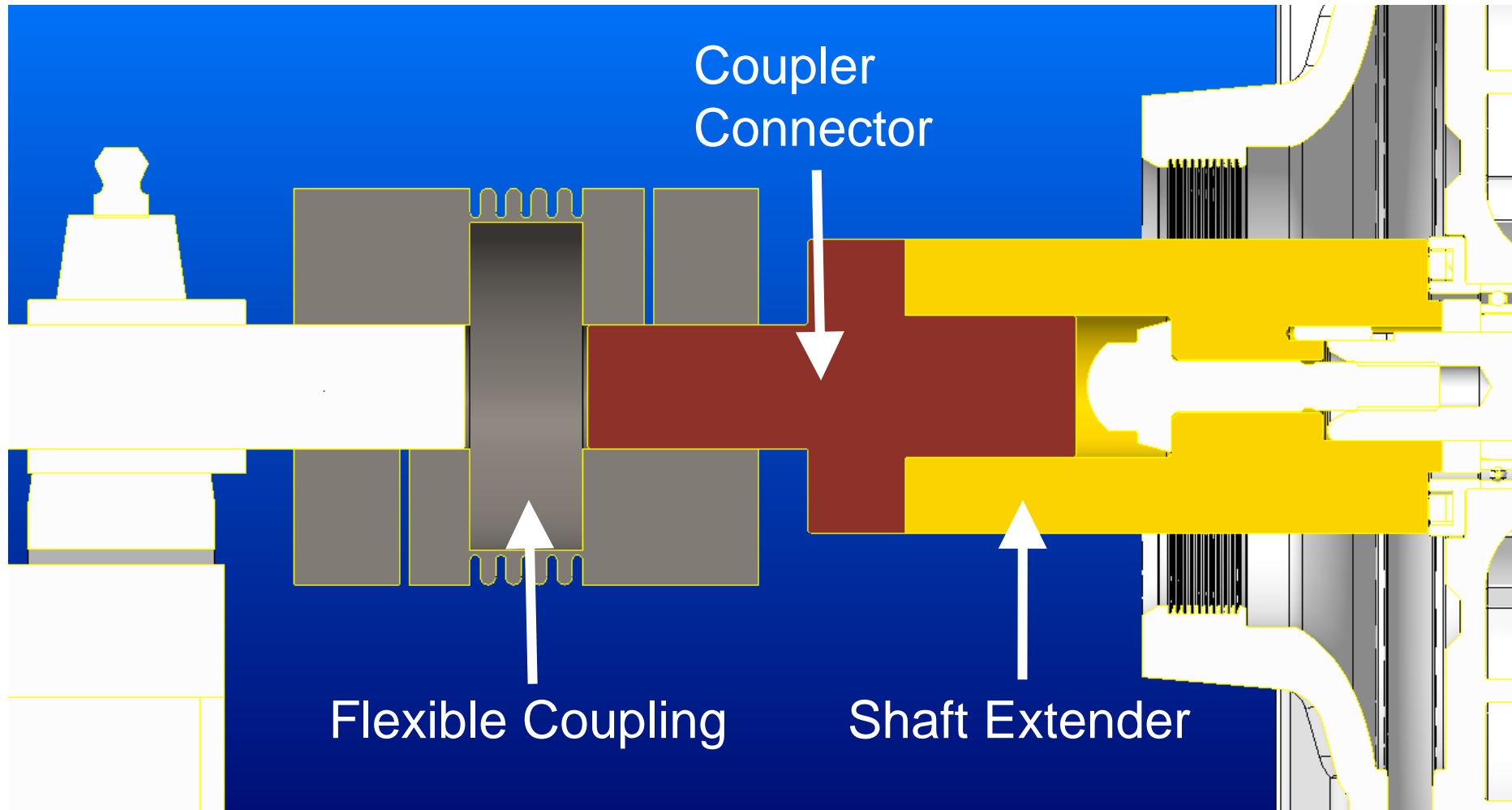
# Coupler Connector

- Two different coupler connectors will be machined
  - Zero-max and BK2 coupling connector
  - Only difference is inner diameter of couplings



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# Current Design



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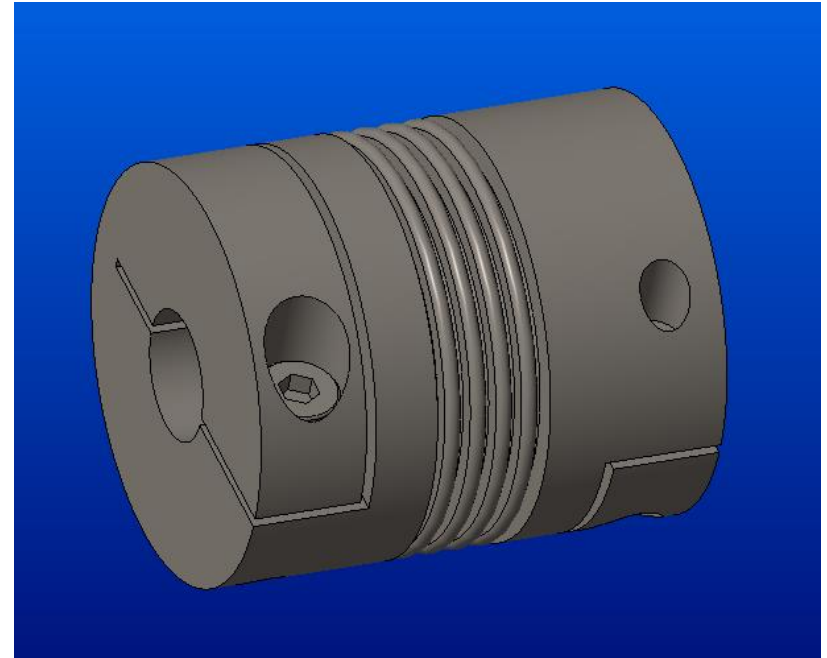
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# CHANGES FROM PREVIOUS DESIGN



# New BK2 Coupling

- BK2 offers Proof of Concept
  - BK2 coupler is only rated to 10,000rpm
  - BK2 coupler has a high speed coupling option rated to 32,000rpm
    - Zero-max does not



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# Zero-Max vs. BK2



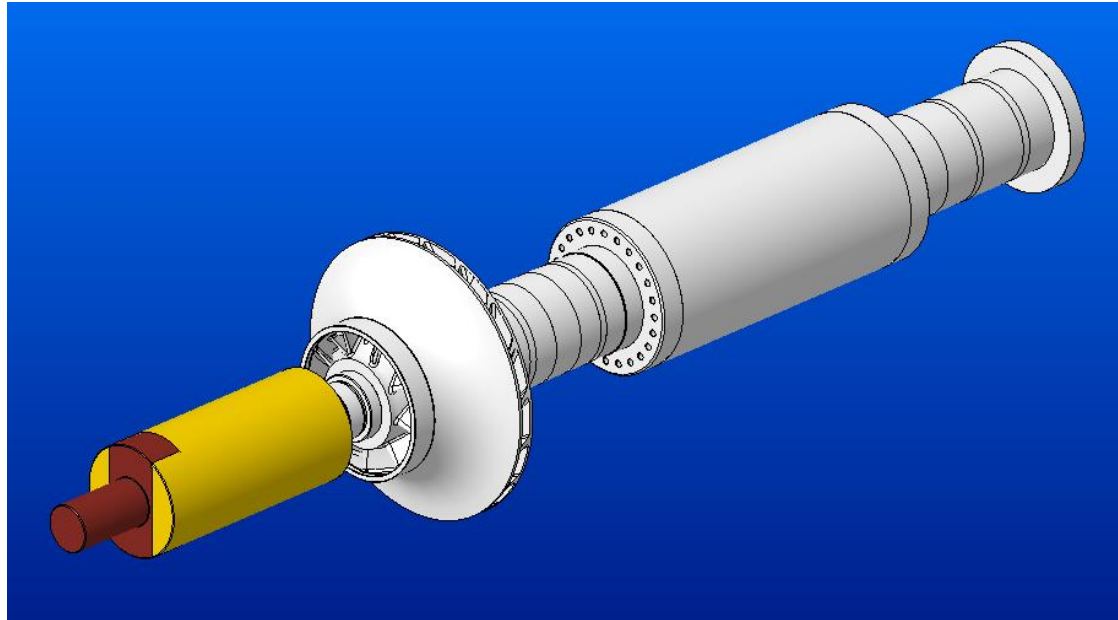
- Two couplings will be tested with our design
  - Zero-max
    - Proven effective last year
    - Not rated past 15,000rpm
  - BK2
    - Not proven to be effective (2015 team)
      - No fixed torque transducer
    - High speed option rated to 32,000rpm
    - Fixed mock transducer should offset the weight of BK2 coupler
      - Weight of BK2 coupler caused issues when testing two years ago

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# Balancing the Shaft

- Shaft must be balanced with Shaft Extender and Coupler Connector
  - Need to find the center of gravity of the shaft
  - Alter program to run properly with our altered shaft



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# Balancing the Shaft

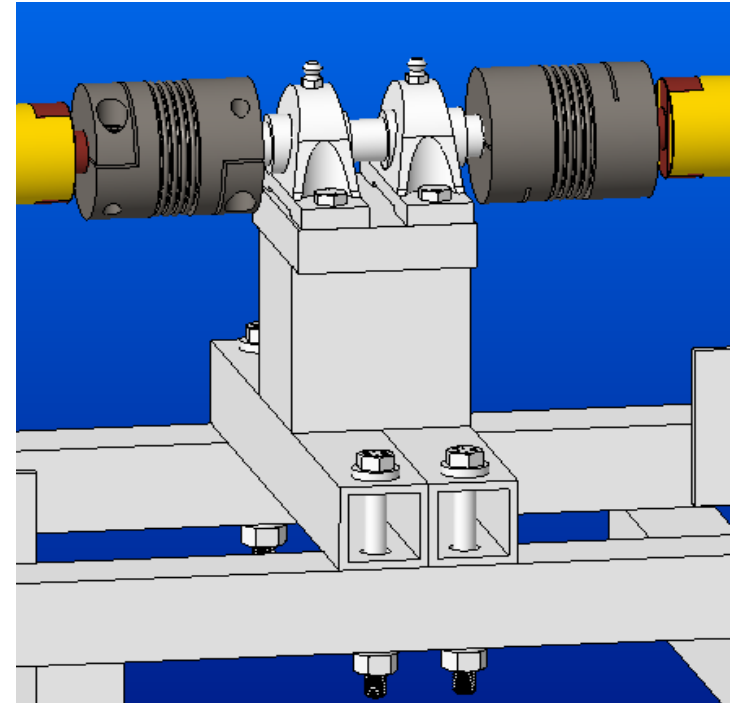


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# Mock Torque Transducer

- Two high speed bearings will act as the mock torque transducer
  - Center height and length simulate the TMHS11 torque transducer
  - Mock transducer was chosen instead of TMHS11 because of cost



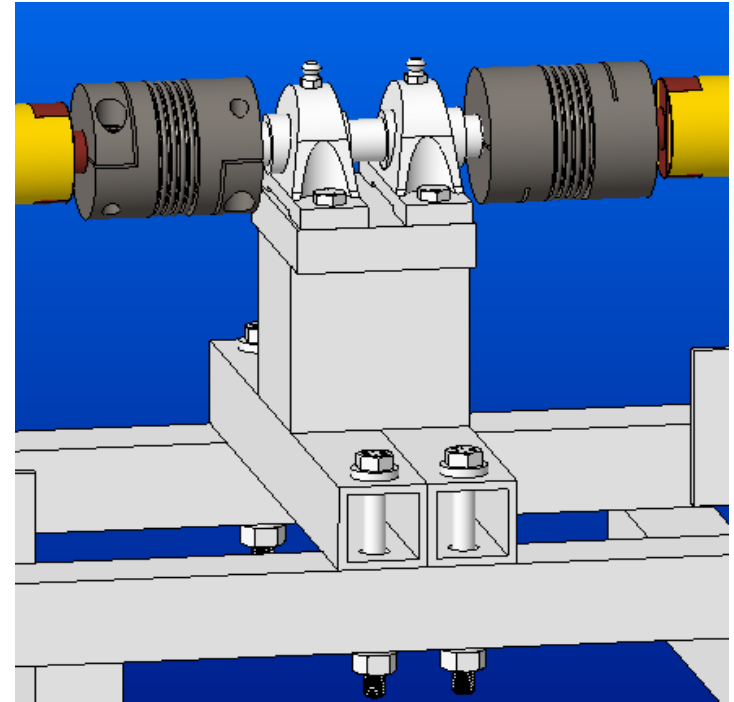
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# Mock Torque Transducer



- Bearings come with set screw to lock onto and prevent axial movement of shaft
  - Minimizing end play

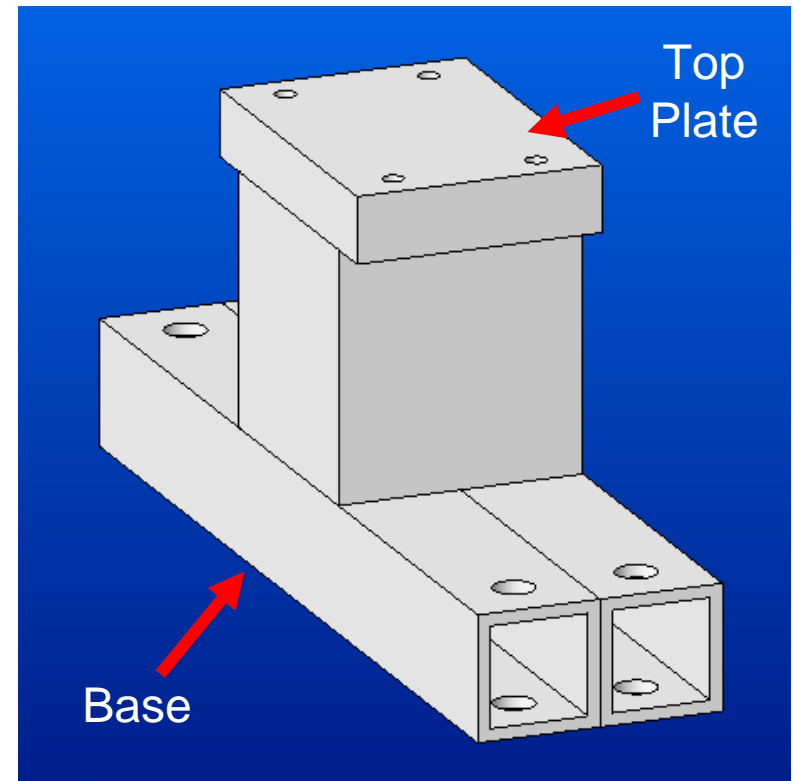


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# Torque Transducer Mount

- Fixed height
- Fixed to stand
- Compressors adjust to torque transducer
- From base to mock torque transducer shaft center is 215.8mm

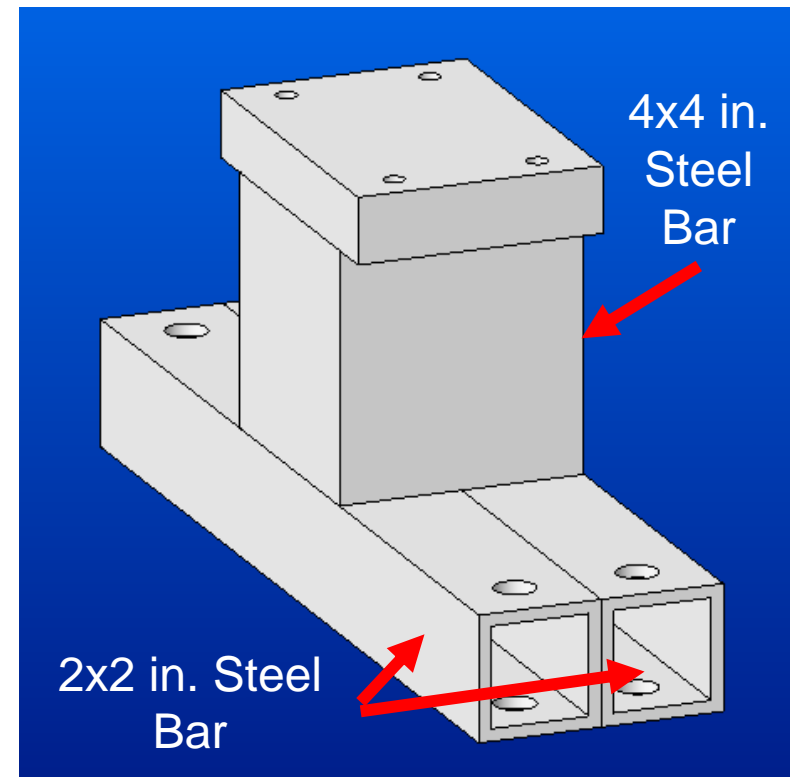


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# Torque Transducer Mount

- Top plate will be machined for final height after welding of mount is completed
  - Ensuring the mock transducer shaft height is the same as the compressor shaft height



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# Torque Transducer Mount



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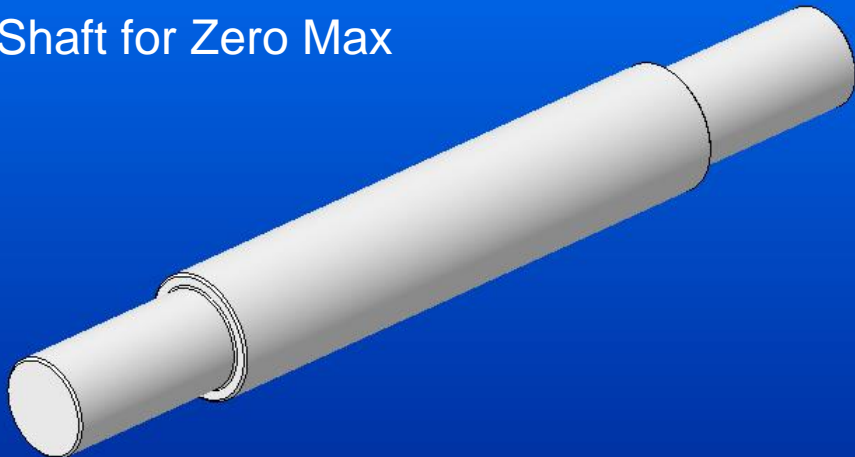
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# Mock Transducer shafts

- Two different shafts to accommodate two different couplers
  - 20mm(Zero-Max) and 25.4mm(BK2) shaft sizes
- Shafts are interchangeable in mock transducer

Shaft for Zero Max



Shaft for BK2



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# Stand Alteration

- Stand needs to be altered to allow for the new locations of compressor feet
- The holes that were used to secure the compressor feet to the stand are no longer in proper position
  - Compressors are further apart due to mock transducer and couplers
  - Stand needs to have 4 holes added to allow the compressor feet to be secured and 2 holes for the mount on each side

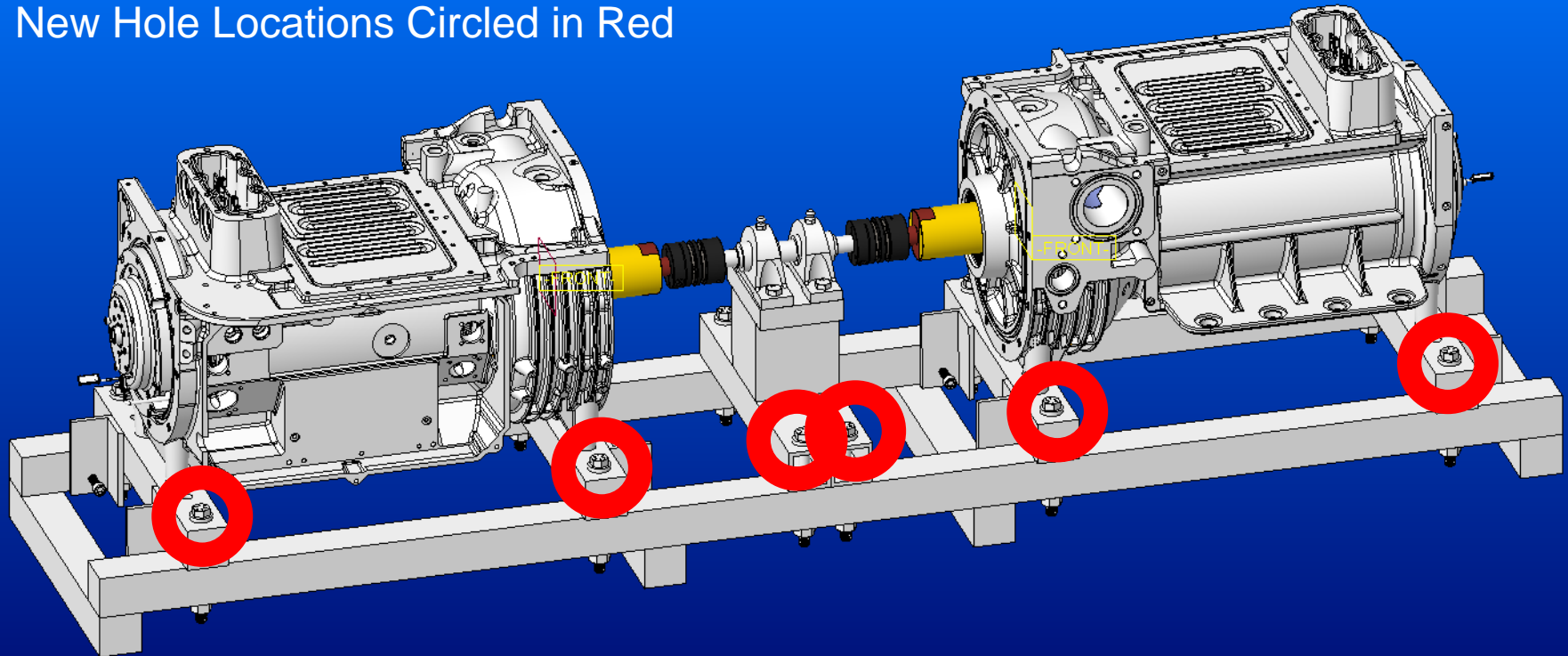
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# Stand Alteration



New Hole Locations Circled in Red



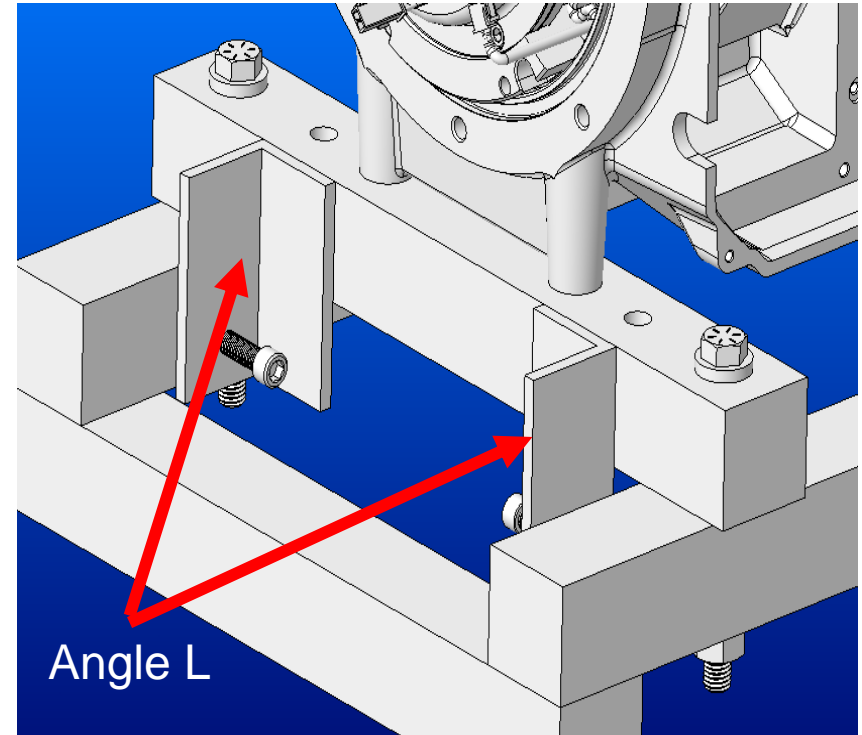
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# Axial Alignment Alteration

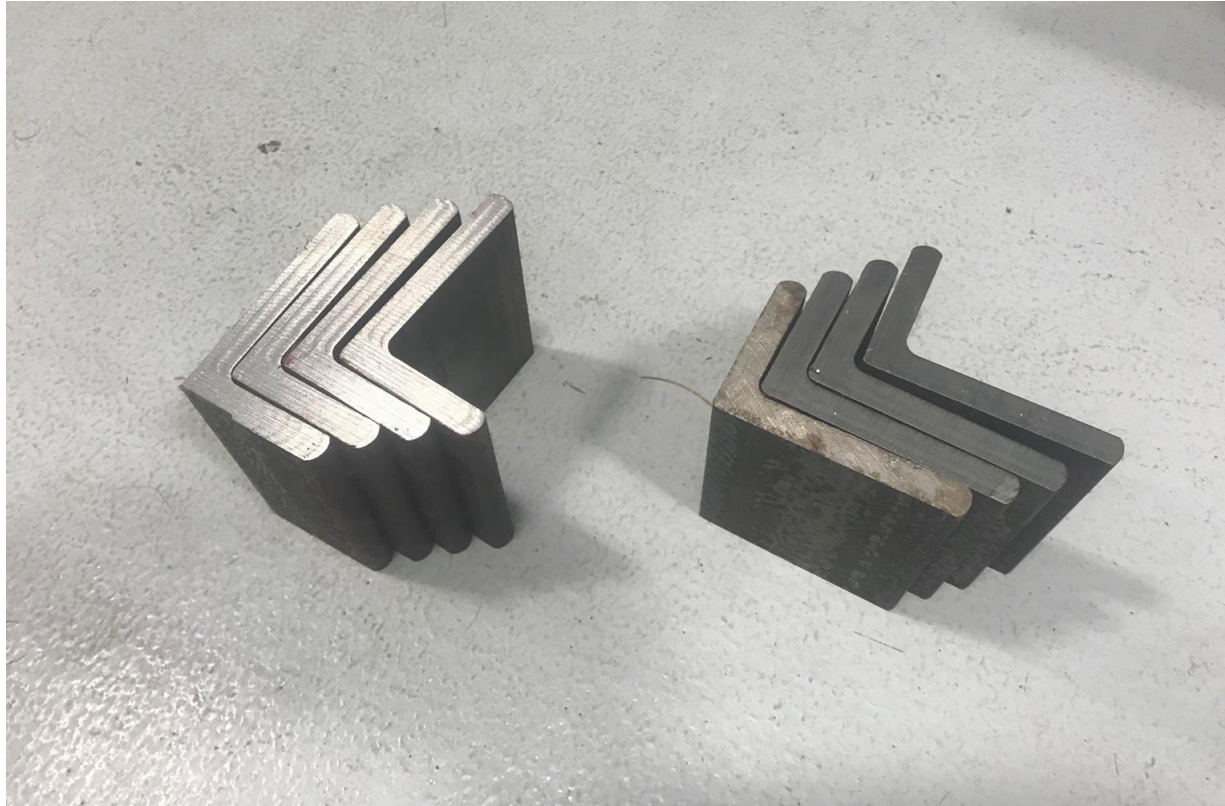
- The axial alignment for the original stand was fixed to the stand
  - Did not allow for distance between compressors to be altered
- Angle Ls will be welded to the compressor feet to adjust axial locations



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# Axial Alignment Alteration



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# SUMMARY OF CURRENT PROGRESS



# Progress



- Purchase orders have all been made
  - McMaster Carr and R+W America
- 2x2 and 4x4 steel framing have been cut to size
  - Ready to have holes added by machine shop at Danfoss for securing to test stand
  - Ready to be welded together at Danfoss
- Angle Ls have been cut to size and tapped
  - Ready to be welded to compressor feet by welder at Danfoss

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- Parts will be completed by the machine shop at Danfoss by March 1
  - (2) Shaft Extender
  - (2) Coupler Connector for Zero-Max Coupling
  - (2) Coupler Connector for BK2 Coupling
  - (8) Angle L
  - (1) Zero-Max Mock Shaft
  - (1) Zero-Max Mock Shaft
  - (1) Top Plate for Mount

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# Progress



Feb 12<sup>th</sup>

- Purchased commercially available parts

Feb 28<sup>th</sup>

- Welding of mock transducer mount

March 1<sup>st</sup>

- Custom parts machined at Danfoss
- Stand alterations completed

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# Finalizing details



- Work order has been created to have shafts removed from current compressor housings to allow for rebalance of shafts
- Work order has been created to have compressor feet removed from compressors on stand to allow for the angle Ls to be welded to the compressor feet

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# FURTHER WORK



# Pre-Testing Process



- Shaft must be balanced with Shaft Extender and Coupler Connector
  - Need to find the center of gravity of the shaft
  - Alter program to run properly with our altered shaft
- Verify all parts align to the stand properly and make any final adjustments before testing
  - Operator at Danfoss will verify software and recalibrate compressor software before testing

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# Testing Process

- Fixed mock torque transducer
- Using Laser alignment tool
  - Align 1st compressor coupling connector shaft to mock torque transducer shaft
  - Align 2nd compressor coupling connector shaft to 1st compressor coupling connector shaft

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# Questions?

