TF COIL STRUCTURAL MODEL

- FEA model of one bundle of the TF coil consists of beam and spring elements
- Stiffness of center-post is equal to 1/24 that of the composite cylinder
- Calculated stiffness of spring elements were adjusted to agree with deflection measurements taken during initial start-up tests

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TEST AND CALIBRATION SHOTS

- Calibration and test shots are used to load test new components on DIII–D
- Some calibration test shots produce lateral load distributions different from maximum design loads. The peak lateral loads can be nearer the coil mid-plane
- Lateral displacements are measured on all 24 outer bundles for every shot

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STRUCTURAL ANALYSIS RESULTS FOR SHOT 111031

- Structural analyses were performed for (1) no slip between outer turns (2) slip between top and bottom 32 inches of the outer turns

- Maximum lateral deflection of the outer turns with no slip is 0.16 in. (0.42 cm)

- The integrated shear flow exceeds the friction limit, indicating that slip would have occurred if not for the epoxy filled studs

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STRUCTURAL ANALYSIS RESULTS FOR SLIP OCCURRING BETWEEN TURNS

- Maximum lateral deflection of outer section with slip between turns is 0.35 in. (0.89 cm)
- This deflection exceeds the deflection limit of 0.25 in. (0.63 cm)
- Angel of twist of the coil center-post is significantly increased by the reduced stiffness of the outer sections

SHEAR STRENGTH OF EPOXY FILLED BOLTS

- If friction forces between turns are exceeded, epoxy filled studs react shear loads
- Tests on epoxy filled insulted studs in double shear were performed
- Results show slight damage of insulating sleeve after loaded to 10^5 lb. (4.45×10^5 N) in double shear

PROPOSED LATERAL LOAD LIMIT

- The total lateral load on an outer bundle between mid-plane and the anti-torque wedges could be calculated in advance by the EFIT code
- Results from EFIT could be input to the plasma control system
- Shots exceed the integrated load limits of 107,500 lb. (4.78×10^5 N) could then be limited by lower coil currents

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PRELOADED INSULATED BOLTS

- High strength (MP 159) preloaded insulated bolts are used to clamp ends of outer turns
- Special washers are used in inject epoxy between insulating sleeve and bolt hole
- Epoxy impregnated gap provides additional safety factor on shear transfer between outer turns if friction forces are exceeded

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CONCLUSIONS

- Test calibration shots can produce peak lateral loads shifted toward the mid-plane of the TF coil
- Design lateral loads for 5 MA plasmas are positioned near the anti-torque wedges
- Preloaded insulated bolts were effective in prevent slip between turns of the TF coil for shot 111031
- Lateral deflections of the TF coil should be closely monitored for test shots similar to shot 111031

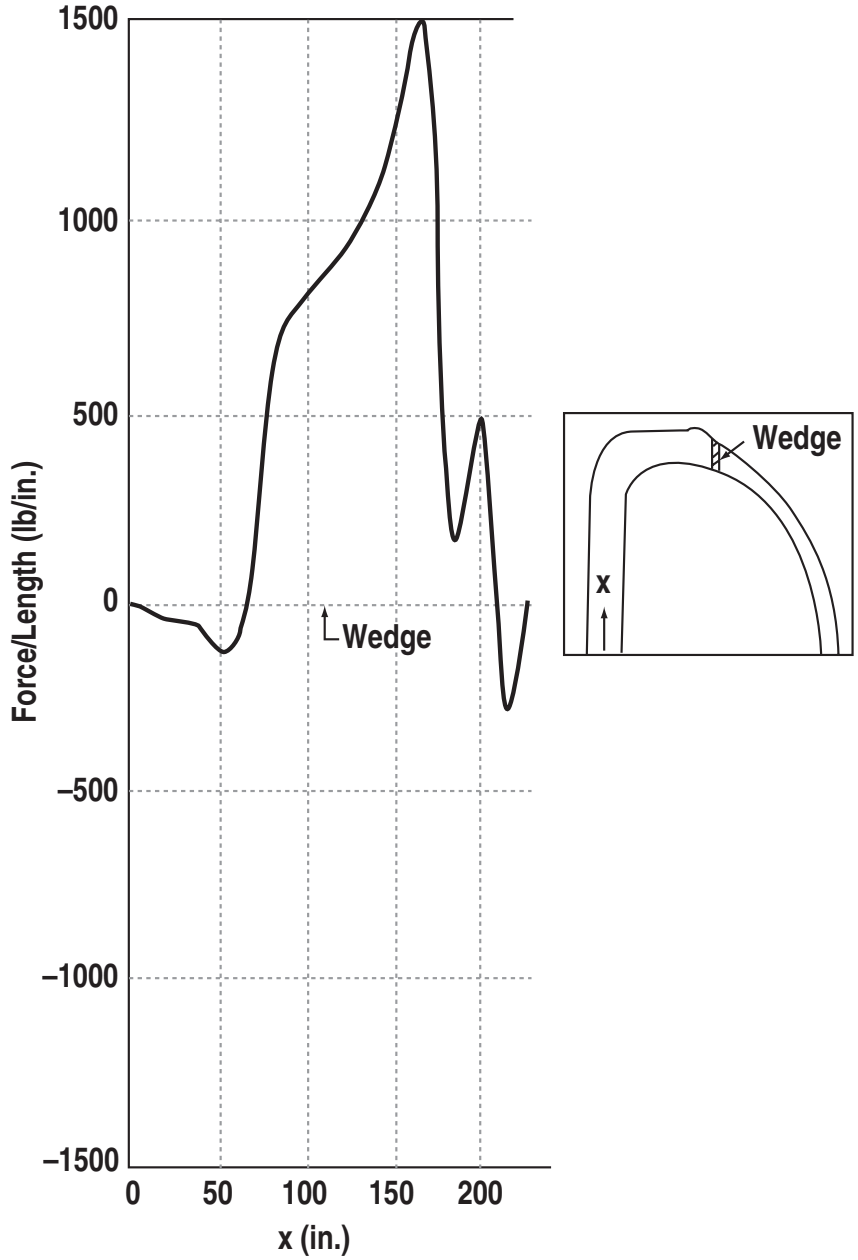
ANTI-TORQUE STRUCTURAL SYSTEM

- Lateral loads act on TF coil due to poloidal fields crossing the coil current
- TF coil center-post and the anti-torque frame react lateral forces to minimize lateral deflections
- Anti-torque structural system reduces fatigue stresses in the coil finger-joint

INTRODUCTION

- Recent calibration shots produced increased lateral loads on outer sections of the TF coil
- Calibration shots without plasma produce lateral distributions different from design loads
- The increased lateral deflections resulted in contact with adjacent equipment
- Structural analysis was performed to determine if slip between turns of outer sections was cause of large deflections

LATERAL LOAD DISTRIBUTION ON TF COIL FOR SHOT 111031



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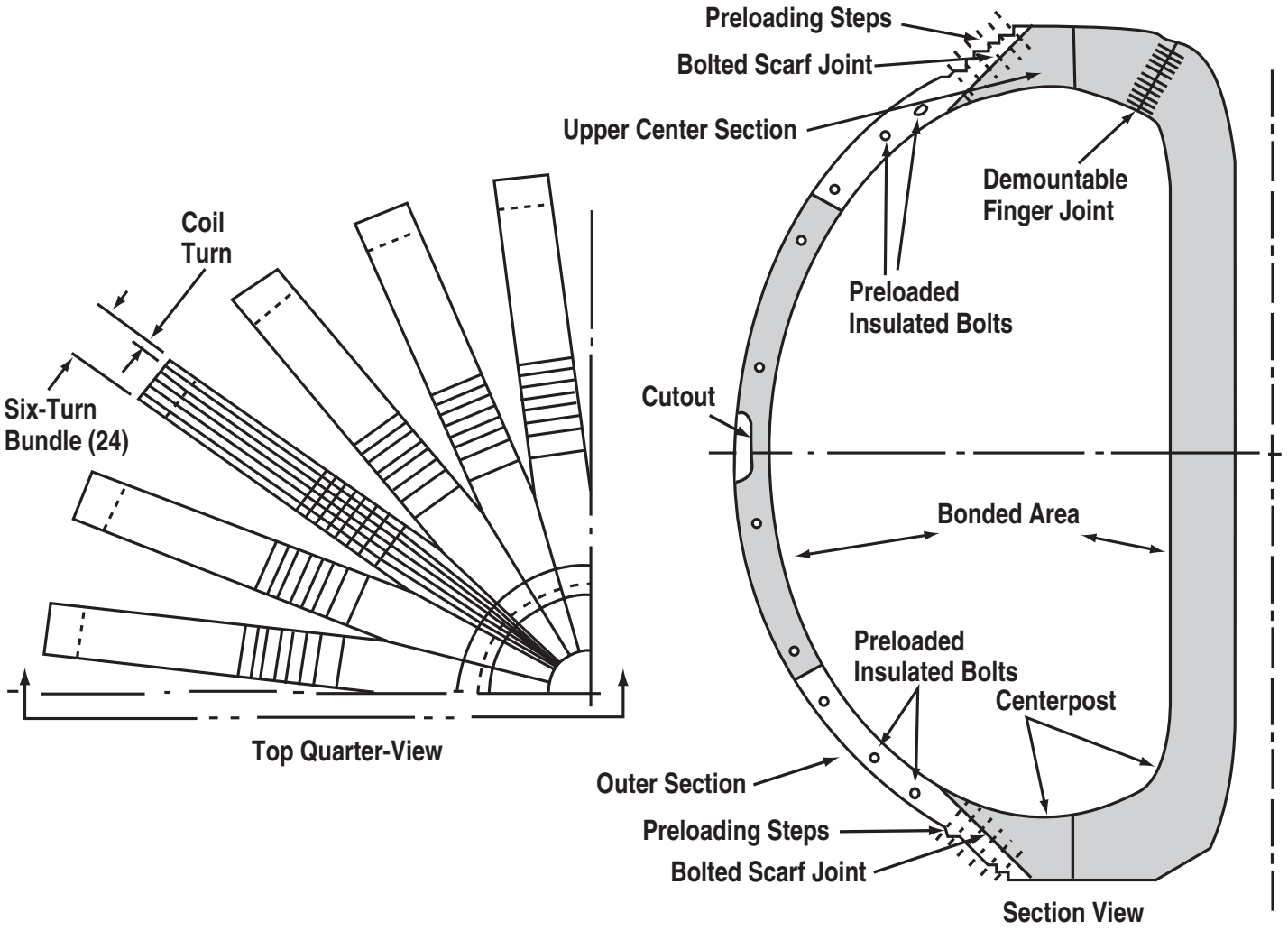
BONDED SECTIONS OF THE TF COIL



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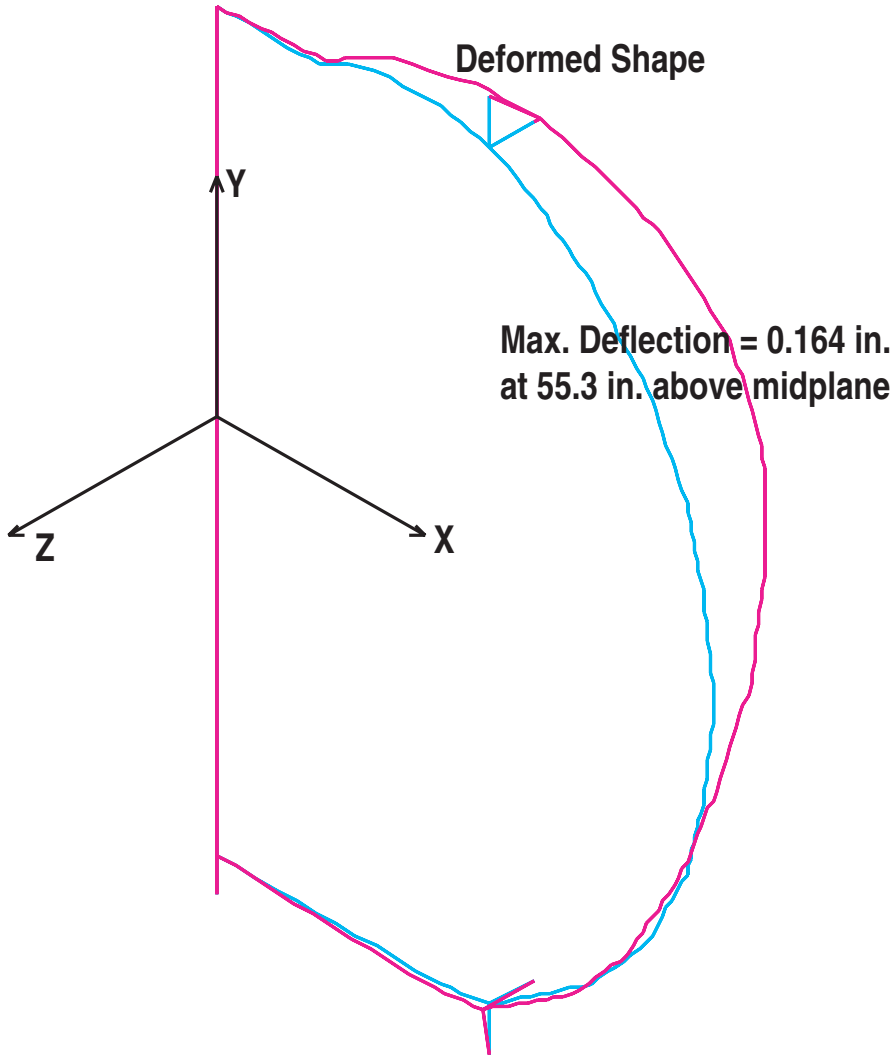
DEFORMED SHAPE FOR SHOT 111031 FOR NO SLIP BETWEEN



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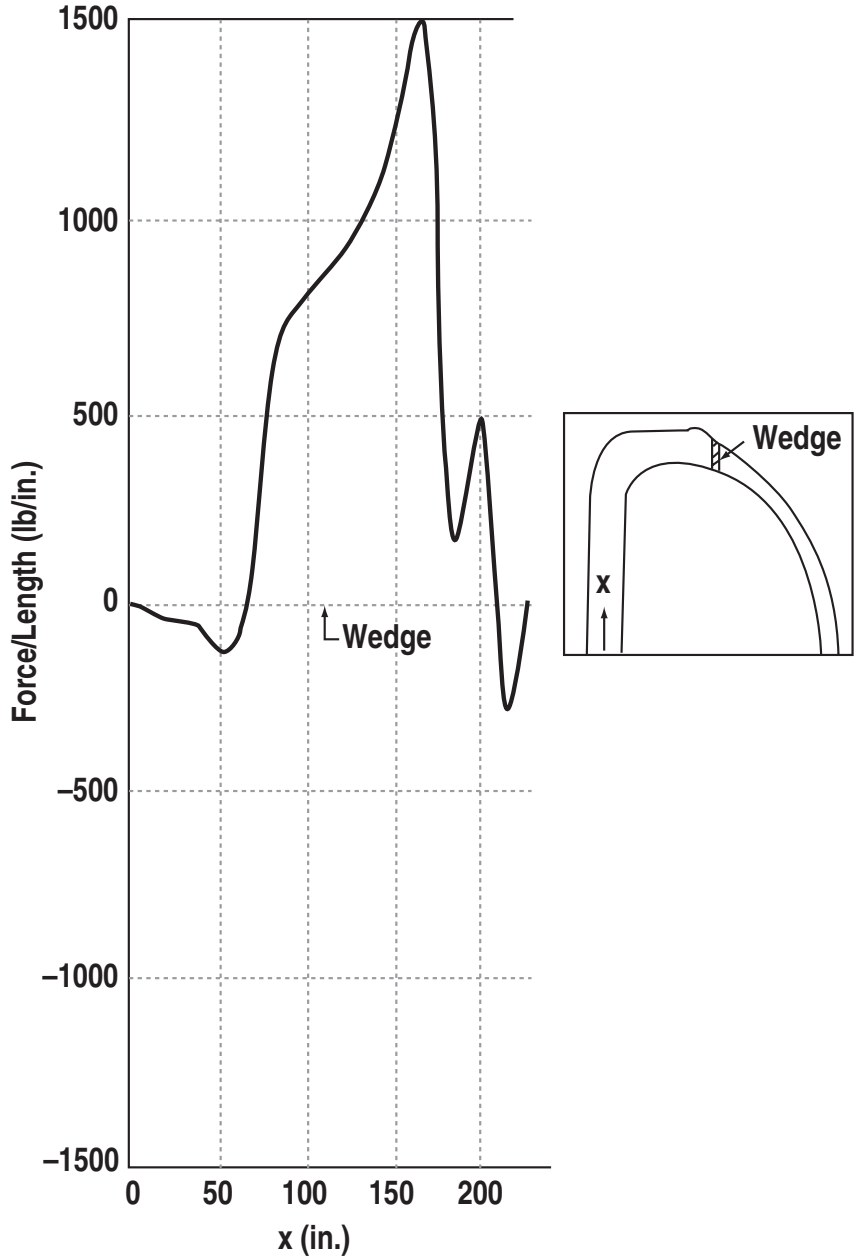
LATERAL LOAD DISTRIBUTION ON TF COIL FOR SHOT 111031



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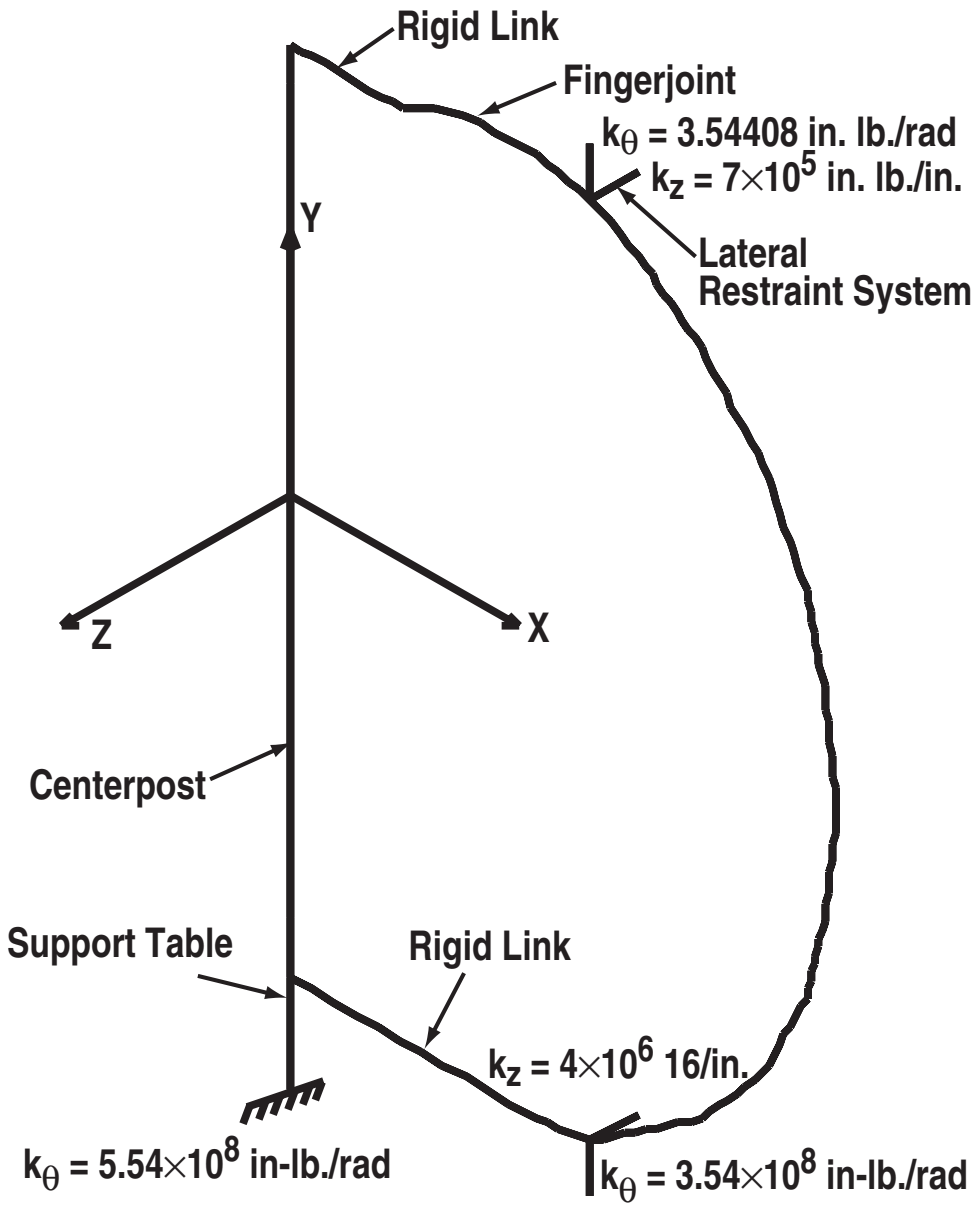
STRUCTURAL MODEL OF TF COIL



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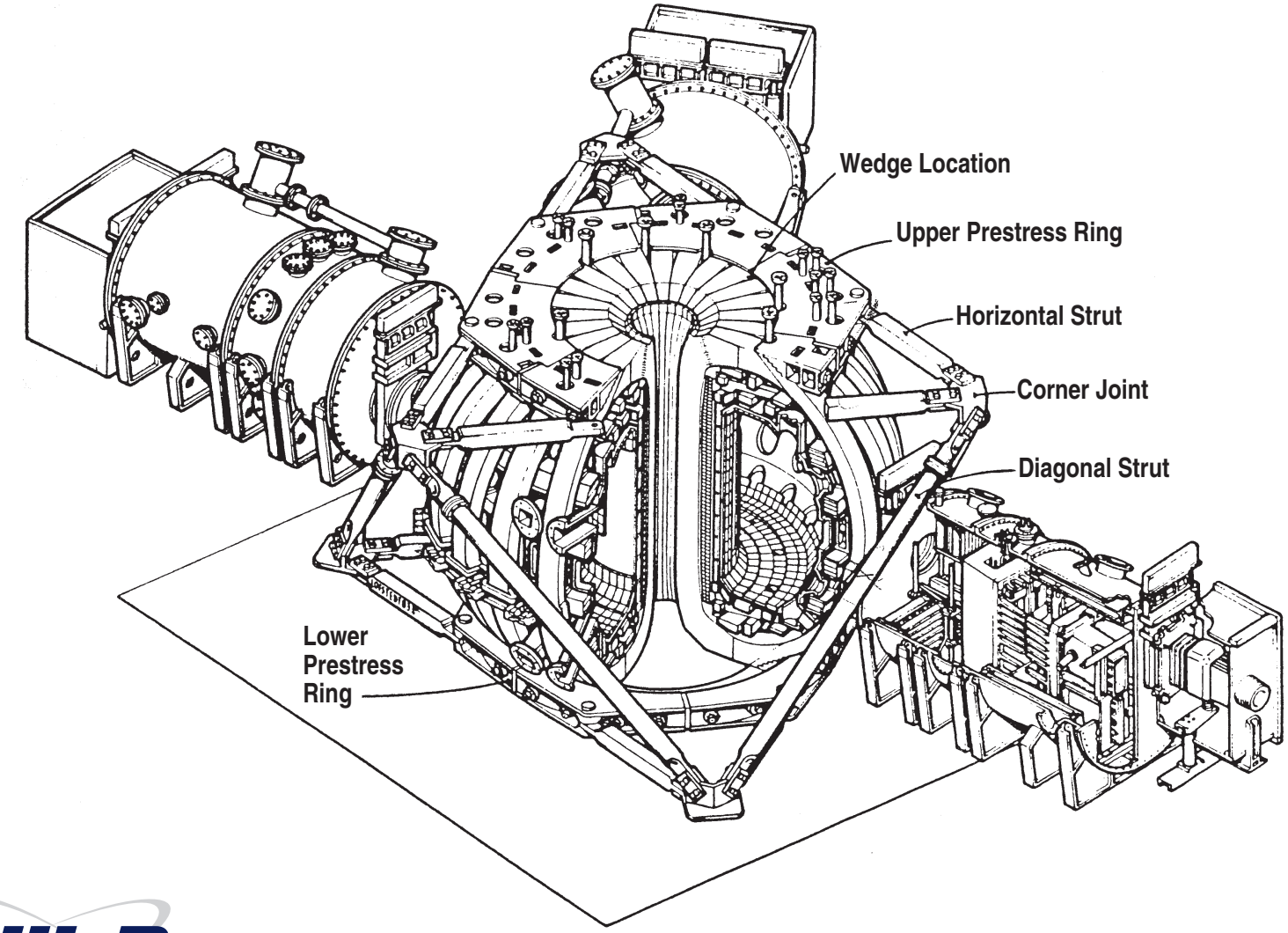
DIII–D ANTI-TORQUE STRUCTURAL ELEMENTS



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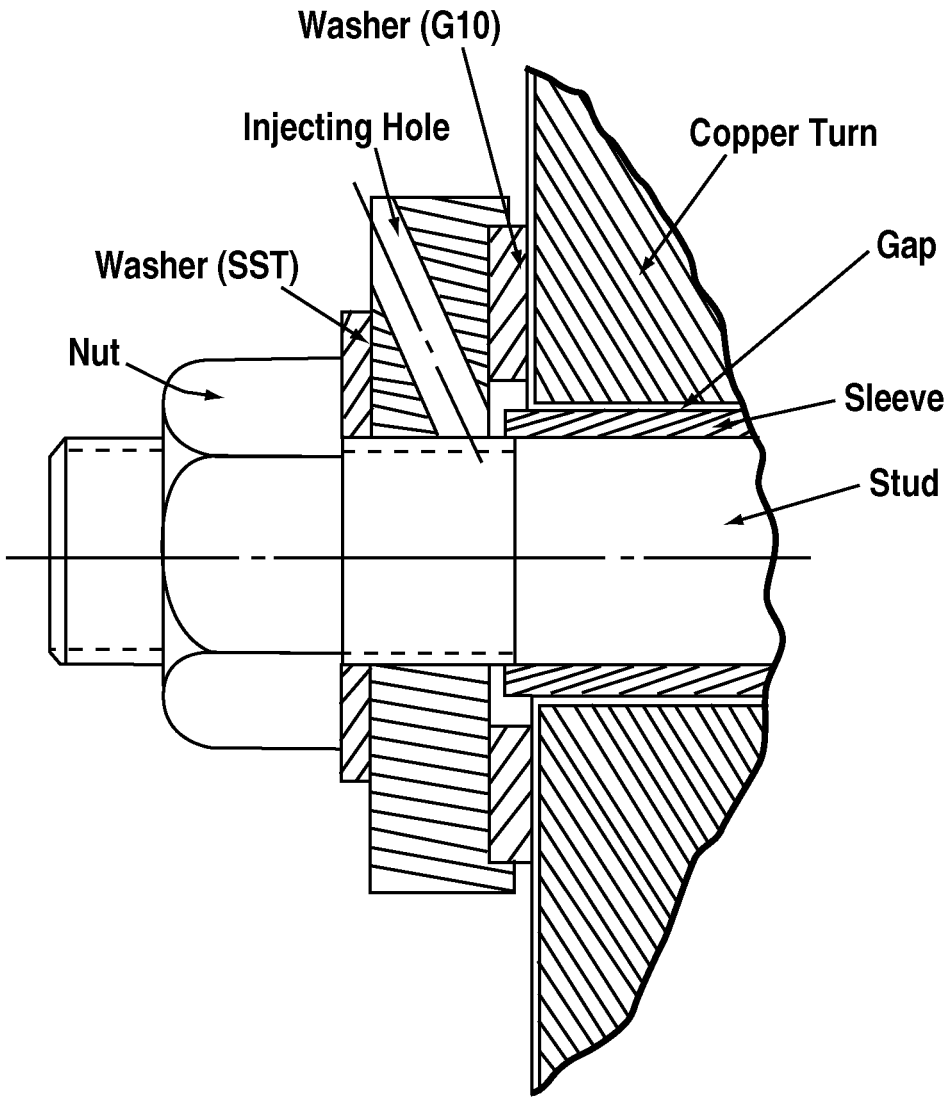
INSULATED SHEAR BOLT CLAMPING HARDWARE



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