

# A Statistical Approach to Bolted Joint Design

## Syllabus

### 1. Define the Joint System (+/-3 $\sigma$ )

- Joint Description  
Geometry, Part Numbers, Drawings,  
Monotonic & Cyclic Material Properties,  
Friction coefficients
- Acceptance Criteria  
Slip Criteria  
Risk Tolerance
- Assembly Information  
Torque Specs, Prevailing Torque, Assembly  
Sequence, Assembly Bias
- Operating Conditions  
Applied Loads, Load Histograms,  
Performance history,  
Comparable joint performance history

### 2. Perform Load path Analysis (+/-3 $\sigma$ )

- Identify load paths for Preload, External  
Loads
- Identify and Quantify Effective Loaded Area

### 3. Identify Potential Failure Modes

- Interference
- Yield/Relaxation/Embedment
- Inadequate Bolt Stretch
- Thread Stripping
- Slip; Initial, Final
- Fatigue
- Thermal Effects
- Contamination
- Over/Under Torque
- Over Load

### 4. Quantify External Loads (+/- 3 $\sigma$ )

- Static Force and Moment
- Dynamic Force and Moment
- Histogram Force and Moment

### 5. Resolve Loads to Bolt Locations

- To Bolt CG
- To Each Bolt Position

### 6. Check for Interferences (+/-3 $\sigma$ )

- Underhead fillet
- Hole chamfer
- Bracket radius

### 7. Calculate Bolt Preload (+/-3 $\sigma$ )

- K-Factor
- Bolt Preload, Initial
- Bolt Preload, after Relaxation

### 8. Calculate Bolt Stress from Preload (+/-3 $\sigma$ )

- Axial Stress
- Torsional Stress
- Combined Stress
- Assessment of Torque Spec

### 9. Calculate Bearing Stress from Preload (+/-3 $\sigma$ )

- Effective Area
- Bearing Stress
- Flow Stress
- Controlled Embedment

### 10. Calculate Joint Stiffness (+/-3 $\sigma$ )

- Calculate Fastener and Joint Stiffness

### 11. Check for Joint Separation/Yield (+/-3 $\sigma$ )

- Calculate Max & Min Tensile Load in Bolt
- Calculate Max & Min Compressive Load in  
Joint
- Construct Joint Diagram
- Tensile/Compressive Yield
- Check for Joint Separation

### 12. Check for Joint Slip (+/-3 $\sigma$ )

- Calculate Shear Capacity at Initial Slip
- Calculate %External Load at Initial Slip

### 13. Check for Bolt Fatigue (+/-3 $\sigma$ )

- Identify Critical Load Conditions
- Calculate Bolt Stresses
- Perform Neuber Analysis
- Calculate Mean Stress Correction
- Calculate Fatigue Life

### 14. Document the Analysis

- Analysis Report  
Vehicle/Product Model and Joint  
Description  
Analysis Inputs and Results  
Conclusions and Recommendations  
Joint Limitations and Opportunities  
Critical Characteristics  
Contacts: Design, Analyst, Supplier  
Code/Tools: Versions/Dates  
Analysis Number, Date, and Record Holder
- Corporate Knowledge  
Update Lessons Learned and Design  
Guidelines.

