(b) The specific use of threaded structural fasteners or components for which Level A Limits are applied may be determined through analysis using the methods of NG-3228.2 or experimental analysis using the methods of NG-3228.4, as described in Mandatory Appendix XIII, Article XIII-4000.

**NG-3232** Level A Service Limits

The number and cross-sectional area of threaded structural fasteners shall be such that the stress intensity limits of this paragraph are satisfied for the Service Loadings or conditions for which Level A Limitations are specified. The stress intensity limits and related design criteria are specified in the Design Specifications and the Design Loadings shall be considered. The total axial load transferred through the fastener threads shall not go to or through zero during the specified Service Loadings.

**NG-3232.1** Average Stress. Elastic analysis of specified conditions shall show that the average primary plus secondary membrane stress including stress from preload meets the following requirements:

- Elastic analysis of specified stress categories, including stress from preload for primary plus secondary membrane stress, shall show that the average primary plus secondary membrane stress, meets the following requirements:

**Figure NG-3232-1** Stress Intensity Limits for Design of Threaded Structural Fasteners

<table>
<thead>
<tr>
<th>Stress Categories</th>
<th>Average Primary Membrane Stress Intensity Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Level A and Level B Service Limits</td>
<td>Average Primary Membrane Stress Intensity Limits</td>
</tr>
<tr>
<td></td>
<td><strong>Membrane Including Stress From Preload</strong></td>
</tr>
<tr>
<td></td>
<td><strong>[Notes (1) and (2)]</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Membrane</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Maximum Stress</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Primary + Secondary</strong></td>
</tr>
</tbody>
</table>

**NOTES:**
(1) If a tight joint is required, the stress due to preload should exceed that due to primary plus secondary membrane other than preload.
(2) $Q_n$ are secondary membrane stresses.
(3) $Q_b$ are secondary bending stresses.
(4) For torquing during installation, the maximum membrane stress intensity shall not exceed 1.2 times these values at installation temperature.
(5) For threaded structural fasteners, in lieu of satisfying these primary plus secondary stress limits, a limit analysis using the methods of NG-3228.2 or experimental analysis using the methods of NG-3228.4, may be performed. There alternate analyses do not apply for torquing during installation.
NG-3232.2 Maximum Stress.

(a) The maximum primary membrane and bending plus secondary membrane and bending stress intensities, including stress from preload but excluding effects of stress concentrations, shall be no greater than 1.33 times the limits of NG-3232.1(a).

(b) For torquing during installation of fasteners, the maximum value of membrane stress intensity shall be no greater than 1.2 times the limits of NG-3232.1(a), and the maximum value of membrane plus bending stress intensity shall be no greater than 1.2 times the limits of (a) at installation temperature.

NG-3232.3 Fatigue Analysis of Threaded Structural Fasteners. Unless threaded structural fasteners meet the conditions of NG-3222.4(d) and thus require no fatigue analysis, the suitability of threaded structural fasteners for cyclic service shall be determined in accordance with the procedures of (a) through (e) below.

(a) Threaded Structural Fasteners Having Less Than 100 ksi (690 MPa) Tensile Strength. Fasteners made of material which has specified minimum tensile strength of less than 100 ksi (690 MPa) shall be evaluated for cyclic service by the methods of NG-3222.4(e), using the applicable design fatigue curves of Section III Appendices, Mandatory Appendix I and an appropriate fatigue strength reduction factor [see (c)].

(b) High-Strength Threaded Structural Fasteners. High-strength fasteners may be evaluated for cyclic service by the methods of NG-3222.4(e) using the applicable design fatigue curve of Section III Appendices, Mandatory Appendix I, provided

(1) the maximum value of primary and secondary stresses, including preload, at the periphery of the fastener cross section (resulting from direct tension plus bending and neglecting stress concentrations) shall not exceed 0.95$f_y$, where $f_y$ is determined at service temperature

(2) threads shall have a minimum thread root radius no smaller than 3 mils (0.08 mm)

(3) fillet radii at the end of the shank shall be such that the ratio of fillet radius to shank diameter is not less than 0.06

(c) Fatigue Strength Reduction Factor (NG-3213.16). Unless it can be shown by analysis or tests that a lower value is appropriate, the fatigue strength reduction factor used in the fatigue evaluation of threaded members shall not be less than 4 for the threaded region. However, when applying the rules of (b) for high-strength fasteners, the value used shall not be less than 4 for the threaded region.

(d) Effect of Elastic Modulus. Multiply $S_{ult}$ (NG-3216.1 or NG-3216.2) by the ratio of the modulus of elasticity given on the design fatigue curve to the value of the modulus of elasticity used in the analysis. Enter the applicable design fatigue curve at this value on the ordinate axis and find the corresponding number of cycles on the abscissa.

(e) Cumulative Damage. The fasteners shall be acceptable for the specified cyclic application of loads and thermal stress provided the cumulative usage factor $U$ as determined in NG-3222.4(e)(5) does not exceed 1.

NG-3233 Level B Service Limits

Level A Service Limits (NG-3232) apply.

NG-3235 Level D Service Limits for Threaded Structural Fasteners

The number and cross-sectional area of threaded structural fasteners shall be such that the requirements of NG-3224 are satisfied for the Service Loadings for which Level C Limits are designated in the Design Specifications. For high-strength structural fasteners [specified minimum tensile strength $f_u \geq 100$ ksi (690 MPa)], the limits of NG-3232.1 and NG-3232.2(a) also apply for these Service Loadings. Any deformation limit prescribed in the Design Specifications shall be considered. The following stipulations apply when using Section III Appendices, Mandatory Appendix XXVII:

(a) The stress limits for high strength threaded structural fasteners with specified minimum ultimate tensile strength greater than or equal to 100 ksi (690 MPa) at operating temperatures for core support structure applications are as given in (1) through (3) below. The requirements of Article XXVII-3000 do not apply.

(1) For component elastic analysis, combined with either elastic or inelastic system analysis, $P_m$ shall not exceed 2$S_m$, and $P_m + P_b$ shall not exceed 3$S_m$.

(2) For component plastic analysis, combined with either elastic or inelastic system analysis, $P_m$ shall not exceed 2$S_m$, and maximum primary stress intensity shall not exceed the larger of 0.67$S_{ult}$ and $[S_y + (1/S_y)(S_{ult} - S_y)]$, but not to exceed 0.9$S_u$, where $S_{ult}$ is defined as the value of ultimate stress obtained from the true stress-strain curve and $S_u$ is defined as the value of ultimate stress from an engineering stress–strain curve.

(3) For component limit analysis, combined with either elastic or inelastic system analysis, in lieu of satisfying the limits on $P_m$ and $P_m + P_b$, the specified loadings shall not exceed 1.33$L_L$ (NG-3213.21).