### Table NF-3221.2-1
Elastic Analysis Stress Categories and Stress Limit Factors for Class 1 Plate- and Shell-Type Supports Designed by Analysis

<table>
<thead>
<tr>
<th>Stress Category</th>
<th>Design</th>
<th>Service Level A [Note (2)]</th>
<th>Service Level B [Note (2)]</th>
<th>Service Level C [Note (3)]</th>
<th>Service Level D [Note (3)]</th>
<th>Test Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary stresses</td>
<td>$K_m = 1.0$</td>
<td>$K_m = 1.0$</td>
<td>$K_m = 1.33$</td>
<td>$K_m = 1.5$</td>
<td>$K_m =$ greater of $1.5$ or $1.2S_y/S_m$</td>
<td>$K_m = 1.33$</td>
</tr>
<tr>
<td></td>
<td>$K_v = 1.0$</td>
<td>$K_v = 1.0$</td>
<td>$K_v = 1.33$</td>
<td>$K_v = 1.5$</td>
<td>$K_v =$ greater of $1.5$ or $1.2S_y/S_m$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$K_{bh} = 1.0$</td>
<td>$K_{bh} = 1.0$</td>
<td>$K_{bh} = 1.33$</td>
<td>$K_{bh} = 1.5$</td>
<td>$K_{bh} =$ greater of $1.5$ or $1.2S_y/S_m$</td>
<td>$K_{bh} = 1.33$</td>
</tr>
<tr>
<td>but stress $\leq \frac{1}{2}$ of critical buckling stress</td>
<td>but stress $\leq \frac{1}{2}$ of critical buckling stress</td>
<td>but stress $\leq \frac{1}{2}$ of critical buckling stress</td>
<td>but stress $\leq \frac{1}{2}$ of critical buckling stress</td>
<td>but stress $\leq \frac{1}{2}$ of critical buckling stress [Note (7)]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Primary plus secondary stresses [Note (5)], [Note (8)]**

**Evaluation is required for critical buckling for all loading categories. The requirements of this subarticle shall be met for this evaluation.**

**Peak stresses**

**Evaluation not required.**

---

**GENERAL NOTE:**

- $K_{bh}$ = stress limit factor applicable to the Design allowable membrane stress intensity or membrane plus bending stress intensity (compression only)
- $K_m$ = stress limit factor applicable to the Design allowable membrane stress intensity or membrane plus bending stress intensity (see NF-3221.1 and NF-3221.2)
- $K_v$ = stress limit factor applicable to the Design allowable shear stress (see NF-3223.2)

**NOTES:**

1. Control of deformation is not assured by these stress limit factors. When required by Design Specification, deformation control must be considered separately.
2. $K_m$, $K_v$, and $K_{bh} = 1.0$ for design of snubbers and dampers.
3. Stress shall not exceed $0.75S_y$.
4. For Service Levels A, B, C, and D, stresses induced on the supports by restraint of free-end displacement and anchor motions of piping shall be considered as primary stresses.
5. Thermal stresses within the support as defined by NF-3121.11 need not be evaluated.
6. Shear stress shall not exceed $0.42S_v$.
7. Two-thirds of the critical buckling stress may be used, provided the critical buckling stress is determined by one of the following methods:
   - (a) comprehensive analysis that considers effects such as geometric imperfections, deformations due to existing loading conditions, nonlinearities, large deformations, residual stresses, and inertial forces
   - (b) tests of physical models under conditions of restraint and loading the same as those to which the configuration is expected to be subjected
8. Service Levels A and B, primary plus secondary stresses shall be limited to a range of $2S_y$ or $S_v$ at temperature, whichever is less for component supports only.
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and NF-3223 multiplied by the appropriate stress intensity limit factor in Table NF-3221.2-1 under Test Loadings.

NF-3221.4 Limit Analysis. The limits on primary membrane plus primary bending stress intensity [NF-3221.1(b)] need not be satisfied at a specific location if it can be shown by means of limit analysis or by tests that the specified loadings do not exceed two-thirds of the lower bound collapse load for Design Loadings and Service Level A and B Loadings, and do not exceed 0.8 times the lower bound collapse load for Service Level C Loadings. Service Level D Loadings shall not exceed 0.9 times the lower bound collapse load. For Service Level D, the lower bound collapse load may be determined using a yield stress in the analysis that is the greater of 1.25σ_y and 1.5S_m, but not larger than 0.75σ_y. For materials in Section II, Part D, Subpart 1 for which allowable stresses, or stress intensities, may reach 90% of the yield strength σ_y at temperature, the specified loading shall not exceed the product of the applicable permanent strain limiting factor of Section II, Part D, Subpart 1, Table Y-2 times the lower bound collapse load.

NF-3222 Derivation of Stress Intensities

One requirement for the acceptability of a design (NF-3130) is that the calculated stress intensities shall not exceed specified allowable limits. These limits differ depending on the stress category (primary, secondary, etc.) from which the stress intensity is derived. This paragraph describes the procedure for the calculation of the stress intensities which are subject to the specified limits. The steps in the procedure are stipulated in (a) through (e).

(a) At the point on the support which is being investigated, choose an orthogonal set of coordinates, such as tangential, longitudinal, and radial, and designate them by the subscripts t, l, and r. The stress components in these directions are then designated σ_t, σ_l, and σ_r for direct stresses and T_{tt}, T_{tl}, and T_{tr} for shear stresses.

(b) Calculate the stress components for each type of loading to which the item will be subjected and assign each set of stress values to one or a group of the following categories:

(1) General primary membrane stress P_m (NF-3121.7)

(2) Primary bending stress P_b (NF-3121.8)

(3) Secondary stress Q (NF-3121.3)

(c) For each category, calculate the algebraic sum of the values of σ_t that result from the different types of loadings, and similarly for the other five stress components. Certain combinations of the categories must also be considered.

(d) Translate the stress components for the t, l, and r directions into principal stresses σ_1, σ_2, and σ_3.

(e) Calculate the stress differences S_{12}, S_{23}, and S_{31} from the following equations:

\[ S_{12} = \sigma_1 - \sigma_2 \]
\[ S_{23} = \sigma_2 - \sigma_3 \]
\[ S_{31} = \sigma_3 - \sigma_1 \]

The stress intensity S is the largest absolute value of S_{12}, S_{23}, and S_{31}.

NOTE: Membrane stress intensity is derived from the stress components averaged across the thickness of the section. The averaging shall be performed at the component stress level in (b) or (c).

NF-3223 Special Stress Limits

The following deviations from the basic stress limits are provided to cover special Service Loadings or configurations. Some of these deviations are more restrictive and some are less restrictive than the basic stress limits. In cases of conflict between these requirements and the basic stress limits, the rules of this paragraph take precedence for the particular situations to which they apply.

NF-3223.1 Bearing Loads.

(a) The average bearing stress for resistance to crushing under the maximum load, experienced as a result of Design Loadings, Test Loadings, or any Service Loadings, except those for which Level D Limits are designated, shall be limited to S_y at temperature, except when the distance to a free edge is larger than the distance over which the bearing load is applied, a stress of 1.5S_y at temperature is permitted.

(b) When bearing loads are applied near free edges, such as at a protruding ledge, the possibility of a shear failure shall be considered. The average shear stress shall be limited to 0.65S_m in the case of primary stress (NF-3121.2) and 0.55S_y in the case of primary stress plus secondary stress (NF-3121.9).

(c) When considering bearing stresses in pins and similar members, the S_y at temperature is applicable, except that a value of 1.5S_y may be used if no credit is given to the bearing area within one pin diameter from a plate edge.

(d) Except for pinned and bolted joints, bearing stresses need not be evaluated for loads for which Level D Service Limits apply.

NF-3223.2 Pure Shear.

(a) The average primary shear stress across a section loaded in pure shear, experienced as a result of Design Loadings, Test Loadings, or any Service Loadings, except those for which Level D Limits are designated, shall be limited to 0.6S_m.
(b) The maximum primary shear, experienced as a result of Design Loadings, Test Loadings, or any Service Loadings except those for which Level D Limits are designated, exclusive of stress concentration at the periphery of a solid circular section in torsion, shall be limited to 0.85 $S_m$. Primary plus secondary shear stresses shall be converted to stress intensities (equal to two times pure shear stress) and as such shall not exceed the basic stress limits of Table NF-3221.2-1.

**NF-3223.3 Triaxial Stresses.** The algebraic sum of the three primary principal stresses ($\sigma_1 + \sigma_2 + \sigma_3$) shall not exceed four times the tabulated value of $S_m$.

**NF-3223.4 Applications of Elastic Analysis for Stresses Beyond the Yield Strength.** Certain of the allowable stresses permitted in the design criteria are such that the maximum stress calculated on an elastic basis may exceed the yield strength of the material.

**NF-3224 Design Stress Values**

The design stress intensity values $S_m$ are given in Section II, Part D, Subpart 1, Tables 2A, 2B, and 4 for support material. Values for intermediate temperatures may be found by interpolation. Values of yield strength and ultimate tensile strength are given in Section II, Part D, Subpart 1, Tables Y-1 and U, respectively. Values of the coefficient of thermal expansion and of the modulus of elasticity are given in Section II, Part D, Subpart 2, Tables TE and TM.

**NF-3225 Design of Bolting**

**NF-3225.1 Design Limits.** The rules and stress limits that must be satisfied for any Design Loading stated in the Design Specification are those given in NF-3324.6.

**NF-3225.2 Service Limits, Level A Through D.** The rules and stress limits which must be satisfied for any Level A through D Service Loading stated in the Design Specification are those given in NF-3324.6 multiplied by the appropriate stress limit factor for the particular service loading level and stress category specified in Table NF-3225.2-1. This product shall not exceed the yield strength of the material at temperature.

---

**Table NF-3225.2-1**

<table>
<thead>
<tr>
<th>Stress Category</th>
<th>Stress Limit Factors for Loading Levels Stated in Design Specification [Note (1)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design</td>
</tr>
<tr>
<td>Tension and shear</td>
<td>$K_{sb} = 1.0$</td>
</tr>
</tbody>
</table>

**GENERAL NOTE:**

$K_{sb} =$ stress limit factor applicable to the Design allowable tensile and shear stresses

**NOTES:**

(1) Not to be used for friction type connections.

(2) Average tensile stress shall not exceed $0.7S_u$ and $S_y$, and average bolt shear stress shall not exceed $0.42S_u$ and $0.6S_y$.

---

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NF-3251.4 Limit Analysis. The limits for Class 1 Plate- and Shell-Type Supports designed by limit analysis apply.

NF-3252 Special Stress Limits

The following deviations from the basic stress limits are provided to cover special Service Loadings or configurations. Some of these deviations are more restrictive and some are less restrictive than the basic stress limits. In cases of conflict between these requirements and the basic stress limits, the rules of this paragraph take precedence for the particular situations to which they apply.

NF-3252.1 Bearing Loads.

(a) The average bearing stress for resistance to crushing under the maximum load, experienced as a result of Design Loadings, Test Loadings, or any Service Loadings, shall be limited to \( S_y \) at temperature, except that when the distance to a free edge is larger than the distance over which the bearing load is applied, a stress of \( 1.5S_y \) at temperature is permitted.

(b) When bearing loads are applied near free edges, such as at a protruding ledge, the possibility of a shear failure shall be considered. In the case of load controlled stress only, the average shear stress shall be limited to \( 0.6S \) in the case of primary stress (NF-3121.2).

(c) When considering bearing stresses in pins and similar members, the \( S_y \) at temperature value is applicable, except that a value of \( 1.5S_y \) may be used if no credit is given to the bearing area within one pin diameter from a plate edge.

(d) Except for pinned and bolted joints, bearing stresses need not be evaluated for loads for which Level D Service Limits apply.

NF-3252.2 Pure Shear.

(a) The average primary shear stress across a section loaded in pure shear, experienced as a result of Design Loadings, Test Loadings, or any Service Loadings, shall be limited to \( 0.6S \).

(b) The maximum primary shear, experienced as a result of Design Loadings, Test Loadings, or any Service Loadings exclusive of stress concentration at the periphery of a solid circular section in torsion, shall be limited to \( 0.8S \).

NF-3253 Compression. The stress limit factors for compression are specified in Table NF-3251.2-1. The material properties used in calculating compressive stresses and critical buckling stresses shall be those at temperature coincident with the loading.

NF-3255 Design of Bolting

The provisions of NF-3225 apply.

NF-3256 Design of Welded Joints

NF-3256.1 Permissible Types of Welded Joints in Plate- and Shell-Type Supports. All welded joints in Plate- and Shell-Type Supports shall be continuous and shall be of one of the types listed in (a) through (d). Typical examples of those permitted types are shown in Figure NF-3256.1-1. Fillet and partial penetration welds shall meet the requirements of NF-3324.5(d), except that
### Table NF-3251.2-1

<table>
<thead>
<tr>
<th>Stress Category</th>
<th>Design</th>
<th>Service Level A [Note (2)]</th>
<th>Service Level B [Note (3)]</th>
<th>Service Level C [Note (4)]</th>
<th>Service Level D [Note (5)]</th>
<th>Test Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary stresses</td>
<td>$K_m = 1.0$</td>
<td>$K_m = 1.0$</td>
<td>$K_m = 1.33$</td>
<td>$K_m = 1.5$</td>
<td>$K_m = 1.33$</td>
<td>$K_m = 1.33$</td>
</tr>
<tr>
<td>[Note (4)]</td>
<td>$K_p = 1.0$</td>
<td>$K_p = 1.0$</td>
<td>$K_p = 1.33$ [Note (6)]</td>
<td>$K_p = 1.5$ [Note (6)]</td>
<td>$K_p = 1.33$ [Note (6)]</td>
<td>$K_p = 1.33$ [Note (6)]</td>
</tr>
<tr>
<td>$K_{bh} = 1.0$</td>
<td>$K_{bh} = 1.0$</td>
<td>$K_{bh} = 1.33$</td>
<td>$K_{bh} = 1.5$</td>
<td>$K_{bh} = 1.33$</td>
<td>$K_{bh} = 1.33$</td>
<td>$K_{bh} = 1.33$</td>
</tr>
<tr>
<td>but stress $\leq \frac{1}{2}$ of critical buckling stress</td>
<td>but stress $\leq \frac{1}{2}$ of critical buckling stress</td>
<td>but stress $\leq \frac{1}{2}$ of critical buckling stress</td>
<td>but stress $\leq \frac{1}{2}$ of critical buckling stress</td>
<td>but stress $\leq \frac{1}{2}$ of critical buckling stress [Note (7)]</td>
<td>but stress $\leq \frac{1}{2}$ of critical buckling stress [Note (7)]</td>
<td></td>
</tr>
</tbody>
</table>

**GENERAL NOTE:**

- $K_{bh}$ = stress limit factor applicable to the Design allowable membrane stress or membrane plus bending stress (compression only)
- $K_m$ = stress limit factor applicable to the Design allowable membrane stress or membrane plus bending stress (see NF-3251.1 and NF-3261)
- $K_p$ = stress limit factor applicable to the Design allowable shear stress (see NF-3252.2 and NF-3261)

**NOTES:**

1. Control of deformation is not assured by these stress limit factors. When required by Design Specification, deformation control must be considered separately.
2. $K_m$ and $K_{bh}$ = 1.0 for design of snubbers and dampers.
3. Stress shall not exceed 0.75 $S_y$.
4. For Service Levels A, B, C, and D, stresses induced on the supports by restraint of free-end displacement and anchor motions of piping shall be considered as primary stresses.
5. Thermal stresses within the support as defined by NF-3121.11 need not be evaluated.
6. Shear stress shall not exceed 0.42 $S_y$.
7. Two-thirds of the critical buckling stress may be used, provided the critical buckling stress is determined by one of the following methods:
   - (a) comprehensive analysis that considers effects such as geometric imperfections, deformations due to existing loading conditions, nonlinearities, large deformations, residual stresses, and inertial forces
   - (b) tests of physical models under conditions of restraint and loading the same as those to which the configuration is expected to be subjected

NF-3324.5(d)(7) does not apply. Plug and slot welds shall meet the requirements of NF-3324.5(e). Lap joints shall meet the requirements of NF-3256.3.

(a) **Butt Joints.** Butt joints shall be one of the following:
   - (1) full penetration, single and double welded, Figure NF-3256.1-1, sketches (a-1) and (a-2).
   - (2) partial penetration, double welded, Figure NF-3256.1-1, sketch (b).

(b) When angle joints are used for connecting a transition in diameter to a cylinder, the angle $\alpha$ of Figure NF-3256.1-1, sketch (n) shall not exceed 30 deg.

(4) A tapered transition having a length not less than three times the offset between the adjacent surfaces of abutting sections, as shown in Figure NF-3226.1(a)-2, shall be provided at joints between sections that differ in thickness by more than one-fourth of the thickness of the thinner section or by more than $\frac{1}{16}$ in. (3 mm), whichever is less. The transition may be formed by any process that will provide a uniform taper. The weld may be partly or entirely in the tapered section or adjacent to it.

(5) When the use of backing rings will result in undesirable conditions such as severe stress or corrosion, the requirements of NF-4240 shall be met.

(b) **Corner Joints.** Corner joints shall be one of the following:
   - (1) full penetration, as shown in Figure NF-3256.1-1, sketch (c)
   - (2) partial penetration with a fillet weld as shown in Figure NF-3256.1-1, sketches (d) and (e)

(c) **Tee Joints.** Tee joints shall be one of the following:
   - (1) full penetration, single or double welded, Figure NF-3256.1-1, sketches (f-1), (f-2), and (h)
   - (2) partial penetration, with or without additional fillet welds, Figure NF-3256.1-1, sketch (g)
(b) Select materials that are resistant to lamellar tearing.
(c) Invoke any of the special fabrication requirements of NF-4441.

**NF-3260  DESIGN BY ANALYSIS FOR CLASS 3**

**NF-3261  Stress Limits**

The design of Class 3 supports shall be in accordance with the requirements of NF-3250 using one of the design procedures indicated in Table NF-3131(a)-1 for Class 3 construction.

**NF-3265  Design of Bolting**

The provisions of NF-3225 apply.

**NF-3266  Design of Welded Joints**

The types of welded joints shall be as stipulated in NF-3256 for Class 2 and MC supports, except that for groove welded T-joints, groove welded corner joints, and fillet welded T-joints, as listed in NF-3256.1(a)(2) and NF-3256.1(a)(3), the welds may be intermittent instead of continuous. Intermittent fillet welds shall meet the requirements of NF-3324.5(d)(7). The allowable stress limits shall be as stipulated in NF-3256.2.

**NF-3270  EXPERIMENTAL STRESS ANALYSIS**

Supports may be designed by experimental stress analysis in accordance with Section III Appendices, Mandatory Appendix II.

**NF-3280  DESIGN BY LOAD RATING**

**NF-3281  Procedure for Load Rating**

The procedure for load rating shall consist of imposing a total load on one or more duplicate full-size samples of a support equal to or less than the load under which the support fails to perform its required function. Full-size samples composed of various parts may have each part or a number of parts load rated, provided that all parts in the load path are either load rated or otherwise qualified per NF-3200, or by experimental stress analysis. When parts are connected by bolting or welding, the connection shall be either load rated or qualified per NF-3225 or NF-3226. Should more than one part be load rated in a single load test, then the load rating equations of NF-3280 shall be evaluated for each part using the part's $S_{y\text{(act)}}$ and $S_{u\text{(act)}}$ values. The part having the lowest load rating shall establish the load rating for the combination of parts. A single test sample is permitted but, in that case, the load ratings shall be reduced by 10%. Otherwise, tests shall be run on a statistically significant number of samples. The permissible types of welded joints shall be as permitted for the specific class of construction in NF-3226.1, NF-3256.1, and NF-3266. The full-size sample shall be fabricated for testing using welds not exceeding weld sizes stipulated in the Design Drawings. Bolted
joints in the test sample shall be made up using the lowest strength bolt material and minimum edge distance allowed by the specification.

(17) **NF-3282 Load Ratings in Relation to Design Service and Test Loadings**

The load rating for Design Loadings shall be determined in accordance with the requirements for Service Level A limits. The load ratings for Service Loadings for which Level A through Level D Limits have been designated shall be determined by means of the equations in the following subparagraphs. The load rating for Test Loadings shall be determined in accordance with the requirements for Service Level B limits.

**NF-3282.1 Nomenclature.** The symbols used in this paragraph are defined as follows:

- **KL** = load rating coefficient for support in compression
- **S** = allowable stress value at the Design Temperature (NF-3112.1) from the applicable tables of Section II, Part D, Subpart 1, ksi (MPa)
- **S_Y** = specified minimum tensile strength of the material used in the support as given in the applicable tables of Section II, Part D, Subpart 1, ksi (MPa)
- **S_u** = see NF-3313.1
- **S_u(act)** = actual tensile strength of the material used in the part or support which had reached ultimate capacity during the test, ksi (MPa)
- **S_Y** = see NF-3313.1
- **S_Y(act)** = actual yield strength of the material used in the part or support which yielded during the test, ksi (MPa)
- **TL_u** = support test load at which a substantial increase in load displacement results in zero or negative increase in actual support load
- **TL_y** = support test load at or below yield

**NF-3282.2 Plate- and Shell-Type Supports.** The load ratings for Plate- and Shell-Type Supports for the Service Loadings shall be determined by the following equations:

**Design and Level A Limits (lower of the two values)**

\[
\text{load rating}_{(yield)} = TL_y \times \frac{S}{S_Y(\text{act})} \quad (1)
\]

\[
\text{load rating}_{(ult)} = TL_u \times \frac{S}{S_u(\text{act})} \quad (2)
\]

**Test and Level B Limits (lower of the two values)**

\[
\text{load rating}_{(yield)} = TL_y \times 1.33 \frac{S}{S_Y(\text{act})} \quad (3)
\]

\[
\text{load rating}_{(ult)} = TL_u \times 1.33 \frac{S}{S_u(\text{act})} \quad (4)
\]

**Level C Limits (lower of the two values)**

\[
\text{load rating}_{(yield)} = TL_y \times 1.5 \frac{S}{S_Y(\text{act})} \quad (5)
\]

\[
\text{load rating}_{(ult)} = TL_u \times 1.5 \frac{S}{S_u(\text{act})} \quad (6)
\]

**Level D Limits (lowest of the three values)**

\[
\text{load rating}_{(yield)} = TL_y \times 2.0 \frac{S}{S_Y(\text{act})} \quad (7)
\]

\[
\text{load rating}_{(ult)} = TL_u \times 0.7 \frac{S}{S_u(\text{act})} \quad (8)
\]

\[
\text{load rating}_{(ult)} = TL_u \times 0.7 \quad (9)
\]

**NF-3282.3 Supports Loaded in Compression.** The load rating for supports loaded in compression shall be determined for Service Levels A through D by the methods of NF-3282.2. In addition, for cases where buckling governs, **TL_u** shall be corrected for the ratio of Young’s Modulus at the Design Temperature to Young’s Modulus at the test temperature. The load rating shall be determined by the following equations:

**Design and Level A Limits**

\[
\text{load rating} = 0.50 KL \times TL_u \quad (10)
\]

**Test and Level B Limits**

\[
\text{load rating} = 0.50 KL \times TL_u \quad (11)
\]

**Level C Limits**

\[
\text{load rating} = 0.50 KL \times TL_u \quad (12)
\]

\[
KL = 1.0 \text{ for elastic buckling}
\]

\[
KL = \frac{S_Y}{S_Y(\text{act})} \text{ for inelastic buckling}
\]
NF-3550  DESIGN BY ANALYSIS FOR CLASS 2, 3, AND MC

NF-3552  Design of Plate- and Shell-Type Component Supports

(a) The design rules and stress limits which must be satisfied for the Design and Service Loadings are given in NF-3250 and NF-3260.

(b) When design by analysis is used, the stress limit factors for each loading and stress category are specified in Table NF-3251.2-1.

NF-3553  Design of Linear-Type Component Supports

The design rules and stress limits which must be satisfied for the Design and Service Loadings are given in NF-3523.

NF-3554  Design of Class 2 and 3 Standard Component Supports

The design of Standard Component Supports shall be in accordance with NF-3524.

NF-3555  Design of Bolting

The provision of NF-3525 shall be met.

NF-3556  Design of Welded Joints

(a) Welded joints in Plate- and Shell-Type Component Supports shall be as stipulated in NF-3256 for Class 2 and MC and NF-3266 for Class 3.

(b) Welded joints in Linear-Type Component Supports shall be as stipulated in NF-3324.5.

NF-3570  EXPERIMENTAL STRESS ANALYSIS

Component supports of all types may be designed by experimental stress analysis in accordance with Section III Appendices, Mandatory Appendix II.

NF-3580  DESIGN BY LOAD RATING

Component supports of all types may be designed by load rating in accordance with the requirements of NF-3280 for Plate- and Shell-Type, NF-3380 for Linear-Type, and the applicable subsubarticle for Standard Component Supports.

The test collapse load may be determined by Section III Appendices, Mandatory Appendix II, II-1430. Supports designed by experimental stress analysis for Level A and B Service Conditions shall not exceed the test collapse load divided by 1.7. Supports designed by experimental stress analysis for Level C Service Condition shall not exceed the test collapse load divided by 1.3. Supports designed by experimental stress analysis for Level D Service Condition shall not exceed the test collapse load.

NF-3600  DESIGN RULES FOR PIPING SUPPORTS

NF-3610  GENERAL REQUIREMENTS

The design of piping supports shall be in accordance with this subarticle and the applicable general requirements of NF-3110, NF-3210, NF-3310, and NF-3410.
**NF-3656  Design of Welded Joints**

(a) Welded joints in Plate- and Shell-Type Piping Supports shall be as stipulated in NF-3256 for Class 2 and NF-3266 for Class 3.

(b) Welded joints used in Linear-Type Piping Supports shall be as stipulated in NF-3324.5.

**NF-3670  EXPERIMENTAL STRESS ANALYSIS**

Piping supports of all types may be designed by experimental stress analysis in accordance with Section III Appendices, Mandatory Appendix II.

**NF-3680  DESIGN BY LOAD RATING**

Piping supports of all types may be designed by load rating in accordance with the requirements of NF-3280 for Plate- and Shell-Type, NF-3380 for Linear-Type, and the applicable subsubarticle for Standard Piping Supports.

The test collapse load may be determined by Section III Appendices, Mandatory Appendix II, II-1430. Supports designed by experimental stress analysis for Level A and B Service Conditions shall not exceed the test collapse load divided by 1.7. Supports designed by experimental stress analysis for Level C Service Condition shall not exceed the test collapse load divided by 1.3. Supports designed by experimental stress analysis for Level D Service Condition shall not exceed the test collapse load.
structure. Analyses performed for derivation of loads and for evaluation of acceptability of components and supports shall consider geometric nonlinearities if appropriate.

**F-1322.5 Strain and/or Deformation Limits.** In addition to the limits given in this Appendix, the strain or deformation limits (if any) provided in the Design Specification shall be satisfied.

**F-1330 ACCEPTANCE CRITERIA USING ELASTIC SYSTEM ANALYSIS**

The acceptance criteria in this Section shall be applied when elastic system analysis is used to determine loads on components and supports. These criteria are subject to the restrictions on methods of evaluation stated in F-1322.

**F-1331 Criteria for Components**

**F-1331.1 Elastic Analysis.**

(a) The general primary membrane stress intensity $P_m$ shall not exceed the lesser of $2.4S_m$ and $0.7S_u$ for austenitic steel, high-nickel alloy, and copper-nickel alloy materials included in Section II, Part D, Subpart 1, Tables 2A and 2B, or $0.7S_u$ for ferritic steel materials included in Table 2A.

(b) The local primary membrane stress intensity $P_L$ shall not exceed 150% of the limit for general primary membrane stress intensity $P_m$.

(c) The primary membrane (general or local) plus primary bending stress intensity $P_L + P_b$ shall be limited in accordance with one of the following provisions:

1. Stress intensity $P_L + P_b$ shall not exceed 150% of the limit for general primary membrane stress intensity $P_m$

2. Static or equivalent static loads shall not exceed 90% of the limit analysis collapse load using a yield stress which is the lesser of $2.3S_m$ and $0.7S_u$, or 100% of the plastic analysis collapse load or test collapse load (F-1321.6)

(d) The average primary shear stress across a section loaded in pure shear shall not exceed 0.42$S_u$.

**F-1331.2 Interaction Method.** As an alternative to the requirements of F-1331.1 above, acceptability of individual members of components may be demonstrated using the interaction method. Procedures for interaction method analysis are given in Article A-9000. The allowable stress $S_{at}$ shall not exceed the lesser of $2.4S_m$ and $0.7S_u$.

**F-1331.3 Bearing Stresses.** Except for pinned and bolted joints, bearing stresses need not be evaluated for loads for which Level D Service Limits are specified.

**F-1331.4 Stress Limits for Bolts.** Bolts shall be evaluated in accordance with the rules of F-1335.

**F-1331.5 Requirements for Compressive Loads.** Components subjected to compressive loads shall be evaluated against buckling limits. Maximum compressive load (or stress) shall be limited to a value established by (a), (b), or (c).

(a) Two-thirds of the value of buckling load (or stress) determined by one of the following methods:

1. Comprehensive analysis which considers effects such as geometric imperfections, deformations due to existing loading conditions, nonlinearities, large deformations, residual stresses, and inertial forces

2. Tests of physical models under conditions of restraint and loading the same as those to which the configuration is expected to be subjected

(b) A value equal to 150% of the limit established by the rules of NB-3133, except that the pressure is permitted to be 250% of the given value when the ovality is limited to 1% or less

(c) A value determined in accordance with the procedures contained in Code Case N-284 for metal containment shell buckling design methods using a factor of safety of 1.34

**F-1332 Criteria for Plate and Shell Type Supports**

The criteria presented in this paragraph pertain to primary stresses only. Stresses resulting from constraint of free end displacement and anchor point motion (NF-3121.12 and NF-3121.13) shall be considered primary stresses in the evaluation. Neither peak stresses nor stresses resulting from thermal expansion within the support need be evaluated.

**F-1332.1 Primary Membrane Stress Intensity and Primary Membrane Stress Limit.**

(a) For Class 1 supports, the general primary membrane stress intensity $P_m$ is limited to the greater of $1.2S_y$ and $1.5S_m$, but may not exceed $0.7S_u$.

(b) For Class 2, 3, and MC supports, the general membrane principal stress is limited to the greater of $1.2S_y$ and $1.5S_m$, but may not exceed $0.7S_u$.

**F-1332.2 Primary Membrane Plus Bending Stress Intensity and Primary Membrane Plus Bending Stress Limit.**

(a) For Class 1 supports, the general primary membrane plus primary bending stress intensity, $P_m + P_b$, shall be limited in accordance with one of the following provisions:

1. 150% of the limit for general primary stress intensity $P_m$

2. Static or equivalent static loads not exceeding 90% of the limit analysis collapse load (F-1321.6) using a yield strength which is the lesser of $1.2S_y$ and $0.7S_u$, or 100% of the plastic analysis collapse load or test collapse load (F-1321.6)

(b) For Class 2, 3, and MC supports, the local membrane plus bending principal stress is limited to the 150% of the general membrane stress limit.
**F-3322.3** Bearing Stress. Except for pinned and bolted joints, bearing stresses need not be evaluated for loads for which Level D Service Limits are specified.

**F-3322.4** Pure Shear. The average primary shear across a section loaded in pure shear shall not exceed 0.42$S_u$.

**F-3322.5** Requirements for Compressive Stresses. Plate and shell type supports subject to compressive stresses shall be evaluated in accordance with the rules of F-3311.5(a).

**F-3322.6** Stress Limits for Bolts. Bolts shall be evaluated in accordance with the rules of F-3335.

(17) **F-3322.7** Load Rating. As an alternative to the requirements of F-3322.1 through F-3322.6 above, plate and shell type supports may be qualified to Service Level D Limits using the procedure for load rating (NF-3282). The load rating for Level D Service Loadings shall be determined by the following equation:

$\text{load rating} = TL \times 0.7 \times \frac{S_{lt}}{S_u}$

but not more than $TL \times \frac{2S_{lt}^a}{S_u}$

where

- $F_{all}$ = allowable stress value (NF-3382.1)
- $S_u$ = tensile strength of the support material at temperature
- $S_{lt}^a$ = tensile strength of the support material at test temperature
- $TL$ = support test load equal to or less than the load under which the support fails to perform its specified support function

but

$\frac{S_{lt}}{S_{lt}^a} \leq 1$

**S** = allowable stress value at the Design Temperature (NF-3382.1)

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**F-3333 Criteria for Standard Supports**

Criteria in F-3332 or F-3334 shall be applied according to whether standard supports are plate and shell or linear type supports.

**F-3334 Criteria for Linear Type Supports**

The criteria presented in this paragraph pertain to primary stresses only. Stresses resulting from constraint of free end displacement and anchor point motion (NF-3121.12 or NF-3121.13) shall be considered primary stresses in the evaluation.

Neither peak stresses nor stresses resulting from thermal expansion within the support need be evaluated.

Unless otherwise specified, the allowable stresses presented (NF-3320) for Level A Service Condition may be increased using the following factors: the smaller of 2 or 1.167$S_u/S_y$ if $S_u > 1.2S_y$, or 1.4 if $S_u \leq 1.2S_y$, where $S_y$ is the yield strength, ksi (MPa), and $S_u$ is the ultimate tensile strength, ksi (MPa), both at temperature. In addition, members must be checked for local and general instability.

**F-3334.1 Stresses in Tension.** The tensile stress on the net section, except at pin holes and in the through-plate thickness direction, shall not exceed the lesser of 1.2$S_y$ and 0.7$S_u$.

**F-3334.2 Stresses in Shear.** The shear stress on the gross section shall not exceed the lesser of 0.72$S_y$ and 0.42$S_u$. Gross section shall be determined in accordance with NF-3322.1(b).

**F-3334.3 Axial Compression.** Maximum load in axially loaded compression members shall be limited in accordance with either (a) or (b).

(a) Two-thirds of the buckling load, as determined by one of the following methods:
the procedure for load rating (NF-3382). The load rating for Level D Service loadings shall be determined by the following equation:

\[
\text{load rating} = TL \times 0.7 \frac{S_u}{S_u^*} \]

but not more than \( TL \times 2.0 \frac{F_{all}}{S_u^*} \)

where

- \( TL \) = support test load equal to or less than the load under which the support fails to perform its specified support function
- \( S_u \) = tensile strength of the support material at temperature
- \( S_u^* \) = tensile strength of the support material at test temperature
- \( F_{all} \) = allowable stress value (NF-3382.1)

\[
\frac{S_u}{S_u^*} \leq 1
\]

\( F_a = P/A_d \) where \( P \) shall be determined in accordance with F-1334.3.

(b) The value of \( F'_e \) shall be taken as

\[
F'_e = \frac{\pi^2 E}{1.30(K_b/k_b)^2}
\]

with terms as defined in NF-3313.1.

(c) \( F_h \) shall be determined using F-1334.4(b) or F-1334.4(c) as appropriate.

(d) In NF-3322.1(e)(1), eq. (21), replace 0.6\( S_y \) with the smaller of 1.2\( S_y \) or 0.7\( S_u \).

- **F-1334.6 Collapse Load Analysis.** As an alternative to the requirements in F-1334.4 above, acceptability of linear type supports may be established using one of the following methods:
  
  (a) using lower bound limit analysis given in NF-3340, static or equivalent static loads shall not exceed 90% of the limit analysis collapse load using a yield stress which is the greater of 1.2\( S_y \) and 1.5\( S_m \), but not larger than 0.7\( S_u \).
  
  (b) 100% of the plastic analysis collapse load
  
  (c) 100% of the test collapse load (F-1321.6)

- **F-1334.7 Interaction Method.** As an alternative to the requirements of F-1334.1 through F-1334.5 above, acceptability for individual structural members of linear type supports may be demonstrated using the interaction method. Procedures for interaction method analysis are given in Article A-9000. The allowable stress \( S_{aj} \) shall not exceed the greater of 1.2\( S_y \) and 1.5\( S_m \), but not larger than 0.7\( S_u \).

- **F-1334.8 Load Rating.** As an alternative to the requirements of F-1334.1 through F-1334.5 above, linear type supports may be qualified to Service Level D Limits using load rating criteria given in F-1332.7.

- **F-1334.9 Stress Limits for Bolts.** Bolts shall be evaluated in accordance with the rules of F-1335.

- **F-1334.10 Bearing Stresses.** Except for pinned and bolted joints, bearing stresses need not be evaluated for loads for which Level D Service Limits are specified.

**F-1335 Requirements for Bolted Joints**

(a) The requirements provided in this Section shall be applied to components and supports. Threaded structural fasteners used in core support structures shall be evaluated using the rules of F-1440.

(b) Allowable stresses for bolts are given in the paragraphs below. These allowable stresses are only applicable if the bolt stresses are calculated using elastic methods.

- **F-1335.1 Allowable Tensile Stress.** The average tensile stress computed on the basis of the available tensile stress area shall not exceed the smaller of 0.7\( S_u \) and \( S_y \). When high strength bolts or threaded parts having an ultimate tensile strength greater than 100 ksi (700 MPa) at
but not more than \( TL \times 2.0 \cdot \frac{S}{S_u^*} \)

\[ S = \text{allowable stress value at the Design Temperature (NF-3282.1)} \]

\( (c) \) As an alternative to the requirements of \((b)\) above, plate and shell type supports may be qualified to Service Level D Limits using the procedure for load rating (NF-3282). The load rating for Level D Service Loadings shall be determined by the following equation:

\[ \text{load rating} = TL \times 0.7 \cdot \frac{S_u}{S_u^*} \]

where

\( S_u = \text{tensile strength of the support material at temperature} \)

\( S_u^* = \text{tensile strength of the support material at test temperature} \)

\( TL = \text{support test load equal to or less than the load under which the support fails to perform its specified support function} \)

but

\[ \frac{S_u}{S_u^*} \leq 1 \]

**F-1343 Criteria for Standard Supports**

The rules of F-1342 or F-1344 shall be applied according to whether standard supports are plate and shell or linear type supports.

**F-1344 Criteria for Linear Type Supports**

The criteria presented in this paragraph pertain to primary stresses only. Stresses resulting from constraint of free end displacement and anchor point motion (NF-3121.12 and NF-3121.13) shall be considered as primary stresses in the evaluation. Neither peak stresses nor stresses resulting from thermal expansion within the support need be evaluated.

Acceptability of linear type supports may be demonstrated using any one of the following methods:

\( (a) \) elastic analysis

\( (b) \) plastic analysis

\( (c) \) collapse load analysis

\( (d) \) plastic instability analysis

\( (e) \) interaction method

The primary stress limits for these alternative methods are given in F-1344.1 through F-1344.5. The other limits given in F-1344.6 and F-1344.7 shall also be satisfied as applicable.

**F-1344.1 Elastic Analysis.** The criteria provided in F-1334 through F-1334.5 shall be applied.

**F-1344.2 Plastic Analysis.** The criteria provided in F-1341.2 shall be applied. In addition, members shall be checked for local and general instability following the requirements given in F-1334.3.

**F-1344.3 Collapse Load Analysis.** The criteria provided in F-1334.6 shall be applied.