APPENDIX G
Buckling Calculations per ASME

In Section 2.5 of this guide, NNSA provides guidance criteria and methods based on the ASME BPVC in evaluating buckling of containment systems. These criteria and methods provide suitable safety factors to account for eccentricities in design configuration and loading. The structural design engineer has the option of applying the rules provided in the appropriate Code sections or to apply ASME Nuclear Code Case N-284-1[G-1] for evaluating external loadings on containment vessels.

As stated in Section 2.5, the following Code sections may be used for demonstrating acceptable containment system resistance to buckling under NCT:

- Paragraph NB-3133[G-2] for Category I content packages.
- Paragraph ND-3133[G-3] for Category II content packages.
- Paragraph NE-3133[G-4] for Category III content packages.

In the applicable Code sections dealing with external loading, the methods provided by "design by rule" are based on the approach outlined in ASME BPVC, Section II,[G-5] Part D, Appendix 3. In all cases, the criteria for demonstrating acceptable HAC performance are provided in ASME BPVC, Section III, Division 1, Appendices,[G-6] Appendix F, F-1331.5. In general, the methods provided in the Code section are simple and easy to use. However, since they are based on "design by rule" methods, they cannot be adapted for external loadings other than those specified. Also, no definitive rules are provided for combining various external loadings.

At the discretion of the structural design engineer and/or analyst, the methods provided in ASME BPVC Code Case N-284-1 may be used. Code Case N-284-1 provides three different methods in evaluating buckling of shells: (1) evaluation by formula (paragraph -1710), (2) evaluation by bifurcation analysis of axisymmetrical shells (paragraph -1720), and (3) evaluation by bifurcation analysis of three-dimensional thin shells (paragraph -1730). Unlike the Code sections, the methods in this Code Case provide a process for evaluating vessel buckling based on stress. As a result, this Code Case provides a means by which finite element analysis stress results can be used for evaluating the buckling resistance of a containment vessel or containment system component. However, users of Code Case N-284-1 should be aware that it has some limitations. One important consideration is that, according to the ASME BPVC Code Case N-284-1, it is only applicable for vessel walls with thicknesses of ¼ in. or greater and a radius to thickness ratio up to 1000. This Code Case can be used at lesser wall thicknesses depending on size and configuration of the component; however, the structural design engineer should use care in accessing the results.

Classical crippling or buckling analyses may also be used in lieu of the methods provided above. However, the factors of safety specified in Code Case N-284-1 cannot be applied in classical crippling or buckling analyses because Code Case N-284-1 applies factors of safety directly to the load to account for ovality and variations in shell thickness. Therefore, they must be evaluated together with the buckling stress methodology to ensure conservatism.

An example of the application of Code Case N-284-1 in evaluating buckling resistance of a containment vessel is provided below as an illustration of the evaluation by formula method (method 1 discussed above). The example illustrates how the stress results for a finite element analysis can be applied in demonstrating acceptable buckling resistance of a containment vessel.

The example below assumes the package is numerically simulated to be subjected to internal pressure and a HAC flat bottom end free drop by some dynamic FEA computer program. It also assumes the containment vessel is a cylindrical shell fabricated from Type 304L stainless steel with a design metal temperature of 100 °F. As such, the material constants (refer to paragraph -1200) of elastic modulus and yield stress of the stainless steel at this design temperature are 28.1 x 10^6 psi and 25,000 psi, respectively. The resulting stresses on the containment vessel are provided in tabular form at the end of this appendix. In this example, the evaluation by formula method of Code Case N-284-1 (paragraph -1710) is used and only the cylindrical shell portion is evaluated.

Example of Evaluation by Formula Method of Code Case N-284-1

Only the cylindrical shell is evaluated in this example. It is 19.32 in. long from the top of the flange to the weld between the cylindrical shell and the bottom ellipsoidal head. The depth of the ellipsoidal head is 6.69 in. and the closure lid thickness is 0.9 in. The length between the line of support of the cylindrical shell is assumed to be the sum of 19.32 in. + 6.69 in./3 + 0.9 in./3 = 21.85 in. (L). The mean radius (R) is 8.9175 in. and the wall thickness (t) is 0.165 in. The radio of the mean radius to wall thickness (R/t) is 54.05 in. Note that no stiffener is used in the containment vessel.

1. Since the containment vessel has no stiffeners the following factors apply from paragraph -1200:

$A_\Phi = 0$

$A_\theta = 0$

$l_\Phi = 21.85$ in.

$l_\theta = 56.03$ in.

$t_\Phi = A_\Phi/l_\theta + t = 0.165$ in.

$t_\theta = A_\theta/l_\Phi + t = 0.165$ in.

$M_\Phi = l_\Phi/(Rt)^{1/2} = 18.0131$ (smaller)

$M_\theta = l_\theta/(Rt)^{1/2} = 46.1910$

2. Determination of Stress Components (paragraph -1330)

The containment vessel is an axisymmetric structure. Under the internal pressure and the flat bottom-end free drop configuration, the containment vessel responds in an axisymmetric manner. As a result, only one element location in the 360° circumference at each elevation along the cylindrical shell wall is required for stress evaluation. The element locations in the radial direction are chosen. There are two elements through the containment vessel wall -- 20000s for the inner surface and 30000s for the outer surfaces. The through-wall stresses are assumed to be the average values of the inner and outer elements at each elevation. For example, stresses at element X0361 are the average stress of those at elements 20361 and 30361. Each stress component (longitudinal, circumferential, and in-plane shear stress) is calculated separately. It is also assumed that the longitudinal and circumferential stresses obtained from the above calculation are membrane stress. Stress results are screened for the maximum value for each stress component.

Three sets of stress components are established at critical locations. Only the stress values at the cylindrical shell wall elements are tabulated in Table G-1. In Table G-1, S22 is the circumferential (hoop) stress, S33 is the longitudinal (axial) stress, and S23 is the in-plane shear stress. Note that when the sum of the longitudinal or circumferential component is in tension, the stress component may be set to zero. The selected sets of stress components to be used in buckling evaluation are shown in shaded area in Table G-1. Three sets of stress component used in the buckling evaluations are shown below.

Set 1. Largest longitudinal compression stress.

σ_Φ = longitudinal stress = -9.98 ksi (use 9.98 ksi)

σ_θ = circumferential stress = 0

$\sigma_{\Phi\theta}$ = in-plane shear stress = 0.15 ksi

Set 2. Largest circumferential compression stress.

σ_Φ = -3.67 ksi (use 3.67 ksi)

σ_θ = -2.05 ksi (use 2.05 ksi)

$\sigma_{\Phi\theta}$ = -0.16 ksi (use 0.16 ksi)

Set 3. Largest in-plane shear stress.

σ_Φ = -5.97 ksi (use 5.97 ksi)

σ_θ = 0

$\sigma_{\Phi\theta}$ = -0.78 ksi (use 0.78 ksi)

3. Factor of Safety (paragraph -1400)

The HAC free drop is considered as a Level D Service Limit; consequently use

FS = 1.34

4. Capacity Reduction Factors (paragraph -1500)

For local buckling of the cylindrical shell, the following calculations are required (paragraph -1511).

(a) Axial Compression – Use the larger of the values determined for $\alpha_{\Phi L}$ from (1) and (2).

(1) Effect of R/t

Because R/t = 54.05 < 600, use the smaller value of following two values:

$\alpha_{\Phi L} = 1.52 - 0.473 \log_{10}(R/t) = 0.7004$

$\alpha_{\Phi L} = (300\ \sigma_y/E) - 0.033 = 0.2339$

Thus, $\alpha_{\Phi L}$ = 0.2339.

(2) Effect of Length

Because M_Φ = 18.0131, $\alpha_{\Phi L}$ = 0.207.

Compare $\alpha_{\Phi L}$ in (1) and (2), the larger value is used $\alpha_{\Phi L} = 0.2339$.

(b) Hoop Compression

$\alpha_{\theta L} = 0.8$

(c) Shear

$\alpha_{\Phi\theta L} = 0.8$ because $R/t = 54.05 \leq 250$

5. Plasticity Reduction Factors (paragraph -1600)

The paragraph -1600 calculations need the value of σ_{iej}, the buckling stress from paragraph -1710. The paragraph -1712 theoretical buckling values for local buckling of cylindrical shells (paragraph -1712.1.1) are first calculated. After all σ_{iej} are obtained, calculations to determine the Plastic Reduction Factors are resumed.

6. Calculation of Theoretical Buckling Values for Local Buckling of Cylindrical Shell (paragraph -1712.1.1)

$M_\Phi = 18.0131$

(a) Axial Compression

$C_\Phi = 0.605$, $M_\Phi \geq 1.73$

$\sigma_{\Phi eL} = C_\Phi Et/R = 314.5593$ ksi

(b) External Pressure

(1) No End Pressure (K = 0)

$C_{\theta r} = 0.92/(M_\Phi - 1.17) = 0.05462$, if $3.0 \leq M_\Phi < 1.65(R/t)$

$\sigma_{\theta eL} = \sigma_{reL} = C_{\theta r} Et/R = 28.3997$ ksi

(2) End Pressure Included (K = 0.5)

$C_{\theta h} = 0.92/(M_\Phi - 0.636) = 0.05294$, if $3.5 \leq M_\Phi < 1.65(R/t)$

$\sigma_{\theta eL} = \sigma_{heL} = C_{\theta h} Et/R = 27.5270$ ksi

(c) Shear

$C_{\Phi\theta} = (4.82/M_\Phi^2)*(1 + 0.0239 M_\Phi^3)^{½} = 0.1762$, if $1.5 < M_\Phi < 26$

$\sigma_{\Phi\theta eL} = C_{\Phi\theta}Et/R = 91.6111$ ksi

7. Go back to calculate Plasticity Reduction Factors (paragraph -1611)

(a) Axial Compression

$\Delta = (\alpha_{\Phi L} * \sigma_{\Phi eL} / \sigma_y) = (0.2339*314.5593)/25 = 2.9430$

$\eta_{\Phi} = 1.31/(1 + 1.15\ \Delta) = 0.2988$

(b) Hoop Compression

$\Delta = (\alpha_{\theta L} * \sigma_{\theta eL} / \sigma_y) = (0.8*28.3997)/25 = 0.9088$

$\eta_{\theta} = 2.53/(1 + 2.29\ \Delta) = 0.8211$

(c) Shear

$\Delta = (\alpha_{\Phi\theta L} * \sigma_{\Phi\theta eL} / \sigma_y) = (0.8*91.6111)/25 = 2.9316$

$\eta_{\Phi\theta} = 0.6/\Delta = 0.2047$

8. Interaction Equations for Local Buckling (paragraph -1713)

Paragraph -1713.1.1 Cylindrical Shells (Elastic Buckling)

FS = 1.34,

$\sigma_{xa} = (\alpha_{\Phi L} * \sigma_{\Phi eL})/FS = (0.2339*314.5593)/1.34 = 54.9070$ ksi

$\sigma_{ha} = (\alpha_{\theta L} * \sigma_{heL})/FS = (0.8*27.5270)/1.34 = 16.4340$ ksi

$\sigma_{ra} = (\alpha_{\theta L} * \sigma_{reL})/FS = (0.8*28.3997)/1.34 = 16.9550$ ksi

$\sigma_{\tau a} = (\alpha_{\Phi\theta L} * \sigma_{\Phi\theta eL})/FS = (0.8*91.6111)/1.34 = 54.6932$ ksi

In the following, evaluations of all three sets of stress components are performed.

Set 1 of stress components:

$\sigma_{\Phi} = 9.98$ ksi

$\sigma_{\theta} = 0$

$\sigma_{\Phi\theta} = 0.15$ ksi

$K = (\sigma_{\Phi}/\sigma_{\theta})*(t_{\Phi}/t_{\theta}) = 9999$ (infinite)

(a) Axial Compression Plus Hoop Compression ($K < 0.5$)

Because K = 9999 (infinite), no interaction check is required here and go to (b).

(b) Axial Compression Plus Hoop Compression ($K \geq 0.5$)

To determine if the relation holds: $\sigma_{\Phi} \leq 0.5*\sigma_{ha}*(t_{\theta}/t_{\Phi})$

Because 9.98 ksi > 8.217 ksi, the above relation is not satisfied. The interaction check is required.

$(\sigma_{\Phi}-0.5*\sigma_{ha}*(t_{\theta}/t_{\Phi}))/(\sigma_{xa}-0.5*\sigma_{ha}*(t_{\theta}/t_{\Phi})) + (\sigma_{\theta}/\sigma_{ha})^2$

$= (9.98-0.5*16.4340*1)/(54.9070-0.5*16.4340*1) + 0$

$= 0.0378 + 0 = 0.0378 < 1$

M.S. = (1/0.0378) – 1 = 25.46

(c) Axial Compression Plus Shear

$(\sigma_{\Phi}/\sigma_{xa}) + (\sigma_{\Phi\theta}/\sigma_{\tau a})^2 = (9.98/54.9070) + (0.15/54.6932)^2$

$= 0.1818 + 7.5217\text{x}10^{-6} = 0.1818 < 1$

M.S. = (1/0.1818) – 1 = 4.50

(d) Hoop Compression Plus In-Plane Shear

$(\sigma_{\theta}/\sigma_{ra}) + (\sigma_{\Phi\theta}/\sigma_{\tau a})^2 = 0 + (0.15/54.6932)^2$

$= 0 + 7.5217\text{x}10^{-6} = 7.5217\text{x}10^{-6} < 1$

M.S. = $(1/7.5217\text{x}10^{-6}) – 1$ = Large

(e) Axial Compression Plus Hoop Compression Plus In-Plane Shear

$K_s = 1 - (\sigma_{\Phi\theta}/\sigma_{\tau a})^2 = 1 - (0.15/54.6932)^2 = 1$

Thus, the above (a) and (b) results remain unchanged.

Set 2 of stress components:

σ_{Φ} = 3.67 ksi

σ_{θ} = 2.05 ksi

$\sigma_{\Phi\theta}$ = 0.16 ksi

$K = (\sigma_\Phi/\sigma_\theta)*(t_\Phi/t_\theta) = 1.7902$

(a) Axial Compression Plus Hoop Compression (K < 0.5)

Because K = 1.7902, no interaction check is required here and go to (b).

(b) Axial Compression Plus Hoop Compression ($K \geq 0.5$)

To determine if the relation holds: $\sigma_\Phi \leq 0.5*\sigma_{ha}*(t_\theta/t_\Phi)$

Because 3.67 ksi < 8.217 ksi, the above relation is satisfied. Thus, no interaction check is required.

(c) Axial Compression Plus Shear

$(\sigma_\Phi/\sigma_{xa}) + (\sigma_{\Phi\theta}/\sigma_{\tau a})^2 = (3.67/54.9070) + (0.16/54.6932)^2$

$= 0.0668 + 8.5580\text{x}10^{-6} = 0.0668 < 1$

M.S. = (1/0.0668) – 1 = 13.97

(d) Hoop Compression Plus In-Plane Shear

$(\sigma_\theta/\sigma_{ra}) + (\sigma_{\Phi\theta}/\sigma_{\tau a})^2 = (2.05/16.9550) + (0.16/54.6932)^2$

$= 0.1209 + 8.5580\text{x}10^{-6} = 0.1209 < 1$

M.S. = (1/0.1209) – 1 = 7.27

(e) Axial Compression Plus Hoop Compression Plus In-Plane Shear

$K_s = 1 - (\sigma_{\Phi\theta}/\sigma_{\tau a})^2 = 1$

Thus, the above (a) and (b) results remain unchanged.

Set 3 of stress components:

σ_Φ = 5.97 ksi

$\sigma_\theta = 0$

$\sigma_{\Phi\theta}$ = 0.78 ksi

$K = (\sigma_\Phi/\sigma_\theta)*(t_\Phi/t_\theta)$ = 9999 (infinite)

(a) Axial Compression Plus Hoop Compression ($K < 0.5$)

Because K = 9999 (infinite), no interaction check is required here and go to (b).

(b) Axial Compression Plus Hoop Compression ($K \geq 0.5$)

To determine if the relation holds: $\sigma_\Phi \leq 0.5*\sigma_{ha}*(t_\theta/t_\Phi)$

Because 5.97 ksi < 8.217 ksi, the above relation is satisfied. Thus, no interaction check is required.

(c) Axial Compression Plus Shear

$(\sigma_\Phi/\sigma_{xa}) + (\sigma_{\Phi\theta}/\sigma_{\tau a})^2 = (5.97/54.9070) + (0.78/54.6932)^2$

$= 0.1087 + 2.0339\text{x}10^{-4} = 0.1089 < 1$

M.S. = (1/0.1089) – 1 = 8.18

(d) Hoop Compression Plus In-Plane Shear

$(\sigma_\theta/\sigma_{ra}) + (\sigma_{\Phi\theta}/\sigma_{\tau a})^2 = 0 + (0.78/54.6932)^2 = 0 + 2.0339\text{x}10^{-4} = 2.0339\text{x}10^{-4} < 1$

M.S. = $(1/2.0339\text{x}10^{-4}) – 1 = 4916$

(e) Axial Compression Plus Hoop Compression Plus In-Plane Shear

$K_s = 1 - (\sigma_{\Phi\theta}/\sigma_{\tau a})^2 = 1$

Thus, the above (a) and (b) results remain unchanged.

9. Interaction Equations of Inelastic Local Buckling (paragraph -1713.2)

Paragraph -1713.2.1 Cylindrical Shells (Inelastic Buckling)

$\sigma_{xc} = \eta_\Phi\sigma_{xa} = 0.2988*54.9070 = 16.4062$ ksi

$\sigma_{rc} = \eta_\theta\ \sigma_{ra} = 0.8211*16.9550 = 13.9218$ ksi

$\sigma_{\tau c} = \eta_{\Phi\theta}\ \sigma_{\tau a} = 0.2047*54.6932 = 11.1957$ ksi

In the following, evaluations of all three sets of stress components are performed.

Set 1 of stress components:

$\sigma_\Phi = 9.98$ ksi

$\sigma_\theta = 0$

$\sigma_{\Phi\theta} = 0.15$ ksi

(a) Axial Compression or Hoop Compression

Axial Compression: $\sigma_\Phi/\sigma_{xc} = 9.98/16.4062 = 0.6083 < 1$

M.S. = (1/0.6083) – 1 = 0.64

Hoop Compression: $\sigma_\theta/\sigma_{rc} = 0/13.9218 = 0$

M.S. = Very Large

(b) Axial Compression Plus Shear

$(\sigma_\Phi/\sigma_{xc}) + (\sigma_{\Phi\theta}/\sigma_{\tau c})^2 = (9.98/16.4062) + (0.15/11.1957)^2$

$= 0.6083 + 1.7951\text{x}10^{-4} = 0.6085 < 1$

M.S. = (1/0.6085) – 1 = 0.64

(c) Hoop Compression Plus Shear

$(\sigma_\theta/\sigma_{rc}) + (\sigma_{\Phi\theta}/\sigma_{\tau c})^2 = 0 + 1.7951\text{x}10^{-4} = 1.7951\text{x}10^{-4} < 1$

M.S. = $(1/1.7951\text{x}10^{-4}) - 1 = 5570$

Set 2 of stress components:

$\sigma_\Phi = 3.67$ ksi

$\sigma_\theta = 2.05$ ksi

$\sigma_{\Phi\theta} = 0.16$ ksi

(a) Axial Compression or Hoop Compression

Axial Compression: $\sigma_\Phi/\sigma_{xc} = 3.67/16.4062 = 0.2237 < 1$

M.S. = (1/0.2237) – 1 = 3.47

Hoop Compression: $\sigma_\theta/\sigma_{rc} = 2.05/13.9218 = 0.1473 < 1$

M.S. = (1/0.1473) – 1 = 5.79

(b) Axial Compression Plus Shear

$(\sigma_\Phi/\sigma_{xc}) + (\sigma_{\Phi\theta}/\sigma_{\tau c})^2 = (3.67/16.4062) + (0.16/11.1957)^2$

$= 0.2237 + 2.0424 \text{x} 10^{-4} = 0.2239 < 1$

M.S. = (1/0.2239) – 1 = 3.47

(c) Hoop Compression Plus Shear

$(\sigma_\theta/\sigma_{rc}) + (\sigma_{\Phi\theta}/\sigma_{\tau c})^2 = (2.05/13.9218) + (0.16/11.1957)^2$

$= 0.1473 + 2.0424 \text{x} 10^{-4} = 0.1475 < 1$

M.S. = (1/0.1475) – 1 = 5.78

Set 3 of stress components:

$\sigma_\Phi = 5.97$ ksi

$\sigma_\theta = 0$

$\sigma_{\Phi\theta} = 0.78$ ksi

(a) Axial Compression or Hoop Compression

Axial Compression: $\sigma_\Phi/\sigma_{xc} = 5.97/16.4062 = 0.3639 < 1$

M.S. = (1/0.3639) – 1 = 1.75

Hoop Compression: $\sigma_\theta/\sigma_{rc} = 0/13.9218 = 0$

M.S. = Very Large

(b) Axial Compression Plus Shear

$(\sigma_\Phi/\sigma_{xc}) + (\sigma_{\Phi\theta}/\sigma_{\tau c})^2 = (5.97/16.4062) + (0.78/11.1957)^2$

$= 0.3639 + 4.8539 \text{x} 10^{-3} = 0.3688 < 1$

M.S. = (1/0.3688) – 1 = 1.71

(c) Hoop Compression Plus Shear

$(\sigma_\theta/\sigma_{rc}) + (\sigma_{\Phi\theta}/\sigma_{\tau c})^2 = 0 + 4.8539 \text{x} 10^{-3} = 4.8539 \text{x} 10^{-3} < 1$

$$M.S. = (1/4.8539 \times 10^{-3}) - 1 = 205$$

10. Other evaluations besides those presented above are not required in this example. All interaction relations are satisfied (all margins of safety are positive).

The results of these calculations are summarized in Table G-1.

Table G-1. Maximum Stress Components and Stress Sets

	Maximum			Set 1			Set 2			Set 3		
Element	S22 (ksi)	S33 (ksi)	S23 (ksi)	S22 (ksi)	S33 (ksi)	S23 (ksi)	S22 (ksi)	S33 (ksi)	S23 (ksi)	S22 (ksi)	S33 (ksi)	S23 (ksi)
X0361	-2.81	-0.55	+0.99									
X0391	-2.72	-0.60	+0.82									
X0421	-3.08	-0.12	-0.76									
X0451	-2.83	-0.06	-0.88									
X0481	-2.40	0	-0.76									
X0511	-2.05	-9.98	-0.78	+0.26 (0)[a]	-9.98	+0.15	-2.05	-3.67	-0.16	+0.46 (0)[a]	-5.97	-0.78
X0541	-0.51	-9.70	-0.78	-0.51	+2.32 (0)[a]	+0.04	+2.20 (0)[a]	-9.70	+0.15	+1.58 (0)[a]	-6.77	-0.78
X0571	0	-9.13	-0.79	+3.50 (0)[a]	-5.26	+0.37	+2.99 (0)[a]	-9.13	+0.03	+3.10 (0)[a]	-5.72	-0.79
X0601	0	-9.00	-0.81	+3.68 (0)[a]	-8.12	-0.17	+2.85 (0)[a]	-9.00	+0.05	+3.10 (0)[a]	-5.62	-0.81
X0631	0	-8.68	-0.60									
X0661	0	-9.26	-0.44	+3.80 (0)[a]	-5.40	-0.35	+2.48 (0)[a]	-9.26	+0.08	+1.61 (0)[a]	-8.08	-0.44
X0691	0	-8.57	-0.38									
X0721	0	-8.25	+0.39									
X0751	0	-8.78	+0.54									
X0781	0	-7.78	+0.40									
X0811	0	-7.97	+0.30									
X0841	0	-7.82	+0.40									
X0871	0	-7.87	+0.61									
X0901	0	-7.47	+0.43									
X0931	0	-7.27	-0.41									
X0961	0	-7.09	-0.39									
X0991	0	-6.83	-0.38									
X1021	-0.32	-7.35	-0.51									
X1051	-0.85	-6.33	-0.83									

[a] Note that when the sum of the longitudinal (S22) or circumferential (S33) component is in tension (> 0), that stress component may be set to zero.

References

G-1 ASME, "Metal Containment Shell Buckling Design Methods," *Boiler and Pressure Vessel Code*, Section III, Code Case N-284-1, New York, New York, 1995.

G-2 ASME, *Boiler and Pressure Vessel Code*, Section III, Division 1, Subsection NB, New York, New York, 2001.

G-3 ASME, *Boiler and Pressure Vessel Code*, Section III, Division 1, Subsection ND, New York, New York, 2001.

G-4 ASME, *Boiler and Pressure Vessel Code*, Section III, Division 1, Subsection NE, New York, New York, 2001.

G-5 ASME, *Boiler and Pressure Vessel Code*, Section II, New York, New York, 2001.

G-6 ASME, *Boiler and Pressure Vessel Code*, Section III, Division 1, Appendices, New York, New York, 2001.