

A — \hat{S}_{ν} for $\phi = 0$ vs. $\beta \rho_0$ (capped cylinder), $\nu = 0.3$



B- \hat{S}_{c} for $\phi = \pi/8$ vs. $\beta \rho_{0}$ (capped cylinder), $\nu = 0.3$



 $D - \hat{S}_{e}$ for $\phi = 3 \pi/8$ vs. $\beta \rho_{0}$ (capped cylinder), $\nu = 0.3$



 $F - \hat{S}_{e} at \phi = \pi/2$ for Case II (extension case)vs. $\beta \rho_{0}$, $\nu = 0.3$



OUTEI 2. MIDDLE SURFACE ŝ. 0 -2 INNER -4.

 $E - \hat{S}_{o}$ for $\phi = \pi/2$ vs. $\beta \rho_{0}$ (capped cylinder), $\nu = 0.3$

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 $\hat{C} - \hat{S}_c$ for $\phi = \pi/4$ vs. $\beta \rho_0$ (capped cylinder), $\nu = 0.3$

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NOTE Reference: "State of Stress in a Circular Cylindrical SHELL WITH A CIRCULAR HOLE," WELDING RESEARCH COUNCIL BULLETIN 102, 1965.



TMI Unit-1 **Total Stress Concentration Factors** for Given Loading Cases

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Toble 3—Otress Cancentration Faster Variations for Different Ap at Various Angles—Capped Cylinder

r = 6.8			
8 m	(Ŝ.)upper	S.	(Ŝ,) louer
		- 0	
	•		
0.14142	2.75054	2.64709	2.54368
0.21213	2.94174	2.81900	2.09020
0.25254	3.13290	3.03570	2,94000
0.30300	3.30842	3.28070	3.2020/
0.42420	3.40933 3.68039	3.00407 3.93496	3.00001
0.56568	3 66795	4 11011	4 57027
0.63639	3.72044	4 40201	5 06357
0.70710	3.73656	4.67874	5,62091
0.84852	3.66013	5.20121	6.74228
0.98994	3.44158	5.66463	7.88769
1.13137	3.09060	6.05690	9.02300
1.27279	2.61996	6.37120	10.12243
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o 14140	•	= T/O	0.10080
0.14142	2.40980	2.33179	2 19372
0.21213	2.00920	2.4/3/8	2.29030
0.26266	2.04919	2.07011	2.40700
0.30300	3 25013	3 13783	3 02553
0 49497	3.41623	3 40126	3 38629
0.56568	3.56589	3.67806	3.79024
0.63639	3.69959	3.96509	4.23059
0.70710	3.81810	4.25958	4.70107
0.84852	4.01561	4.86482	5.71403
0.98994	4.16952	5.48212	6.79472
1.13137	4.29120	6.10374	7.91627
1.27279	4.39120	6.72431	9.05741
		/	
	•		
0.14142	1.79394	1.00884	1.34374
0.21213	2.01190	1.00360	1.29580
0.20204	2.23900	1.70710	1 23014
0.30300	2. 40000	2 06304	1 49488
0.42420	2 93776	2 24160	1 54544
0.56568	3.18071	2.43944	1.69816
0.63639	3,43312	2.65648	1.87983
0.70710	3.69754	2.89277	2.06800
0.84852	4.27107	3.42439	2.57771
0.98994	4.91382	4.03512	3.15642
1.13137	5.63074	4.72359	3.81643
1.27279	6.42060	5.48575	4.55090
	A 1	- 3-/8	
0 14142	1 12040	0 80340	0 48640
0.21213	1.35527	0.81807	0.28087
0.28284	1.59750	0.83819	0.07888
0.35355	1.84227	0.86252	-0.11723
0.42426	2.08946	0.88996	-0.30964
0.49497	2.34032	0.91983	-0.50065
0.56568	2.59629	0.95182	-0. 69263
0.63639	2.85862	0.96598	-0.88675
0.70710	3.12823	1.02243	-1.08337
0.84852	3.69078	1.10414	-1.48249
0.98994	4.28578	1.20142	-1.88293
1.13137	4.91210	1.31909	-2.27291
1.41210	0.00/31	1.40410	- 2.03594
	• •	/2	
0.21213	1.06342	0.46892	-0.14557
0.28284	1.32929	0.44570	-0.43787
0.35355	1 57420	0.41483	-0.74454
0.42426			
	1.81091	0.37473	-1.06744
0.49497	1.81 69 1 2.05720	0.37473 0.32403	-1.05744 -1.40912
0.49497 0.56568	1.81691 2.05720 2.29480	0.37473 0.32403 0.26158	-1.06744 -1.40912 -1.77164
0.49497 0.56568 0.63639	1.81691 2.06720 2.29480 2.52926	0.37473 0.32403 0.26158 0.18654	-1.05744 -1.40912 -1.77164 -2.15617
0.49497 0.56568 0.63639 0.70710	1.81691 2.06720 2.29480 2.52926 2.75997	0.37473 0.32403 0.26158 0.18654 0.09861	-1.06744 -1.40912 -1.77164 -2.15617 -2.56273 -2.56273
0.49497 0.56568 0.63639 0.70710 0.84852 0.98994	1.81691 2.05720 2.29480 2.52925 2.75997 3.20525 3.62929	0.37473 0.32403 0.26158 0.18654 0.09861 -0.11635 -0.38079	-1.06744 -1.40912 -1.77164 -2.15617 -2.56273 -3.43897 -4.3896
0.49497 0.56568 0.63639 0.70710 0.84852 0.98994 1.13137	1.81691 2.05720 2.29480 2.52928 2.75997 3.20626 3.62829 4.02201	0.37473 0.32403 0.26158 0.18654 0.09661 -0.11635 -0.38079 -0.66948	$\begin{array}{r} -1.05744 \\ -1.40912 \\ -1.77164 \\ -2.15617 \\ -2.56273 \\ -3.43897 \\ -4.38968 \\ -5.40137 \end{array}$

Table 3-Continued

S. (Middle Surface only)						
8m	• = 0	₹/10	=/5	3=/10	2=/5	₹/2
1.4142	6.6163	7.1556	7.2307	4.7200	0.6424	-1.4030
1.5000	6.7936	7.7349	8.3542	5.6384	0.6623	-1.8994
1.7677	6.9059	8.4207	9.5285	6.6467	0.7164	-2.4293



$$\mu = \frac{1}{2} \sqrt[4]{3(1-V^2)} \frac{r}{\sqrt{Rt}}$$

The membrane stress concentration factor $S_{\rm c}$ and the total stress concentration factor $\widehat{S}_{\rm c}$ are, respectively, defined by

$$S_{c} = \frac{\text{largest of } (N_{1}, N_{2})}{\text{largest of } (N_{1}^{0}, N_{2}^{0})} = S_{c}$$
(middle surface)

$$\widehat{S}_{c} = \frac{\text{largest of } (\sigma 1, \sigma 2)}{\text{largest of } (\sigma 1^{0}, \sigma 2^{0})} \quad \text{(for fixed } r, \phi)$$

where N_1^0 , N_2^0 are the nominal principal stress resultants and $\sigma 1^0$, $\sigma 2^0$ are the nominal flexural stresses for the shell under the same loading but without the hole. N_1 and N_2 denote the principal stress resultants, σ_1 and σ_2 the principal stresses respectively. The stress concentration factor is calculated as a function of ϕ .

NOTE Reference: "State of stress in a circular cylindrical Shell with a circular hole," Welding Research Council Bulletin 102, 1965.





(C) CAPPED CYLINDER UNDER INTERNAL PRESSURE

DDU Nuclear TMI Unit-1

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Stress Distribution around Openings in Cylindrical Shells



p. 5C.FIG-4

5 NODAL POINT NUMBER

(15) PANEL NUMBER

2 PANEL TYPE NUMBER

ALL DIMENSIONS ARE GIVEN IN INCHES



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Grid for Finite Element Analysis of Stresses Around **Equipment Hatch in RCB**





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Layer Thickness and Designation





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Member Stresses around Opening Edge (Vessel Subject to Internal Pressure)







Surface Stresses around Opening Edge (Vessel Subject to Internal Pressure)

-164-10-11

PHOTOELASTICITY -----

HUGGENBERGER TENSOMETER •

FINITE ELEMENT SOLUTION _____



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Hoop Stresses along Longitudina Subject to Internal Pressure)	l Axis (Vessel
	Fig. 5C-8

p. 5C.FIG-8

EXPERIMENTAL

FINITE ELEMENT SOLUTION -----



데민 Nuclear	Update - 1
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Axial Stresses along Transverse A to Internal Pressure)	Axis (Vessel Subject
	Fig. 5C-9



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Hoop Stress - Resultant N _O along S (Test problem)	ymmetry Axes



WHERE THE TERMS ARE IDENTIFIED AS FOLLOWS:

ro	=	1'-2"	r = variable least Radius of DRAPED Tendo	NS
t	I	84"	P = RADIAL TENDON FORCE	

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Effect of Tendon Curvature	



p. 5C.FIG-12

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TMI Unit-1

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Nodal Forces Due to Curvature of Tendons in Neighborhood of Opening







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TMI Unit-1

Normal Winter Operating Temperature Gradient -Transition Wall Near Equipment Opening

p. 5C.FIG-15



Image: The systemUpdate -1TMI Unit-17/82

Winter Accident Temperature Gradient - 84" Thick Wall Near Equipment Opening



p. 5C.FIG-17



Nuclear

Wall Near Equipment Opening

Winter Accident Temperature Gradient - Transition

TMI Unit-1

p. 5C.FIG-18

Fig. 5C-18

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INTERACTION DIAGRAM FOR AXIAL COMPRESSION/TENSION AND BENDING





EQUIPMENT ACCESS



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EQUIPMENT ACCESS

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SYMBOL	ELEMENT	DIRECTION
•	55	HOOP
©	99	MERIDIONAL



EQUIPMENT ACCESS SYMBOL ELEMENT DIRECTION HOOP 44 •

SCALE: HOR. 1"= 1000 IN-K/IN. VERT. 1 = 100 K/IN.



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EQUIPMENT ACCESS

SYMBOL	ELEMENT	DIRECTION	
•	73	HOOP	







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p. 5C.FIG-27

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EQUIPMENT ACCESS

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SYMBOL	ELEMENT	DIRECTION
0	99	HOOP
•	100	HOOP

SCALE: - COMPRESSION KIN. HOR. 1 = 1000 IN-K/IN VERT. 1 = 100 K/IN 300 (-6630,-235) (-2102,-217) 200 (-4578,-137) (1500,-145) 100 ◬ -MIN-K/IN. **€**0 ▲ A 00 (575,0) (-565,0) 5000 4000 8000 3000 1000 7000 6000 2000 1000 2000 (670,30) +PU,NØ 100 +MU,MØ 84" 200 300 +TENSION K/IN. P. C.FIG-28 SURFACE







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Sheer Transfer Plates