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CHAPTER

Pressure Vessels

Q.1 A thin cylinder of inner radius 500 mm and thickness 10 mm is subjected to an internal pressure of 5 MPa. The average circumferential stress is
(a) 100 MPa (b) 250 MPa
(c) 500 MPa (d) 1000 MPa

Q.2 A thin walled spherical shell is subjected to an internal pressure. If the radius of the shell is increased by 1% and the thickness is reduced by 1%, with the internal pressure remaining the same, the percentage change in the circumferential stress is
(a) 0 (b) 1
(c) 1.08 (d) 2.02

Q.3 Match List-I with List-II and select the correct answer using the codes given below:

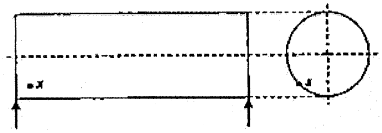
List-I (2D stress system loading)
A. Thin cylinder under internal pressure
B. Thin sphere under internal pressure
C. Shaft subjected to torsion

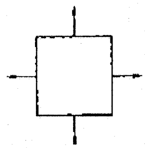
List-II (Ratio of principal stress)
1. 3.0
2. 1.0
3. −1.0
4. 2.0

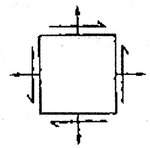
Codes:

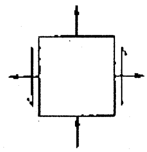
	A	B	C
(a)	4	2	3
(b)	1	3	2
(c)	4	3	2
(d)	1	2	4

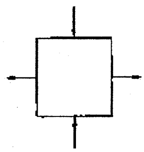
Q.4 A thin cylinder with closed lids is subjected to an internal pressure and supported at the ends as shown in figure. The state of stress at point x is as represented by



(a)


(b)


(c)


(d)


Q.5 Assertion (A): A thin cylindrical shell is subjected to an internal fluid pressure that induces a 2D-stress state in the material along the longitudinal and circumferential directions.
Reason (R): The circumferential stress in the thin cylindrical shell is two times the magnitude of longitudinal stresses.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.6 Assertion (A): For a thin cylinder under internal pressure, atleast three strain gauges are needed to know the stress state completely at any point on the shell.
Reason (R): If the principal stress directions are not known, the minimum number of strain gauges needed is three in a biaxial field.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.7 A thick cylinder is subjected to an internal pressure of 60 MPa. If the hoop stress on the outer surface is 150 MPa, then the hoop stress on the internal surface is
(a) 105 MPa (b) 180 MPa
(c) 210 MPa (d) 135 MPa

Q.8 Consider the following statements:
1. When $\frac{d}{t} \geq 50$, it is normally called as thin cylinder.
2. Thin cylinders are subjected to hoop and longitudinal stresses.
3. Steam pipes can be termed as thin cylinder.
Which of these statements are correct?
(a) both 1 and 2 (b) both 2 and 3
(c) both 1 and 3 (d) 1, 2 and 3

Q.9 Which of the following assumptions are made in Lame's theory of thick cylinders?
1. The material is stressed within the elastic limit
2. The material is homogeneous and isotropic.
3. All the fibres of the material are free to expand or contract independently without being constrained by the adjacent fibres.
Select the correct answer using the codes given below:
(a) both 1 and 2 (b) both 1 and 3
(c) both 2 and 3 (d) 1, 2 and 3

Q.10 Consider the following statements at a given point in the case of thick cylinder subjected to fluid pressure:
1. Radial stress is compressive
2. Hoop stress is tensile
3. Hoop stress is compressive
4. Longitudinal stress is tensile and it varies along the length
5. Longitudinal stress is tensile and remains constant along the length of the cylinder
Which of these statements are correct?
(a) only 1, 2 and 4 (b) only 3 and 4
(c) only 1, 2 and 5 (d) only 1, 3 and 5

Q.11 A thin cylindrical shell is subjected to internal pressure p. The Poisson's ratio of the material of shell is 0.3. Due to internal pressure, the shell is subjected to circumferential strain and axial strain. The ratio of circumferential strain to axial strain is
(a) 0.425 (b) 2.25
(c) 0.225 (d) 4.25

Q.12 Hoop stress and longitudinal stress in a boiler shell under internal pressure are 100 MN/m² and 50 MN/m² respectively. Young's modulus of elasticity and Poisson's ratio of the shell material are 200 GN/m² and 0.3 respectively. The hoop strain in the boiler shell is
(a) 0.425×10^{-3} (b) 0.500×10^{-3}
(c) 0.575×10^{-3} (d) 0.750×10^{-3}

Q.13 Match List-I with List-II and select the correct answer using the codes given below:
List-I
A. Wire winding
B. Lame's theory
C. Solid sphere subjected to uniform pressure on the surfac
D. Autofrettage

List-II
1. Hydrostatic stress
2. Strengthening of thin cylindrical shell
3. Strengthening of thick cylindrical shell
4. Thick cylinder

Codes:

	A	B	C	D
(a)	2	4	3	1
(b)	4	2	1	3
(c)	4	2	3	1
(d)	2	4	1	3

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Answers Pressure Vessels

1. (b) 2. (d) 3. (a) 4. (a) 5. (b) 6. (d) 7. (c) 8. (b) 9. (d) 10. (c)
11. (d) 12. (a) 13. (d)

Explanations Pressure Vessels

1. (b)

$r = 500\text{ mm}$
$t = 10\text{ mm}$
$p = 5\text{ MPa}$

$$\therefore \quad \sigma_c = \frac{pr}{t} = \frac{5 \times 500}{10}$$
$$= 250\text{ MPa}$$

2. (d)

$$\sigma_c = \frac{pr}{t}$$
$$\sigma_{co} = \frac{p(1.01r)}{0.99t} = 1.0202\frac{pr}{t}$$

∴ Percentage change

$$= \frac{(1.0202-1)\frac{pr}{t}}{\frac{pr}{t}} \times 100 = 2.02\%$$

4. (a)
Point x is subjected to circumferential and longitudinal stress; i.e., tensile stress on all faces. Shear is absent because vessel is supported freely outside.

5. (b)
In thin cylinders, the magnitude of radial stress is very much smaller than the magnitude of hoop and longitudinal stresses.
Therefore, for all practical purposes, radial stress in these cylinders are neglected.

6. (d)
For thin cylinder, radial stress can be neglected, so only longitudinal and circumferential stress have to be measured. So only two strain gagues are needed.

7. (c)
Internal pressure,
$$p_i = 60\text{ MPa}$$
$$\sigma_c = \frac{p_i r_i^2}{r_o^2 - r_i^2}\left\{\frac{r_o^2}{r^2} + 1\right\}$$

Given, $\sigma_c = 150\text{ MPa}$, when $r = r_o$

$$\therefore \quad 150 = 60\frac{r_i^2}{r_o^2 - r_i^2}\left\{\frac{r_o^2}{r_o^2} + 1\right\}$$
$$= 120\frac{r_i^2}{r_o^2 - r_i^2}$$
$$\Rightarrow \frac{r_i^2}{r_o^2 - r_i^2} = \frac{150}{120} = \frac{5}{4}$$
$$\Rightarrow \frac{r_o^2}{r_i^2} = \frac{9}{5}$$

At $r = r_i$;

$$\sigma_c = 60\frac{r_i^2}{r_o^2 - r_i^2}\left\{\frac{r_o^2}{r_i^2}+1\right\}$$

$$= 60\times\frac{5}{4}\left\{\frac{9}{5}+1\right\}$$

$$= 210\,\text{MPa}$$

8. (b)

	Thin	Thick
Limiting proportions	$d/t > 20$	$d/t < 25$
Statically determinate	yes	No
Stress state	Membrane i.e. biaxial	triaxial
Stress – radial, σ_r	zero	varies with radius
– tangential, σ_t	uniform	varies with radius
– axial, σ_a	uniform	uniform

11. (d)

$$\sigma_h = \frac{pd}{2t}, \quad \sigma_l = \frac{pd}{4t}$$

$$\epsilon_h = \frac{pd}{2tE}\left[1-\frac{\mu}{2}\right] = \frac{pd}{2tE}\left(1-\frac{0.3}{2}\right)$$

$$= \frac{0.425\,pd}{tE}$$

$$\epsilon_l = \frac{pd}{2tE}\left[\frac{1}{2}-0.3\right] = \frac{0.1\,pd}{tE}$$

$$\frac{\epsilon_h}{\epsilon_l} = \frac{0.425}{0.1} = 4.25$$

12. (a)

$\sigma_h = 100\ \text{MN/m}^2$, $\sigma_l = 50\ \text{MN/m}^2$

$E = 200\ \text{GN/m}^2$, $\nu = 0.3$

$$\epsilon_h = \frac{1}{E}(\sigma_h - \mu\sigma_l)$$

$$= \frac{1}{200\times 10^9}(100 - 50\times 0.3)\times 10^6$$

$$= 0.425\times 10^{-3}$$

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