UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2014/2015

COURSE NAME	:	PRESSURE VESSEL DESIGN
COURSE CODE	:	BNL 40103
PROGRAMME	:	2 BNL
EXAMINATION DATE	:	JUNE 2015 / JULY 2015
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 A cylindrical steel pressure vessel 300 mm in diameter with a wall thickness of 20 mm, is subjected to an internal pressure of 4.5 MN/m^2.

(a) Calculate the tangential and longitudinal stresses in the steel.

(6 marks)

(b) Suggest to what value may the internal pressure be increased if the stress in the steel is limited to 120 MN/m2?

(4 marks)

(c) If the internal pressure were increased until the vessel burst, sketch the type of fracture that would occur.

(5 marks)

(d) Sketch a horizontal pressure vessel showing the its major components. Label each component and the associated joints.

(8 marks)

(e) Explain why welded joint efficiency in pressure vessel is less than unity.

(2 marks)

Q2 A structure must be designed to resist gross plastic deformation and collapse under all the conditions of loading. The loads to which a process vessel will be subject in service can be classified as major loads and subsidiary loads.

(a) State four design loads in each classification.

(4 marks)

(b) The ends of a cylindrical vessel are closed by heads of various shapes. List the principal types used by sketching each type.

(8 marks)

(c) All process vessels will have openings for connections, manways, and instrument fittings. Which effect of openings to pressure vessel?

(2 marks)

(d) To compensate the effect of an opening, the wall thickness is increased in the region adjacent to the opening. Welded pad, insert nozzle, and forged ring are common types of reinforcement. Draw each reinforcement type.

(6 marks)

(e) Flanged joints are used for connecting pipes and instruments to vessels, for manhole covers, and for removable vessel heads when ease of access is required. List five principal types of flanged joints commonly used in the process industries.

(5 marks)

Q3 According to ASME Section VIII Pressure Vessel Codes, conical shell and transition sections have a variety of configuration. **Figure Q3** shows the cone, the two cylinders, and the area at the cone–to–cylinder junctions. Axial compressive load at cone vicinity from mounted equipment is 50 kips. The design data are given in **Table Q3**.

Table Q3

Data	Small Cylinder	Cone	Large Cylinder	Reinforcing Ring
Allowable stress, psi	15,000	16,000	17,500	13,000
Joint Efficiency	0.85	1.0	0.85	-
Modulus of Elas., ksi	27,000	29,000	25,000	30,000
Pressure, psi	100	100	100	-

(a) Calculate the required thickness, t, for the small shell, cone, and large shell.

(6 marks)

(b) At the large cone–to–shell junction, you shall:

(i) Determine the required area of reinforcement (A_{rL})

(4 marks)

(ii) Calculate the available area at the junction, (A_{eL})

(3 marks)

(iii) Calculate the additional area needed at the junction for reinforcement.

(2 marks)

(c) At the small cone–to–shell junction, you shall:

(i) Determine the required area of reinforcement (A_{rs})

(4 marks)

(ii) Calculate the additional area needed at the small junction for reinforcement and the minimum thickness at the small end.

(3 marks)

(d) Propose your design of the reinforcing ring by modifying the **Figure Q3**. Use 1 inch thick bar.

(3 marks)

Q4 The method used to support a vessel will depend on the size, shape, and weight of the vessel; the design temperature and pressure; the vessel location and arrangement; and the internal and external fittings and attachments.

(a) Sketch three types of vessel supports commonly used in process industries.

(7 marks)

(b) All completed pressure shall be subjected to a hydrostatic test. If the maximum allowable working pressure is 100 psi, calculate the minimum hydrostatic test pressure.

(2 marks)

(c) Pressure vessel must be designed to withstand the worst combination of the loads likely to occur in the actual situations. List four actual situations to be considered.

(4 marks)

(d) State four major sources of dead weight loads of vessels.

(4 marks)

(e) During operation the shell or components of the vessel, they may be subjected to cyclic stresses. List four causes that arise from cyclic stresses.

(4 marks)

(f) Draw the major components of a vertical tray column with skirt support. Label each component.

(4 marks)

– END OF QUESTIONS –

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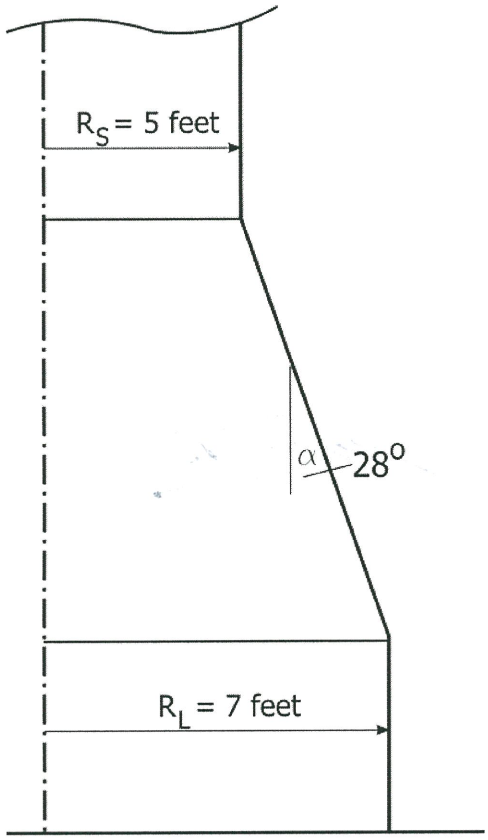

Figure Q3

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Thin Cylindrical Shell:

The required thikness in the circumferential direction due to internal pressure:

$$t = \frac{PR}{SE - 0.6P}, \quad \text{when } t < 0.5R \text{ or } P < 0.385 \times SE \tag{1}$$

E:Joint efficiency factor; P: Internal pressure; R: Internal radius; S: Allowable stress in material; t: Thickness of the cylinder

Reinforcement at the junction of connection to cylinder under internal pressure.

For internal pressure, the design equation for a conical section is given by:

$$t = \frac{PD}{2\cos\alpha(SE - 0.6P)}, \quad \text{where } \alpha \leq 30^{\circ} \tag{2}$$

Junction at the Large End

The required area:

$$A_{rL} = kQ_L \frac{R_L}{S_s} E_1 (1 - \Delta/\alpha) \tan\alpha \tag{3}$$

E_1	Joint efficiency factor of the longitudinal joint in the cylinder
E_c	Modulus of elasticity of the cone, psi
E_r	Modulus of elasticity of the reinforcing ring, psi
E_s	Modulus of elasticity of the cylinder, psi
k	= 1 when additional area of reinforcement is not required. = $\frac{y}{S_r E_r}$ but not less than 1.0, when a stiffening ring is required.
Q_L	Axial load at the large end, lb/in, including pressure end load
R_L	Inside large radius of the cone, in.
S_c	Allowable stress in the cone, psi
S_r	Allowable stress in the reinforcing ring, psi
S_s	Allowable stress in the cylinder, psi
y	= $S_s \times E_s$ For reinforcing ring on the shell = $S_c \times E_c$ For reinforcing ring on the cone
Δ	Angle obtained from Table A and B.

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Table A – Values of Δ for Junction at the Large Cylinder

$\frac{P}{S_s}E_1$	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
Δ, deg	11	15	18	21	23	25	27	28.5	30

Table B – Values of Δ for Junction at the Small Cylinder

$\frac{P}{S_s}E_1$	0.002	0.005	0.010	0.020	0.040	0.080	0.100	0.125
Δ, deg	4	6	9	12.5	17.5	24	27	30

Area of excess metal for reinforcement, sq. in.:

$$A_{eL} = (t_s - t)\sqrt{R_L t_s} + (t_c - t_r)\sqrt{\frac{R_L t_c}{\cos\alpha}} \quad (4)$$

The distance from the junction within which the additional reinforcement shall be situated in inch:$\sqrt{R_L t_s}$ The distance from the junction within which the centroid of the reinforcement shall be situated in inch:$0.25 \times \sqrt{R_L t_s}$

Junction at the small end

Required area of reinforcement in inch when tension governs:

$$A_{rs} = kQ_s \frac{R_s}{S_s} E_1 (1 - \Delta/\alpha)\tan\alpha \quad (5)$$

Area of excess metal available for reinforcement in inch square:

$$A_{es} = 0.78\sqrt{R_s t_s} \times [t_s - t + \frac{t_c - t_r}{\cos\alpha}] \quad (6)$$

The distance from the junction within which the centroid of the reinforcement shall be situated in inch:$\sqrt{R_s t_s}$ The distance from the junction within which the centroid of the reinforcement shall be situated in inch:$0.25 \times \sqrt{R_s t_s}$