Bharatiya Vidya Bhavan's

Sardar Patel College of Engineering

(A Government Aided Autonomous Institute)
Munshi Nagar, Andheri (West), Mumbai – 400058

Re-Examination
June 2018

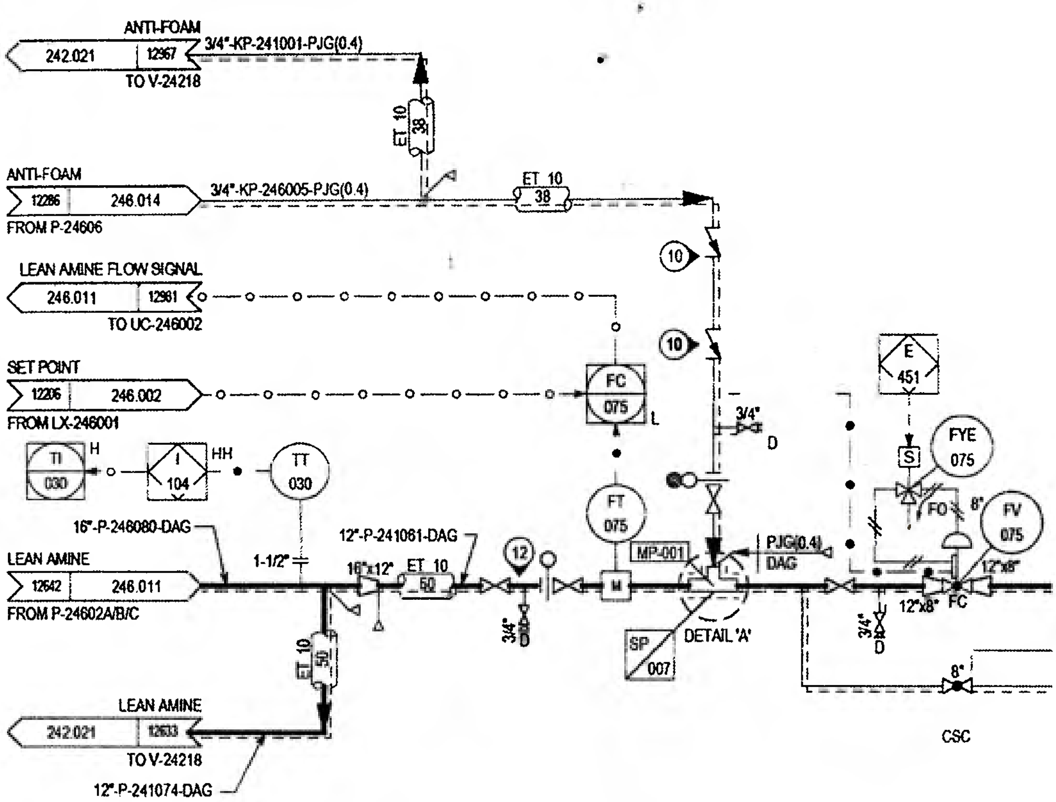
Program: **B.Tech. in Mechanical Engineering** Date: **June 2018**
Class: **Final Year B.Tech. (Mechanical)** Duration: **3 Hr.**
Course code: **BTM710** Max. Points: **100**
Name of the Course: **Process Eqpt. Design and Piping Engineering** Semester: **VII**
Instructions:

- Question no. 1 is **compulsory.** Attempt any **four** out of remaining six questions
- Assume suitable data if necessary.

	Question	Max. Points	CO No.	Mod No.
Q1 A)	Consider yourself as process equipment design engineer in a large multinational EPC organization. You shall be assisting your project manager to prepare a presentation regarding process equipment design capabilities of your organization. Compose the contents of presentation highlighting different aspects of process equipment design and explain in brief.	(5)	1	1
B)	Explain different methods of selecting pipe size for a process plant.	(5)	4	6
C)	You shall be visiting manufacturing facility of a reputed supplier in Europe which supplies important welded, forged and bolted subassemblies for your organization. Prepare a checklist listing all the machines/inspection devices which you would like to inspect, mentioning features to be checked for each machine/device (for example, if machine is plate rolling machine, one of the feature you need to check is maximum plate width and thickness which can be rolled).	(5)	3	2
D)	A critical section of pressure vessel consists of 500 ND sch XS pipe welded to 500 ND 900# flange. Design temperature of the section is 125 deg.C. Allowable stress for both pipe and flange materials is 125 MPa. Corrosion allowance is 1 mm. Calculate the maximum allowable internal pressure for the section.	(5)	2	3
Q2 A)	A cylindrical vessel of 2800 mm ID is subjected to an internal pressure of 2.0 MPa. Design the reinforcing pad for a nozzle opening with following data. The nozzle axis makes an angle of 80° with the axis of shell.	(10)	2	4

Internal dia. Of nozzle = 475 mm	Noz. height above vessel = 200 mm
Thickness of vessel = calculate and round to the nearest even integer value	Permissible stress for shell and nozzle = 180 MPa
Thk. of nozzle wall = calculate and round to the nearest even integer value	Corrosion allowance = 3 mm

	Question	Max. Points	CO No.	Mod No.
B)	Describe different types of process diagrams used in process plant design. Explain contents of P&ID and different symbols used therein. Following figure shows part of P&ID for a process plant. Sketch the diagram and describe function/type of instrument/valve, nature of connection lines, interpretation of pipeline tag and other relevant information.	(10)	1	1



Q3 A) Design skirt support for a vertical vessel with the data given below. **(15)** *3*

Vessel ID/thickness = 3000 / 28 mm Skirt ID = 2500 mm	Permissible stress, skirt = 160 MPa (tension), 70 MPa (compression)
Total height of vessel = 60 m	Permissible bending stress, base plate = 140 MPa
Operating weight of vessel = 6000 kN	Permissible stress, bolts = 140 MPa
Empty weight of vessel = 5000 kN	Permissible compressive stress, foundation = 21 MPa
Wind pressure, H>20m = 1600 N/m^2 Wind pressure, H<20m = 800 N/m^2	Seismic factor, C = 0.10

B) Discuss the procedure to perform piping flexibility analysis using a typical commercial software. Highlight important software features that will aid the analyst during the modelling and evaluation of flexibility. Define following terms: (i) Stress Intensification Factor, (ii) Flexibility factor. **(5)** *4*

Q4 A) Write a short note on different material types and their selection for process equipment. Which material will you select for: (i) Food processing equipment, (ii) High pressure reactor working at 480 deg. C, (iii) Vessel exposed to highly corrosive fluid at medium pressure, (iv) Large storage tank for utility water. **(10)** *1*

Discuss the contents of 'Piping Material Specification' which is issued for a specific project by EPC consultant. How this document is used during design phase of a project?

B) A 550 ND sch XS pipeline has equivalent length of 500 m for pressure drop calculations. The pipe inside surface has surface roughness of 0.07 mm. The fluid flowing through pipeline has density of 800 kg/m^3, viscosity of 1.4 cP and mass flow rate of 200,000 kg/hr. Calculate the pressure drop inside the pipeline. Explain importance of pressure drop calculations in piping system design. **(10)** *4*

Q5 A) A carbon steel pressure vessel has shell of 2000 mm inside diameter, '*t*' thickness and 4500 mm unsupported length. The shell is subjected to external pressure of 0.15 MPa at 300° C due to fluid in its external jacket. Calculate the required thickness '*t*' of the shell. Calculate the size of the stiffeners. Corrosion allowance is zero. **(10)** *2* *3*

B) Explain different types of supports used in design of piping system. Discuss the procedure followed in selection of standard spring hangers from manufacturer's catalogue. **(10)** *4* *7*

Q6 A) What is the purpose of providing baffles in a heat exchanger? Write short note on arrangement of baffles in heat exchangers. Mention about function of baffles, types of baffles, baffle hole size, thickness of baffles and tie rod design. **(5)** *3* *5*

B) Describe different international codes and standards which are commonly used for design of process equipment and piping components. Include organization of typical codes and standards. **(5)** *1* *1*

C) Describe different types of analysis which need to be carried out for designing a pressure component using DBA method of ASME. Explain different alternative options available to perform each of the analysis type. **(10)** *3* *4*

List down steps involved in carrying out plastic collapse check using elastic analysis.

Discuss the concept of stress categorization/linearization in the context of stress analysis of pressure components with suitable illustrative example.

Q7 A) Design flange with flat face as per following data. **(10)** *2* *4*

Design pressure = 7.2 MPa	Flange inside diameter= 950 mm
Allowable flange stress = 250 MPa	Gasket* = PTFE (*m*=2.75, *y*=25.5 MPa)
Allowable bolt stress: operating =220 MPa, gasket seating condition = 200 MPa	

* you may modify *m* and *y* factors if necessary.

B) A vertical tower vessel of welded construction has following design specification. **(10)** *2* *3*

Inside diameter = 2000 mm	Material = Carbon steel
Straight length of shell = 15,000 mm	Liquid level = 10,000 mm from bottom straight line
Type of heads = 2:1 ellipsoidal at bottom and hemispherical at top end	Liquid specific gravity = 1.30
Design internal pressure = 6.1 MPa	Allowable stress = 125 MPa
Design temperature = 280° C	Corrosion allowance = 3 mm
Joint efficiency = 0.90	Hydrotest pressure = nil

Calculate as per pressure vessel design code: (i) Thickness of shell and top/bottom heads, (ii) Pressure-temperature rating class of flanges fitted on the vessel.

Annexure 1

Pipe Schedule

NPS inches	N.D.	O.D. mm	10	20	30	STD	40	60	XS	80	100	120	140	160
20	500	508	6.35	9.53	12.70	9.52	15.08	20.62	12.7	26.19	32.54	38.1	44.45	50.01
22	550	558.8	6.35	9.53	12.70	9.52	15.87	22.22	12.7	28.57	34.92	41.27	47.62	53.97
24	600	609.6	6.35	9.53	12.70	9.52	17.47	24.61	12.7	30.96	38.89	46.02	52.37	59.54

Weld Joint Efficiency

Type No.	Joint Description	Joint Category	Degree of Radiographic Examination (a) Full [Note (1)]	(b) Spot [Note (2)]	(c) None
(1)	Butt joints as attained by double welding or other means which will obtain the same quality of deposited weld metal on the ins and outside weld surfaces to agree with t requirements of UW 35. Welds using met backing strips which remain in place are excluded.	A, B, C & D	1.00	0.85	0.70
(2)	Single welded butt joint with backing strip other than those included under (1)	A, B, C & D	0.90	0.80	0.65
		A, B & C	0.90	0.80	0.65

Factor Y

Materials	Temperature, °C (°F) ≤ 482 (900 & Lower)	510 (950)	538 (1000)	566 (1050)	593 (1100)	≥ 621 (1150 & Up)
Ferritic steels	0.4	0.5	0.7	0.7	0.7	0.7
Austenitic steels	0.4	0.4	0.4	0.4	0.5	0.7

Pressure-temperature rating class for carbon steel flanges

Class Temp., °C	Working Pressure by Classes, bar 150	300	400	600	900	1500	2500
−29 to 38	19.8	51.7	68.9	103.4	155.1	258.6	430.9
50	19.5	51.7	68.9	103.4	155.1	258.6	430.9
100	17.7	51.5	68.7	103.0	154.6	257.6	429.4
150	15.8	50.2	66.8	100.3	150.5	250.8	418.1
200	13.8	48.6	64.8	97.2	145.8	243.2	405.4
250	12.1	46.3	61.7	92.7	139.0	231.8	386.2
300	10.2	42.9	57.0	85.7	128.6	214.4	357.1

Useful expressions for support skirt design against wind and seismic load

$T = 6.35 \times 10^{-5}(H/D)^{1.5}(W/t)^{0.5}$ where W is in kN; wind load $P = k_1 k_2 p H D_0$, wind shape factor k_1=0.7 to 0.85, wind factor related to period, k_2 = 1 if T<0.5 sec, else k_2 = 2

Useful expressions for flange design

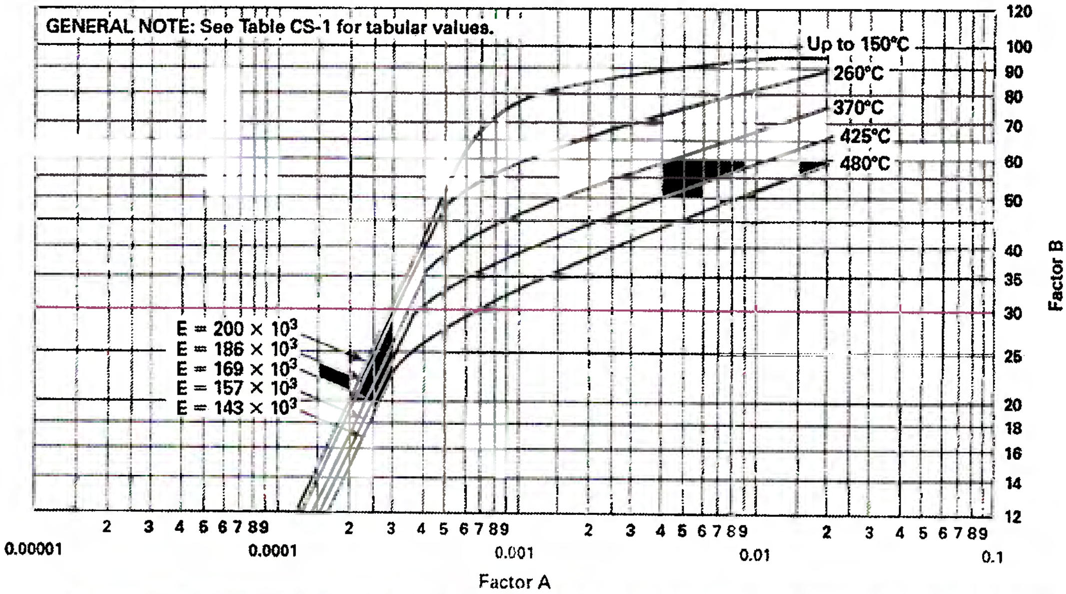
Factor $Y = \frac{1}{K-1}\left[0.66845 + 5.71690\frac{K^2 \log_{10} K}{K^2-1}\right]$, $K = (\text{flange OD})/(\text{flange ID})$

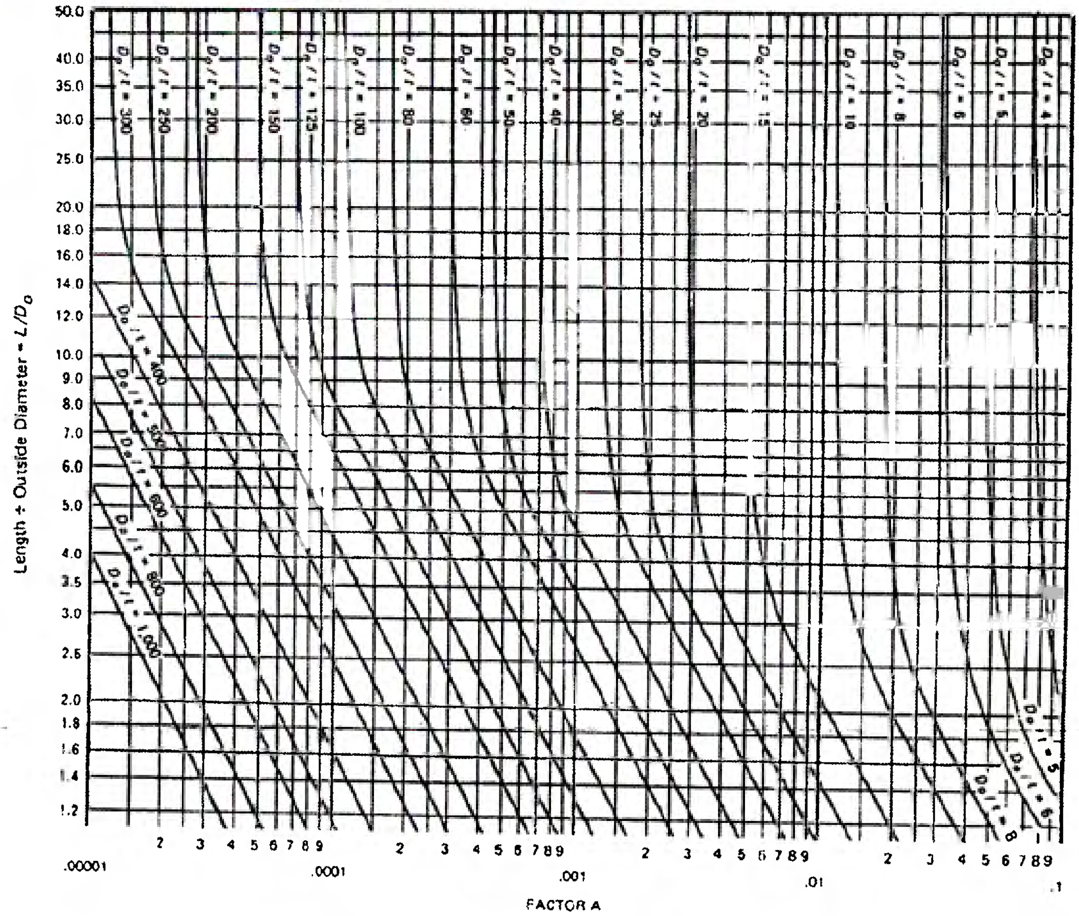
Pressure Drop Calculations

$f_D = 0.3164 R_e^{-0.25}$

Colebrook White equation: $\frac{1}{\sqrt{f_D}} = -2\log_{10}\left(\frac{e}{3.7D} + \frac{2.51}{R_e\sqrt{f_D}}\right)$

External pressure design charts for carbon steel





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