



LIDCO, Pars SEE Zone, Assaluyeh,
Integrated Methanol and Ammonia
Plant 3000 MTPD MeOH / 900 MTPD NH3 PROJECT



Pulsation Study Approach 1 Calculations

Document No. 17735-24

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code-2
M. Vakili

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Design approach 1 in accordance with API 618

Project: Integrated Methanol and Ammonia Plant
Location: Iran
Equipment: Air Compressor
Purchase order: LIDCO-PO-NEC-278-6019
Airpack reference: 17735-COM

Requirements

Pulsation levels have to meet the limits as per paragraph 7.9.4.2.5.2.2.1 as well as the criteria in paragraph 7.9.2 through 7.9.3.

para 7.9.4.2.5.2.5.1

The peak-to-peak cyclic stress range is far below 180 N/mm^2 , therefore this paragraph is considered as not applicable.

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para 7.9.3.2

$$V_s = 8,1 \cdot PD \cdot \left(\frac{k \cdot T_s}{M} \right)^{1/4}$$

$$V_d = 1,6 \cdot \left(\frac{V_s}{(R)^{1/k}} \right)$$

$$V_s \geq V_d$$

$$V_s \geq 0,03 \text{ m}^3$$

$$V_d \geq 0,03 \text{ m}^3$$

$$\frac{l}{ID} \leq 4.0$$

- V_s = minimum required suction surge volume [m³]
 V_d = minimum required discharge surge volume [m³]
 K = isentropic compression exponent at average operating gas pressure and temperature
 T_s = absolute suction temperature [K]
 M = molecular weight
 PD = total net displaced volume per revolution of all compressor cylinders to be manifolded in the surge volume
 R = stage pressure ratio at cylinder flanges (= quotient of absolute discharge and suction pressures)
 l = surge volume length
 ID = surge volume inside diameter

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para 7.9.4.2.5.2

$$P_{cf} = 3R \%$$

$$P_{cf} \leq 7 \%$$

P_{cf} = maximum allowable unfiltered peak-to-peak pulsation level, as a percentage of average absolute line pressure at the compressor cylinder flange [%]

para 7.9.4.2.5.3.1

$$\Delta p = \frac{1,67 \cdot (R - 1)}{R}$$

$$\Delta p \leq 0,25 \%$$

Please refer to comment on page 5/9. this is clause 7.9.4.2.5.2.1. Is it required for approach 1?

Δp = maximum pressure drop based on steady flow through a pulsation suppression device, as a percentage of the average absolute line pressure at the inlet of the device [%]

R = stage pressure ratio at cylinder flanges (= quotient of absolute discharge and suction pressures)

para 7.9.2

please correct this. gas is specified in purchasr datasheet.

The gas composition at 1st year summer is considered as the basis of this calculation. No other gas compositions are considered. During sizing of the compressors all 6 scenarios have been calculated, and differences are negligible.

para 7.9.4.2.5.2.2.1

$$P_l = \frac{4,1}{(P_L)^{1/3}}$$

P_l = maximum allowable peak-to-peak pulsation level at any discrete frequency, as a percentage of average absolute pressure [%]

P_L = average absolute line pressure [bar(a)]

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Input

		stage 1	stage 2	
K	isentropic compression exponent	0,9991	0,9982	
T_s	abs. suction temperature	313,15	313,15	K
M	molecular weight	28,959	28,959	
PD	total net displaced volume per revolution	2,259 E-3 [note 1]	8,451 E-4 [note 2]	m^3
R	stage pressure ratio	2,453	1,357	
P_L	avg abs. line pressure	17,368	26,250	kg/cm ² (a)

Compressor stage data

	1 st stage	2 nd stage	Unit
Suction pressure	9,5	22,1	Bar
Discharge pressure	23,3	30	Bar
Pressure ratio	2,453	1,357	
Suction temperature	313,15	313,15	K

[note 1]
1st stage

stroke 130 mm
cyl bore 55 mm
rod dia 30 mm
Single acting

$$PD = \frac{1}{4} \pi (0,055)^2 - (0,030)^2 \cdot 0,13 = 2,259 \cdot 10^{-3} m^3$$

[note 2]
2nd stage

stroke 130 mm
cyl bore 35 mm
rod dia 30 mm
Single acting

$$PD = \frac{1}{4} \pi (0,035)^2 - (0,030)^2 \cdot 0,13 = 8,451 \cdot 10^{-4} m^3$$

Please recheck this value (in last revision of dsh, another value is mentioned)

Please recheck the formula. It seems since compressor is single acting, the cylinder bore area should be multiplied by stroke (Not subtracting the rod area), please refer to attachment.

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Output

para 7.9.3.2

1st stage

$$V_s = 8,1 \cdot 2,459 \cdot 10^{-3} \cdot \left(\frac{0,9991 \cdot 313,15}{28,959} \right)^{1/4} = 0,033 \text{ m}^3 = 33 \text{ dm}^3$$

$$V_d = 1,6 \cdot \left(\frac{0,033}{(2,453)^{1/0,9991}} \right) = 0,022 \text{ m}^3 = 22 \text{ dm}^3$$

Some of the following 3 equations are not true, hence calculated sizes are not acceptable. Sizes are too small for API 618, minimum sizes of 0,03 m³ must be used.

$$V_s \geq V_d \text{ True}$$

$$V_s \geq 0,03 \text{ m}^3 \text{ True}$$

$$V_d \geq 0,03 \text{ m}^3 \text{ not true! } V_d = 0,022 \text{ m}^3, \text{ according to API 618} \rightarrow V_d = 0,03 \text{ m}^3.$$

2nd stage

$$V_s = 8,1 \cdot 8,451 \cdot 10^{-4} \cdot \left(\frac{0,9982 \cdot 313,15}{28,959} \right)^{1/4} = 0,012408 \text{ m}^3 = 12,4 \text{ dm}^3$$

$$V_d = 1,6 \cdot \left(\frac{0,012408}{(1,357)^{1/0,9982}} \right) = 0,014617 \text{ m}^3 = 14,6 \text{ dm}^3$$

Some of the following 3 equations are not true, hence calculated sizes are not acceptable. Sizes are too small for API 618, minimum sizes of 0,03 m³ must be used.

$$V_s \geq V_d \text{ Not True, so } V_s = 0,03 \text{ m}^3$$

$$V_s \geq 0,03 \text{ m}^3 \text{ Not True, so } V_s = 0,03 \text{ m}^3$$

$$V_d \geq 0,03 \text{ m}^3 \text{ Not True, so } V_d = 0,03 \text{ m}^3$$

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summary

	1 st stage	2 nd stage	
V_s	33,0	12,4	dm ³
V_d	22,0	14,6	dm ³

Sizes are too small for API 618, minimum sizes of 0,03 m³ (30 dm³) must be used. Therefore the final volume is equal to 0,03 m³.

therefore the final volumes are:
First stage suction: 33
first stage discharge: 30
second stage suction: 30
second stage discharge: 30

para 7.9.4.2.5.2

1st stage

$$P_{cf} = 3 \cdot 2,453 = 7,359 \%$$

7,359 % is slightly more, but acceptable according to 7.9.4.2.5.2.1, since pulsation is bigger as per API 618, minimum size of 0,03m³.

What we understand from API clause is that P_{cf} shall be less than minimum (3R , 7). It means P_{cf} shall be compared with these values as acceptance criteria not these values with each other as acceptance criteria. In other words: vendor assumed below: if 3R > 7 not accepted if 3R < 7 accepted. However, this clause mentions that it is accepted when P_{cf} < minimum (3R , 7). Please also note that we understand from CL 7.9.4.2.2 is that for approach 1, the criteria of 7.9.4.2.5.2.2.1 and 7.9.4.2.5.3.1 shall be met and 7.9.4.2.5.2.1 is not mentioned for approach 1. (It means that in CL. 7.9.4.5.2 procedure No. 1 only the criteria of 7.9.4.2.5.2.2.1 and 7.9.4.2.5.3.1 is mentioned not this)

2nd stage

$$P_{cf} = 3 \cdot 1,357 = 4,071 \%$$

4,071 % is less than 7%, therefor accepted.

para 7.9.4.2.5.3.1

1st stage

$$\Delta p = 1,67 \left(\frac{2,453 - 1}{2,453} \right) = 0,989 \%$$

0,989 % of 23,3 bar discharge pressure is 0,23 bar, which is below the required 0,25 bar.

2nd stage

$$\Delta p = 1,67 \left(\frac{1,357 - 1}{1,357} \right) = 0,439 \%$$

0,439 % of 30 bar discharge pressure is 0,13 bar, which is below the required 0,25 bar.

What we understand from API clause of 7.9.4.2.5.3.1 is that "delta P" shall be less than the maximum of (0,25 , 1.67(R-1)/R) And delpap is the maximum pressure drop as a percentage of mean absolute line pressure. (It means 0.25 is not bar , it is a criteria for delta P as a percentage) In other words, what we understand is that delta_p shall be calculated and then to be compared with the criteria of 7.9.4.2.5.3.1 (in other words, the maximum of (0.25 , 1.67(R-1)/R)

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para 7.9.4.2.5.2.2.1

Maximum allowable peak-to-peak pulsation level at any discrete frequency, expressed as a percentage of average mean absolute pressure.

1st stage suction

$$P_l = \frac{4,1}{(9,500)^{1/3}} = 1,936 \%$$

1st stage discharge

$$P_l = \frac{4,1}{(17,368)^{1/3}} = 1,583 \%$$

2nd stage suction

$$P_l = \frac{4,1}{(22,100)^{1/3}} = 1,461 \%$$

2nd stage discharge

$$P_l = \frac{4,1}{(26,250)^{1/3}} = 1,380 \%$$

Please refer to
7.9.4.2.5.2 item 1. it mentions that pressure drop across the pulsation suppression device shall be calculated and to be compared with this criteria