



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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05	02-08-2024	Issued for Information	S.K.	J.J.	S.K.
04	15-07-2024	Issued for Information	K.P.	J.J.	S.K.
03	20-06-2024	Issued for Information	S.K.	J.J.	S.K.
02	13-12-2023	Issued for Information	S.K.	J.J.	S.K.
01	14-09-2023	Issued for Information	S.K.	J.J.	S.K.
REV.	DATE	DESCRIPTION	DRAWN	CHECKED	APPROVED

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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

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

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

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

The gas composition, specified in the purchaser datasheet is considered as the basis of this calculation.

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	1,4	1,4	
T_s	abs. suction temperature	319,15	333,15	K
M	molecular weight	28,959	28,959	
PD	total net displaced volume per revolution	2,376 E-3 [note 1]	9,621 E-4 [note 2]	m ³
R	stage pressure ratio	2,314	1,342	
P_L	avg abs. line pressure	17,032	25,742	Bar(a)

Compressor stage data

	1 st stage	2 nd stage	Unit
Suction pressure	10,5	23,1	Bar(a)
Discharge pressure	24,3	31	Bar(a)
Pressure ratio	2,314	1,342	
Suction temperature	319,15	333,15	K

[note 1]

1st stage

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

$$PD = \frac{1}{4} \pi (0,055)^2 \cdot 0,13 = 2,376 \cdot 10^{-3} m^3$$

[note 2]

2nd stage

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

$$PD = \frac{1}{4} \pi (0,035)^2 \cdot 0,13 = 9,621 \cdot 10^{-4} m^3$$

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Output

para 7.9.3.2

1st stage

$$V_s = 8,1 \cdot 2,376 \cdot 10^{-3} \cdot \left(\frac{1,4 \cdot 319,15}{28,959} \right)^{1/4} = 0,0381 \text{ m}^3 = 38,1 \text{ dm}^3$$

$$V_d = 1,6 \cdot \left(\frac{0,0381}{(2,314)^{1/1,4}} \right) = 0,0322 \text{ m}^3 = 32,2 \text{ dm}^3$$

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

$$V_s \geq 0,03 \text{ m}^3 \text{ True, so } V_s = 0,0381 \text{ m}^3$$

$$V_d \geq 0,03 \text{ m}^3 \text{ True, so } V_d = 0,0322 \text{ m}^3$$

2nd stage

$$V_s = 8,1 \cdot 9,621 \cdot 10^{-4} \cdot \left(\frac{1,4 \cdot 333,15}{28,959} \right)^{1/4} = 0,0156 \text{ m}^3 = 15,6 \text{ dm}^3$$

$$V_d = 1,6 \cdot \left(\frac{0,0156}{(1,342)^{1/1,4}} \right) = 0,0202 \text{ m}^3 = 20,2 \text{ dm}^3$$

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

Some sizes are too small for API 618, minimum sizes of 0,03 m³ (30 dm³) must be used. Therefore the final minimum suction and discharge volumes are as per below.

	1 st stage	2 nd stage	
V_s	38,1	30,0	dm ³
V_d	32,2	30,0	dm ³

para 7.9.4.2.5.2.1

1st stage

$$P_{cf} = 3 \cdot 2,314 = 6.942 \%$$

According to para 7.9.4.2.5.2.1 the cylinder flange pressure pulsation P_{cf} shall be limited at the lesser of 7% or the value from the above equation.

6.942 % is less than 7%, therefore the pulsation have to be lower than 6.942%, this is acceptable as per compressor information

2nd stage

$$P_{cf} = 3 \cdot 1,342 = 4,026 \%$$

According to para 7.9.4.2.5.2.1 the cylinder flange pressure pulsation P_{cf} shall be limited at the lesser of 7% or the value from the above equation.

4.026 % is less than 7%, therefore the pulsation have to be lower then 4.026%, this is acceptable as per compressor information

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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 higher than the calculated differential pressure across the pulsation dampeners. (0.12bar)

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 higher than the calculated differential pressure across the pulsation dampeners. (0.08bar)

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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

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

Maximum allowable peak to peak is 1,936 % is 0.45bar. The calculated peak to peak is significantly lower due to pulsation dampers

1st stage discharge

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

Maximum allowable peak to peak is 1,583 % is 0.37bar. The calculated peak to peak is significantly lower due to pulsation dampers

2nd stage suction

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

Maximum allowable peak to peak is 1,461 % is 0.44bar. The calculated peak to peak is significantly lower due to pulsation dampers

2nd stage discharge

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

Maximum allowable peak to peak is 1,380 % is 0.41bar. The calculated peak to peak is significantly lower due to pulsation dampers