	LIDCO, Pars SEE Zone, Assaluyeh, Integrated Methanol and Ammonia Plant 3000 MTPD MeOH / 900 MTPD NH3 PROJECT						
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Pulsation Study Approach 1 Calculations

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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 7.9.4.2.5.2.2.1as 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.

para 7.9.3.2

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

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

$$V_s \geq V_d$$

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

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

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

V_s	=	minimum required suction surge volume [m^3]
V_d	=	minimum required discharge surge volume [m^3]
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

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 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)]

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

	1st stage	2nd 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

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

Output

para 7.9.3.2

1st stage

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

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

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 m^3 must be used.

$V_s \geq V_d$ True

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

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

2nd stage

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

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

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 m^3 must be used.

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

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

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

summary

	1st stage	2nd 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 m^3 (30 dm^3) must be used. Therefor the final volume is equal to 0,03 m^3.

para 7.9.4.2.5.2

1^{st} 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 dampener will be sized bigger as per API 618, minimum size of 0,03m^3.

2^{nd} 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

1^{st} 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.

2^{nd} 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.

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

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