



**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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### 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  $180 \text{ N/mm}^2$ , 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 [m<sup>3</sup>]  
 $V_d$  = minimum required discharge surge volume [m<sup>3</sup>]  
 $K$  = 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

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

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

$\Delta p$  = 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 1<sup>st</sup> 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	11,888	110,306	kg/cm <sup>2</sup> (a)

[note 1]

1<sup>st</sup> 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]

2<sup>nd</sup> stage

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

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

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**Output**

**para 7.9.3.2**

**1<sup>st</sup> 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 m<sup>3</sup> must be used.

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

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

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

**2<sup>nd</sup> 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 m<sup>3</sup> 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 <sup>st</sup> stage	2 <sup>nd</sup> stage	
$V_s$	33,0	12,4	dm <sup>3</sup>
$V_d$	22,0	14,6	dm <sup>3</sup>

Sizes are too small for API 618, minimum sizes of 0,03 m<sup>3</sup> (30 dm<sup>3</sup>) must be used.

para 7.9.4.2.5.2

1<sup>st</sup> stage

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

2<sup>nd</sup> stage

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

para 7.9.4.2.5.3.1

1<sup>st</sup> stage

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

2<sup>nd</sup> stage

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

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para 7.9.4.2.5.2.2.1  
1<sup>st</sup> stage suction

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

1<sup>st</sup> stage discharge

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

2<sup>nd</sup> stage suction

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

2<sup>nd</sup> stage discharge

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