code-3
M. Vakili

REV.	DATE	DESCRIPTION	DRAWN	CHECKED	APPROVED
01	14-09-2023	Issued for Information	S.K.	J.J.	S.K.

LIST OF REVISED PAGES

Rev. / Page	01	02	03	04	05	Rev. / Page	01	02	03	04	05	Rev. / Page	01	02	03	04	05	Rev. / Page	01	02	03	04	05
1	X					**26**						**51**						**76**					
2	X					**27**						**52**						**77**					
3	X					**28**						**53**						**78**					
4	X					**29**						**54**						**79**					
5	X					**30**						**55**						**80**					
6	X					**31**						**56**						**81**					
7	X					**32**						**57**						**82**					
8	X					**33**						**58**						**83**					
9	X					**34**						**59**						**84**					
10						**35**						**60**						**85**					
11						**36**						**61**						**86**					
12						**37**						**62**						**87**					
13						**38**						**63**						**88**					
14						**39**						**64**						**89**					
15						**40**						**65**						**90**					
16						**41**						**66**						**91**					
17						**42**						**67**						**92**					
18						**43**						**68**						**ATTACHMENT**					
19						**44**						**69**						**1**					
20						**45**						**70**						**2**					
21						**46**						**71**						**3**					
22						**47**						**72**						**4**					
23						**48**						**73**						**5**					
24						**49**						**74**						**6**					
25						**50**						**75**						**7**					

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)]

these values will be checked with datasheet

Input

		stage 1	stage 2	
K	isentropic compressio	0,9991	0,9982	
T_s	abs. suction temperatu	313,15	313,15	K
M	molecular weight	28,959	28,959	
PD	total net displaced volu	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	$kg/cm^2(a)$

please report this value for suction/ discharge of both stages (4 values are required as used in page 9/9)

[note 1]

to be clarified.

Please recheck this.

1st stage

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

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

please clarify why rod section area is subtracted. (vendor stated it is single act and it seems cylinder section area should be multiplied by stroke(

[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	dm³
V_d	22,0	14,6	dm³

therefore please mention the final volume are queal to 0.03m3

Sizes are too small for API 618, minimum sizes of 0,03 m³ (30 dm³) must be used.
para 7.9.4.2.5.2
1st stage

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

2nd stage

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

please clarify how it can be concluded that maximum allowable pulsation level at the compressor cylinder flange is below the calculated values (or 7%). (How it can be concluded that 7.9.4.2.5.2 is followed?)

para 7.9.4.2.5.3.1

1st stage

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

2nd stage

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

please clarify how it can be concluded that maximum pressure drop at the inlet of the device is below of 0.25? (How it can be concluded that 7.9.4.2.5.3.1 is followed?)

please clarify how it can be concluded that pulsation level at the line side of the pulsation device is below the calculated values. (How it can be concluded that 7.9.4.2.5.2.2.1 is followed?)

para 7.9.4.2.5.2.2.1
1st stage suction

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

1st stage discharge

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

please recheck this value (operating pressure in P&ID is 23.3 for first stage discharge)

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 recheck this value (operating pressure in P&ID is 30barg for second stage discharge)