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Anlage	**TBD**
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Titel	CRITERIA FOR SIZING VENT SYSTEM KRITERIEN FÜR DIE GRÖSSE DES ENTLÜFTUNGSSYSTEMS
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bioplusLNG

SIAD MACCHINE IMPIANTI

OGE

Proj.-Nr.	DG-001115

Renzenhof

Dokumentenbenennung

CRITERIA FOR SIZING VENT SYSTEM
KRITERIEN FÜR DIE GRÖSSE DES ENTLÜFTUNGSSYSTEMS

Schutzvermerk ISO 16016 beachten	Maßstab 1/
	/

F-Tech.	Standortkurzname	A-Art	Anl-Nr.	Anl-Teil	D-Art	Lfd-Nr.	Blatt	Änd.
520	REZH	730	001	001	USP	001	01+	0A

Ursprung:	Ers. f.:	Ers. d.
GTS19/854 Rev.0A		

CRITERIA FOR SIZING OF VENT SYSTEM

FOR LIQUEFIER SMART TB-LNG 140 TPD

REV. Rev.	DATA Date	DESCRIZIONE Description	COMPILATO Compiled	APPROVATO Approved
0A	22/05/2023	First issue	Zetti	Antonelli

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1 INTRODUCTION

This document covers:

1 – information related to the flow rate of the safety valves for thermal expansion of gas or evaporation of liquid in case of fire. The sizing of the safety valves orifice is not the subject of this document.

2 – definition of the flow rates vented in the various design cases.

The API 521 code is used for the definition of the discharge flow rates of the safety valves.

The reference documents are:

- Document No. I 20784 – 520REZH700001000SRI002 – Piping & Instrumentation Diagram
- Document No. 2220698-00-10-001/EST105701 – 520REZH598004003SRI001 – NG Treatment unit - Piping & Instrumentation Diagram

2 DISCHARGE FLOW RATE DEFINITION OF SAFETY VALVES FOR FIRE CASE

The discharge flow rates of the safety valves calculated for thermal expansion due to fire in the various sections of the plant are listed below.

<u>plant inlet and liquefier section</u>

PSV603 – 746 Nm3/h – 607 kg/h
PSV605 – 296 Nm3/h – 241 kg/h
PSV704 – 667 Nm3/h – 536 kg/h
PSV705 – 19 Nm3/h – 15 kg/h
PSV707 – 20 Nm3/h – 16 kg/h
PSV721 – 5 Nm3/h – 3 kg/h
PSV720 – 213 Nm3/h – 171 kg/h
PSV716 – 213 Nm3/h – 171 kg/h
Total flow rate: 2179 Nm3/h equal to 1760 kg/h with average M.W. of 18,1 kg/kmole

<u>Regeneration gas and Boil-Off Gas section</u>

PSV529 – 23 Nm3/h – 21 kg/h
PSV526 – 23 Nm3/h – 19 kg/h
PSV530 – 174 Nm3/h – 140 kg/h
PSV501 – 81 Nm3/h – 65 kg/h
PSV502 – 81 Nm3/h – 65 kg/h
PSV503 – 81 Nm3/h – 65 kg/h
PSV507 – 15 Nm3/h – 12 kg/h
PSV905 – 92 Nm3/h – 94 kg/h
PSV914 – 234 Nm3/h – 179 kg/h (note 1)
PSV915 – 242 Nm3/h – 248 kg/h
PSV913 – 152 Nm3/h – 155 kg/h
PSV901 – 81 Nm3/h – 65 kg/h

PSV902 – 81 Nm3/h – 65 kg/h
PSV903 – 81 Nm3/h – 65 kg/h
PSV907 – 15 Nm3/h – 12 kg/h
Total flow rate: 1456 Nm3/h equal to 1270 kg/h with average M.W. of 19,55 kg/kmole.

Note 1: the cold box zone and EW9000 heater surfaces are considered; the KO drum zone is not considered because located in a separate area and with a smaller surface.
Note 2: PSV1608 (on hot flare header) not considered because the hot flare is in a separate area.

Gas treatment section

PSV144 – 270 Nm3/h – 217 kg/h
PSV135 – 45 Nm3/h – 37 kg/h
PSV103 – 106 Nm3/h – 87 kg/h
PSV167 – 1204 Nm3/h – 967 kg/h
PSV129 – 1478 Nm3/h – 1187 kg/h
PSV117 – 747 Nm3/h – 618 kg/h
PSV489 – 997 Nm3/h – 801 kg/h
PSV422 – 405 Nm3/h – 326 kg/h
PSV436 – 997 Nm3/h – 801 kg/h
PSV437 – 997 Nm3/h – 801 kg/h
PSV451 – 114 Nm3/h – 92 kg/h
PSV465 – 155 Nm3/h – 124 kg/h
PSV482 – 191 Nm3/h – 153 kg/h
PSV478 – 248 Nm3/h – 199 kg/h
PSV484 – 51 Nm3/h – 41 kg/h
PSV419 – 358 Nm3/h – 288 kg/h
PSV421 – 127 Nm3/h – 102 kg/h
Total flow rate: 8490 Nm3/h equal to 6841 kg/h with average M.W. of 18,06 kg/kmole.

Storage and truck loading section

PSV1905A – 198 Nm3/h – 159 kg/h
PSV1907 – 12 Nm3/h – 13 kg/h
PSV1906 – 500 Nm3/h – 402 kg/h
PSV1904A – 87 Nm3/h – 70 kg/h
PSV1901A – 237 Nm3/h – 190 kg/h
PSV1AA – 1307 Nm3/h – 1051 kg/h (Note 1)
PSV8A – 3 Nm3/h – 2 kg/h
PSV1905B – 198 Nm3/h – 159 kg/h
PSV1904B – 87 Nm3/h – 70 kg/h
PSV1901B – 237 Nm3/h – 190 kg/h
PSV1BB – 1307 Nm3/h – 1051 kg/h (Note 1)

PSV8B – 3 Nm3/h – 2 kg/h
PSV1930A – 237 Nm3/h – 190 kg/h
PSV1932A – 69 Nm3/h – 56 kg/h
PSV1933A – 13 Nm3/h – 10 kg/h (Note 2)
PSV1940A – 69 Nm3/h – 56 kg/h
PSV1938A – 119 Nm3/h – 96 kg/h
PSV1930B – 237 Nm3/h – 190 kg/h
PSV1932B – 69 Nm3/h – 56 kg/h
PSV1933B – 13 Nm3/h – 10 kg/h (Note 2)
PSV1940B – 69 Nm3/h – 56 kg/h
PSV1938B – 119 Nm3/h – 96 kg/h
PSV1955A – 76 Nm3/h – 78 kg/h
PSV1956A – 119 Nm3/h – 96 kg/h
PSV1957A – 5 Nm3/h – 5 kg/h
PSV1958A – 5 Nm3/h – 5 kg/h
PSV1959A – 5 Nm3/h – 5 kg/h
PSV1954A – 74 Nm3/h – 76 kg/h
PSV1961A – 195 Nm3/h – 157 kg/h
PSV1950A – 119 Nm3/h – 96 kg/h
PSV1951A – 119 Nm3/h – 96 kg/h
PSV1952A – 119 Nm3/h – 96 kg/h
PSV1960A – 119 Nm3/h – 96 kg/h
PSV1977A – 8 Nm3/h – 9 kg/h
PSV1955B – 76 Nm3/h – 78 kg/h
PSV1956B – 119 Nm3/h – 96 kg/h
PSV1957B – 5 Nm3/h – 5 kg/h
PSV1958B – 5 Nm3/h – 5 kg/h
PSV1959B – 5 Nm3/h – 5 kg/h
PSV1954B – 74 Nm3/h – 76 kg/h
PSV1961B – 195 Nm3/h – 157 kg/h
PSV1950B – 119 Nm3/h – 96 kg/h
PSV1951B – 119 Nm3/h – 96 kg/h
PSV1952B – 119 Nm3/h – 96 kg/h
PSV1960B – 119 Nm3/h – 96 kg/h
PSV1977B – 8 Nm3/h – 9 kg/h
Total flow rate: 7116 Nm3/h equal to 5805 kg/h with average M.W. of 18,28 kg/kmole.

Note 1: only 1 PSV of LNG tanks is considered because each valve is designed for full capacity.

Note 2: only 1 PSV of LNG pumps is considered because each valve is designed for full capacity.

3 VENT FLOW RATE DEFINITION

For the definition of the flow rates to be vented, the following design cases were considered:
CASE 1: emergency condition due to fire in the production section
CASE 2: emergency plant shutdown
CASE 3: emergency vent from HV715 valve
CASE 4: emergency vent from PSV530 safety valve
CASE 5: emergency condition due to fire in the storage section
For each case, the calculation of the vent flow rate is described below.

CASE 1: emergency condition due to fire in the production section

The flow rate discharged in this condition is generated by all the safety valves discharge in the gas treatment + liquefaction + regeneration gas Boil-Off Gas management zone considering both the gas expansion and the vaporization of the LNG liquid due to the fire. The safety valves of the storage area (LNG tanks and loading bays) are not considered since the production area and the storage area are considered independent and not subject to a domino effect.

Based on what is indicated in the previous chapter 2, the vent flow rate for this case is the sum of the following flow rates:
Plant inlet section and liquefier: 1760 kg/h with average M.W. 18.1 kg/kmole
Regeneration gas section and Boil-Off Gas: 1270 kg/h with average M.W. 19.55 kg/kmole
Gas treatment section: 8490 Nm3/h equal to 6841 kg/h with average M.W. 18.06 kg/kmol

The total flow rate is therefore 9871 kg/h with average M.W. 18.26 kg/kmole at a temperature of +178 °C. The temperature is calculated on the basis of the temperature increase resulting from the pressure increase for the high pressure process circuit from the operating value up to the set value of the safety valves.

CASE 2: emergency plant shutdown

The vented flow rate in this condition is generated by the discharge of the LNG present in the cold box and of the natural gas present in the cold box and in the gas treatment plant (dryer section and absorption section) during emergency depressurization.

The discharge flow rate is calculated considering the depressurization sequence described below.

CASE 2.1: first step - drain of the LNG present in the cold box from the HV711 drain valve

- Volume of liquid present in the cold box: 0,88 m3
- Mass of liquid to be drained: 415 kg (density 471 kg/m3)
- Liquid pressure upstream the drain valve: 3 bara (liquid head included)
- Liquid pressure downstream the drain valves: 2 bara (discharge back pressure)
- Temperature: -159 / -166 °C

- Required time for drain: 2,5 minutes

To discharge the mass in 2,5 minutes the discharge flow rate is 415*60/2,5 = 9960 kg/h

The attachment 1 – case 1 shows the calculation of the HV711 valve

CASE 2.2: second step - depressurization in parallel of the liquefier section, the dryer section and the absorption section

A - Liquefier section depressurization

Depressurization always takes place by venting the gas from the HV711 valve

- Volume of gas to be vented: 1 m3 at a pressure of 43.5 bar upstream of the PV703 valve
- Depressurisation end pressure: 6 bara; at this pressure the introduction of nitrogen begins
- Gas temperature for mass calculation: 10°C, corresponding to the gas temperature upstream of the liquefier exchanger
- Pressure upstream of the HV711 valve (and downstream of the PV703 valve): is kept at 4 bara as the control of the PV703 valve is switched to the controller PIC715C
- Pressure downstream of the HV711 valve: 2 bara
- Temperature of the discharged gas: -134°C (the gas cools down as it passes through the liquefaction exchanger up to this temperature)
- Quantity of gas to be vented during depressurization from 43.5 bara to 6 bara: 1 x (43,5-6) x (273/283) x (18.03/22,414) = 29,1 kg

The following conditions shall be verified:

a – the PV703 valve can discharge the mass within an acceptable time frame (not exceeding 10 minutes).

b – the PV703 and HV711 valves can discharge the mass in the 1st minute in order to reduce the pressure to 33 bara.

a – check that the PV703 valve can discharge the mass within an acceptable time frame to reduce the pressure from 43.5 bara to 6 bara

- The gas flow rate that the HV711 valve can discharge when 100% opened is 2900 kg/h (see attachment 2 – case 2)
- The PV703 valve, 100% opened, can discharge 2803 kg/h, value given by interpolation between the flow rate of 2900 kg/h with an inlet pressure of 45 bara (attachment 4 - case 1) and 2575 kg/h with inlet pressure of 40 bara (attachment 7 – case 3)
- The reduction of flow rate discharged by the PV703 valve 100% opened as the inlet pressure decreases is indicated below:
  inlet pressure 45 bara: 2900 kg/h attachment 4 – case 1)
  inlet pressure 40 bara: 2575 kg/h attachment 7 – case 3)
  inlet pressure 35 bara: 2250 kg/h attachment 7 – case 1)
  inlet pressure 30 bara: 1927 kg/h attachment 6 – case 3)
  inlet pressure 25 bara: 1605 kg/h attachment 6 – case 2)
  inlet pressure 20 bara: 1285 kg/h attachment 6 – case 1)

inlet pressure 15 bara: 965 kg/h attachment 5 – case 3)
inlet pressure 10 bara: 630 kg/h attachment 5 – case 2)
inlet pressure 6 bara: 326 kg/h attachment 5 – case 1)

- Interpolating between the above values, the flow rate calculated as the inlet pressure to the PV703 valve decreases by every 1 bar is equal to: 1 m3 x (1) bar x (273/283) x (18,03/22,414) = 0,776 kg/bar. With this value the time corresponding to each pressure reduction of 1 bar is then calculated. Attachment 9 shows the calculation of the time required to reduce the pressure from 43,5 bar to 6 bar. As a demonstration, the calculation of the first pressure reduction step from 43,5 to 42 bara (Deltap=1,5 bar) is shown below:
  (0,776 kg/bar x 1,5 bar) /((2803 kg/h + 2705 kg/h)/2) x 60 min/h = 0,025 min.
  The time required to depressurize the liquefier section up to 6 bara is 1,5 minutes.
- Therefore the total time for LNG drainage and liquefier section depressurization is 4 minutes.

<u>b – check that the PV703 and HV711 valves can discharge the mass in the 1st minute in order to reduce the pressure from 43,5 to 33 bara</u>

- The mass to be discharged in the 1st minute is 1m3 x (43,5-33) bara x (273/283) x (18.03/22.414) x 60 min/h= 525 kg/h.

From attachment 2 - case 1 it is verified that the HV711 valve can discharge this flow rate.
From attachment 4 - case 3 it is verified that the PV703 valve can discharge this flow rate of 525 kg/h even at the minimum pressure of 33 bara with opening less than 100%.

<u>B - Depressurization of the dryer section</u>

Depressurization takes place by venting the gas from the HV705 valve (ON_OFF ball valve) and limiting the flow with the FO708 orifice.

- Volume of gas to be vented: 3,5 m3 starting from a pressure of 44 bara and considering 2 pressurized dryer vessels: worst case condition with one vessel in operation and one vessel at the beginning of depressurization.

- Depressurisation end pressure: 6 bara; at this pressure the introduction of nitrogen begins.

- Pressure downstream of the orifice: 2 bara

- Average temperature of the gas to be vented: 20°C

- Quantity of gas to be vented: 3,5 m3 x (44-6) bara x (273/293) x (18,06/22,414) = 100 kg

With the 15,5 mm orifice diameter, 6 bara are reached after 260 seconds (4 minutes and 20 sec) and the flow rate at the beginning (maximum flow rate) is equal to 0,94 kg/sec (3384 kg/h).

Furthermore, the 33 barA are reached after 38 sec. (less than 1 minute).

Attachment 10 shows the calculation of the depressurization.

Note: if only one vessel has to be depressurised (the vessel in operation) the volume is 2,2 m3 instead of 3,5 m3 and the pressure of 6 bara is reached after 160 seconds and the pressure of 33 bara after 22 seconds.

<u>C - Absorption section depressurization</u>

Depressurization takes place by venting the gas from the HV764 valve (ON_OFF ball valve) and limiting the flow rate with the RO169 orifice.

- Volume of gas to be vented: 7,2 m3 starting from a pressure of 44 bara
- Depressurisation end pressure: 6 bara; at this pressure the introduction of nitrogen begins
- Pressure downstream of the orifice: 2 bara
- Average temperature of the gas to be vented: 40°C
- Quantity of gas to be vented: 7,2 m3 x (44-6) bara x (273/313) x (18,06/22,414) = 192 kg

With the 17.3 mm orifice diameter, 6 bara are reached after 405 seconds (6 minutes and 45 sec.) and the flow rate at the beginning (maximum flow rate) is equal to 1,123 kg/sec (4043 kg/h).

Furthermore, 33 bara are reached after 60 sec (1 minute)

Attachment 11 shows the calculation of the depressurization

In summary, the vent conditions for emergency depressurization are:

- Capacity: 2900 + 3384 + 4043 = 10327 kg/h

- Temperature: (2900x(-134)+3384x20+4043x40)/10327 = -15.1°C

- Molecular weight: 2900x18,03+3384x18,06+4043x18,06)/10327 = 18,05 kg/kmole

CASE 3: emergency vent from HV715 valve

The emergency condition considered in this case is the one corresponding to the failure of the J/T PV703 valve fully opened and in the conservative hypothesis that the liquefaction exchanger can liquefy and subcool the entire flow rate (condition of maximum flowing mass). The HV715 valve with HIC715 controller set at 5 barg protects the system from opening of the safety valve PSV705 set at 5 barg. Attachment 8 - case 2 shows the calculation sheet of the PV703 valve 100% open with the fluid at operating conditions:

- inlet pressure 43,15 bara
- outlet pressure 5 bar
- inlet temperature -168 / -159 °C
- liquid density: 457,97 kg/h

The maximum flow rate is 10900 kg/h.

Attachment 3 - case 1 shows the calculation sheet for the HV715 valve venting such flow rate with an inlet pressure of 5 bara and an outlet pressure of 2 bara.

CASE 4: emergency vent from PSV530 safety valve

The emergency condition considered in this case is the one corresponding to the spurious opening of the regeneration valve of the absorber vessel in operation.

The flow rate discharged from the spurious opening of the regeneration valve in operation is limited by the calibrated orifice FO530 and is equal to 6717 kg/h (1,866 kg/sec) at a temperature of 20°C.

This flow rate is obtained by sizing the diameter of the FO530 orifice based on the maximum acceptable pressure drop of 0,3 bar with the nominal regeneration flow rate. The PSV530 is in any case sized to discharge the entire flow rate of 6717 kg/h.

Attachment 12 shows the calculation of the FO530 orifice.

CASE 5: emergency condition due to fire in the storage section

The vented flow rate in this condition is generated by the discharge of all the safety valves of the storage and tank loading area considering both the gas expansion and the vaporization of the LNG liquid due to the fire.

Considering what is indicated in chapter 2, the flow rate at the vent in this case is 5805 kg/h with M.W. 18,28 kg/kmole and temperature -138,65 °C, equilibrium temperature of the evaporating LNG at a pressure of 6 bara (set pressure of the PSVs of the LNG tank which act first).

4 ATTACHMENT

Attachment 1: HV711 valve calculation sheet – case 1

Attachment 2: HV711 valve calculation sheet – case 1 and case 2

Attachment 3: HV715 valve calculation sheet – case 1

Attachment 4: PV703 valve calculation sheet – case 1 and case 3

Attachment 5: PV703 valve calculation sheet – case 1, case 2 and case 3

Attachment 6: PV703 valve calculation sheet – case 1, case 2 and case 3

Attachment 7: PV703 valve calculation sheet – case 1 and case 3

Attachment 8: PV703 valve calculation sheet – case 2

Attachment 9: Liquefier Depressurization Time Calculation Sheet

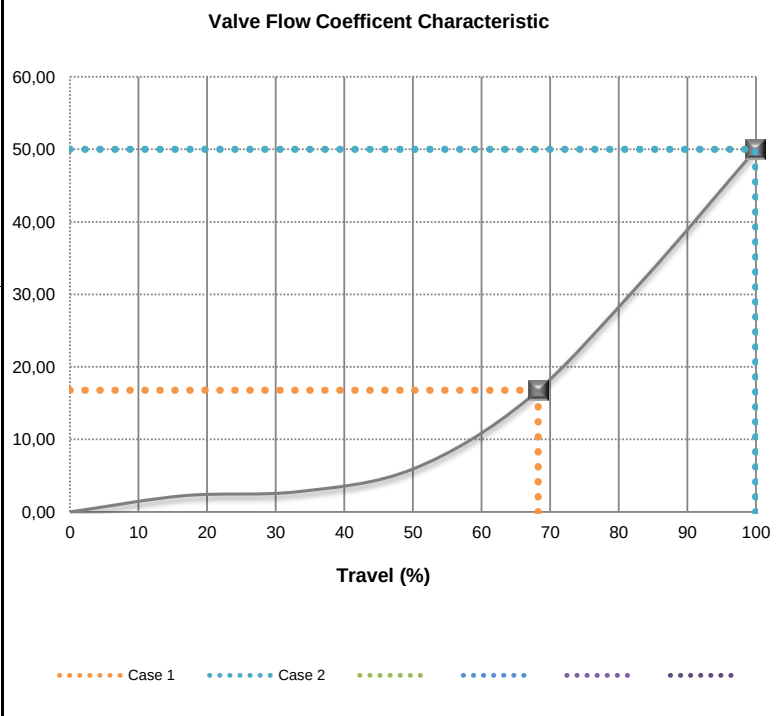
Attachment 10: FO708 orifice depressurization calculation spreadsheet

Attachment 11: RO169 orifice depressurization calculation spreadsheet

Attachment 12: FO530 orifice depressurization calculation spreadsheet

ATTACHMENT 1

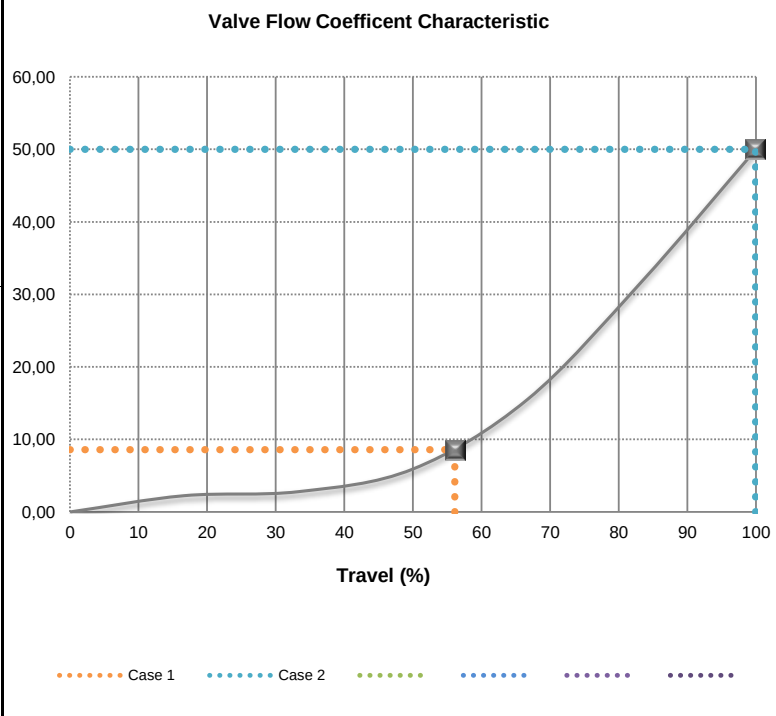
	OMC	**OMC Calculation Sheet**			Filled By			
					Date	18/05/2023		
						Vmech 3.9.5		
1	Quotation No.	Rev.			Project			
2	Customer				End User			
3	RFQ No.				Location			
4	**Item**	Item			PED (2014/68/CE) Category	B + C2		
5		Quantity	1		NACE	Not required		
6		Tag No.	**HV 711**		Piping diam. – Schedule	3" - Schedula 40		
7		Service			Min Ambient / Medium Temp.	20 C / 20 C		
8		Valve Type	Globe single seat		Design Press. / Temp.			
9		Medium / State	LNG		Liquid			
10	**Process Data**		Units	Case 1	Case 2			
11		Density	kg/m3	470,880				
12		Viscosity	cP	0,120				
13		Flow rate	kg/h	9960,000				
14		Inlet pressure	bar.a	3,000				
15		Outlet pressure	bar.a	2,000				
16		DP	bar.a	1,000				
17		Temperature	C	-166,530				
18	**Results and Factors**	Remarks						
19		Calculated	Cv	16,780				
20		Selected	Cv	50				
21		Travel	%	**68,3**				
22		SPL @ 1m	Db	**58,770**				
23		Velocity on intlet line	m/s	1,232				
24		Velocity on outlet line	m/s	1,232				
25	**Valve Model**	**KA10**	**KA12-15-2"-AP28-3/15**			**Valve Function**	**Control**	
26	**Body / Bonnet**	Inlet/Outlet Size	2"					
27		Inlet/Outlet conn.	ANSI 150 SW					
28		Body Material	ASME SA-351 CF8M					
29		Body Gasket	ARMED GRAPHITE					
30		Studs	ASME SA-193 B8M					
31		Nuts	ASME SA-194 GM					
32		Bonnet type	EXTENDED					
33		Bonnet Material	ASTM A182 F316					
34		Balancing System	Not Required					
35	**Trim**	Cv	50					
36		Seat Type	Threaded					
37		Seat material	ASTM A182 F316					
38		Seat size	49,0 mm					
39		Flow action	To Open					
40		Stem Material	VIRGIN PTFE					
41		Flow Divider	NO					
42		Flow Divider Material	-					
43		Plug Characteristic	EQP					
44		Plug (Mat.)	ASTM A182 F316					
45		Seal Type / Material	SOFT/VIRGIN PTFE					
46		Leakage Class	VI					
47		Leakage Standard	EN60534-4 / ANSI FCI					
48	**Packing**	Type	ECOPACK1					
49		Material	GRAPHITE					
50	**Actuator**	Actuator type	AP28					
51		Air failure	Open					
52		Stroke (mm)	20					
53		Actuator Signal (Psi)	3/15					
54		Shutoff pressure	-					
55		Spring case/Yoke	Carbon Steel					
56		Diaphragm material	NBR					
57		Handwheel	NO					
58		Spring Action	Normally open					
59	**Notes**							**Page 1/1**



Remarks

ATTACHMENT 2

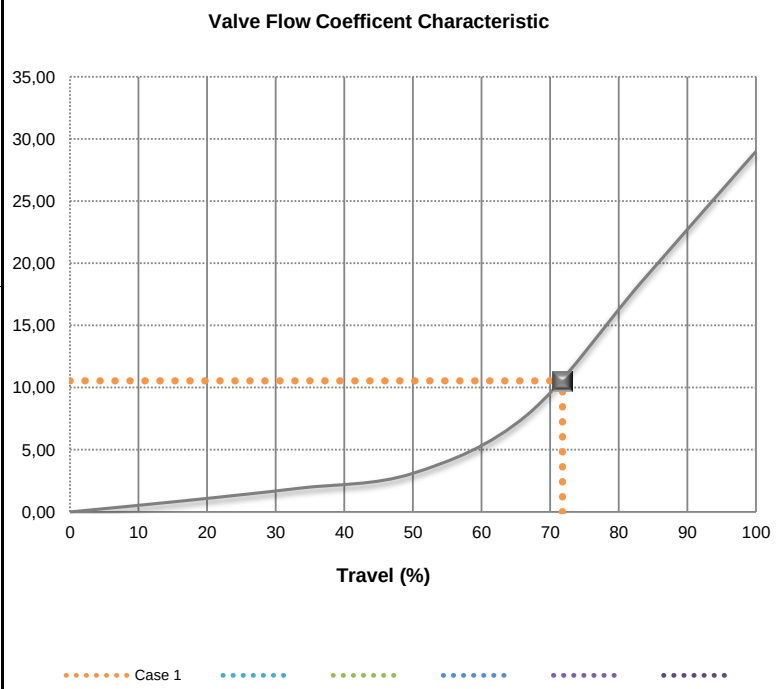
	OMC	**OMC Calculation Sheet**			Filled By			
					Date	18/05/2023		
						Vmech 3.9.5		
1	Quotation No.	Rev.			Project			
2	Customer				End User			
3	RFQ No.				Location			
4	**Item**	Item			PED (2014/68/CE) Category	B + C2		
5		Quantity	1		NACE	Not required		
6		Tag No.	**HV 711_**		Piping diam. – Schedule	3" - Schedula 40		
7		Service			Min Ambient / Medium Temp.	20 C / 20 C		
8		Valve Type	Globe single seat		Design Press. / Temp.			
9		Medium / State	LNG		Gas	Molecular weight	18,03	
10	**Process Data**		Units	Case 1	Case 2			
11		Density	kg/m3	4,420	4,420			
12		Viscosity	cP	0,001	0,001			
13		Flow rate	kg/h	525,000	2899,955			
14		Inlet pressure	bar.a	4,000	4,000			
15		Outlet pressure	bar.a	2,000	2,000			
16		DP	bar.a	2,000	2,000			
17		Temperature	C	-134,000	-134,000			
18	**Results and Factors**	Remarks						
19		Calculated	Cv	8,583	50,000			
20		Selected	Cv	50	50			
21		Travel	%	**56,1**	**100,0**			
22		SPL @ 1m	Db	**75,081**	**78,410**			
23		Velocity on intlet line	m/s	6,919	38,219			
24		Velocity on outlet line	m/s	9,812	54,199			
25	**Valve Model**	**KA10**	**KA12-15-2"-AP28-3/15**			**Valve Function**	**Control**	
26	**Body / Bonnet**	Inlet/Outlet Size	2"					
27		Inlet/Outlet conn.	ANSI 150 SW					
28		Body Material	ASME SA-351 CF8M					
29		Body Gasket	ARMED GRAPHITE					
30		Studs	ASME SA-193 B8M					
31		Nuts	ASME SA-194 GM					
32		Bonnet type	EXTENDED					
33		Bonnet Material	ASTM A182 F316					
34		Balancing System	Not Required					
35	**Trim**	Cv	50					
36		Seat Type	Threaded					
37		Seat material	ASTM A182 F316					
38		Seat size	49,0 mm					
39		Flow action	To Open					
40		Stem Material	VIRGIN PTFE					
41		Flow Divider	NO					
42		Flow Divider Material	-					
43		Plug Characteristic	EQP					
44		Plug (Mat.)	ASTM A182 F316					
45		Seal Type / Material	SOFT/VIRGIN PTFE					
46		Leakage Class	VI					
47		Leakage Standard	EN60534-4 / ANSI FCI					
48	**Packing**	Type	ECOPACK1					
49		Material	GRAPHITE					
50	**Actuator**	Actuator type	AP28					
51		Air failure	Open					
52		Stroke (mm)	20					
53		Actuator Signal (Psi)	3/15					
54		Shutoff pressure	-					
55		Spring case/Yoke	Carbon Steel					
56		Diaphragm material	NBR					
57		Handwheel	NO					
58		Spring Action	Normally open					
59	**Notes**							



Remarks

ATTACHMENT 3

	OMC	**OMC Calculation Sheet**			Filled By			
					Date	18/05/2023		
						Vmech 3.9.5		
1	Quotation No.	Rev.			Project			
2	Customer				End User			
3	RFQ No.				Location			
4	**Item**	Item	3		PED (2014/68/CE) Category	B + C2		
5		Quantity	1		NACE	Not required		
6		Tag No.	**HV 715**		Piping diam. – Schedule	3" - Schedula 40		
7		Service			Min Ambient / Medium Temp.	-25 C / -166,5 C		
8		Valve Type	Globe single seat		Design Press. / Temp.	9,013 bar.a / 9,013 C		
9		Medium / State	LNG		Liquid			
10	**Process Data**		Units	Case 1				
11		Density	kg/m3	475,970				
12		Viscosity	cP	0,120				
13		Flow rate	kg/h	10900,000				
14		Inlet pressure	bar.a	5,000				
15		Outlet pressure	bar.a	2,000				
16		DP	bar.a	3,000				
17		Temperature	C	-168,000				
18	**Results and Factors**	Remarks						
19		Calculated	Cv	10,545				
20		Selected	Cv	29				
21		Travel	%	**71,8**				
22		SPL @ 1m	Db	**66,929**				
23		Velocity on intlet line	m/s	1,334				
24		Velocity on outlet line	m/s	1,334				
25	**Valve Model**	**KA10**	**KA12-15-2"-AP34-15/60**		**Valve Function**	**Control**		
26	**Body / Bonnet**	Inlet/Outlet Size	2"					
27		Inlet/Outlet conn.	ANSI 150 SW					
28		Body Material	ASME SA-351 CF8M					
29		Body Gasket	ARMED GRAPHITE					
30		Studs	ASME SA-193 B8M					
31		Nuts	ASME SA-194 GM					
32		Bonnet type	EXTENDED					
33		Bonnet Material	ASTM A182 F316					
34		Balancing System	Not Required					
35	**Trim**	Cv	29					
36		Seat Type	Threaded					
37		Seat material	ASTM A182 F316					
38		Seat size	38,0 mm					
39		Flow action	To Open					
40		Stem Material	316 S.S. STL.GR.6					
41		Flow Divider	NO					
42		Flow Divider Material	-					
43		Plug Characteristic	EQP					
44		Plug (Mat.)	ASTM A182 F316					
45		Seal Type / Material	METALLIC/316 S.S. STL.GR.6					
46		Leakage Class	V					
47		Leakage Standard	EN60534-4 / ANSI FCI					
48	**Packing**	Type	LP200					
49		Material	VIRGIN PTFE					
50	**Actuator**	Actuator type	AP34					
51		Air failure	Close					
52		Stroke (mm)	20					
53		Actuator Signal (Psi)	15/60					
54		Shutoff pressure	9,013 bar.a					
55		Spring case/Yoke	Carbon Steel					
56		Diaphragm material	NBR					
57		Handwheel	NO					
58		Spring Action	Normally close					
59	**Notes**							**Page 1/1**



Remarks

ATTACHMENT 4

SAMSON CALCULATION SHEET

L43374

1	Customer	SIAD MACCHINE IMPIANTI		Tag No.	**PV 703**				
2	Project No.	L43374							
3	Unit			Item	3	Qty.	1	Status	
4	PID			Quot. No.	161087539			Revision	0
5	Line No.	LNG-101-2"-C27-N / LNG-102-2"-A27-N		Order No.				Date	22.05.2023
6	**PROCESS DATA**								
7	Service	Throttling		Medium	Natural Gas				
8	Phase	gas		Medium Cust.					

			Unit	Case 1	Case 2	Case 3
9						
10	Flow Rate	W	kg/h	2900		525
11	Inlet Pressure	p1	bar(a)	45		33
12	Outlet Pressure	p2	bar(a)	4		4
13	Inlet Temperature	T1	°C	-134		-134
14	Inlet molecular Weight	M	g/mol	18,03		18,03
15	Vapor Pressure	pv	bar(a)			
16	Critical Pressure	pc	bar(a)			
17	Ratio of Specific Heats	γ	-	1,37		1,37
18	Compressibility	Z	-	0,869		0,971
19	Inlet Viscosity	η	mPas	0,0101		0,00887
20	Outlet Vapor Content	xd2	%			
21	Outlet Vapor Density	ρv2	kg/m³			
22	Flow Conditions	-	-			
23	**RESULTS AND FACTORS**					
24	Min Required Size	d	mm	43		18,3
25	Outlet Velocity	w	Mach	0,447		0,0752
26	Valve Coeff. Calculated	Cv	-	3,01		0,775
27	Relative Travel	T	%	**100**		**64,8**
28	SPL(SAMSON Standard values)	LA	dB (A)	**94**		**81**
29	Differential Pressure Ratio	xF|x	-	0,91		0,88
30	FL Value	FL	-	0,96		0,98
31	xFmr/xT Value	xFmr|xT	-	0,79		0,81
32	Valve Style Factor	Fd	-	0,48		0,41
33	xFz Value at Load	xFz	-			
34	Level Exponent	F1|G1	-	-3,86		-4,06
35	Slope Exponent	F2|G2	-	1,55		1,5
36	Correction Term	DLf	dB			

37	**DESIGN**					
38	Shut-Off Pressure	Min	0 bar(g)	Max	52 bar(g)	
39	t1max			Max	-168 °C	
40	Supply Pressure	Min	4,2 bar(g)	Max	10 bar(g)	
41	Pressure	Min	bar(g)	Max	bar(g)	
42	Temperature	Min	°C	Max	°C	
43	Ambient Temp.	Min	-25 °C	Max	40 °C	
44	**VALVE BODY / BONNET**					
45	Manufacturer / Type	SAMSON / 3248				
46	Style	Globe Globe valve				
47	Nominal Size	NPS 1 1/2				
48	Rating	Class 600				
49	Body Material	A351 CF8				
50	Connection In/Out	Welding ends				
51	Connection In/Out	SWE, ASME B16.34/B16.5				
52	Bonnet Type	Bellows				
53	Bellow Material	316Ti				
54	Packing Material	PTFE				
55	Packing Type	Standard				
56	Body Gasket	-				
57	Flow Direction	FTO				
58	NACE					
59	**TRIM**					
60	Valve Coefficient	Cv 3				
61	Rated Travel	15 mm				
62	Seat Bore	24 mm				
63	Stem Ø	16 mm				
64	Characteristic	Equal perc.				
65	Noise Reduction	-				
66	Balanced	-				
67	Plug Facing	Metal				
68	Plug Material	R30016				
69	Stem Material	A479 316/A479 316L				
70	Seat Facing	Stellited				
71	Seat Material	A182 F316/A182 F316L				
72	Cage Material					
73	Flow Divider Mat.					
74	Leakage Class	IV				

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77	**LINE**					
78		Size / Rating / Pipe Class				
79	In	NPS 2" / Schedule 10S /				
80	Out	NPS 2" / Schedule 10S /				
81	Pipe Inner Dia. / Wallthickness			54,8 mm / 2,8 mm		
82	Insu.	none				
83	**ACTUATOR**					
84	Manufacturer / Type	SAMSON / 3277				
85	Size	355 cm²				
86	Fail Action	Fail close				
87	Bench/Oper. Range	1.9 to 3.3 bar/2,95 ... 3,65 bar				
88	Actuator Body Mat.	1.0976 / 1.0982				
89	Actuator Style	Pneumatic				
90	Stroke Limit.	-				
91	Membrane Material	NBR				
92	Handwheel	-				
93	Set Point / -Range	/				
94	**ACTUATOR RESULTS**					
95	Safety Factor	Open	12,1	Close	1,66	
96	Req. Act. Force	6,31 kN				
97	Max. Act. Force	Fmax	45 kN			
98	Max. dp	Dpmax	90,58 bar			
99	Min. Press. Act.	ps0req	1,95 bar			
100	Req. Dp	Dps	0,05 bar			
101	Req. Dp	Dpst100-0	bar			
102	Actuator Force	Fa	10,47 kN			
103	Min. required Supply		3,85 bar(g)			
104	Max. allowable Supply		6 bar(g)			
105	**ATTENUATION PLATES**					
106	Type					
107	Size In / Out					
108	Rating					
109	Plates Material			Qty.		
110	**REMARKS**					
111						
112						
113						
114						
115						
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ATTACHMENT 5

SAMSON CALCULATION SHEET

L43374

Customer	SIAD MACCHINE IMPIANTI		Tag No.	**PV 703**				
Project No.	L43374							
Unit			Item	3	Qty.	1	Status	
PID			Quot. No.	161087539			Revision	0
Line No.	LNG-101-2"-C27-N / LNG-102-2"-A27-N		Order No.				Date	22.05.2023

PROCESS DATA

Service	Throttling		Medium	Natural Gas		
Phase	gas		Medium Cust.			

			Unit	Case 1	Case 2	Case 3
Flow Rate	W	kg/h		326	630	965
Inlet Pressure	p1	bar(a)		6	10	15
Outlet Pressure	p2	bar(a)		4	4	4
Inlet Temperature	T1	°C		-134	-134	-134
Inlet molecular Weight	M	g/mol		18,03	18,03	18,03
Vapor Pressure	pv	bar(a)				
Critical Pressure	pc	bar(a)				
Ratio of Specific Heats	γ	-		1,37	1,37	1,37
Compressibility	Z	-		0,869	0,869	0,869
Inlet Viscosity	η	mPas		0,0101	0,0101	0,0101
Outlet Vapor Content	xd2	%				
Outlet Vapor Density	ρv2	kg/m³				
Flow Conditions	-	-				
RESULTS AND FACTORS						
Min Required Size	d	mm		14,4	20	24,8
Outlet Velocity	w	Mach		0,0468	0,0905	0,139
Valve Coeff. Calculated	Cv	-		3	3	3
Relative Travel	T	%		**100**	**100**	**100**
SPL(SAMSON Standard values)	LA	dB (A)		**62**	**75**	**81**
Differential Pressure Ratio	xF|x	-		0,33	0,6	0,73
FL Value	FL	-		0,96	0,96	0,96
xFmr/xT Value	xFmr|xT	-		0,79	0,79	0,79
Valve Style Factor	Fd	-		0,48	0,48	0,48
xFz Value at Load	xFz	-				
Level Exponent	F1|G1	-		-3,86	-3,86	-3,86
Slope Exponent	F2|G2	-		1,5	1,5	1,5
Correction Term	DLf	dB				

DESIGN

Shut-Off Pressure	Min	0 bar(g)	Max	52 bar(g)
t1max			Max	-168 °C
Supply Pressure	Min	4,2 bar(g)	Max	10 bar(g)
Pressure	Min	bar(g)	Max	bar(g)
Temperature	Min	°C	Max	°C
Ambient Temp.	Min	-25 °C	Max	40 °C

VALVE BODY / BONNET

Manufacturer / Type	SAMSON / 3248
Style	Globe Globe valve
Nominal Size	NPS 1 1/2
Rating	Class 600
Body Material	A351 CF8
Connection In/Out	Welding ends
Connection In/Out	SWE, ASME B16.34/B16.5
Bonnet Type	Bellows
Bellow Material	316Ti
Packing Material	PTFE
Packing Type	Standard
Body Gasket	-
Flow Direction	FTO
NACE	

TRIM

Valve Coefficient	Cv 3
Rated Travel	15 mm
Seat Bore	24 mm
Stem Ø	16 mm
Characteristic	Equal perc.
Noise Reduction	-
Balanced	-
Plug Facing	Metal
Plug Material	R30016
Stem Material	A479 316/A479 316L
Seat Facing	Stellited
Seat Material	A182 F316/A182 F316L
Cage Material	
Flow Divider Mat.	
Leakage Class	IV

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LINE

	Size / Rating / Pipe Class		
In	NPS 2" / Schedule 10S /		
Out	NPS 2" / Schedule 10S /		
Pipe Inner Dia. / Wallthickness		54,8 mm / 2,8 mm	
Insu.	none		

ACTUATOR

Manufacturer / Type	SAMSON / 3277			
Size	355 cm²			
Fail Action	Fail close			
Bench/Oper. Range	1.9 to 3.3 bar/2,95 ... 3,65 bar			
Actuator Body Mat.	1.0976 / 1.0982			
Actuator Style	Pneumatic			
Stroke Limit.	-			
Membrane Material	NBR			
Handwheel	-			
Set Point / -Range	/			

ACTUATOR RESULTS

Safety Factor	Open	12,1	Close	1,66
Req. Act. Force	6,31 kN			
Max. Act. Force	Fmax	45 kN		
Max. dp	Dpmax	90,58 bar		
Min. Press. Act.	ps0req	1,95 bar		
Req. Dp	Dps	0,05 bar		
Req. Dp	Dpst100-0	bar		
Actuator Force	Fa	10,47 kN		
Min. required Supply		3,85 bar(g)		
Max. allowable Supply		6 bar(g)		

ATTENUATION PLATES

Type		
Size In / Out		
Rating		
Plates Material		Qty.

REMARKS

ATTACHMENT 6

SAMSON CALCULATION SHEET

L43374

1	Customer	SIAD MACCHINE IMPIANTI		Tag No.	**PV 703**			
2	Project No.	L43374						
3	Unit			Item	3	Qty. 1	Status	
4	PID			Quot. No.	161087539		Revision	0
5	Line No.	LNG-101-2"-C27-N / LNG-102-2"-A27-N		Order No.			Date	22.05.2023
6	**PROCESS DATA**							
7	Service	Throttling		Medium	Natural Gas			
8	Phase	gas		Medium Cust.				

			Unit	Case 1	Case 2	Case 3
9						
10	Flow Rate	W	kg/h	1285	1605	1927
11	Inlet Pressure	p1	bar(a)	20	25	30
12	Outlet Pressure	p2	bar(a)	4	4	4
13	Inlet Temperature	T1	°C	-134	-134	-134
14	Inlet molecular Weight	M	g/mol	18,03	18,03	18,03
15	Vapor Pressure	pv	bar(a)			
16	Critical Pressure	pc	bar(a)			
17	Ratio of Specific Heats	γ	-	1,37	1,37	1,37
18	Compressibility	Z	-	0,869	0,869	0,869
19	Inlet Viscosity	η	mPas	0,0101	0,0101	0,0101
20	Outlet Vapor Content	xd2	%			
21	Outlet Vapor Density	ρv2	kg/m³			
22	Flow Conditions	-	-			
23	**RESULTS AND FACTORS**					
24	Min Required Size	d	mm	28,6	32	35,1
25	Outlet Velocity	w	Mach	0,188	0,233	0,282
26	Valve Coeff. Calculated	Cv	-	3	3	3
27	Relative Travel	T	%	**100**	**100**	**100**
28	SPL(SAMSON Standard values)	LA	dB (A)	**84**	**87**	**89**
29	Differential Pressure Ratio	xF|x	-	0,8	0,84	0,87
30	FL Value	FL	-	0,96	0,96	0,96
31	xFmr/xT Value	xFmr|xT	-	0,79	0,79	0,79
32	Valve Style Factor	Fd	-	0,48	0,48	0,48
33	xFz Value at Load	xFz	-			
34	Level Exponent	F1|G1	-	-3,86	-3,86	-3,86
35	Slope Exponent	F2|G2	-	1,5	1,5	1,51
36	Correction Term	DLf	dB			

37	**DESIGN**					
38	Shut-Off Pressure	Min	0 bar(g)	Max	52 bar(g)	
39	t1max			Max	-168 °C	
40	Supply Pressure	Min	4,2 bar(g)	Max	10 bar(g)	
41	Pressure	Min	bar(g)	Max	bar(g)	
42	Temperature	Min	°C	Max	°C	
43	Ambient Temp.	Min	-25 °C	Max	40 °C	
44	**VALVE BODY / BONNET**					
45	Manufacturer / Type	SAMSON / 3248				
46	Style	Globe Globe valve				
47	Nominal Size	NPS 1 1/2				
48	Rating	Class 600				
49	Body Material	A351 CF8				
50	Connection In/Out	Welding ends				
51	Connection In/Out	SWE, ASME B16.34/B16.5				
52	Bonnet Type	Bellows				
53	Bellow Material	316Ti				
54	Packing Material	PTFE				
55	Packing Type	Standard				
56	Body Gasket	-				
57	Flow Direction	FTO				
58	NACE					
59	**TRIM**					
60	Valve Coefficient	Cv 3				
61	Rated Travel	15 mm				
62	Seat Bore	24 mm				
63	Stem Ø	16 mm				
64	Characteristic	Equal perc.				
65	Noise Reduction	-				
66	Balanced	-				
67	Plug Facing	Metal				
68	Plug Material	R30016				
69	Stem Material	A479 316/A479 316L				
70	Seat Facing	Stellited				
71	Seat Material	A182 F316/A182 F316L				
72	Cage Material					
73	Flow Divider Mat.					
74	Leakage Class	IV				

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77	**LINE**					
78		Size / Rating / Pipe Class				
79	In	NPS 2" / Schedule 10S /				
80	Out	NPS 2" / Schedule 10S /				
81	Pipe Inner Dia. / Wallthickness			54,8 mm / 2,8 mm		
82	Insu.	none				
83	**ACTUATOR**					
84	Manufacturer / Type	SAMSON / 3277				
85	Size	355 cm²				
86	Fail Action	Fail close				
87	Bench/Oper. Range	1.9 to 3.3 bar/2,95 ... 3,65 bar				
88	Actuator Body Mat.	1.0976 / 1.0982				
89	Actuator Style	Pneumatic				
90	Stroke Limit.	-				
91	Membrane Material	NBR				
92	Handwheel	-				
93	Set Point / -Range	/				
94	**ACTUATOR RESULTS**					
95	Safety Factor	Open	12,1	Close	1,66	
96	Req. Act. Force	6,31 kN				
97	Max. Act. Force	Fmax	45 kN			
98	Max. dp	Dpmax	90,58 bar			
99	Min. Press. Act.	ps0req	1,95 bar			
100	Req. Dp	Dps	0,05 bar			
101	Req. Dp	Dpst100-0	bar			
102	Actuator Force	Fa	10,47 kN			
103	Min. required Supply		3,85 bar(g)			
104	Max. allowable Supply		6 bar(g)			
105	**ATTENUATION PLATES**					
106	Type					
107	Size In / Out					
108	Rating					
109	Plates Material			Qty.		
110	**REMARKS**					
111						
112						
113						
114						
115						
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ATTACHMENT 7

SAMSON CALCULATION SHEET

L43374

1	Customer	SIAD MACCHINE IMPIANTI		Tag No.	**PV 703**			
2	Project No.	L43374						
3	Unit			Item	3	Qty. 1	Status	
4	PID			Quot. No.	161087539		Revision	0
5	Line No.	LNG-101-2"-C27-N / LNG-102-2"-A27-N		Order No.			Date	22.05.2023
6	**PROCESS DATA**							
7	Service	Throttling		Medium	Natural Gas			
8	Phase	gas		Medium Cust.				

			Unit	Case 1	Case 2	Case 3
9						
10	Flow Rate	W	kg/h	2250		2575
11	Inlet Pressure	p1	bar(a)	35		40
12	Outlet Pressure	p2	bar(a)	4		4
13	Inlet Temperature	T1	°C	-134		-134
14	Inlet molecular Weight	M	g/mol	18,03		18,03
15	Vapor Pressure	pv	bar(a)			
16	Critical Pressure	pc	bar(a)			
17	Ratio of Specific Heats	γ	-	1,37		1,37
18	Compressibility	Z	-	0,869		0,869
19	Inlet Viscosity	η	mPas	0,0101		0,0101
20	Outlet Vapor Content	xd2	%			
21	Outlet Vapor Density	ρv2	kg/m³			
22	Flow Conditions	-	-			
23	**RESULTS AND FACTORS**					
24	Min Required Size	d	mm	37,9		40,5
25	Outlet Velocity	w	Mach	0,332		0,387
26	Valve Coeff. Calculated	Cv	-	3		3
27	Relative Travel	T	%	**100**		**100**
28	SPL(SAMSON Standard values)	LA	dB (A)	**91**		**92**
29	Differential Pressure Ratio	xF|x	-	0,89		0,9
30	FL Value	FL	-	0,96		0,96
31	xFmr/xT Value	xFmr|xT	-	0,79		0,79
32	Valve Style Factor	Fd	-	0,48		0,48
33	xFz Value at Load	xFz	-			
34	Level Exponent	F1|G1	-	-3,86		-3,86
35	Slope Exponent	F2|G2	-	1,52		1,53
36	Correction Term	DLf	dB			

37	**DESIGN**					
38	Shut-Off Pressure	Min	0 bar(g)	Max	52 bar(g)	
39	t1max			Max	-168 °C	
40	Supply Pressure	Min	4,2 bar(g)	Max	10 bar(g)	
41	Pressure	Min	bar(g)	Max	bar(g)	
42	Temperature	Min	°C	Max	°C	
43	Ambient Temp.	Min	-25 °C	Max	40 °C	
44	**VALVE BODY / BONNET**					
45	Manufacturer / Type	SAMSON / 3248				
46	Style	Globe Globe valve				
47	Nominal Size	NPS 1 1/2				
48	Rating	Class 600				
49	Body Material	A351 CF8				
50	Connection In/Out	Welding ends				
51	Connection In/Out	SWE, ASME B16.34/B16.5				
52	Bonnet Type	Bellows				
53	Bellow Material	316Ti				
54	Packing Material	PTFE				
55	Packing Type	Standard				
56	Body Gasket	-				
57	Flow Direction	FTO				
58	NACE					
59	**TRIM**					
60	Valve Coefficient	Cv 3				
61	Rated Travel	15 mm				
62	Seat Bore	24 mm				
63	Stem Ø	16 mm				
64	Characteristic	Equal perc.				
65	Noise Reduction	-				
66	Balanced	-				
67	Plug Facing	Metal				
68	Plug Material	R30016				
69	Stem Material	A479 316/A479 316L				
70	Seat Facing	Stellited				
71	Seat Material	A182 F316/A182 F316L				
72	Cage Material					
73	Flow Divider Mat.					
74	Leakage Class	IV				

75	**Rev.**	**Date**	**Description**	**Prpd.**	**Chd.**	**App.**
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77	**LINE**					
78		Size / Rating / Pipe Class				
79	In	NPS 2" / Schedule 10S /				
80	Out	NPS 2" / Schedule 10S /				
81	Pipe Inner Dia. / Wallthickness			54,8 mm / 2,8 mm		
82	Insu.	none				
83	**ACTUATOR**					
84	Manufacturer / Type	SAMSON / 3277				
85	Size	355 cm²				
86	Fail Action	Fail close				
87	Bench/Oper. Range	1.9 to 3.3 bar/2,95 ... 3,65 bar				
88	Actuator Body Mat.	1.0976 / 1.0982				
89	Actuator Style	Pneumatic				
90	Stroke Limit.	-				
91	Membrane Material	NBR				
92	Handwheel	-				
93	Set Point / -Range	/				
94	**ACTUATOR RESULTS**					
95	Safety Factor	Open	12,1	Close	1,66	
96	Req. Act. Force	6,31 kN				
97	Max. Act. Force	Fmax	45 kN			
98	Max. dp	Dpmax	90,58 bar			
99	Min. Press. Act.	ps0req	1,95 bar			
100	Req. Dp	Dps	0,05 bar			
101	Req. Dp	Dpst100-0	bar			
102	Actuator Force	Fa	10,47 kN			
103	Min. required Supply		3,85 bar(g)			
104	Max. allowable Supply		6 bar(g)			
105	**ATTENUATION PLATES**					
106	Type					
107	Size In / Out					
108	Rating					
109	Plates Material			Qty.		
110	**REMARKS**					
111						
112						
113						
114						
115						
116						

ATTACHMENT 8

SAMSON CALCULATION SHEET

L43374

1	Customer	SIAD MACCHINE IMPIANTI		Tag No.	**PV 703**			
2	Project No.	L43374						
3	Unit			Item	3	Qty. 1	Status	
4	PID			Quot. No.	161087539		Revision	0
5	Line No.	LNG-101-2"-C27-N / LNG-102-2"-A27-N		Order No.			Date	22.05.2023
6	**PROCESS DATA**							
7	Service	Throttling		Medium	Natural Gas			
8	Phase	liquid		Medium Cust.				

			Unit	Case 1	Case 2	Case 3
9						
10	Flow Rate	W	kg/h		10900	
11	Inlet Pressure	p1	bar(a)		43,15	
12	Outlet Pressure	p2	bar(a)		5	
13	Inlet Temperature	T1	°C		-168	
14	Inlet Density	rho1	kg/m³		475,97	
15	Vapor Pressure	pv	bar(a)		3,61	
16	Critical Pressure	pc	bar(a)		46	
17	Ratio of Specific Heats	γ	-			
18	Compressibility	Z	-			
19	Inlet Viscosity	η	mPas		0,069	
20	Outlet Vapor Content	xd2	%			
21	Outlet Vapor mol. Weight	ρv2	g/mol			
22	Flow Conditions	-	-		Critical cavitation	
23	**RESULTS AND FACTORS**					
24	Min Required Size	d	mm		40,2	
25	Outlet Velocity	w	m/s		5,06	
26	Valve Coeff. Calculated	Cv	-		3	
27	Relative Travel	T	%		**100**	
28	SPL(SAMSON Standard values)	LA	dB (A)		**79**	
29	Differential Pressure Ratio	xF|x	-		0,96	
30	FL Value	FL	-		0,96	
31	xFmr/xT Value	xFmr|xT	-		0,7	
32	Valve Style Factor	Fd	-		0,48	
33	xFz Value at Load	xFz	-		0,53	
34	Level Exponent	F1|G1	-		-7,14	
35	Slope Exponent	F2|G2	-		0,3	
36	Correction Term	DLf	dB		4,06	

37	**DESIGN**					
38	Shut-Off Pressure	Min	0 bar(g)	Max	52 bar(g)	
39	t1max			Max	-168 °C	
40	Supply Pressure	Min	4,2 bar(g)	Max	10 bar(g)	
41	Pressure	Min	bar(g)	Max	bar(g)	
42	Temperature	Min	°C	Max	°C	
43	Ambient Temp.	Min	-25 °C	Max	40 °C	
44	**VALVE BODY / BONNET**					
45	Manufacturer / Type	SAMSON / 3248				
46	Style	Globe Globe valve				
47	Nominal Size	NPS 1 1/2				
48	Rating	Class 600				
49	Body Material	A351 CF8				
50	Connection In/Out	Welding ends				
51	Connection In/Out	SWE, ASME B16.34/B16.5				
52	Bonnet Type	Bellows				
53	Bellow Material	316Ti				
54	Packing Material	PTFE				
55	Packing Type	Standard				
56	Body Gasket	-				
57	Flow Direction	FTO				
58	NACE					
59	**TRIM**					
60	Valve Coefficient	Cv 3				
61	Rated Travel	15 mm				
62	Seat Bore	24 mm				
63	Stem Ø	16 mm				
64	Characteristic	Equal perc.				
65	Noise Reduction	-				
66	Balanced	-				
67	Plug Facing	Metal				
68	Plug Material	R30016				
69	Stem Material	A479 316/A479 316L				
70	Seat Facing	Stellited				
71	Seat Material	A182 F316/A182 F316L				
72	Cage Material					
73	Flow Divider Mat.					
74	Leakage Class	IV				

75	**Rev.**	**Date**	**Description**	**Prpd.**	**Chd.**	**App.**
76	0	22.05.2023		zanabo		

77	**LINE**					
78		Size / Rating / Pipe Class				
79	In	NPS 2" / Schedule 10S /				
80	Out	NPS 2" / Schedule 10S /				
81	Pipe Inner Dia. / Wallthickness			54,8 mm / 2,8 mm		
82	Insu.	none				
83	**ACTUATOR**					
84	Manufacturer / Type	SAMSON / 3277				
85	Size	355 cm²				
86	Fail Action	Fail close				
87	Bench/Oper. Range	1.9 to 3.3 bar/2,95 ... 3,65 bar				
88	Actuator Body Mat.	1.0976 / 1.0982				
89	Actuator Style	Pneumatic				
90	Stroke Limit.	-				
91	Membrane Material	NBR				
92	Handwheel	-				
93	Set Point / -Range	/				
94	**ACTUATOR RESULTS**					
95	Safety Factor	Open	12,1	Close	1,66	
96	Req. Act. Force	6,31 kN				
97	Max. Act. Force	Fmax	45 kN			
98	Max. dp	Dpmax	90,58 bar			
99	Min. Press. Act.	ps0req	1,95 bar			
100	Req. Dp	Dps	0,05 bar			
101	Req. Dp	Dpst100-0	bar			
102	Actuator Force	Fa	10,47 kN			
103	Min. required Supply		3,85 bar(g)			
104	Max. allowable Supply		6 bar(g)			
105	**ATTENUATION PLATES**					
106	Type					
107	Size In / Out					
108	Rating					
109	Plates Material			Qty.		
110	**REMARKS**					
111						
112						
113						
114						
115						
116						

ATTACHMENT 9

Calculation of depressurization time for cold box

Calculation of flow rate of valve PV703 at following conditions:

relative travel %	100
gas temperature °C	-134
outlet pressure bara	4

Inlet pressure bara	flow rate kg/h	
45	2900	from supplier calculation
44	2835	interpolation
43.5	2803	interpolation
43	2770	interpolation
42	2705	interpolation
41	2640	interpolation
40	2575	from supplier calculation
39	2510	interpolation
38	2445	interpolation
37	2380	interpolation
36	2315	interpolation
35	2250	from supplier calculation
34	2185	interpolation
33	2121	interpolation
32	2056	interpolation
31	1992	interpolation
30	1927	from supplier calculation
29	1863	interpolation
28	1798	interpolation
27	1734	interpolation
26	1669	interpolation
25	1605	from supplier calculation
24	1541	interpolation
23	1477	interpolation
22	1413	interpolation
21	1349	interpolation
20	1285	from supplier calculation
19	1221	interpolation
18	1157	interpolation
17	1093	interpolation
16	1029	interpolation
15	965	from supplier calculation
14	898	interpolation
13	831	interpolation
12	764	interpolation
11	697	interpolation
10	630	from supplier calculation
9	554	interpolation
8	478	interpolation
7	402	interpolation
6	326	from supplier calculation

volume of gas to be vented m3	1
gas temperature °C	10
gas moleculare weight kg/kmole	18.03

Calculation of depressurization time for each 1 bar pressure reduction:

step number	starting pressure P1 bara	end pressure P2 bara	vented mass M1 kg	PV703 flow rate at P1 Q1 kg/h	PV703 flow rate at P2 Q2 kg/h	time of step min
1	43.5	42	1.164	2803	2705	0.025
2	42	41	0.776	2705	2640	0.017
3	41	40	0.776	2640	2575	0.018
4	40	39	0.776	2575	2510	0.018
5	39	38	0.776	2510	2445	0.019
6	38	37	0.776	2445	2380	0.019
7	37	36	0.776	2380	2315	0.020
8	36	35	0.776	2315	2250	0.020
9	35	34	0.776	2250	2185.4	0.021
10	34	33	0.776	2185.4	2120.8	0.022
11	33	32	0.776	2120.8	2056.2	0.022
12	32	31	0.776	2056.2	1991.6	0.023
13	31	30	0.776	1991.6	1927	0.024
14	30	29	0.776	1927	1862.6	0.025
15	29	28	0.776	1862.6	1798.2	0.025
16	28	27	0.776	1798.2	1733.8	0.026
17	27	26	0.776	1733.8	1669.4	0.027
18	26	25	0.776	1669.4	1605	0.028
19	25	24	0.776	1605	1541	0.030
20	24	23	0.776	1541	1477	0.031
21	23	22	0.776	1477	1413	0.032
22	22	21	0.776	1413	1349	0.034
23	21	20	0.776	1349	1285	0.035
24	20	19	0.776	1285	1221	0.037
25	19	18	0.776	1221	1157	0.039
26	18	17	0.776	1157	1093	0.041
27	17	16	0.776	1093	1029	0.044
28	16	15	0.776	1029	965	0.047
29	15	14	0.776	965	898	0.050
30	14	13	0.776	898	831	0.054
31	13	12	0.776	831	764	0.058
32	12	11	0.776	764	697	0.064
33	11	10	0.776	697	630	0.070
34	10	9	0.776	630	554	0.079
35	9	8	0.776	554	478	0.090
36	8	7	0.776	478	402	0.106
37	7	6	0.776	402	326	0.128

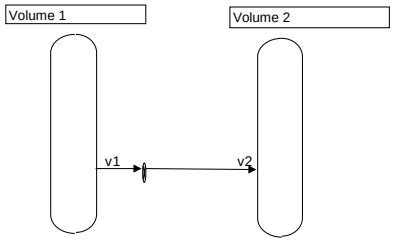
Gas depressurization time (min)	1.470
Time for liquid drain (min)	2.5
Total drain and depressurization time (min)	**3.970**

ATTACHMENT 10

PRESSURIZATION RATE **FO708 orifice**

Volume to discharge	V1 =	3.5	m3	
Initial discharge pressure of volum V1	P1 =	44.00	bar a	
Gas temperature in volume V1	T1 =	20.0	°C	
Receiver volume	V2 =	100000	m3	
Receiver pressure at the beginning of the cycle	P2 =	2.00	bar a	
Gas temperature in volume V2 at the start of the cycle	T2 =	20.0	°C	
Molecular mass	MM =	18.03	kg/kmole	
Isentropic exponent	k=	1.3		
Minimum flow section (V3 valve or pipe or orifice)	A=	188.69	mm2	15.5 diam. orifice
Outflow coefficient	Kdr=	0.600		**Kdr is a parameter to be assumed based on experience (value <= 1)**
Discretization time interval		10	sec	
Coefficient C function of the isentropic exponent	C=	2.6344		
Critical gas pressure	PCr=	46.000	bar a	
Critical gas temperature	Tcr=	190.00	°K	
Critical pressure ratio		0.5457		
P1 pressure reduced	P1r=	0.96		Pr<2 - positive check
P2 pressure reduced	P2r=	0.04		Pr<2 - positive check
Reduced T1 temperature	T1r =	1.54		Tr>1.22 - positive check
Reduced T2 temperature	T2r =	1.54		Tr>1.22 - positive check
compressibility coeff. of volume V1 at the beginning of the discharge	Z1=	0.928		
compressibility coeff. of volume V2 at the beginning of the discharge	Z2=	0.997		
Mass in volume V1 at start of discharge	m1=	123	kg	153 Nm3
Mass in volume V2 at start of discharge	m2=	148519	kg	184631.0 Nm3
Pipe section upstream of the orifice	A1 =	2163	mm2	
Pipe section downstream of the orifice	A2 =	5384	mm2	

note : 6 barA reached after 260 sec- with max. 0.94kg/s



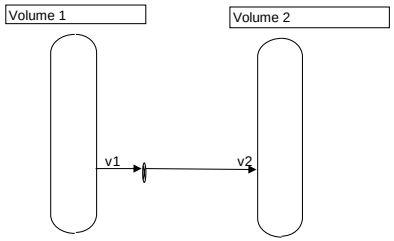
Step no	Step duration	Time from start of unloading to the end of step n	Mass m1 in volume V1 at initial step	Mass m2 in volume V2 at initial start	Critical flow pressure	Flow type	Correction factor for subcritical flow	Temp. T1 reduced	P1 pressure reduced	Coeff. compress in volume V1	Mass flow transferred from V1 to V2 first attempt	Mass flow transferred from V1 to final V2 (limited by downstream speed of sound)	Mass m1 in volume V1 at the end of step first attempt	Mass m1 in volume V1 at the end of the final step	Press P1 end of step first attempt	Press P1 at the end of the final step	Velocity in downstream orifice tube first attempt	Velocity in the pipe downstream of the final orifice	Mass m2 in volume V2 at the end of step first attempt	Mass m2 in volume V2 at the end of the final step	Temp. T2 end of step	Coeff. compress in volume V2 at the end of step n	Press P2 at the end of step first attempt	Press P2 at the end of the final step	speed of sound in the gas downstream of the orifice	Velocity in pipe upstream of first attempt orifice	Velocity in the pipe upstream of the final orifice			
	sec	sec	kg	kg	bar a						kg/sec	kg/sec	kg	kg	bar a	bar a	m/s	m/s	kg	kg	°C		bar a	bar a	m/sec	m/sec	m/sec			
no	tn	t	m1i	m2i	Pcf		kb	tr	pr	Z1	dmt	dmt	m1f	m1f	P1f	P1f	v2	v2	m2f	m2f	T2f	Z2	P2f	P2f	c	v1	v1			
0	Unloading start instant	0	123	148519																								P2f with Z=1	P2r	T2r
1	10	10	123	148519	24.01	critic	1.000	1.54	0.96	0.928	0.939	0.939	113	113	40.6	40.6	113.6	113.6	148528	148528	20.0	0.997	2.0	2.0	419.2	14.4	14.4	2.01	0.044	1.54
2	10	20	113	148528	22.18	critic	1.000	1.54	0.88	0.934	0.864	0.864	105	105	37.8	37.8	104.9	104.9	148537	148537	20.0	0.997	2.0	2.0	419.2	14.3	14.3	2.01	0.044	1.54
3	10	30	105	148537	20.61	critic	1.000	1.54	0.82	0.938	0.801	0.801	97	97	35.0	35.0	97.5	97.5	148545	148545	20.0	0.997	2.0	2.0	419.2	14.3	14.3	2.01	0.044	1.54
4	10	40	97	148545	19.13	critic	1.000	1.54	0.76	0.943	0.742	0.742	89	89	32.5	32.5	90.5	90.5	148552	148552	20.0	0.997	2.0	2.0	419.2	14.3	14.3	2.01	0.044	1.54
5	10	50	89	148552	17.74	critic	1.000	1.54	0.71	0.947	0.687	0.687	82	82	30.1	30.1	83.9	83.9	148559	148559	20.0	0.997	2.0	2.0	419.2	14.2	14.2	2.01	0.044	1.54
6	10	60	82	148559	16.45	critic	1.000	1.54	0.66	0.951	0.635	0.635	76	76	27.9	27.9	77.8	77.8	148565	148565	20.0	0.997	2.0	2.0	419.2	14.2	14.2	2.01	0.044	1.54
7	10	70	76	148565	15.25	critic	1.000	1.54	0.61	0.954	0.588	0.588	70	70	25.9	25.9	72.1	72.1	148571	148571	20.0	0.997	2.0	2.0	419.2	14.2	14.2	2.01	0.044	1.54
8	10	80	70	148571	14.12	critic	1.000	1.54	0.56	0.958	0.543	0.543	65	65	24.0	24.0	66.8	66.8	148577	148577	20.0	0.997	2.0	2.0	419.2	14.2	14.2	2.01	0.044	1.54
9	10	90	65	148577	13.08	critic	1.000	1.54	0.52	0.961	0.502	0.502	60	60	22.2	22.2	61.8	61.8	148582	148582	20.0	0.997	2.0	2.0	419.2	14.2	14.2	2.01	0.044	1.54
10	10	100	60	148582	12.10	critic	1.000	1.54	0.48	0.964	0.464	0.464	55	55	20.5	20.5	57.2	57.2	148586	148586	20.0	0.997	2.0	2.0	419.2	14.1	14.1	2.01	0.044	1.54
11	10	110	55	148586	11.20	critic	1.000	1.54	0.45	0.967	0.429	0.429	51	51	19.0	19.0	53.0	53.0	148591	148591	20.0	0.997	2.0	2.0	419.2	14.1	14.1	2.01	0.044	1.54
12	10	120	51	148591	10.35	critic	1.000	1.54	0.41	0.969	0.396	0.396	47	47	17.5	17.5	49.0	49.0	148595	148595	20.0	0.997	2.0	2.0	419.2	14.1	14.1	2.01	0.044	1.54
13	10	130	47	148595	9.57	critic	1.000	1.54	0.38	0.971	0.366	0.366	43	43	16.2	16.2	45.3	45.3	148598	148598	20.0	0.997	2.0	2.0	419.2	14.1	14.1	2.01	0.044	1.54
14	10	140	43	148598	8.85	critic	1.000	1.54	0.35	0.974	0.338	0.338	40	40	15.0	15.0	41.8	41.8	148602	148602	20.0	0.997	2.0	2.0	419.2	14.1	14.1	2.01	0.044	1.54
15	10	150	40	148602	8.17	critic	1.000	1.54	0.33	0.976	0.312	0.312	37	37	13.8	13.8	38.7	38.7	148605	148605	20.0	0.997	2.0	2.0	419.2	14.1	14.1	2.01	0.044	1.54
16	10	160	37	148605	7.55	critic	1.000	1.54	0.30	0.977	0.288	0.288	34	34	12.8	12.8	35.7	35.7	148608	148608	20.0	0.997	2.0	2.0	419.2	14.1	14.1	2.01	0.044	1.54
17	10	170	34	148608	6.97	critic	1.000	1.54	0.28	0.979	0.265	0.265	31	31	11.8	11.8	33.0	33.0	148610	148610	20.0	0.997	2.0	2.0	419.2	14.1	14.1	2.01	0.044	1.54
18	10	180	31	148610	6.44	critic	1.000	1.54	0.26	0.981	0.245	0.245	29	29	10.9	10.9	30.5	30.5	148613	148613	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
19	10	190	29	148613	5.94	critic	1.000	1.54	0.24	0.982	0.226	0.226	27	27	10.0	10.0	28.1	28.1	148615	148615	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
20	10	200	27	148615	5.48	critic	1.000	1.54	0.22	0.984	0.208	0.208	24	24	9.3	9.3	25.9	25.9	148617	148617	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
21	10	210	24	148617	5.06	critic	1.000	1.54	0.20	0.985	0.192	0.192	23	23	8.6	8.6	23.9	23.9	148619	148619	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
22	10	220	23	148619	4.67	critic	1.000	1.54	0.19	0.986	0.177	0.177	21	21	7.9	7.9	22.1	22.1	148621	148621	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
23	10	230	21	148621	4.31	critic	1.000	1.54	0.17	0.987	0.163	0.163	19	19	7.3	7.3	20.4	20.4	148622	148622	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
24	10	240	19	148622	3.97	critic	1.000	1.54	0.16	0.988	0.150	0.150	18	18	6.7	6.7	18.8	18.8	148624	148624	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
25	10	250	18	148624	3.66	critic	1.000	1.54	0.15	0.989	0.139	0.139	16	16	6.2	6.2	17.3	17.3	148625	148625	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
26	10	260	16	148625	3.38	critic	1.000	1.54	0.13	0.990	0.128	0.128	15	15	5.7	5.7	16.0	16.0	148626	148626	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
27	10	270	15	148626	3.11	critic	1.000	1.54	0.12	0.991	0.118	0.118	14	14	5.3	5.3	14.7	14.7	148628	148628	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
28	10	280	14	148628	2.87	critic	1.000	1.54	0.11	0.991	0.109	0.109	13	13	4.8	4.8	13.6	13.6	148629	148629	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
29	10	290	13	148629	2.65	critic	1.000	1.54	0.11	0.992	0.100	0.100	12	12	4.5	4.5	12.5	12.5	148630	148630	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
30	10	300	12	148630	2.44	critic	1.000	1.54	0.10	0.993	0.092	0.092	11	11	4.1	4.1	11.5	11.5	148631	148631	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
31	10	310	11	148631	2.25	critic	1.000	1.54	0.09	0.993	0.085	0.085	10	10	3.8	3.8	10.6	10.6	148632	148632	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
32	10	320	10	148632	2.07	critic	1.000	1.54	0.08	0.994	0.078	0.078	9	9	3.5	3.5	9.8	9.8	148632	148632	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
33	10	330	9	148632	1.91	subcritical	0.998	1.54	0.08	0.994	0.072	0.072	8	8	3.2	3.2	9.0	9.0	148633	148633	20.0	0.997	2.0	2.0	419.2	14.0	14.0	2.01	0.044	1.54
34	10	340	8	148633	1.76	subcritical	0.987	1.54	0.07	0.995	0.066	0.066	8	8	3.0	3.0	8.2	8.2	148634	148634	20.0	0.997	2.0	2.0	419.2	13.8	13.8	2.01	0.044	1.54
35	10	350	8	148634	1.62	subcritical	0.961	1.54	0.06	0.995	0.059	0.059	7	7	2.7	2.7	7.4	7.4	148634	148634	20.0	0.997	2.0	2.0	419.2	13.4	13.4	2.01	0.044	1.54
36	10	360	7	148634	1.50	subcritical	0.918	1.54	0.06	0.996	0.052	0.052	7	7	2.5	2.5	6.5	6.5	148635	148635	20.0	0.997	2.0	2.0	419.2	12.7	12.7	2.01	0.044	1.54
37	10	370	7	148635	1.39	subcritical	0.853	1.54	0.06	0.996	0.045	0.045	6	6	2.4	2.4	5.6	5.6	148635	148635	20.0	0.997	2.0	2.0	419.2	11.8	11.8	2.01	0.044	1.54
38	10	380	6	148635	1.30	subcritical	0.762	1.54	0.05	0.996	0.037	0.037	6	6	2.2	2.2	4.7	4.7	148636	148636	20.0	0.997	2.0	2.0	419.2	10.4	10.4	2.01	0.044	1.54
39	10	390	6	148636	1.22	subcritical	0.642	1.54	0.05	0.996	0.030	0.030	6	6	2.1	2.1	3.7	3.7	148636	148636	20.0	0.997	2.0	2.0	419.2	8.7	8.7	2.01	0.044	1.54
40	10	400	6	148636	1.16	subcritical	0.487	1.54	0.05	0.997	0.021	0.021	5	5	2.0	2.0	2.7	2.7	148636	148636	20.0	0.997	2.0	2.0	419.2	6.5	6.5	2.01	0.044	1.54
41	10	410	5	148636	1.11	subcritical	0.287	1.54	0.04	0.997	0.012	0.012	5	5	2.0	2.0	1.5	1.5	148636	148636	20.0	0.997	2.0	2.0	419.2	3.8	3.8	2.01	0.044	1.54

ATTACHMENT 11

PRESSURIZATION RATE **RO169 orifice**

Volume to discharge	V1 =	7.2	m3	
Initial discharge pressure of volum V1	P1 =	44.00	bar a	
Gas temperature in volume V1	T1 =	40.0	°C	
Receiver volume	V2 =	100000	m3	
Receiver pressure at the beginning of the cycle	P2 =	2.00	bar a	
Gas temperature in volume V2 at the start of the cycle	T2 =	40.0	°C	
Molecular mass	MM =	18.03	kg/kmole	
Isentropic exponent	k=	1.3		
Minimum flow section (V3 valve or pipe or orifice)	A=	235.06	mm2	17.3 diam. orifice
Outflow coefficient	Kdr=	0.600		**Kdr is a parameter to be assumed based on experience (value <= 1)**
Discretization time interval		10	sec	
Coefficient C function of the isentropic exponent	C=	2.6344		
Critical gas pressure	PCr=	46.000	bar a	
Critical gas temperature	Tcr=	190.00	°K	
Critical pressure ratio		0.5457		
P1 pressure reduced	P1r=	0.96		Pr<2 - positive check
P2 pressure reduced	P2r=	0.04		Pr<2 - positive check
Reduced T1 temperature	T1r =	1.65		Tr>1.22 - positive check
Reduced T2 temperature	T2r =	1.65		Tr>1.22 - positive check
compressibility coeff. of volume V1 at the beginning of the discharge	Z1=	0.943		
compressibility coeff. of volume V2 at the beginning of the discharge	Z2=	0.997		
Mass in volume V1 at start of discharge	m1=	233	kg	289 Nm3
Mass in volume V2 at start of discharge	m2=	138938	kg	172720.5 Nm3
Pipe section upstream of the orifice	A1 =	2163	mm2	
Pipe section downstream of the orifice	A2 =	5384	mm2	

note : 6 barA reached after 405 sec - with max. 1,123kg/s



Step no	Step duration	Time from start of unloading to the end of step n	Mass m1 in volume V1 at initial step	Mass m2 in volume V2 at initial start	Critical flow pressure	Flow type	Correction factor for subcritical flow	Temp. T1 reduced	P1 pressure reduced	Coeff. compress in volume V1	Mass flow transferred from V1 to V2 first attempt	Mass flow transferred from V1 to final V2 (limited by downstream speed of sound)	Mass m1 in volume V1 at the end of step first attempt	Mass m1 in volume V1 at the end of the final step	Press P1 end of step first attempt	Press P1 at the end of the final step	Velocity in downstream orifice tube first attempt	Velocity in the pipe downstream of the final orifice	Mass m2 in volume V2 at the end of step first attempt	Mass m2 in volume V2 at the end of the final step	Temp. T2 end of step	Coeff. compress in volume V2 at the end of step n	Press P2 at the end of step first attempt	Press P2 at the end of the final step	speed of sound in the gas downstream of the orifice	Velocity in pipe upstream of first attempt orifice	Velocity in the pipe upstream of the final orifice			
	sec	sec	kg	kg	bar a						kg/sec	kg/sec	kg	kg	bar a	bar a	m/s	m/s	kg	kg	°C		bar a	bar a	m/sec	m/sec	m/sec			
no	tn	t	m1i	m2i	Pcf		kb	tr	pr	Z1	dmt	dmt	m1f	m1f	P1f	P1f	v2	v2	m2f	m2f	T2f	Z2	P2f	P2f	c	v1	v1			
0	Unloading start instant	0	233	138938																								P2f with Z=1	P2r	T2r
1	10	10	233	138938	24.01	critic	1.000	1.65	0.96	0.943	1.123	1.123	222	222	41.9	41.9	145.5	145.5	138949	138949	40.0	0.997	2.0	2.0	433.2	17.9	17.9	2.01	0.044	1.65
2	10	20	222	138949	22.85	critic	1.000	1.65	0.91	0.945	1.067	1.067	211	211	40.0	40.0	138.5	138.5	138960	138960	40.0	0.997	2.0	2.0	433.2	17.8	17.8	2.01	0.044	1.65
3	10	30	211	138960	21.82	critic	1.000	1.65	0.87	0.948	1.017	1.017	201	201	38.2	38.2	132.2	132.2	138970	138970	40.0	0.997	2.0	2.0	433.2	17.8	17.8	2.01	0.044	1.65
4	10	40	201	138970	20.82	critic	1.000	1.65	0.83	0.950	0.969	0.969	191	191	36.4	36.4	126.2	126.2	138979	138979	40.0	0.997	2.0	2.0	433.2	17.8	17.8	2.01	0.044	1.65
5	10	50	191	138979	19.87	critic	1.000	1.65	0.79	0.953	0.924	0.924	182	182	34.7	34.7	120.4	120.4	138989	138989	40.0	0.997	2.0	2.0	433.2	17.8	17.8	2.01	0.044	1.65
6	10	60	182	138989	18.95	critic	1.000	1.65	0.75	0.955	0.880	0.880	173	173	33.1	33.1	114.9	114.9	138998	138998	40.0	0.997	2.0	2.0	433.2	17.7	17.7	2.01	0.044	1.65
7	10	70	173	138998	18.07	critic	1.000	1.65	0.72	0.957	0.839	0.839	165	165	31.6	31.6	109.6	109.6	139006	139006	40.0	0.997	2.0	2.0	433.2	17.7	17.7	2.01	0.044	1.65
8	10	80	165	139006	17.24	critic	1.000	1.65	0.69	0.959	0.799	0.799	157	157	30.1	30.1	104.5	104.5	139014	139014	40.0	0.997	2.0	2.0	433.2	17.7	17.7	2.01	0.044	1.65
9	10	90	157	139014	16.43	critic	1.000	1.65	0.65	0.961	0.761	0.761	149	149	28.7	28.7	99.7	99.7	139021	139021	40.0	0.997	2.0	2.0	433.2	17.7	17.7	2.01	0.044	1.65
10	10	100	149	139021	15.67	critic	1.000	1.65	0.62	0.963	0.725	0.725	142	142	27.4	27.4	95.1	95.1	139029	139029	40.0	0.997	2.0	2.0	433.2	17.7	17.7	2.01	0.044	1.65
11	10	110	142	139029	14.93	critic	1.000	1.65	0.59	0.964	0.690	0.690	135	135	26.1	26.1	90.6	90.6	139036	139036	40.0	0.997	2.0	2.0	433.2	17.7	17.7	2.01	0.044	1.65
12	10	120	135	139036	14.23	critic	1.000	1.65	0.57	0.966	0.657	0.657	128	128	24.9	24.9	86.4	86.4	139042	139042	40.0	0.997	2.0	2.0	433.2	17.7	17.7	2.01	0.044	1.65
13	10	130	128	139042	13.56	critic	1.000	1.65	0.54	0.968	0.626	0.626	122	122	23.7	23.7	82.3	82.3	139048	139048	40.0	0.997	2.0	2.0	433.2	17.6	17.6	2.01	0.044	1.65
14	10	140	122	139048	12.92	critic	1.000	1.65	0.51	0.969	0.596	0.596	116	116	22.6	22.6	78.4	78.4	139054	139054	40.0	0.997	2.0	2.0	433.2	17.6	17.6	2.01	0.044	1.65
15	10	150	116	139054	12.31	critic	1.000	1.65	0.49	0.971	0.567	0.567	110	110	21.5	21.5	74.7	74.7	139060	139060	40.0	0.997	2.0	2.0	433.2	17.6	17.6	2.01	0.044	1.65
16	10	160	110	139060	11.73	critic	1.000	1.65	0.47	0.972	0.540	0.540	105	105	20.5	20.5	71.2	71.2	139066	139066	40.0	0.997	2.0	2.0	433.2	17.6	17.6	2.01	0.044	1.65
17	10	170	105	139066	11.17	critic	1.000	1.65	0.44	0.973	0.514	0.514	100	100	19.5	19.5	67.8	67.8	139071	139071	40.0	0.997	2.0	2.0	433.2	17.6	17.6	2.01	0.044	1.65
18	10	180	100	139071	10.64	critic	1.000	1.65	0.42	0.975	0.489	0.489	95	95	18.6	18.6	64.6	64.6	139076	139076	40.0	0.997	2.0	2.0	433.2	17.6	17.6	2.01	0.044	1.65
19	10	190	95	139076	10.13	critic	1.000	1.65	0.40	0.976	0.466	0.466	90	90	17.7	17.7	61.5	61.5	139080	139080	40.0	0.997	2.0	2.0	433.2	17.6	17.6	2.01	0.044	1.65
20	10	200	90	139080	9.65	critic	1.000	1.65	0.38	0.977	0.443	0.443	86	86	16.8	16.8	58.6	58.6	139085	139085	40.0	0.997	2.0	2.0	433.2	17.6	17.6	2.01	0.044	1.65
21	10	210	86	139085	9.19	critic	1.000	1.65	0.37	0.978	0.422	0.422	82	82	16.0	16.0	55.8	55.8	139089	139089	40.0	0.997	2.0	2.0	433.2	17.6	17.6	2.01	0.044	1.65
22	10	220	82	139089	8.74	critic	1.000	1.65	0.35	0.979	0.401	0.401	78	78	15.3	15.3	53.1	53.1	139093	139093	40.0	0.997	2.0	2.0	433.2	17.6	17.6	2.01	0.044	1.65
23	10	230	78	139093	8.32	critic	1.000	1.65	0.33	0.980	0.382	0.382	74	74	14.5	14.5	50.6	50.6	139097	139097	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
24	10	240	74	139097	7.92	critic	1.000	1.65	0.32	0.981	0.363	0.363	70	70	13.8	13.8	48.1	48.1	139100	139100	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
25	10	250	70	139100	7.54	critic	1.000	1.65	0.30	0.982	0.345	0.345	67	67	13.2	13.2	45.8	45.8	139104	139104	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
26	10	260	67	139104	7.18	critic	1.000	1.65	0.29	0.983	0.329	0.329	64	64	12.5	12.5	43.6	43.6	139107	139107	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
27	10	270	64	139107	6.83	critic	1.000	1.65	0.27	0.984	0.313	0.313	60	60	11.9	11.9	41.5	41.5	139110	139110	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
28	10	280	60	139110	6.50	critic	1.000	1.65	0.26	0.984	0.297	0.297	57	57	11.3	11.3	39.5	39.5	139113	139113	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
29	10	290	57	139113	6.19	critic	1.000	1.65	0.25	0.985	0.283	0.283	55	55	10.8	10.8	37.6	37.6	139116	139116	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
30	10	300	55	139116	5.88	critic	1.000	1.65	0.23	0.986	0.269	0.269	52	52	10.3	10.3	35.8	35.8	139119	139119	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
31	10	310	52	139119	5.60	critic	1.000	1.65	0.22	0.987	0.256	0.256	49	49	9.8	9.8	34.0	34.0	139121	139121	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
32	10	320	49	139121	5.33	critic	1.000	1.65	0.21	0.987	0.243	0.243	47	47	9.3	9.3	32.4	32.4	139124	139124	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
33	10	330	47	139124	5.07	critic	1.000	1.65	0.20	0.988	0.231	0.231	45	45	8.8	8.8	30.8	30.8	139126	139126	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
34	10	340	45	139126	4.82	critic	1.000	1.65	0.19	0.988	0.220	0.220	42	42	8.4	8.4	29.3	29.3	139128	139128	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
35	10	350	42	139128	4.59	critic	1.000	1.65	0.18	0.989	0.209	0.209	40	40	8.0	8.0	27.9	27.9	139130	139130	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
36	10	360	40	139130	4.36	critic	1.000	1.65	0.17	0.990	0.199	0.199	38	38	7.6	7.6	26.5	26.5	139132	139132	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
37	10	370	38	139132	4.15	critic	1.000	1.65	0.17	0.990	0.189	0.189	36	36	7.2	7.2	25.2	25.2	139134	139134	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
38	10	380	36	139134	3.95	critic	1.000	1.65	0.16	0.991	0.180	0.180	35	35	6.9	6.9	24.0	24.0	139136	139136	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
39	10	390	35	139136	3.75	critic	1.000	1.65	0.15	0.991	0.171	0.171	33	33	6.5	6.5	22.8	22.8	139138	139138	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
40	10	400	33	139138	3.57	critic	1.000	1.65	0.14	0.991	0.163	0.163	31	31	6.2	6.2	21.7	21.7	139139	139139	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
41	10	410	31	139139	3.39	critic	1.000	1.65	0.14	0.992	0.155	0.155	30	30	5.9	5.9	20.6	20.6	139141	139141	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
42	10	420	30	139141	3.23	critic	1.000	1.65	0.13	0.992	0.147	0.147	28	28	5.6	5.6	19.6	19.6	139142	139142	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65
43	10	430	28	139142	3.07	critic	1.000	1.65	0.12	0.993	0.140	0.140	27	27	5.3	5.3	18.7	18.7	139144	139144	40.0	0.997	2.0	2.0	433.2	17.5	17.5	2.01	0.044	1.65

44	10	440	27	139144	2.92	critic	1.000	1.65	0.12	0.993	0.133	0.133	26	26	5.1	5.1	17.8	17.8	139145	139145	40.0	0.997	2.0	2.0	433.2	17.4	17.4	2.01	0.044	1.65
45	10	450	26	139145	2.78	critic	1.000	1.65	0.11	0.993	0.126	0.126	24	24	4.8	4.8	16.9	16.9	139146	139146	40.0	0.997	2.0	2.0	433.2	17.4	17.4	2.01	0.044	1.65
46	10	460	24	139146	2.64	critic	1.000	1.65	0.11	0.994	0.120	0.120	23	23	4.6	4.6	16.1	16.1	139147	139147	40.0	0.997	2.0	2.0	433.2	17.4	17.4	2.01	0.044	1.65
47	10	470	23	139147	2.51	critic	1.000	1.65	0.10	0.994	0.114	0.114	22	22	4.4	4.4	15.3	15.3	139149	139149	40.0	0.997	2.0	2.0	433.2	17.4	17.4	2.01	0.044	1.65
48	10	480	22	139149	2.39	critic	1.000	1.65	0.10	0.994	0.109	0.109	21	21	4.2	4.2	14.5	14.5	139150	139150	40.0	0.997	2.0	2.0	433.2	17.4	17.4	2.01	0.044	1.65
49	10	490	21	139150	2.27	critic	1.000	1.65	0.09	0.995	0.103	0.103	20	20	4.0	4.0	13.8	13.8	139151	139151	40.0	0.997	2.0	2.0	433.2	17.4	17.4	2.01	0.044	1.65
50	10	500	20	139151	2.16	critic	1.000	1.65	0.09	0.995	0.098	0.098	19	19	3.8	3.8	13.1	13.1	139152	139152	40.0	0.997	2.0	2.0	433.2	17.4	17.4	2.01	0.044	1.65
51	10	510	19	139152	2.05	critic	1.000	1.65	0.08	0.995	0.093	0.093	18	18	3.6	3.6	12.5	12.5	139153	139153	40.0	0.997	2.0	2.0	433.2	17.4	17.4	2.01	0.044	1.65
52	10	520	18	139153	1.95	subcritical	0.999	1.65	0.08	0.995	0.089	0.089	17	17	3.4	3.4	11.9	11.9	139154	139154	40.0	0.997	2.0	2.0	433.2	17.4	17.4	2.01	0.044	1.65
53	10	530	17	139154	1.85	subcritical	0.996	1.65	0.07	0.996	0.084	0.084	16	16	3.2	3.2	11.2	11.2	139154	139154	40.0	0.997	2.0	2.0	433.2	17.3	17.3	2.01	0.044	1.65
54	10	540	16	139154	1.76	subcritical	0.987	1.65	0.07	0.996	0.079	0.079	15	15	3.1	3.1	10.6	10.6	139155	139155	40.0	0.997	2.0	2.0	433.2	17.2	17.2	2.01	0.044	1.65
55	10	550	15	139155	1.68	subcritical	0.973	1.65	0.07	0.996	0.074	0.074	15	15	2.9	2.9	9.9	9.9	139156	139156	40.0	0.997	2.0	2.0	433.2	16.9	16.9	2.01	0.044	1.65
56	10	560	15	139156	1.60	subcritical	0.954	1.65	0.06	0.996	0.069	0.069	14	14	2.8	2.8	9.3	9.3	139157	139157	40.0	0.997	2.0	2.0	433.2	16.6	16.6	2.01	0.044	1.65
57	10	570	14	139157	1.52	subcritical	0.927	1.65	0.06	0.996	0.064	0.064	13	13	2.7	2.7	8.6	8.6	139157	139157	40.0	0.997	2.0	2.0	433.2	16.1	16.1	2.01	0.044	1.65
58	10	580	13	139157	1.45	subcritical	0.893	1.65	0.06	0.997	0.059	0.059	13	13	2.5	2.5	7.9	7.9	139158	139158	40.0	0.997	2.0	2.0	433.2	15.5	15.5	2.01	0.044	1.65
59	10	590	13	139158	1.39	subcritical	0.850	1.65	0.06	0.997	0.054	0.054	12	12	2.4	2.4	7.2	7.2	139158	139158	40.0	0.997	2.0	2.0	433.2	14.7	14.7	2.01	0.044	1.65
60	10	600	12	139158	1.33	subcritical	0.797	1.65	0.05	0.997	0.048	0.048	12	12	2.3	2.3	6.4	6.4	139159	139159	40.0	0.997	2.0	2.0	433.2	13.7	13.7	2.01	0.044	1.65
61	10	610	12	139159	1.28	subcritical	0.735	1.65	0.05	0.997	0.043	0.043	11	11	2.3	2.3	5.7	5.7	139159	139159	40.0	0.997	2.0	2.0	433.2	12.6	12.6	2.01	0.044	1.65
62	10	620	11	139159	1.23	subcritical	0.661	1.65	0.05	0.997	0.037	0.037	11	11	2.2	2.2	4.9	4.9	139160	139160	40.0	0.997	2.0	2.0	433.2	11.3	11.3	2.01	0.044	1.65
63	10	630	11	139160	1.19	subcritical	0.576	1.65	0.05	0.997	0.031	0.031	11	11	2.1	2.1	4.2	4.2	139160	139160	40.0	0.997	2.0	2.0	433.2	9.8	9.8	2.01	0.044	1.65
64	10	640	11	139160	1.16	subcritical	0.480	1.65	0.05	0.997	0.025	0.025	10	10	2.1	2.1	3.4	3.4	139160	139160	40.0	0.997	2.0	2.0	433.2	8.1	8.1	2.01	0.044	1.65
65	10	650	10	139160	1.13	subcritical	0.370	1.65	0.04	0.997	0.019	0.019	10	10	2.0	2.0	2.5	2.5	139160	139160	40.0	0.997	2.0	2.0	433.2	6.2	6.2	2.01	0.044	1.65
66	10	660	10	139160	1.11	subcritical	0.246	1.65	0.04	0.997	0.012	0.012	10	10	2.0	2.0	1.7	1.7	139161	139161	40.0	0.997	2.0	2.0	433.2	4.1	4.1	2.01	0.044	1.65
67	10	670	10	139161	1.09	subcritical	0.083	1.65	0.04	0.997	0.004	0.004	10	10	2.0	2.0	0.6	0.6	139161	139161	40.0	0.997	2.0	2.0	433.2	1.4	1.4	2.01	0.044	1.65

ATTACHMENT 12

Calculation of FO530

Flow rate through orifices (gas) - Perry ref - eq. 10.20		
orifice Ø	mm	21
Pipe internal Ø	mm	82.9
Pinlet	BarA	43.4
Poutlet	BarA	8
Molecular weight	kg/kmole	18.03
Temperature	°C	20
Coefficient cp/cv	-	1.34
Critical pressure ratio rc	-	0.5386
Pressure ratio r	-	0.1843
Check sonic/subsonic flow	-	SONIC
Compressibility factor	-	0.9
Factorβ (orifice Ø/pipe internal Ø)	-	0.25
Coefficient of Expansion Y	-	0.7496
Density ρ	kg/m³	35.680
Dynamic viscosity	cpoise	0.0170
Velocity in the orifice	m/sec	150.99
Reynolds number		6654730
Discharge Coefficient C	-	0.60
ΔP used in the calculation	Pascal	2002470
Orifice passage area A	m²	0.0003464
$Q = 3600 * Y * C * A * \sqrt{\frac{2 * \Delta P/\rho}{1-(\beta^4)}}$	m³/h	***188.26***
	kg/h	***6717.24***
	kg/sec	***1.866***
	Nm3/h	***8350.54***