

# **EURISG**

## **European Industrial Sizing Group**

EURISG Sizing Case Report

**ESC\_114**

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### Sizing of a tank breathing device

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GESCHÄFTSFÜHRER:  
Prof. Dr. Jürgen Schmidt  
Prof. Dr. Jens Denecke

HRB NR. 722490  
Amtsgericht Mannheim  
Umsatzsteuer-ID: DE300689965

DEUTSCHE BANK IN NEUSTADT  
IBAN DE41 5467 0024 0033 6164 00  
BIC DEUTDE33



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## Table of contents

<b>Revisions</b>	<b>2</b>
<b>Table of contents</b>	<b>3</b>
<b>1 Task description</b>	<b>5</b>
<b>2 Test data and references</b>	<b>9</b>
2.1 Experimental data of Sigel et al.	9
2.2 Experimental data of Holtkötter et al.	11
<b>3 Approach</b>	<b>15</b>
3.1 Scenario boundary conditions	15
3.2 Fluid property data	15
3.2.1 Thermodynamically critical data	15
3.2.2 Evaluation of the real gas behaviour	15
3.2.3 Fluid property models	16
3.3 Sizing calculations	16
3.3.1 Calculation models according to the standards	16
3.3.2 Calculation model according to Förster et al. [4]	17
3.3.3 Calculation model according to Fullarton [17,18]	18
3.3.4 Calculation model according to Davies and Moncalvo [19]	19
3.4 Sizing of the venting device	20
<b>4 Results</b>	<b>22</b>
4.1 Case 1	22
4.1.1 Selection of suitable equipment according to the standards	22
4.1.2 Maximum inbreathing flow rate according to literature models	23
4.2 Case 2	24
4.2.1 Selection of suitable equipment according to the standards	24
4.2.2 Maximum inbreathing flow rate	25
<b>5 Discussion</b>	<b>27</b>
<b>6 Lessons learned</b>	<b>28</b>
<b>7 References</b>	<b>29</b>
<b>9 Annex</b>	<b>31</b>
<b>A Symbols and Units</b>	<b>31</b>



## 1 Task description

In this task, a tank breathing device shall be sized to protect a tank from pressure changes of the tank atmosphere. Thus, the maximum required inbreathing rate  $Q_{v,in}$  must be calculated in order to choose a device.

This task is divided into two cases of different tank content and tank sizes, see below. Both tanks are cylindrical storage tanks and exposed to ambient conditions. They are located at an open area in Pfinztal. The average storage temperature is 25°C and there is no insulation on the tank surface.

In both cases the temperature of the hot tank atmosphere drops rapidly to ambient temperature due to heavy rain. The venting scenario is displayed in Figure 1-1.

A specification of the tanks, as well as the boundary conditions for each case are given in **Table 1-1** to **Table 1-7**.

### Case 1:

Sizing Task: Determine the required inbreathing rate to protect the tank from vacuum and choose a venting device to be installed.

Additional assumptions/ boundary conditions:

- The roof of the tank has a coned shape, see figure 1
- The tank is filled with air under ambient conditions
- The tank surface is not insulated
- The average storage temperature is 25°C

**Table 1-1:** Tank data (Case 1)

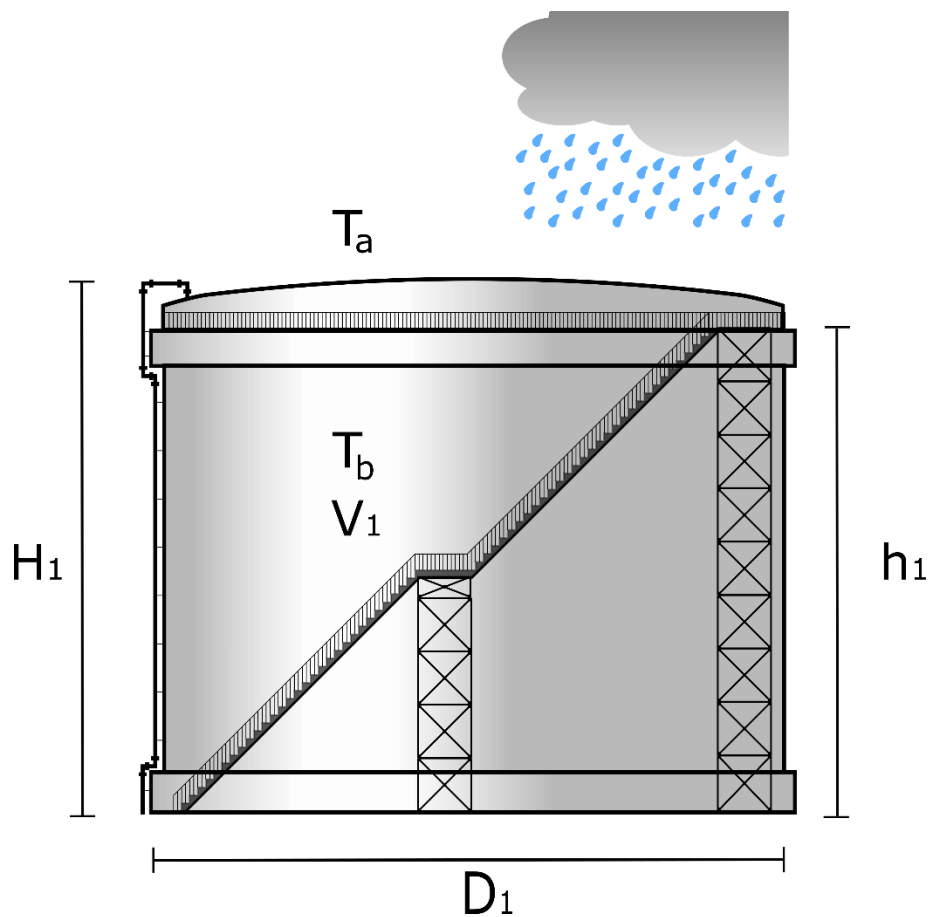
- Cylindrical height $h_1$ :	10,6 m
- Total height $H_1$ :	11,6 m
- Diameter $D_1$ :	8,5 m
- Volume $V_1$ :	617,5 m <sup>3</sup>
- Wall thickness $s_{w,1}$ :	5 mm
- Wall density $\rho_{w,1}$ :	7850 kg/m <sup>3</sup>
- Wall specific heat capacity $c_{p,w,1}$ :	469 J/kg K
- Wall thermal conductivity $\lambda_{w,2}$ :	21 W/m K
- Design pressure vacuum $p_{set}$	20 mbar

**Table 1-2:** Property Data (Case 1)

- Medium	Air
- Initial temperature $T_{b,1}$	33°C

**Table 1-3:** Ambience Data (Case 1)

- Ambient pressure $p_a$ :	1,01325 bar a
- Ambient temperature $T_a$ :	22°C
- Rain temperature $T_r$ :	14°C
- Rain intensity $G_r$ :	225 kg/m <sup>2</sup> hr
- Rain impingement angle $\theta_r$ :	68°



**Figure 1-1:** Venting scenario for case 1

## Case 2

Sizing Task: Determine the required inbreathing rate to protect the tank from vacuum and choose a venting device to be installed.

Additional assumptions/ boundary conditions:

- The roof of the tank has a flat shape, see figure 2
- The tank is filled with methanol steam and air under ambient conditions
- In the beginning, the gas phase is in equilibrium state between air and methanol
- The tank surface is not insulated
- The average storage temperature is 25°C

**Table 1-4:** Tank data (Case 2)

- H/D ratio	1.5
- Diameter $H_2$ :	1.5 m
- Volume $V_2$ :	1.18 m <sup>3</sup>
- Wall thickness $s_{w,2}$ :	1.2 mm
- Wall density $\rho_{w,2}$ :	7850 kg/m <sup>3</sup>
- Wall specific heat capacity $c_{p,w,2}$ :	469 J/kg K
- Wall thermal conductivity $\lambda_{w,2}$ :	21 W/m K
- Design pressure vacuum $p_{set}$	20 mbar

**Table 1-5:** Property Data (Case 2)

- Medium of the stored liquid and vapor	methanol
- Medium non-condensable gas	air
- Physical state at operating conditions	equilibrium state
- Void mass fraction of methanol	0,696
- Initial temperature $T_{b,2}$	55°C

**Table 1-6:** Ambience Data (Case 2)

- Ambient pressure $p_a$ :	1,01325 bar a
- Ambient temperature $T_a$ :	15°C
- Rain temperature $T_r$ :	15°C
- Rain intensity $G_r$ :	40 kg/m <sup>2</sup> hr
- Rain impingement angle $\theta$ :	68°

For the calculation of the heat transfer some heat transfer coefficients are given in **Table 1-7**.

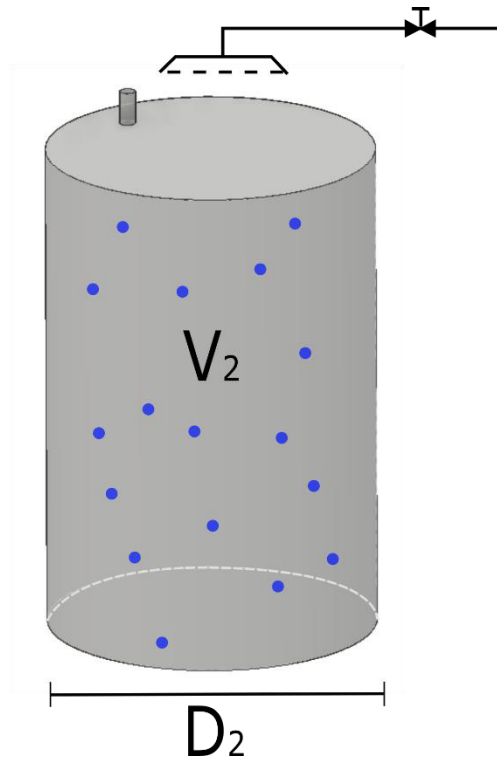
**Table 1-7:** Heat transfer coefficients

- $\alpha_i$ on the inner surface of the tank wall	5 W/m <sup>2</sup> K
- $\alpha_{Rain}$ between the tank wall and the rain film	5000 W/m <sup>2</sup> K

-  $\alpha_{out}$  between the rain film and ambience

25 W/m<sup>2</sup> K

Note that  $\alpha_i$  is assumed as heat transfer to a dry wall.



**Figure 1-2: Venting scenario for case 2**