EURISG

European Industrial Sizing Group

EURISG Sizing Case Report

ESC_114

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Sizing of a tank breathing device

CSE – ENGINEERING CENTER OF SAFETY EXCELLENCE GMBH MIT SITZ IN PFINZTAL

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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 m³
- Wall thickness $s_{w,1}$:	5 mm
- Wall density $\rho_{w,1}$:	7850 kg/m³
- 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/m² hr
- Rain impingement angle θ_r:	68°

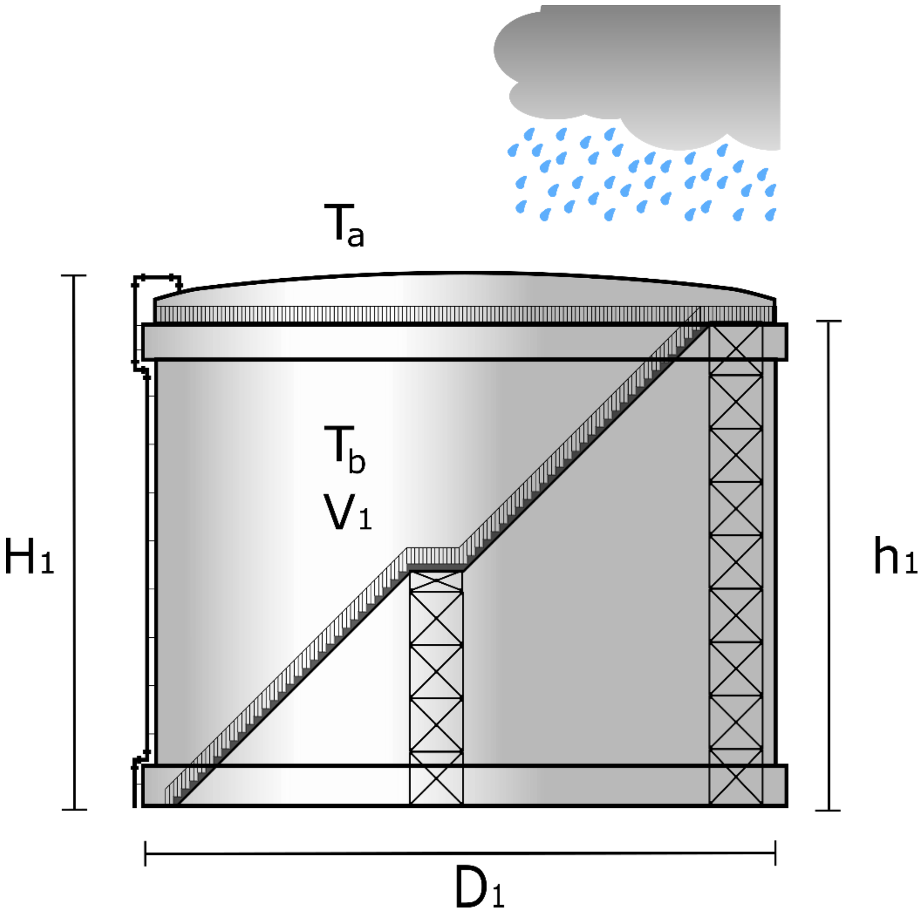

Figure 1-1: Venting scenario for case 1

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 m³
- Wall thickness $s_{w,2}$:	1.2 mm
- Wall density $\rho_{w,2}$:	7850 kg/m³
- 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/m² hr
- Rain impingement angle θ:	68°

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

Table 1-7: Heat transfer coefficients

- α_i on the inner surface of the tank wall	5 W/m² K
- α_{Rain} between the tank wall and the rain film	5000 W/m² K

- α_{out} between the rain film and ambience 25 W/m² K

Note that α_i is assumed as heat transfer to a dry wall.

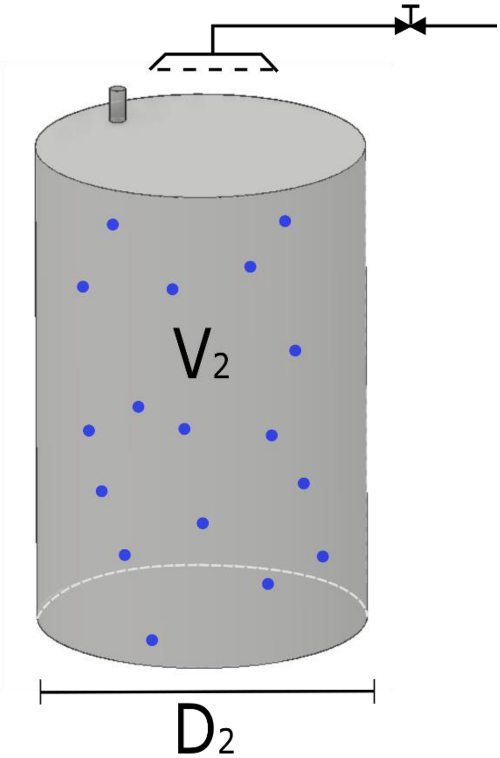

Figure 1-2: Venting scenario for case 2