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European Industrial Sizing Group

EURISG Sizing Case Report

ESC_113

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Protection of a low-pressure collector head connected to a high-pressure nitrogen purging system considering Multiple choking

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

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Revisions

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180621_ESC113_Multiple_choking	First version (CSE-Engineering)	21.06.2018
190311_ESC113_Multiple_choking	Insert of: what should be considered during the sizing and which alternatives are possible for the safety device	17.06.2019

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1 Task description

In this report, the design of a safety relief system for Nitrogen discharge is analyzed. Nitrogen is used as purge gas. The scenario to be considered is an overpressure at the collector head, triggering the safety relief valve SV-100 (see **Figure 1**). Multiple choking positions of critical flow rates are possible due to the geometry and process conditions.

The system is composed of a tiny Nitrogen supply pipe with 10 mm inner diameter, designed to deliver 30 bar abs Nitrogen. This pipe is linked to the collector head with a maximum allowable working pressure (MAWP) of 10 bar g. A safety relief valve SV-100 of API type D is installed to protect the collector head against overpressure. The outlet of the safety valve is connected to a flare by a pipe of 20 m length and 2” nominal diameter. An isometry can be found in **Figure 1**. Detailed information about the Nitrogen line and the collector head is given in **Table 1**. Information about the relief system including piping (downstream of the collector head) is provided in **Table 2**. The block valves are assumed to be fully open. The determination of the fluid property data is part of the task.

Two sizing cases are defined for this report as follows:

CASE 1

It is to be evaluated, whether the safety valve capacity is sufficient to safeguard the collector head. The Nitrogen mass flow rate to be discharged through the safety valve is to be determined:

a) As a first approximation, the Nitrogen flow rate should be modeled via an isentropic nozzle using the Nitrogen supply pipe diameter as a nozzle diameter and neglecting all pipe elements.
b) As a more detailed analysis, the pressure losses of all the isometry elements in **Figure 1** should be taken into account.

A restriction orifice downstream of the block valves may have to be installed in order to protect the system by restricting the Nitrogen mass flow rate.

CASE 2

Due to changes in the Nitrogen supply of the plant, the inlet pressure in the Nitrogen Line is planned to be increased from 30 bar abs to 100 bar abs. Re-evaluate the safety valve design for this change (analogous procedure as in case 1)

a) Sizing of the safety valve and the restriction orifice without consideration of piping
b) Sizing of the safety valve considering the piping.

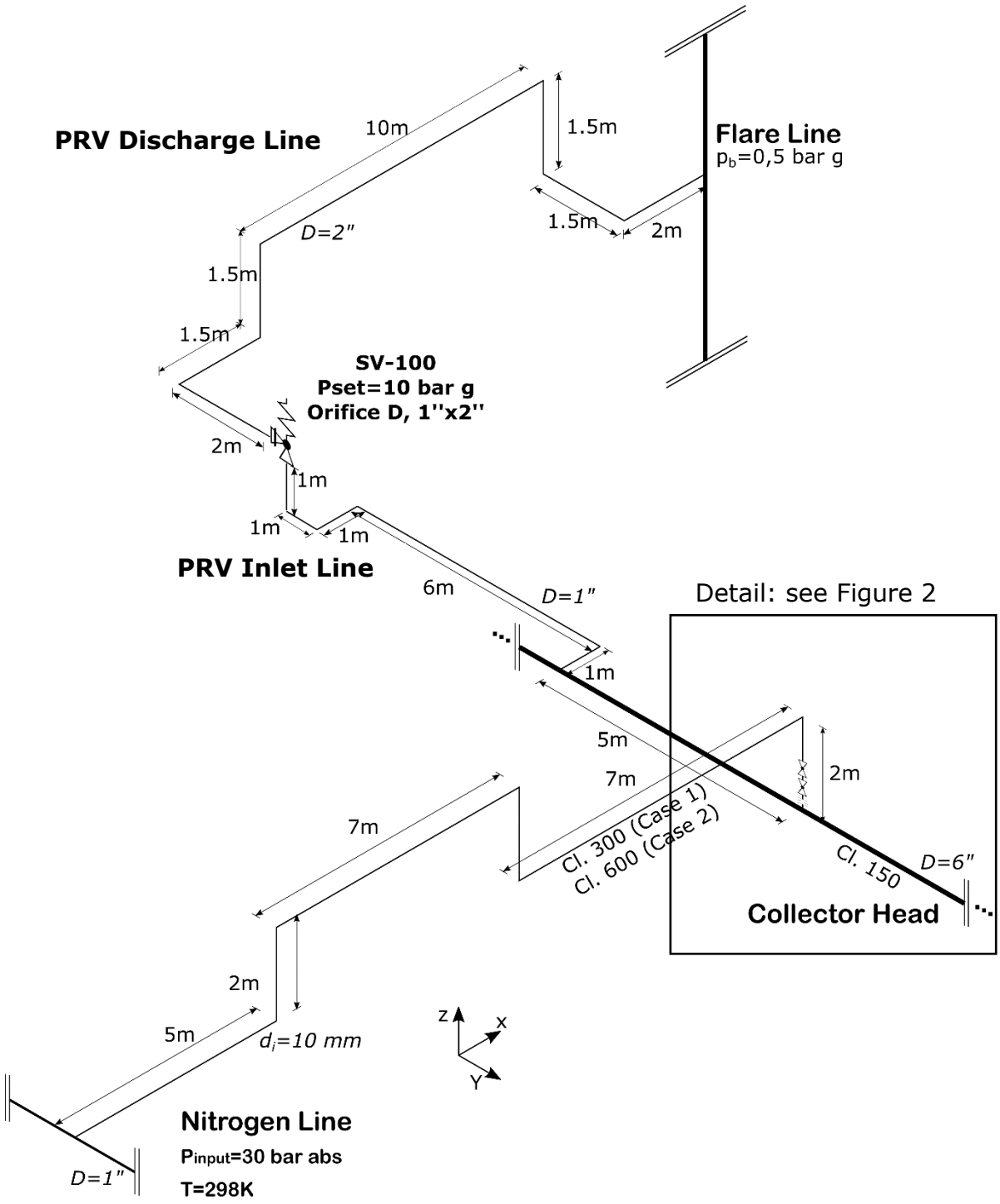

Figure 1: Isometry of relief system with Nitrogen Line for purging

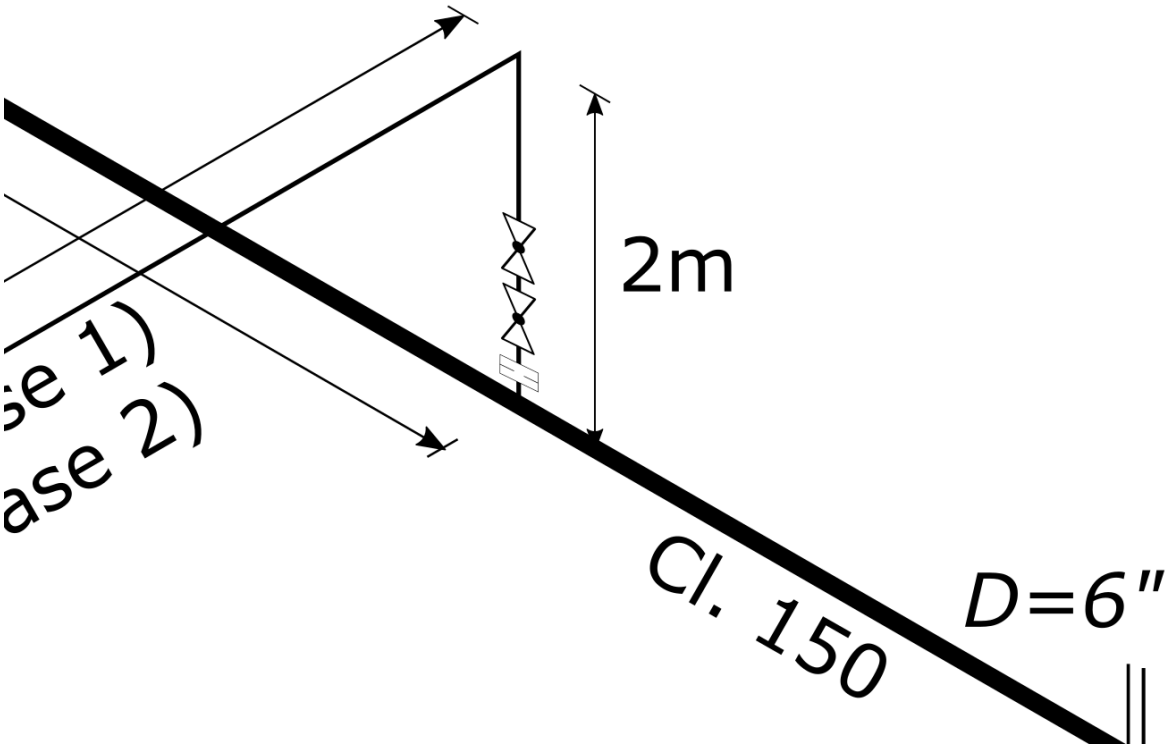

Figure 2: Detail from Figure 1, showing the block valves and the restriction orifice. The pressure change is arranged after the restriction orifice.

Table 1: Parameters in the nitrogen purge line

▪ Medium:	Nitrogen
▪ Initial temperature:	298 K
▪ Initial pressure:	30 bar abs
▪ Nitrogen Line diameter:	10 mm
▪ Block valve inner diameter:	10 mm
▪ Pipe and head material:	40S
▪ Roughness:	70 µm
▪ Geometry Bends:	90° (R/D=2.5)

Table 2: Parameters in the Safety Relief System

▪ MAWP Head:	10 bar g
▪ Nominal Diameter Pipe Head:	6”
▪ Pipe and head material:	40S
▪ Pipe Roughness:	70 µm
▪ Safety valve SV-100:	DN 1” x 2”
▪ Safety valve area SV-100:	145 mm²
▪ Reduced discharge coefficient for gas flow $K_{dr,g}$:	0.53
▪ Set pressure safety valve SV-100:	10 bar g
▪ Back pressure flare:	0.5 bar g
▪ Geometry Bends:	90° (R/D=2.5)

Other relevant data can be found in Figure 1.