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Pressure drop calcaulted by Flarenet in PSV outlet Flange

Bahareh Mahdavian

Looking for new challenges

We did sizing of a wellhead PSV and some checking for its tail pipe by flarenet.
The PSV vendor has proposed the nozzle of 3"x 4""whereas there is other option of 4"x 6" for PSV with type L and the capacity of 124667 kg/h.
The problem is that the 4"outlet nozzle give us very high back pressure (47.6 bara) and the pressure drop only in a piece of nozzle (assumed 20 cm) is around 46.8 bar. Therefore we have to choose higher rating for outlet flange .But we calculated and evaluated this pressure drop for 4"nozzle by hydraulic excel sheet and we came up with completely different result.(3 bar pressure drop)
In addition the velocity is much higher than sound velocity.
We are not sure if the flarenet results can be trustable or not.
I would like to know if any body had such a problem in the past or have any experience and can share it here.

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5 comments

Arun

Arun kumar

Senior Process Engineer at Saipem

The FlareNet Results are trustable,

In Case of PSV Type selection or the Orifice Selection. The Vendor has his own set of Orifice plate dimensions.this is the reason to have different flarenet Calculation and the values provided by the vendor.
In the Flare Net there is an option to update the Type of PSV size manually and update the values given by the Vendor. then see the values will match. One more thing the Values given by the Vendor will based on some Backpressure stated by you. check the values given to him...

Important thing is that the velocity in the tail pipe can Reach 1 Mach as per API, but you will have to give proper support to it .

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S M

S M Kumar

Process Design Consultant

Bahreh: In a piping system at subsonic conditions, upstream pressure @ point B = Downstream Pressure @ Point A + Frictional Pressure Drop in the piping between A and B.

In cases where sonic flow occurs, Pressure at Point B is decided by choked flow pressure and not be frictional Delta P between A and B, that is, "pressure for a given mass flow that will maintain the flow velocity at point B at sonic".

For instance, under subsonic conditions if you reach velocity V m/s at Point B with a 6" pipe, when you use a 4" pipe velocity will be V*(6/4)^2 = 2.25V. But if you have already reached sonic velocity with 6" pipe, velocity at B cannot become 2.25 Sonic. It will remain sonic. How? by the pressure at B raising 2.25 times to maintain velocity at sonic.
* It is known as terminal pressure or choked flow pressure*.

Simple pressure drop calculation is not valid to determine upstream pressure when there is pressure discontinuity due to sonic flow – that is downstream pressure does not affect the upstream pressure.

I have written it in simple terms. Trust this is clear.

For your case, assuming a simple configuration, I notice that even with a 6” tail pipe, you get high tail pipe pressure > 17 bar, the limit of 150# piping. You may have to go for 300# tail pipe until the size becomes >8”. [This you have to check – as your configuration may be different.]

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Frank

Frank Petz

research at Consultant

usual design for PSV is critical flow (a condition in many cases obtained when outlet pressure < 0.5 * inlet pressure),
a high back pressure should be verified for above condition,
another point to consider is the mach number on outlet line,
usual values are in the range 0.5-0.7 (but could be higher),
to size the outlet line you may consider the maximum volumetric flow (max mass flow divided by density at outlet conditions) then calculate speed of sound (at outlet condition), divide max volumetric flow by 0.6*speed of sound to obtain a initial value for piping area, with this value you can calculate pressure drop and correct something if required.
Flarenet should do all this automatically.
As said on another forum make sure to select the proper thermodynamic options for fluids properties and unit operations (i.e. PSV and piping),
You can verify the results in Excel with a library such as PRODE PROPERTIES,
for such high pressures I would prefer to model rigorously the PSV (I do this in Excel with the specific isentropic nozzle macro available in PRODE)
the procedure calculates discharging temperature, then you can calculate density and size the line for some predefined mach number,
to calculate speed of sound for gas, liquid and two-phase (with HEM model) flow use the macro =StrSS(1)
which retuns the speed of sound, as said usually I limit mach number to 0.7 for tail pipe and 0.5 for main header.

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S M

S M Kumar

Process Design Consultant

If I may add, I observe during my one-to-one coaching or training classes, good process engineers get confused on sonic flow issues or the choked flow pressure – pressure discontinuity.

As an analogy, as offered by a good old Thermodynamic Prof, that usually end up confusing the issue, consider a river system as it finds its way from the hills to the plains to the reservoir – ocean or lake (I am sitting next to Lake Michigan as I write this). In plants it is the storage tanks.

In the plains, as the river flows from Town A to B, it is clear Town A is at a higher elevation. Water level in Town A will be higher too. Level in Town A is decided by flow and level in Town B. That is there is a level continuity. How about water fall in the hilly regions of the river?. Level upstream of the fall is not decided by the downstream level for any flow. Downstream level has no influence on upstream level.

How to calculate the critical or choked flow pressure? You know mass flow and gas properties – find the sonic velocity for the gas Mol Wt and Temperature. Divide mass flow by sonic velocity to get the density at critical condition. By trial and error find the pressure that will give you the critical density. Again this is a simplified version as there is a temperature correction involved – if you do this 2-3 times, then the concept will be clear.

P at a Point = Maximum (Pchoked, Pd/s+Delta P).

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Mojtaba Habibi likes this

Frank

Frank Petz

research at Consultant

a problem with such high back pressure and mach number near 1.0 could be the difficult to estimate the effective pressure drop in discharging line,
this because at constant mass flow density (and velocity) depend from t,p on each segment and there is the limiting value of sonic flow to consider (a series of different diameters may be required).
Also it is important to select a suitable thermodynamic package to estimate local density and speed of sound, with hydrocarbons, usually I select in PRODE the standard or extended Peng Robinson or Soave which give reasonable values.

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