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BDV allowable back pressure

Saiedeh Nikraftar
Independent Consultant

Dear all, I need to now what is the effect of back pressure on BDVs releasing to flare? There is a Auto check button in Flarenet which specifies the allowable back pressure as 50% of relief pressure. What is the basis of 50% criteria?

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Frank

Frank Petz
research at Consultant

a) generally a similar criteria (outlet pressure < 50% inlet pressure) should determine a condition of critical flow in valves / devices (which may give some advantages in your case being the critical flow the max sustainable flow)
b) in general you can model BDV / PSV etc. devices with both critical and non-critical flow condition, for a BDV there are operations as constant energy flash which allow a rigorous simulation in both conditions, the same for a PSV (modeled as isoentropic nozzle).

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Saiedeh

Saiedeh Nikraftar
Independent Consultant

Let me explain my case more clearly. I am working on header sizing for a flare where one BDV releaves at a point near the end of the header and back pressure at that point is slightly more than 50% of set pressure- around 10% higher-. I want to decide whether I should add up the header size in order to deecrease the back pressures or not. Please advise!

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Frank

Frank Petz
research at Consultant

If you are simulating blow down of one or more vessels / piping etc.
the decision depends from several factors,
 blow down is a dynamic process and you may accept high pressures at beginning providing the pressure drop across BDV is sufficient to sustain the required discharging flow and it's acceptable during the whole process (contact the manufacturer for detailed data to use in simulation, see also the notes on my previous post for the procedures),
to verify that you can recalculate BDV flow and pressure diagram for flare network at regular intervals during discharge (keeping in account process conditions in different intervals) and see if the BDV flow is acceptable, according API criteria or project specifications.

if (instead) is for a PSV you may simulate the device (as isentropic nozzle) to calculate vena contracta conditions,
if back pressure is close to vena contracta conditions (usually it's in the range 45%-55% of discharging pressure) you may contact manufacturer for a detailed analysis,
however I wouldn't recommend such a solution for a conventional PSV also you should also verify specifications and standards in your project to see if it's acceptable.

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Saeid Rahimi Mofrad
Senior Specialty Process Engineer at Fluor

For BDVs, Flarenet specifies the default allowable backpressure of 50% of the relief pressure (as a typical critical pressure) because the flow through BDV is constant (choked flow) as long as the backpressure is less than about 50% of the upstream pressure. The capacity of blowdown valve decreases when the backpressure increases beyond the critical pressure. This means that you need to incorporate the backpressure into depressuring model in order to make sure that API requirements (on fire depressuring time to reach the final pressure for instance) are met.

As mentioned by Frank, the backpressure is function of depressuring rate which decreases by time. Since upstream pressure also decreases during depressuring, therefore you need to update the depressuring model backpressure during the depressuring which is not easy especially with software like Hysys where you don't have this option to change the BDV backpressure during depressuring.

Flarenet can produce the backpressure at reduced depressuring rates but how to feed this backpressures into Hysys depressuring model (in order to get the realistic results) is the main challenge.

From valve sizing view point, as long as the same backpressure is specified in the blowdown valve datasheet, there should be no problem.

if you don't want to get into this, you can review other options like reducing depressuring flow or increasing the flare header size.

By the way, when you are talking about backpressure of 60% of relieving pressure and I assume the vessel design pressure of at least 17.0 barg (say 20 barg relieving pressure) where depressuring facility is usually provided, the backpressure for this BDV is about 12.0 barg which is quite high for any flare system. I am thinking about the limitation that such a high backpressure will impose on the relief valve selection. Refer to API-526 and limitation on the availability of large spring loaded relief valves at high pressures.

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S M

S M Kumar
Process Design Consultant

Saiedeh: 50% criteria is a legacy rule of thumb. This ensures choked flow via BDV allowing flow calculation as a function of flow area and upstream pressure (F=A*P1). Modeling is simple

If the back-pressure is above 50%, flow becomes a function of area and delta P (F=A*(P1-P2)).

In a blowdown system, downstream flow rapidly declines with time and backpressure will also fall as square of the flow. You may specify for P2, the initial backpressure in Hysys. The prevailing backpressure is likely to be low after the initial few minutes. This may make the flow more than predicted by Hysys. That means the blowdown time will be faster than predicted by Hysys.

This initial-subcritical with >50% backpressure, is OK as long as this does not increase the BDV size. BDVs are usually 2" and you may go ahead with subcritical flow if this source is a minor contributor.

If the source is a major contributor and you wish to decrease the BDV size and its initial flow, you may carry out blowdown in stages – that is a select a size; blowdown for a few minutes; reset this as the initial condition and specify a reduced backpressure based on reduced or declining flow from all sources, based on a composite flow Vs time curve. Will require a few days of additional work and give you the satisfaction of a good analysis.

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Saiedeh

Saiedeh Nikraftar
Independent Consultant

Saied: Thank you for your reply.
1- In this case, vessel design pressure is 7 barg and it contains liquified Hydrocarbon and its content is more than 2 tons. Hence, it has to be depressurised, regardless of the design pressure (Total Practice).
Back pressure in the system is not too high: around 4.7 bar.

2- I suppose our main problem is in orifice sizing for RO after BDV, because BDV itself is an On/Off valve.
In designing RO, do you think if I specify higher back pressure with calculated flow rate from Hysys, that would be OK?

Mr Kumar: Could you please introduce a reference or procedure for suggested method?

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Frank

Frank Petz
research at Consultant

blow down procedures in simulators generally assume critical flow in RO (normal condition for sonic flow is Pout < 0.5 * Pin) and calculate flow accordingly based on system pressure,
in your case, possibly, the mass flow in RO will be lower than critical (that will depend from backpressure which will not be constant during blow down process).
(I have a similar problem with the depressuring procedure included in PRODE PROPERTIES which however allows to specify a variable flow which mitigates the problem).
if your simulator doesn't allow to specify that condition (i.e. to define a variable backpressure or the flow through BDV at different intervals) you may evaluate the errors introduced in simulation by calculating the ratio of critical / real flow at regular intervals, integrate and estimate the correct results, for example you can average the volumes discharged corrected by density to keep in account the different operating conditions and calculate a correction factor.
As alternative you can model the whole process with a direct integration procedure,
With direct integration you simulate directly the blowdown process by calculating at regular intervals of time the mass discharged and the conditions in vessel.
You can do that with Excel or a similar tool by accessing the methods in your software for solving flash operations and fluid properties,
I use PRODE PROPERTIES for that but I think Hysys should do the same.
By the way the main difficult with these procedures (assuming that backpressure > 0.5 Pin is allowed by project specifications) is that you must be prepared to provide detailed technical support to your calcs,
most engineers accept without discussions the results from a simulator but may ask many questions if you introduce some variants.

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S M

S M Kumar
Process Design Consultant

Saiedeh: I do not have a reference unless Saied writes one for his site or I prepare one. Latter is unlikely (*_*)!! Briefly,

(1) Please enter in an Excel sheet the declining loads from all the sources – time 0,3,6,9,12,15 against kg/h. Graph time Vs total load

(2) You know the pressure profile at time 0 and you should be able to figure out the pressure profile at other time periods in Excel, taking tip pressure drop as choked pressure for sonic conditions; velocity head for subsonic condition. Yes, blown down or vented gas property from all the sources changes all the time, gases getting heavier. Yes, all the gases are not going linearly thru the header. Ignore for the first pass. [Rigorous Flarenet modelling to get exact back-pressure is possible with Hysys data.]

(3) Plot in the same graph, declining source pressure of the source 7 bar vessel. You can instinctively figure out at what point in time the back-pressure changes from >50% to <50%. If it happens in the initial 2-4 minutes, you can take the back pressure <50% from time 0 as the flow from the source will be critical and constant as predicted by Hysys. I believe with a source pressure of 7 barg or 8 bar, you need a backpressure of about <4.4 bar or 3.4 barg for the flow to become critical. That is at about 85% of time 0 flow. It should happen after 1 minute. Again, if the source is a small one – compared to the rest, say with about 10% of total load, you don't have to worry.

This may look crude – but considering the degree of inaccuracy in Hysys and Flarenet predictions, it is OK. Remember when we did not have Hysys blowdown or Flarenet model, not long ago, we took Grote's equation and sized the systems. Availability of tools, in a few instances, instead of saving time has exponentially increased it..
If you wish to go for a rigorous validation, I guess the above method will instinctively provide the road map. Sorry, I could not be of much help.

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Saiedeh

Saiedeh Nikraftar
Independent Consultant

Thank you Mr Kumar. Thanks everyone for guidance and help. This is a very useful thread indeed.

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S M

S M Kumar
Process Design Consultant

Appreciate your initiative and interest to check out, than taking the easy way out of increasing the header size. Like we value our personal $, we need to keep an eye on hiking project cost. I have reduced large flare headers to reasonable size during reviews. I am sure you now have satisfaction of doing it right. Best!

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Bala

Bala subramaniam

Senior Process Engineer at WorleyParsons

Thank you all for sharing valuable information

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