Nozzle momentum criteria for K.O. drum and gas/liquid separator

Learn Syan Lee
Process Design Engineer

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Dear friends,

Below is a query regarding nozzle momentum criteria (mix density multiplied by two-phase flow velocity squared) for K.O. drum and gas/liquid separator.

As per clause 1.3.1 of DEP 80.45.10.10 (design of pressure relief, flare and vent systems), the momentum criterion for inlet and outlet nozzles of K.O. drum are given below:

1. Inlet nozzle (half-open pipe): Momentum < 5000 Pa
2. Inlet nozzle (schoepentoeter): Momentum < 10000 Pa
3. Outlet nozzle: Momentum < 6000 Pa

However, as per Appendix II of DEP 31.22.05.11 (gas liquid separators – type selection and design rules), the momentum criterion for inlet and outlet nozzles of gas/liquid separators are given below:

1. Inlet nozzle (half-open pipe): Momentum < 2100 Pa
2. Inlet nozzle (schoepentoeter): Momentum < 8000 Pa
3. Gas outlet nozzle: Momentum < 4500 Pa

Appreciate if anyone from the group can shed some light on the possible reasons for discrepancies in the nozzle momentum criteria (ρV^2) as mentioned in the relevant Shell DEP above.

Thanks and regards,
Syan

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Mojtaba

Mojtaba Habibi
Process Engineer at Wood Group

Dear Syan,

My 2 cents:

1. In my view one of the reasons can be difference between hydraulic design constrain for flare network and process piping such that for the former high mach no. values can be used (due to intermittent nature of relieving streams, improved combustion at flare tip, etc) while for the latter the allowable velocity and pressure drop is more stringent (due to cost issue).

2. For flare KOD I suppose most of the time you should not be concerned for momentum because based on order of precedence for different design constrains back pressure issue is at highest priority and usually if your design meet back pressure design constrain then momentum design constrain will be OK as well. That is why usually no reducer/expander is considered for flare KOD inlet/outlet nozzles.

3. For process separators I have seen some companies do not consider any such momentum criteria and consider inlet/outlet nozzle size same as connected line size.

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S M

S M Kumar
Process Design Consultant

In Oil-Gas Sep, with lower allowable values, you want good separation to minimize liquid carry over to downstream units, say a compressor. These separators have internal demister etc to enhance performance.

In flare KOD, the criteria is not strict, you can tolerate some liquid droplets to say 400-600μ, that can get entrained/ atomized and burnt with gas.

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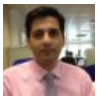

Saeid Rahimi Mofrad
Senior Specialty Process Engineer at Fluor
Top Contributor

It is not only Shell that have relaxed the flare KOD nozzle criteria. Some companies don't size the flare KOD nozzles based ρV^2 and take the nozzle size the same as line size required as result of flare network simulation.

But on the technical side, ρV^2 is:

• Indication of stream momentum which is very important on the inlet side of the vessel to prevent liquid shattering and re-entrainment. On the gas outlet nozzle, ρV^2 can be important as it causes localized high velocities in the part of the mist extractor which can impede the mist extractor performance. Considering the fact that mist extractors are not often used in this application, it seems that ρV^2 is not important form momentum viewpoint.

• The sign of vibration when it is compared with what we used as criteria for sizing inlet nozzle ($\rho V^2 < 6000$ Pa) during the heat exchanger design. I think you will see sort of this parameter in the mechanical design calculation of the vessel's nozzles too.

• A major contributor in the pressure drop within the vessel. For example, the pressure drops of inlet and outlet nozzles are 0.5 ρV^2 and 0.22 ρV^2, respectively.

• Quite comparable with the erosional velocity limit in two phase systems ($V = 100 / \rho^{0.5}$ or $\rho V^2 = 10{,}000$). Therefore, the erosional velocity may be still important for the inlet nozzle when the size of nozzle is calculated.

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kyoumars rahimi, Learn Syan Lee like this

Jaganathan

Jaganathan B
Asst. Manager (Process) at Larsen & Toubro Limited

I too came across similar observation on momentum critieria. In this WHP facility, closed drain vessel act as KOD for cold vent handling blocked flow arm blocked discharge relief. Due to little higher momentum of 5385, vendor proposed even flow vane as inlet device for closed drain vessel. But I never came across such inlet device for CDV ! My queries are
1. Is it really required for short duration relief?
2. I may propose to limit this relief by providing 2003 voting PT on flowline to limit the relief and size the vessel for handling normal drain and well unloading. This will make system reliable and safe for operation.
please propose any other alternative

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S M

S M Kumar
Process Design Consultant

Jagan: 5385 Vs 5000 or 6000. We are engineers. It is not a good idea to put any internal in a vessel in the path of vented/ flared gas.

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Shital Shah, Learn Syan Lee like this

Jaganathan

Jaganathan B
Asst. Manager (Process) at Larsen & Toubro Limited

I agree with you sir.
Here its a safety concern than momentum for a short time relief !! But Mr. Syan referred SHELL DEP says we should put internal in flare KOD as per the criteria. Can you explain why this requirement to be met on which scenario/case?

Mr.Saeid response says SHELL DEP has relaxed this criteria, please share the reference.

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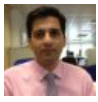

Saeid Rahimi Mofrad
Senior Specialty Process Engineer at Fluor
Top Contributor

Jaganathan,

I guess Kumar was trying to tell you that nothing is going to happen even if the inlet ρV2 reaches 5400, especially in flare KOD and for a short time relief. Furthermore, you can increase the inlet nozzle to reduce it below 5000 and avoid inlet multivane device and extra costs, if you are really concerned about such a small deviation.

Most probably, his proposal (It is not a good idea to put any internal in a vessel in the path of vented/ flared gas) is based on some of the Client standard in which using any kind of device on the flare KOD inlet and outlet nozzles that can fail and block the relief path is not acceptable. But if your Client is Shell, you are allowed to use schoepentoeter on the flare KOD inlet nozzle.

The relaxation I was taking about is nothing but what had been discussed in Syan's post. If you check the older versions of shell DEP, you will find out that the acceptable ρV2 for flare KOD was higher. Only very recently they have realized that such a stringent requirement is not really needed for flare KOD and revised the criteria as below:

1. Inlet nozzle (half-open pipe): Momentum < 5000 Pa
2. Inlet nozzle (schoepentoeter): Momentum < 10000 Pa
3. Outlet nozzle: Momentum < 6000 Pa

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Jaganathan B likes this

Mojtaba

Mojtaba Habibi
Process Engineer at Wood Group

Dear Saeid,

"But if your Client is Shell, you are allowed to use schoepentoeter on the flare KOD inlet nozzle."

Any reason/justification to support using schoepentoeter?

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Jaganathan

Jaganathan B
Asst. Manager (Process) at Larsen & Toubro Limited

Dear saeid, thanks for detailed clarification. I tried increasing nozzle size but not possible due to load. Can you check/confirm my second option. Thanks.

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S M

S M Kumar
Process Design Consultant

Jagan: I would not go for 2oo3 for this case. You are talking about 7-8% on momentum or 3-4% on flow in excess. If your team can consider reduced flow from wells on account of increased backpressure (flow arm at relief pressure), you should be able to meet the criteria. In other words, first try number crunching. If not a schoepentoeter could be a beter alternative to 2oo3.

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Learn Syan

Learn Syan Lee
Process Design Engineer

Dear friends,

Many thanks for the useful feedback on this topic with regards to nozzle momentum criteria.

Further, I would like to hear from the group members regarding the interpretation of below DEP clauses to clarify on the following query:

• As per clause 2.3.1 (Feed Inlet) of DEP 31.22.05.11-Gen, Feb 2012,

"the criterion for nozzle sizing is that the momentum of the feed shall not exceed prescribed levels (as in Appendix II). The maximum allowable inlet momentum can be increased by fitting inlet devices."

• As per Appendix II (Sizing of Feed Nozzles) of DEP 31.22.05.11-Gen, Feb 2012,

"for vessels with normally no liquid, sizing the inlet nozzle for an inlet momentum of 8000 Pa at normal operating conditions is allowed."

• As per clause 4.1.3.1 (Nozzle Sizes) of DEP 80.45.10.10-Gen, Feb 2012,

"the essential dry case need not follow the above criterion; however, the mechanical design shall still consider the momentum (nozzle load)."

• As per clause 6.5.1 (Mechanical Requirements: Loads) of DEP 31.20.20.31-Gen, Feb 2012,

"unless stated otherwise on the data/requisition sheet or in the order, the Schoepentoeter or inlet pipes shall be designed to withstand the following load:
* A maximum operating load over the column nozzle of 15 kPa (2.18 psi)
* A Schoepentoeter or half-open pipe shall be strong enough to bear its own weight plus the weight of the fluids a process conditions."

Query:
1. In case of exceeding inlet nozzle momentum criteria (> 8000 Pa) for an existing KO drum without inlet device for essentially dry case,

(a) Should we recommend to install a half-open pipe, for which DEP allows to increase the momentum limit up to maximum operating load of 15000 Pa?

Or

(b) Can we accept the higher momentum for inlet nozzle, since separation is not a concern (for essentially dry case, i.e. gas relief case) and as long as the dynamic load is within the standard mechanical nozzle design load as per ASME Sec VIII?

2. In case the latter option is considered, how can we correlate the estimated momentum (in unit kPa or Pa) to nozzle operating load or forces (in unit kN or N)? Is it correct to correlate using simple formula:
F = P x A,
where:
F is the force in unit N;
P is the estimated momentum (rho*V2) in unit Pa;
A is the cross-sectional area of the nozzle.

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