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PSV Sizing for Tube Rupture scenario.

N Venkata Srinivasu
Process Design Engineer at Jord International Pvt Ltd

Dear All,

Scenario: Vaporizing iso-pentane in a kettle type reboiler. The tube side fluid is water @ 80 bar & 135.5 C, 3600 kg/hr while the shell side fluid is iso pentane (liquid phase, 90% i-pentane mole frac) @ 7.1 bar & 35 C, 760 kg/hr . Design Pressure, shell side: 26 bar & the set pressure of the PSV is 29 bar.

1. What would be the outlet temperature of the resultant mixture from PSV in case of a tube rupture?
2. After tube rupture, what would happen to i-pentane?

a. Vaporize first & then pressurize?
b. Pressurize first & then vaporize?

3. How can we do a PSV sizing for this scenario?

Thanks & Regards,
Sriniii

Comments

aziz zehachi, Alireza Tabatabaei like this

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Jatinder Singh

Jatinder Singh Mander
Proposal Engineer Flares at Escher Process Modules

Dear Venkata

API 521 addresses all about it that is to design and protect heat exchangers against overpressure due to tube rupture.
So, you are having a kettle type reboiler i.e. heat exchanger in simple term.

Normally , a complete tube rupture is assumed occurring at the tubesheet, such that on one side you have tubeside fluid flowing through the tubesheet (assumed an orifice) and on the other side , tubeside fluid flowing through the remaining part of the tube.

You have to calculate the flow through the tubesheet side (orifice) and flow through the tubesheet + tube side.You have to also consider whether flow through the tube is choked or not.Being a 2 phase flow,"omega" method has to be used to calculate flows from both sides.

Once you have calculated flow from both sides , you add them and it becomes your relief load.You will have to know physical properties at the Relief pressure.

Once you have the relief load, the PSV needs to be sized. Again, use "omega" method (Appendix D, API 520)to calculate required relief area.

you can also use DIERS HEM equations.

Methodology using DIERS HEM equations.

1 – calculate the compressible flow parameter, w

This parameter is a measure of the fluids compressibility. The larger the value of w, the more the fluid behave like a compressible fluid. Values of 2 fall into these categories:

Flashing flow : w>1
Gas/vapor : w = 1
Nonflashing flow: 0 < w < 1
Liquid flow: w = 0

Step 2 – calculate pressure ratio, nc

Step 3 – calculate dimensionless mass flux through the tube sheet rupture

Step 4 – calculate actual mass flux through tubesheet

Step 5 – determine mass flux through the tube side of the broken tube. (the compressible flow parameter is the same) – this consist of (inlet nozzle, flow through the tube and flow through the tube discharge).

I have a technical paper which explains DIERS HEM method in detail and with examples. So if you send you email adress, I can send you the technical paper.

Regards
Jatinder

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Naveen Kumar, N Venkata Srinivasu like this

Frank

Frank Petz
research at Consultant

in addition to what said by Jatinder I would suggest to read the papers of Leung discussing the basis of simplified HEM model (Omega) with applications and examples,
HEM gives (in many cases) conservative values (compared, for example, to HNE),
for the case of water (initially under saturation pressure) there may be quite large differences,
as you correctly noticed a problem is the definition of a credible scenario to evaluate the peak flow to discharge,
I have used a constant energy flash to model a tube rupture but there are several models available and discussed in literature (and standards as API),
generally PSV sizing is not a problem,
nowadays you can simulate a PSV with HEM, HNE, NHNE etc. models directly in Excel,
see for example http://prodesoftwareapplications.blogspot.de

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marco

marco brianti
Attended polimi milano

API recommends to consider complete tube rupture scenario if there is a likelihood that the tube could experience an instantaneous tube rupture during operation,
for this case (complete tube rupture) a simple approach is to consider tube failure as an orifice flow exercise, there are papers from Leung discussing this application see Fauske site,
for two-pahse flow you can use both a simplified HEM (Omega, based on Leung's work) or rigorous HEM, HNE could be an option, too, as said by Frank and discussed in API.

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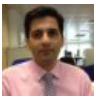

Saeid Rahimi Mofrad
Senior Specialty Process Engineer at Fluor

Venkata,

Let's go through the situation step by step then discuss about rupture flow and relief rate calculations.

Both side of exchanger are liquid filled during normal operation. If tube ruptures, the hot water will flow from tube @ 80bar to the shell @ 7.1bar. There will be no water flashing across the rupture at this condition (there is no need for two phase calculation) but hot water can cause iC5 to vaporize at 7bar, however, there will be no relief because the shell relief valve set pressure is 29 bar. The iC5 vaporization will cease quickly when the shell pressure reaches to about 15 bar. From this time onward, there will be no iC5 vaporization and extra water increases the pressure of shell to 29 bar when relief valve opens (so relief valve see only liquid too).

The rupture flow can be calculated based on liquid flow through one orifice + one tube (or simply 2 orifices).

The relief valve should be sized for liquid service and since the water density is higher than iC5, the relief rate (kg/hr) = rupture flow (kg/hr)

Can you explain why shell design pressure (26.0 bara) is lower than the relief valve set pressure

(29.0bar)!?

Saeid

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Frank

Frank Petz

research at Consultant

I think Saeid is correct,
before to answer I have not verified C5 saturation temperature curve against PSV pressure (anyway the discussion about methods for vapor+liquid may be useful for different applications),
Frank

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Wilfredo

Wilfredo Garcia

Process Specialist at Ecopetrol

Hi sir,

We developed a procedure in order to estimate the issues you're asking for. I could submit this to you, so please drop me an email to wilfredo.garcia@btinternet.com including the questions.

Cheers,

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Morteza

Morteza Younesi

Senior Process Engineer at Namvaran Consulting Engineers; Managers

Dear Venkata
Could you please provide tube OD size and thickness. Then I can help you to calculate Tube rupture case flowrate.

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N Venkata

N Venkata Srinivasu

Process Design Engineer at Jord International Pvt Ltd

Dear Saeid,

Sorry for the late reply.

Shell Side design pressure and set pressure of PSV is same 26 barg only. i have mentioned wrong in the my first post.

Dear Morteza,

Please find the Exchanger geometry deatils in the below.

Tube OD :19.05 mm
Tube Thickness: 2.77 mm
Length:6096 mm
Tube No: 36 U

Thanks & Regards,
Srinii

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Jatinder Singh

Jatinder Singh Mander

Proposal Engineer Flares at Escher Process Modules

will get back to you on this soon !

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