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PSV load calculation for gas expantion fire case

Damoon Nasseri
Lead Process Engineer at Foster Wheeler Energy Ltd

I have an existing Instrument air dryer with a PSV installed to protect against fire expansion.
This is an existing facility and I am validating the original design, which is done 20 years ago.
The problem is if I size PSV according to API, the existing PSV is not sufficient, and I was wondering if I can take credit (positive or negative) for having desiccant inside the drum and how much, as this is not an empty vessel.

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6 comments

Sam

Sam Izadpanah
Principal Process Engineer at Jacobs

Since the vessel is dry and there is no wetted surface, you need to be concerned with gas expansion PLUS water vapour coming off the desiccant. You can take positive credit for the volume occupied by desiccant but I think you should try to calculate the amount of water that will be released from the desiccant at high temperature. And it is a single component so it will probably come out of the adsorbent at the same time!

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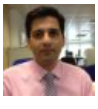

Saeid Rahimi Mofrad
Senior Specialty Process Engineer at Fluor
Top Contributor

You need to calculate the heat transfer rate inside the vessel through Q = h A (Tw –Tg)
Where
h = free convention heat transfer = 0.59 (Gr Pr)^1/4 if (Gr Pr)< 10^9
h = free convention heat transfer = 0.10 (Gr Pr)^1/3 if (Gr Pr)> 10^9

Gr and Pr are calculated at the film temperature of (Tw + Tg)/2

A is the total vessel surface area below 7.4 m (basically cylindrical portion). Tw can be considered as 593°C. Tg can be assumed as the water boiling temperature at the relief valve set pressure.

The relief load will be W = Q / water latent heat at relief valve set pressure

This ignores the vessel content heating up period and MCp DT and simply assumes that all heat input is used for water vaporization.

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Ahmad

Ahmad Ehsani
Management Consultant at Oil and Energy Industries Development co. OEID/ Senior Technical Consultant at LUKOIL

Dont Worry About the size of the PSV. The vessel is full of desicant so there is small free space for air or gas . Also the water adsorbed by desicant is not too much to make problem in case of fire.it can be checked by reviewing the data sheet for dryer .
The real vessel volume for PSV sizing in this case is much less than the apparent vesel volume .

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Saeid Rahimi Mofrad
Senior Specialty Process Engineer at Fluor
Top Contributor

I don't agree with Ahmad that there is no worry about the size of the PSV in this service. As far as there is a gas inside the system, the gas expansion needs to be considered. And in this particular case when the gas temperature reaches water boiling temperature, water will vaporize and over-pressurize the vessel. It is only a bit more complicated as the liquid inside the vessel is not in contact with vessel metal similar to fire - wetted case.

In fact, referring to API equation for unwetted vessels under fire, the gas volume has no effect on the relief rate. It does not matter if 80% of the system is filled with desiccant or 10%, the fire rate is function of DT/Dtime for the trapped gas. Therefore, fire case is applicable and the relief valve should be adequately sized for that. Furthermore, considering the fact that desiccants are porous the actual gas volume is most probably much more than the volume of those parts of the vessel where there is no adsorbent (which is anyway irrelevant).

The solution I have propoesd is indeed the basis on which the API fire equation for unwetted vessels has been developed. For more information, please refer to the paper titled as "The Basis of API Correlation for Fire Relief of Unwetted Vessels" on my website
http://www.chemwork.org/board.html

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Baher Binesh, M.Sc likes this

Damoon

Damoon Nasseri
Lead Process Engineer at Foster Wheeler Energy Ltd

Thanks for valuable advise

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Paul

Paul Frey
Principal Consultant Relief and Flare at Foster Wheeler Energy Ltd

Did you compare the API gas expansion method with the estimated water vaporisation rate as proposed by Saeid ?

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