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Validity of API 521 Method for Sonic Flare Stack

Mojtaba Habibi
Process Engineer at Petroleum Engineering and Development Company (PEDEC)
Top Contributor

Dears,

Annex C of the API 521(2007 edition) titled as "Sample Calculation for Sizing a Sub-sonic Flare Stack" presents 2 methods and some graphs for flare stack sizing.

Does the title mean that this annex can not be used for Sonic flare stacks?

If so, which approach do you recommend for sonic flare stack sizing?

Many thanks for your time.

Best,
Mojtaba

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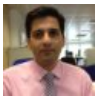

Saeid R. Mofrad
Principal Process Engineer at Petrofac (P.E.)
Top Contributor

As far as heat radiation calculation is concerned, the method described in this annex is applicable to sonic flares too.
The only point is that there are some parameter in calculations (such as fraction of heat radiated) which are different for sonic flares than what have been given in this API for subsonic ones.

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Mojtaba

Mojtaba Habibi
Process Engineer at Petroleum Engineering and Development Company (PEDEC)
Top Contributor

Dear Saeid,

Let's discuss those parameters one by one:

1. Fraction of Heat Radiated:

I could find following explanation for sonic flare tips:

"For sonic tip, typically can try F=0.1-0.12 Heavy gas i.e. C3, higher F factor may be experienced. Above just for your prelim studies,"

Reference: http://www.cheresources.com/invision/topic/7447-flare-stack-sizing-with-sonic-flare-tip/

1. Mach No. :

Based on good engineering practice mach no. of 0.5-0.7 can be used. Also value of 0.8 is recommended in another practice.

1. Pressure Drop:

Based on good engineering practice pressure drop of 3 - 5 bar can be used.

Let me know your idea and experiences on above mentioned values.

Any other parameter to be considered?

Many thanks for your time.

Best,
Mojtaba

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S M

S M Kumar
Process Design Consultant
Top Contributor

Dear Mojtaba:

API numbers are based on subsonic flares. In a typical refinery atmospheric or crude column operating pressure decides the flare system pressure, say 7 psig or 50 kPag. That is LP Flare.

1. Sonic flares aerate better (suck-in more air) with less soot production. A good value for F=0.1

2A. Tip Mach No: 0.5-0.8 are good for LP Flare. Once you say sonic, Mach No = 1. Remember once upstream or tip pressure is above 10 - 15 psig (25 - 30 psia = 170 - 200 kPaa), you get sonic velocity. That is the maximum velocity achievable. But if you can allow a higher pressure drop for the tip, then the tip diameter can be less.

2B. Flare Header Mach No: 0.7 Even with a sonic tip, the maximum allowable velocity for the flare header/subheader/tail pipe is 70% sonic. The high pressure drop or back pressure imposed by a sonic tip will reduce volumetric flow and hence reduce flare header diameter. Explanation. With a sub-sonic flare operating at 30 kPag, the flare header piping + KOD may operate at say 150 kPaa; with a sonic tip, the flare header piping + KOD pressure may be say 450 kPaa, there is a 3 fold reduction in volume; 60% diameter. That is a real gain.

3. Pressure Drop: For a sonic flare, tip pressure drop can be 3-5 bar; operating pressure of the header can be 8-10 barg and tail pipes 10-15 barg. This depends. If you want a tail pipe pressure of 15 barg, then the conventional PSV should be set at 150 barg; and a balanced bellow PSV should be set at 30 barg. Highly unlikely design pressure in an Oil & Gas Production Separator. So there can't be a standard value. Go case by case with a flarenet run. Distribute evenly the pressure drop over different diameters of main and sub-headers. Good rule is have equal pressure drop per length travelled. Do not give all the pressure drop to tip or the shorter tail pipes. With 2 runs in Flarenet, you should come with a good distribution of available pressure drop between tip, headers and tail pipes.

4. Other Factors: LP Flare have a longer flame length that drifts towards the observer. For a stack located at a given distance, the flame centre is closer to observer; hence taller stacks. HP or sonic tips produce short and erect flames. With a multi-head or hydra tip <Google search, images, "Hydra Flare tip">, you can divide the gas flow and hence individual flame lengths, keeping the flame centre far away.

Regards
Kumar

Saeid: The typing space is only a single line space. Could you get it fixed please

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Mojtaba Habibi likes this

Mojtaba

Mojtaba Habibi
Process Engineer at Petroleum Engineering and Development Company (PEDEC)
Top Contributor

Dear Mr.Kumar,

Thank you so much for your nice explanation and technical support.

Could you please explain for the fourth parameter (flame length) how to modify API 521 method for sonic flare tip?

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S M

S M Kumar
Process Design Consultant
Top Contributor

Good point. I have not seen any published or open literature correlation to estimate how short the sonic flame would be. Since flame envelope is nothing but an indication of air: HC mixture in combustible range, I have seen feeble attempts to estimate the flame length based on dispersion rules.

I have also read vendor papers that compare radiation levels measured versus estimated, showing a good variation. I have seen clients complaining about actual radiation being higher than predicted and wanted the engineer who predicted a lower level to be tied to a pole at the foot of the flare bridge and roasted alive.

So, go with present API method and use it to check any abnormally low value vendor may thrust on you! If you think about it, the present method predicts longer flame and hence flame center located far away from the tip. With shorter sonic flames, the flame center would be closer to the tip and closer to the observer!

If you analyse the API method, all it does is assume a sphere of radius D, divides the total heat output*F by the surface of the sphere – uniform radiation in all direction! Everything, the plus minus errors, as my professor used to say, is factored in F=0.1. [Do not buy the argument by some vendor sales person – not vendor technical engineer, in a multi-tip with multiple short flames, the flames far away from the observer is shielded by the flames near the observer!]. The more you dig – the more confused you will get (*_*)!!

Eid Mubarak

Kumar

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Vijay Prasad

Vijay Prasad K
Principal HSE Engineer at PDO FEED Office

For Sub Sonic flare system design - 0.5 Mach in flare header and 0.7 Mach at flare tip seems optimal depending on design back pressure and selection of PSVs etc.

have heard of the complaints from field operators about radiation even if the design is verified for 1.5 kw/m2 at sterile zone boundary (grade). The F factors are validated only for C1 mostly. Flare vendors calculations are to be verified and questioned.

I am not too sure whether the 1 kw/m2 solar radiation accounted for - is it geographically consistent (e.g. in Middle East Asia during peak summer day - will it be more?).

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