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Non-Slam Check Valve for Gas Service

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

Dears,

In most of the projects which involves gas compression, I have seen one common note at P&ID that check valve at discharge line of compressor should be "Non-Slam Type".

I found 2 technical papers which are published regarding to non-slam check valves which are used for liquid services and at pump dischage lines and also liquid product transfer pipelines:

1. Design and Selection Criteria of Check Valves, which can be accessed via:
http://www.valmatic.com/checkvalves.html

2. A methodology for predicting check valve slam, Journal AWWA, March 2007

Based on above mentioned papers, "slam" means system pressure surge and "non-slam check valve" is the one that minimizes the effects of pressure surge. This is also mentioned that "the best way to prevent slam is to close the valve very fast".

Now my question is:

What does "non-slam" requirement mean for gas service? How special is "non-slam check valve" for gas service? Why the check valve at compressor discharge should be "non-slam"?

Thanks for your time.
Mojtba

Comments

B. Eng. Glenda Gutiérrez Capriles MSc PMP TUV-FS., VIMALESH AGNIHOTRI and 4 others like this
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Stuart

Stuart Williamson
Dynamic Simulation Consultant at CB&I

Hi Mojtba
Good question. The only references I can find is that non-slam NRVs close very quickly and should be fully closed by the time that the pressure profile reverses, thereby preventing the possibility of back flow through the NRV before it closes. If its the NRV directly on the compressor discharge this can be to prevent reverse rotation on rundown (i.e. after a trip).
I've asked the same question on the rotating equipment discussion board to see if this produces any additional reasons.

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ANJARIA HITESHKUMAR M. likes this

Mojtaba

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

Dear Stuart,

As per section 4.3.4 of API 521, single check valve can not be regarded as reliable layer of protection against back flow. API statement is a general one and does not differentiate between non-slam check valve or other types of check valve.

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VIMALESH

VIMALESH AGNIHOTRI
Senior Process Engineer at Engineers India Limited

Dera Mojtaba, thanks for starting such good discussion. Dear Stuart, does it mean that non slam NRV will be helpful to reduce the settle out pressure of compressor? or will work as a anti-surge controller?

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Stuart

Stuart Williamson
Dynamic Simulation Consultant at CB&I

Hi Vimalesh
The NRV downstream of the anti-surge loop should prevent backflow from downstream and prevent the settleout pressure from rising while any ESDV closes.
Mojtaba, I agree with your statement, but I was making the point that from what I have read, if you assume it functions as expected, the non-slam nature should prevent any backflow as the NRV should closes as quickly as the pressure reverses.

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S M

S M Kumar
Process Design Consultant
Top Contributor

As I understand
(1) Non-slam check valve provided at centrifugal compressor discharge, as pointed out by Stuart prevents back flow thru the compressor after a trip that could damage the blades. As soon as a compressor trips, anti-surge opens and equalizes the suction and discharge pressure. Once the pressure are equal in milliseconds or seconds, the tendency to backflow via the compressor ceases.

(2) A second normal check valve provided at stage outlet (after anti-surge take-off). This defines a stage domain, prevents loss of recycle gas of the next stage to the previous stage by backflow when the compressor is on total recycle back from a running train while the stage outlet ESDV closes.

The non-slam used to be a must in all old designs. I do hear 2 schools of thoughts from compressor mechanical engineers. Some compressor vendors no longer require it. Variations in this opinion: (AA) Check valves are still installed in compressor discharge though sometime not installed interstage when there are no isolation valves between stages (BB) Anti surge valve's actuating mechanism do fail from time to time and hence its fast action cannot be the last line of defence and non-slam check valve is a must. (CC) In low pressure compressors with large inertia there may be a case to do without check valve, subject to supplier agreement and client appetite for risk management (DD) The check valve need not be non-slam; ordinary valve will do.

So check with your supplier and owner and let us wait to hear from Stuart on response to his query to rotating equipment discussion board

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S M

S M Kumar
Process Design Consultant
Top Contributor

Additional query:
HAZOP studies consider the non-slam or first check valve get stuck and act as a blocked outlet. This can prevent the compressor to reach settle out condition and void the machinery protection. Is it better to remove the first check valve?

My response: Interesting query as the PAHH trip and PSV on compressor discharge side are located downstream of the (stuck) check valve and can no longer protect the compressor.

Machinery protection for normal case via anti-surge and Hazop's perceived threats are 2 different issues. Let us look only at Hazop's scenario: If check valve is stuck, the discharge pressure will rise fast. As there is no flow thru the machine the compressor's anti-surge control will open the recycle valve. As this valve is downstream of the stuck check valve, no flow is available to recycle back to suction. Hence compressor will go into surge. Compressor starts vibrating and will be tripped by its vibration switches. Usually the compressor casing is designed for pressure developed at the surge point (highest head) at 110% of speed as limited by shaft power. This

reasoning is usually good enough for Hazop.

[Note: It makes sense to design the discharge piping and the check valve to the same pressure as compressor casing. While it is a usual practice in oil & gas industry to design the compressor discharge side to surge head at 110% of speed as limited by shaft power, other industries may just rate the discharge to 110-120% of normal discharge pressure with a PSV set at 110-120% pressure.] I'd like to hear from other members views on this.

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Stuart

Stuart Williamson
Dynamic Simulation Consultant at CB&I

Hi SM
A comment to point (1) in your first (of 2) posts above is that the discharge NRV is there to minimise backflow through the machine on the event of a trip, and prevent possible reverse rotation which could potentially damage the driver. This is especially true where the downstream volume (in the compressor loop) includes a large air cooler and possibly other equipment. Obviously it also minimises the surge volume that may backflow through the compressor (if a hot gas bypass valve loop is not installed).
Pressure equalisation when the recycle valve opens may take much longer than you suggest, and will depend on the volumes in the loop.
The point about the NRV blcokages is interesting. On the whole I have seen the PSHH upstream of the NRV, but often the PSVs are downstream. You mention using a limit of shaft power when designing the casing, but I know some companies don't allow for use of the rated power on motors where the maximum available torque (e.g. on a fixed speed motor) can be far in excess of the motor rated torque.

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S M

S M Kumar
Process Design Consultant
Top Contributor

Thanks Stuart. If you notice I have said "The non-slam used to be a *must* in all old designs". But project info indicates that both suppliers and owners are accepting the removal of this valve. I am not saying you do that. All I am pointing out is different school of thought and info I get from current projects. As you would observe my conclusion was "So check with your supplier and owner".

Regarding limit of shaft power. I am unable to understand your statement. One of the practices is to take the design pressure at surge head at 110% of the speed. But the provided driver may not able to even develop the power required to develp the head even at 105% speed. In such cases, the design pressure is taken as surge head at 105% speed - that is condider the driver limitation in deciding the max head

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Stuart

Stuart Williamson
Dynamic Simulation Consultant at CB&I

With respect to the maximum discharge pressure obtainable (or the maximum mass flow obtainable as it realtes to a similar exercise for PSV sizing), when you say take the design pressure at the surge head at 105% speed, this then depends on the suction pressure (as this could have risen considerably from its normal value and could be close to any suction PSHH setting). Obviously as the suction pressure rises, whilst the volume flow stays the same, the mass flow and power increase correspondingly (as does the maximum discharge pressure obtainable at say the 105% speed surge head). For a fixed speed motor, if you look at the torque speed curve, the peak torque can be up to 2.5 times the rated torque, i.e. in the short term and assuming the motor keeps running the power can increase to well above the rated power (by up to the factor of 2.5 times). Hence from my experience some companies don't accept the use of driver power limitations in compressor discharge relief valve calculations, especially for motor driven machines, and this would apply similarly to the discussion on setting the discharge design pressure for the blocked NRV case.

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S M

S M Kumar
Process Design Consultant
Top Contributor

Stuart: Message is clear. Thanks for this info. Then how do we fix the maximum discharge head developed – assuming suction is at PAHH - for motor driven compressor. Or is it going to be an arbitrary number? As the discharge PSV is located d/s of the check valve, its set point is not going to

decide. Usually the PAHH is also sited next to it. What machinery protection we have for the stuck closed check valve case. Thanks in advance.

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