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SAFETY VALVE NOISE; LIMITS, REDUCTION AND CONTROL

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1. FIRST A LITTLE PHILOSOPHY

1. As a Contractor's Engineer, one wants to have a model or other method of solution in place before one meets a cause for it's use.
2. Surely to have "no available model" shows absence of prior thought.
3. Some models will show lack of thought ,
eg1 A model inconsistent with the known facts or common sense,
eg2 No data to substantiate the maths,
eg3 Predictions inconsistent with the data.
4. A simple or basic model is better than no model at all, because, as information is gathered, the extra descriptions and data can be used to improve or change the model.

2. WHAT IS A SAFETY VALVE? HOW OFTEN, LONG, AND LOUD IS IT'S NOISE?

The safety valve is a device to avoid a dangerous build up of pressure within a system that it is designed to protect. The device may release the process fluid directly to the atmosphere via a short stub pipe, or release the process fluid via a pipe to a flare, or some other equipment. These will be called "open vent" and "closed" systems respectively. Such a safety valve is actuated by upstream pressure and is characterised by a "pop" action upon opening. Thus one should not expect a gentle release of gas proportional to valve lift. A **safety valve** is normally used with compressible fluids, and is distinguished from a **relief valve** which is primarily used with incompressible fluids (See the introduction to Ref 1 API 520). The safety valve is generally known as a PSV.

PSV noise can be expected to be in the region of 150 -170 dB PWL. I will guess a figure of "once in a hundred years" for the operational frequency of a single PSV, and thus on a plant with a hundred PSVs a noise from a PSV might be heard once a year.

While the system is depressurising the PSV will make noise. The noise changes and decays with time as the pressure decreases. The noise is greatest while the pressure drop across the valve induces sonic velocities in the valve. The higher the pressure ratio the higher the noise. The PSV may "chatter" due to flow instability while the gas flow continues, and it may not re-seat when the pressure is low enough for this to happen.

We shall define these emergency releases of gas as transient noise sources, but it may take hours for the total inventory to be released to the atmosphere or to the flare.

3. WHAT CRITERIA MIGHT BE USED IN THE EVALUATION OF SAFETY VALVE NOISE?

Three noise related criteria are suggested for PSVs,
1. Noise received at the local community,
2. Acoustic fatigue of the components and associated pipe-work,

3. Noise received by a worker who is 'close' to an actuated PSV,
This paper is related to only the third of these.

Noise is radiated from the downstream piping and equipment as well as the wall of the PSV, but with open vent systems the majority of the noise exits via the open vent at the end of a stub pipe. PSVs with stub pipes to atmosphere might occur with Steam, Air, or Nitrogen, but rarely with Hydrocarbons.

Plant Owners' noise limits, for the avoidance of hearing damage risk, from such transient sources can be expected to be in the region of 100 to 125 dB(A) Sound Level. The 115 dB(A) limit in API EA7301 can be considered typical (See pages 16,17 of Ref 2).
The level is to be measured/ predicted at the worker location (or where he is expected to be, i.e. at Ground level, and on Platforms, Ladders, and Stairs).

4. WHAT REGULATIONS AND STANDARDS APPLY TO PSV'S AND THEIR NOISE?

Not all countries and standards organisations require that the safety valve be treated as a source of sound which has to be limited.
As an example of what might later be seen as an enlightened standards organisation, we might look at NORSOK and it's view that noise from PSVs should not be considered during design. (see Section 6.5.2 of Ref 3) [The noise limits shall not apply to design emergency conditions e.g. near safety --- valves, firepumps or outdoor areas during full emergency flaring, etc.]

References 4 to 11 are offered for review. The question to be answered (Designers and PSV vendors please note) is:
Does this SI etc. apply to my system and it's PSVs?

Below are the names of four documents which include noise limits that seem appropriate in the UK for any review of PSV noise.
API Medical Research Report EA7301.
This document dates from 1973. It describes the situation under discussion today. It set a limit of 115 dB(A) to steady sound, and 140 dB(peak) to impulsive noise. These were based on the US. OSHA 1970 Act.
Department of Employment Code of Practice. (Ref 12)
This document from 1972 sets an upper SPL limit of 135 dB(fast), or with an impulse noise an instantaneous SPL of 150 dB, for the unprotected ear.
86/188/ECC. (Ref 13)
This directive states that if a maximum value of the unweighted instantaneous sound pressure level is greater than 200 Pa "suitable and adequate" ear protectors , which can be reasonably expected to keep the risk to hearing to below the risk arising from exposure to 200 Pa, must be used
It is on this Directive that the UK's Noise at work regulations are based.
The Noise at work regulations. (Ref 14)
In this instrument there is reference to a peak action level of 200 Pa and they state that in cases of (likely) exposure above this level "suitable" ear protection shall be worn so as to keep the risk of hearing damage to below that caused by exposure to the peak action level.

We should note that in neither 86/188/ECC nor The noise at work regulations is the 200 Pa limit an absolute one. Above this pressure one can use "ear protection".
We might, however, reflect on the 200 Pa limit and the questions,
Is this a peak or rms. level?

What dB(A) level shall we assign to this 200 Pa?
What dB(Lin) level shall we assign to this 200 Pa?
Does it matter?
What we have to do is make a prediction of the expected sound and have a series of design options ready as we approach or exceed the limit.

5. HOW DO WE CALCULATE THE PSV NOISE AT KNOWN WORKER POSITIONS?

Standard methods of calculation for valve noise at a distance are available. Two methods for calculation of the noise are suggested: Sections 4.3.5 and 5.4.4.3 of API 521 (Ref 15), which appears to be based on the method described by Franken (See chapter 24 of Ref 16); and the new IEC/BSEN standard for control valve noise prediction (See Ref 17). It is reasonable to suppose that the noise at the manned positions close to the PSV will be a function of:

- valve and pipe radiation (themselves functions of frequency)
- vent radiation which is directly to atmosphere (a function of frequency)
- the distance to the nearest " worker position"
- any directivity associated with the ratio of, wave length of sound to vent diameter.

(the gas may be cold or hot and possibly about mach 0.5)

We will consider the case of an open vent rather than a closed system as it represents the most onerous case.

A simple method was developed to predict the sound level at an angle and distance from the pipe vent.
Assumptions were;
1. The API 521 calculation provided a dB(Lin) value that could be approximated to the same value in dB(A)
2. Directivity factors for the stub pipe's vent could be found and used.
3. A peak frequency of noise could be selected so as to act as a guide to the directivity factor.
4. Reduction of noise with increase of distance would follow the inverse square law.

A simplified set of directivity curves was used for the initial trial calculations with this method. They provided the increase or decrease of sound with angle and were based on data in ISVR Course notes (See Chapter 9 of Ref 18) which was itself based on BBN data from 1952 and VDI 3733 data of 1983. This directivity data is not given in VDI 3733 of July 1996.

Initially, there was a lot a work involved in gathering the data on the positions of the platforms ladders and stairs, and the positions of the closest PSV vents, but now, with the help of Foster Wheeler / Intergraph 3D PDS. it is a much quicker process.

6. "SO YOU KNOW IT'S NOISY, NOW WHAT?"

As contractors we expect to purchase equipment that complies with relevant laws, codes, standards etc. We expect vendors of equipment to comply with such stipulations, to have carried out sufficient research so that they can calculate the expected noise, warn of any foreseen dangers, and reduce the noise as much as reasonably practicable.

Recently, in furtherance of the work described above, an additional activity was undertaken. This was to seek the views of the PSV vendors on the current limits, and methods of noise reduction and control

A letter of enquiry was sent out to a number of PSV vendors. An edited copy is provided in the Appendix to this paper. The letter covered:

- Limit to PSV noise
- Philosophy for PSV noise released directly to atmosphere
- Noise Reduction
  The possibility of a quiet (<115 dB(A) at 1.5 m) PSV or PSV and silencer element
- Noise Control

* Current method of noise calculation and test basis of noise data
* Responsibility for noise prediction
* A proposal to provide to PSV vendors design information related to the position of the PSV vents and manned positions, so that the vendor could use it to advantage in their proposed solutions.
* Five possible methods were mooted.

Of the ten companies contacted we received two written replies.

7. CONCLUSION

1. The discharge from a PSV is noisy.
2. The limits are various, may be impossible to achieve, and pose the question,
How do we demonstrate by calculation that the limits have been complied with?
3. Some organisations absolve PSVs from compliance with noise restrictions in emergency conditions.
4. It would appear that some PSV vendors have yet to "grasp the nettle" and provide noise data for their ranges of safety valves.
5. Contractors may have understood their obligations but find it difficult to provide accurate information on the SL or SPL to be measured at a selected worker position.

8. REFERENCES

1. API RP 520. Sizing, selection and installation of pressure relieving devices in refineries.
Pt 1. Sizing and selection (March 1993)
Pt 2. Installation (December 1994)
2. Guidelines on noise. Medical Research Report EA 7301. API 1973
3. Design principles: Working environment. Norsok Standard S-DP-002 Rev 1, Dec. 1994 (PO Box 547, N-4001 Stavanger, Norway. Fax (47) 51562105.)
4. Health and safety at work etc. act 1974 HMSO
5. The offshore installations (construction and survey) regulations. SI No 289, 1974
6. The construction (design and management) regulations. SI No 3140, 1994
7. The supply of machinery (safety) regulations. SI No 3073, 1992
8 The supply of machinery (safety) (amendment)regulations. SI No 2063, 1994*
9. Offshore electricity and noise regulations. SI No 1993, 1997
10. Offshore Installations: guidance on design, construction and certification.
Fourth edition. 1990. Section 52 and Appendix A52. Department of Energy. HMSO
11. Draft noise at work (offshore) regulations 199- . A Health and Safety Commission consultative document. HSE Books, 1996.

12. Code of practice for reducing the noise exposure of employed persons to noise.
Department of Employment. 1972 HMSO
13. 86/188/EEC Council Directive of 12 May 1986 on the protection of workers from the risks related to the exposure to noise at work.

14. The noise at work regulations. SI No. 1790, 1989.

15. API RP 521. Guide for pressure relieving and depressuring systems (March 1997)
16. Noise Reduction. L L Beranek (Ed) McGraw-Hill (Pub. 1960)
17. IEC 534-8-3: 1995 Industrial process control valves
Part 8 Noise Considerations
Section 3 Control valve aerodynamic noise prediction method
This standard has the dual number BSEN 60534-8-3 1996
18. Noise control for engineers in processing industries. Course notes 1990.
Institute of Sound and Vibration Research. University of Southampton.

APPENDIX TO
SAFETY VALVE NOISE; LIMITS, REDUCTION AND CONTROL

February 1996

Dear Sir,
LIMITS AND CONTROL OF NOISE FROM THE RELEASE OF SAFETY VALVES DIRECTLY TO ATMOSPHERE

1. Philosophy for Safety Valve Noise

Currently, we have occasion to consider what philosophy we should adopt on future projects in regard to the noise from safety valves which release directly to atmosphere, i.e. those that are not connected to a flare or other system. This letter, and your reply, will help define our future philosophy.

2. Limits to Safety Valve Noise

Limits to noise from "emergency vents" are often set at about 115 to 125 dB(A) at the ear of the nearest personnel. See, for example, the 115 dB(A) of API EA7301 (1973). Here 'emergency' relates to foreseeable design situations such as safety valve operation and emergency depressurisation.

3. Request for Comment

We seek your comments on the possibility of purchase of, say:-

1. a Safety Valve which does not exceed 115 dB(A), both at 1.5 m from the pipe vent and at positions 1 m from the valve body and 1 m from the down-stream pipe;

2. a Safety Valve with associated silencer element, which does not exceed the limits given above.

We also seek your comments on other possibilities for reduction or control of Safety Valve noise at the nearest personnel. Here we have in mind by way of example,

a. quieter valve designs;
b. quieter valve systems;
c. common silencers to a group of Safety Valves,

d. high level discharge, i.e. tall vent-pipes on individual valves or groups of valves, to take advantage of increased distance and directivity;
e. injection of water to cool the process fluid, say air or steam;
f. water curtains to act as a barrier to sound;
g. permanently installed sound barriers near to the Safety Valves or the personnel positions.

The foregoing should in no circumstance be taken as recommended solutions by FWEL.

4. Responsibility for Calculation and Test

We seek your comments on the suggestion that a Safety Valve vendor should be responsible for both the calculation to verify the noise from the Safety valve and the test procedure and measurement of the sound pressure level and sound power level. The same responsibility would remain with the vendor where a Safety Valve and an associated silencer element were bought from the Safety Valve vendor.

At this juncture, we also request that you send to us notes and information on:-
1. your current calculation method and its justification;
2. the test basis of your current range of noise data for Safety Valves.

5. Noise at Platforms, Stairways, and Ladders

The difficulty and cost of noise control may be reduced if advantage is taken of the distance and directivity between a Safety Valve vent and the nearest platform, stairway, or ladder (P,S,L).

We invite your comments on the proposal to provide vendors with details of both Safety Valve vent positions and P,S,L positions in order that they may take appropriate advantage of the distance and directivity effects of their proposed solutions.

6. General Nature of this Enquiry

Please treat this enquiry as a discussion document, which may be seen as " for the general good", and thus need not be regarded as strictly confidential.

Yours faithfully,

MDGR.