

# *Dynamics* **BREAK** **THE** *bottleneck*

Prabhat Panigrahy and Jens Balmer, Wintershall, Germany, Miquel Angel Alos and Michael Brodkorb, Inprocess Technology, Spain, and Brian Marshall, Softbits Consultants, UK, demonstrate the ways in which a dynamic flare system modelling study allows for safer blow down, using a Wintershall facility as an example.

**F**lare and relief systems commonly found in processing plants in the oil, gas and petrochemical industries are constantly under examination. New constructions, extension of existing plants or changes in safety regulations all require detailed analysis of several aspects of the flare and relief system. In many cases, steady state analysis will suffice; but more often than not, complex or marginal problems require dynamic analysis to resolve an apparently bottlenecked flare system.

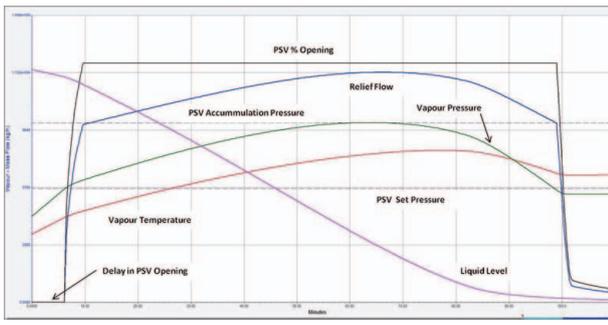
The benefits of analysing the transient behaviour of flare relief sources during an emergency situation or a normal blow down have been examined in various recent journal articles.<sup>1-3</sup> However, there has not been much discussion on what occurs when the scope of the dynamic simulation is broadened to include the flare header system. By doing so, the inherent transient behaviour of relief flows is accounted for and the different phenomena to be taken into account in such a study can be described.

This approach has recently been successfully applied to analyse and improve the blow down strategy for an existing gas utilisation plant (GUP) owned and operated by Wintershall in Libya. The results of that project are an example of the valuable potential of the dynamic approach.

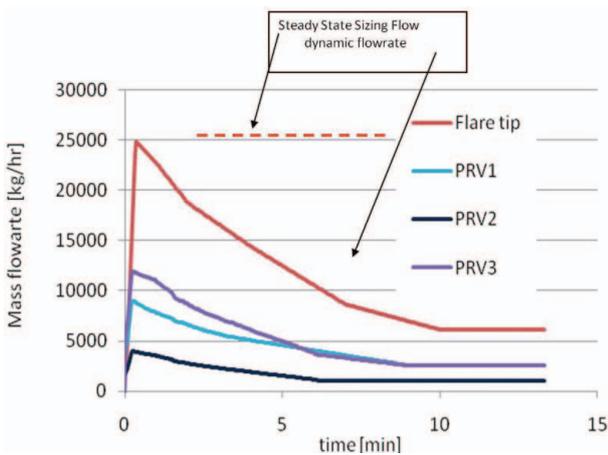
## **The importance of accurate modelling**

For many years, modelling of flare and relief systems has been done on a steady state basis. In many cases, this has provided for oversized but safe systems that have been in service for a long time and thankfully have never had to see full design conditions.

The current trend for minimal design and project expenditure has seen for more tightly designed flare and relief systems, without compromising on safety. Smaller offshore installations and floating production, storage



**Figure 1.** Dynamic analysis for pressure safety valve (PSV) sizing shows significantly more information (in this case the dynamic flare load curve versus time from a PSV fire case).



**Figure 2.** The dynamic depressuring behaviour of three pressure relief valves.

Table 1. The methods currently in common use by engineers for ensuring adherence to industry standards			
Area	Requirements	Steady state	Dynamic
The sources	Generation of relief loads under individual or combinations of emergency scenarios	<ul style="list-style-type: none"> <li>Hand calculations</li> <li>Spreadsheets</li> <li>Most process simulators</li> </ul>	<ul style="list-style-type: none"> <li>Most process simulators</li> <li>BLOWDOWN</li> </ul>
		Poor data used in these methods can lead to over or under designed systems. No consistency in methods	Much more accurate; gives real time analysis of flowrates and fluid conditions. For pressure relief valves, shows time delay before valve opens (Figures 1 and 2). Accurately predicts material temperatures
The system	Analysis of flare header system under load. Calculation of line velocities, noise levels and valve back pressures	<ul style="list-style-type: none"> <li>Hand calculations</li> <li>Spreadsheets</li> <li>Aspen Flare System Analyser, UniSim® Flare, SimSci VISUAL FLOW, in house</li> </ul>	<ul style="list-style-type: none"> <li>Hybrid use of process simulator and network hydraulic analyser (as shown in the Wintershall case study).</li> </ul>
		No account is taken for line packing (significant in large systems), nor transient delays in flows and non-concurrent reliefs; e.g. Fire in Zone 3: all pressure relief valves are assumed to open concurrently	Allows combination of benefits of both software packages. Requires specialised knowledge to accurately model and interoperate results
The disposal	Determination of sterile areas due to flare radiation levels. Stack heights, shielding or water curtains if required	<ul style="list-style-type: none"> <li>Hand calculations</li> <li>Spreadsheets</li> <li>FlareSim, PHAST, in house</li> </ul>	<ul style="list-style-type: none"> <li>Step by step calculations can be used to model a quasi dynamic radiation and temperature prediction.</li> </ul>
		Flare rates taken from header analysis assume constant flowrate to tip with no transient decay of flows. Can over predict radiation and temperature levels	Requires specialised knowledge to accurately model and interoperate results

and offloading (FPSO) conversions have given flare design engineers the challenge of fitting adequate systems into seemingly inadequate spaces. Often the size of the required flare system can make otherwise attractive projects unattractive, both financially and technically.

As a consequence, the viability of potential plant revamps can rely on the ability of the engineer to prove the adequacy of the existing flare and relief system with minimal or no modifications.

## Current modelling potential

In order to conform to present industry standards (such as API 520, 521 or Norsok) several areas of flare and relief systems have to be considered. Various methods are currently in common use by engineers in order to determine whether systems match up to these standards are detailed in Table 1.

Dynamic simulation of flare and relief systems is most valuable in plant revamps or expansions. The ability to prove the worthiness of the existing system with the new operational or capacity changes can result in significant savings in equipment and work time. Being able to combine the currently available software with significant modelling experience allows complex studies to be undertaken.

## Wintershall case study

### Background and objective

Wintershall was operating a GUP as part of one of their field operations in Libya. The GUP is divided into a number of sections, which can be blown down individually. The objective of the study was to understand what measures are required to allow a complete blow down of the plant within 15 minutes.

Wintershall decided to work with Inprocess Technology and Consulting to use dynamic process simulation to find an optimised design, in order to meet the stated objective. It was decided that an optimised design should be based on an optimal usage of the existing flare equipment on site. This goal was achieved, and it was even possible to reduce overall investment of the project significantly by avoiding the construction of an additional flare pit.

Wintershall worked together with Inprocess to apply dynamic process simulation (Aspen HYSYS Dynamics) to determine the transient blow down behaviour of the plant.

It is important to note that all models developed as part of the study were calibrated and validated with existing plant data. This included back pressure, flare tip information and pressure profile from the vendor, and liquid hold up in the flare knock out vessel. This approach assured high confidence in the results.

The following activities were part of the study:

### Study blow down flare loads

The study aimed to determine the transient blow down loads for each of the sections by using dynamic process simulation. In addition, the restriction orifice diameters of the blow down valves were varied in order to optimise flow versus time for the complete plant.

Also, the application of 'constant flow valves' (which allowed blow down of a section with a constant flow over a 15 minute period) was analysed. Such valves distribute the total flare load over the total allowed time and therefore provide peak shaving, or debottlenecking, of the flare header.

### *Hydraulic modelling of the flare header*

This part of the study investigated the transient effects in the flare header during the blow down (e.g. line packing). This was achieved by using a hybrid approach based on HYSYS Dynamics and Aspen Flarenet.

The hybrid approach was necessary due to the lack of a validated dynamic flare system modelling tool at the time of the study. The flare header was modelled in both Flarenet and HYSYS Dynamics. The Flarenet model was used to accurately model the hydraulic limits of the system (back pressure, velocity etc.). The HYSYS Dynamics model was then tuned and validated against the Flarenet model for different flow rates. This approach was required because HYSYS Dynamics does not account for pressure recovery.

### *Dynamic modelling of the complete plant*

Combined modelling of the plant sections and the flare system was undertaken to analyse the transient behaviour of the complete system. A number of simultaneous blow down scenarios were carried out (including and excluding different sections) to understand the hydraulic limits of the complete system.

## Results

The constraint for this study was to limit the maximum flare load from the units that blow down simultaneously to 100% of the flare system's hydraulic design capacity (back pressure, velocity, etc.). When applying the steady state modelling approach for the flare header, the sum of the maximum flows from all sections equals 208% (of total capacity). This could be accepted to a degree, as the blow down was carried out as a manual staggered blow down to avoid reaching capacity limits.

From this base case, the following scenarios were consecutively studied:

- ▶ Exclude non-critical sections from simultaneous blow down: when excluding two partially underground sections from the complete

blow down, the sum of the maximum flows is calculated to be 160% (of total capacity).

- ▶ Additional investment option: when considering constant blow down valves for three sections in order to reduce their maximum flow, the sum of maximum flows could be reduced to 83% (of total capacity).
- ▶ Use complete dynamic model: when applying dynamic modelling for the complete system (accounting for line packing, peak lengths etc.), the maximum flare load was reduced to 75% (of total capacity).

Additionally, the results show that the future inclusion of an additional, yet to be built process section in the blow down scheme would ensure the flare capacity limit of 100% can still be met.

## Conclusion

The main conclusions from the dynamic blow down study carried out for Wintershall are:

- ▶ The dynamic process modelling approach can be used for modelling the complete process plant as well as the flare headers.
- ▶ The proposed hybrid flare header modelling approach allows for the analysis of the inherently dynamic flare system phenomena (line packing etc.).
- ▶ The dynamic blow down approach showed additional capacity of the existing flare system.
- ▶ In this specific case, a low investment solution was identified, which could be implemented without any major revamp of the flare system. This in turn allowed a significant reduction in investment for the flare system upgrade by avoiding the construction of one additional flare pit. 

## References

1. GRUBER et.al.: 'Are there alternatives to an expensive overhaul of a bottlenecked flare system?' (*PTQ* Q1 2010).
2. MARRIOT, J., MARSHALL, B., HARO, A.: 'A dynamic future for Flare Design' (*Hydrocarbon Engineering*, Sep 2010).
3. DISSINGER, G.: 'Studying Simulation', (*Hydrocarbon Engineering*, May 2008).