



Blowdown Analysis and Optimisation

The blowdown and flare system is the most important process safety system as their purpose during an accidental event or emergency situation is to reduce the pressure in process segments in order to reduce the risk of rupture and escalation.

API 521 (Clause 4) discusses the principal causes of overpressure and offers guidance in plant design to minimize the effects of these causes. Analysis of the causes and magnitudes of overpressure is a special and complex study of material and energy balances in a process system.

Clause 5 in API 521 concerns calculation of individual relieving rates, and the standard emphasizes that good engineering judgment, rather than blind adherence to the guidelines, should be followed in each case. In no instance should the safety of a plant or its personnel be compromised.

Clause 5.15.2.1 in API 521: The appropriate fire sizing equation from the API or ISO standard that applies to the equipment being evaluated should be used. The fire-sizing equations in Clause 5 apply to process vessels and storage vessels, including those designed to the pressure-design code. They assume typical in-plant conditions for facilities within the scope of the standard but can be understated for vessels in partially enclosed or enclosed areas, such as those in buildings or on offshore platforms. The standard makes reference to *Guidelines for the protection of pressurised systems exposed to fire (Scandpower)* and *Guidelines for the design and protection of pressure systems to withstand severe fires (Institute of Petroleum)*.

These two guidelines provide an alternative approach based on analytical methods and can be used to model fire-heat input for all types and sizes of fire. To use these methods for fire-relief calculations, it is necessary to specify the average fire temperature, rather than the instantaneous peak temperature.

Performing a blowdown analysis requires the use of a computer system that can handle dynamic process phenomena including evaporation, condensing and flashing. In a fire situation, the successful blowdown is a blowdown that removes the risk for over-pressuring the system, or in case of loss of integrity that the risk of escalation is removed.

Petrell has conducted hundreds of blowdown (depressurization) analysis using VessFire, both fire cases and adiabatic cases. VessFire complies fully with the analysis method suggested in the two guidelines referenced above. Blowdown analysis is the major task in segment survivability analysis and process system fire integrity analysis.

There are many useful results from a blowdown analysis. VessFire allows to play with different materials, specifications, wall thicknesses, passive fire protection, blowdown valve arrangement and orifice diameters, in order to explore ways to improve blowdown system performance and meet acceptance criteria. Acceptance criteria can be those suggested in the Guidelines mentioned above, or they can be defined by the client.

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Traditionally, many engineers have taken the example in API 521 Clause 5.20.1 as a general rule, leading to the “requirement” of 50% of the operating pressure within 15 minutes. The following example shows that this may not be the case.

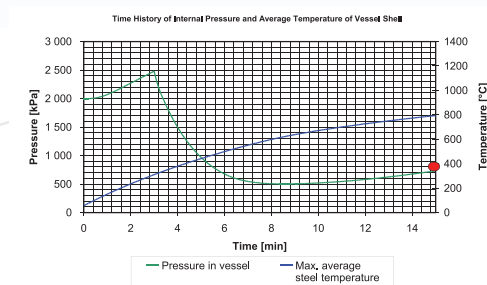


Figure 1 - Time history of internal pressure and average temperature of vessel shell.

Figure 1 shows depressurization of a segment comprising piping and a vessel. The fluid is a mixture of gas, heavier HC components, and water. After 3 minutes the blowdown valve is opened and the pressure starts to decrease. After 15 minutes the pressure is down and meets the “15 minutes-requirement”. However, at that time there are still heavy HC components and water in the vessel, and at around 10 minutes these liquids starts to boil off. Figure 2 shows two pressure peaks due to boiling off of liquids.

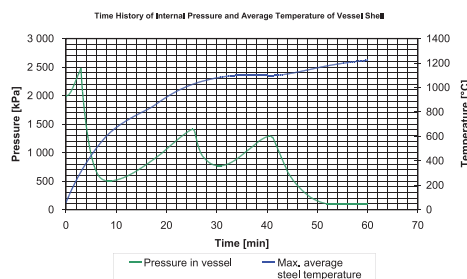


Figure 2 - Time history continued (ref. Figure 1).

Figure 2. The stress in the vessel shell due to the pressure will follow the pressure profile.

Figure 3 shows that the vessel, in this case will rupture after about 19 minutes, when calculated stress is in excess of UTS.

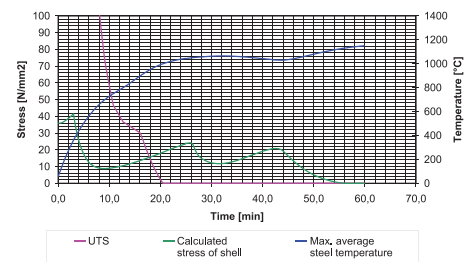


Figure 3 - Ultimate tensile stress (UTS) and calculated stress, including maximum temperature in the shell.