VESSFIRE

Fire Integrity of Process Equipment

National legislation and international standards, as well as company defined risk acceptance criteria, impose certain requirements on the design of process facilities regarding their ability to sustain a fire situation. We have developed tools and work methods to address these issues, and we have a long list of reference projects.

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Fire integrity of pipe-work and equipment under pressure is a function of fluid characteristics, process conditions, materials, the presence of passive fire protection, blowdown and depressurization facilities. When e.g. a hydrocarbon fluid is heated, components will boil off in accordance with its thermodynamic properties, and the pressure inside the pipe-work/vessel will increase. The increased pressure will impose a higher load on the process equipment. As the material in pipe-work and vessels is heated, the material starts to lose its strength.

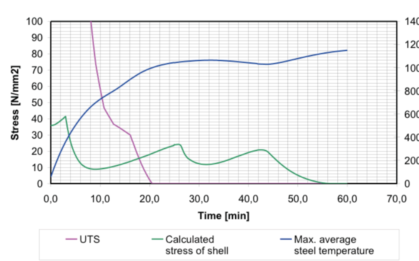

Figure 1 - Weakening of UTS as functional temperature compared with calculated stress in pipe wall

The required fire integrity of a process system is related to how long the system must keep the inventory inside the system to allow for safe escape and evacuation of personnel and to prevent escalation. This may be 15 minutes, but it is more likely more time is needed, e.g. 30 minutes or maybe 1 hour. VessFire is developed to assist engineers in ensuring that process plants have sufficient blowdown capacity and structural integrity in defined fire scenarios. VessFire calculates blowdown rates in compliance with advanced methods put forward in ISO 23251:2006/API 521. In addition, VessFire calculates the temperature development in the steel and the corresponding change in strength, which is measured with the stress resulting from the change in system pressure.

Figure 2 a gas-filled pipe without insulation is exposed to a jet fire load of 350 kW/m2 and a background heat load of 100 kW/m2. Rupture occurs after approximately 3-4 minutes, when the calculated stress exceeds the ultimate tensile strength.
In Figure 3 the same pipe exposed

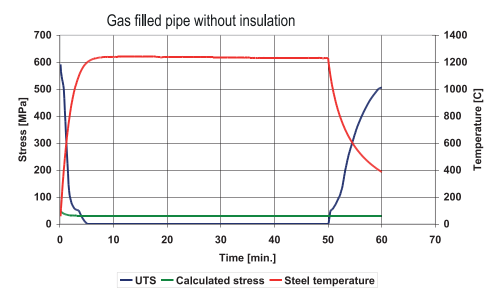

Figure 2 - Figure 2 Rupture of a gas filled pipe without insulation.

to the same jet fire load is filled with liquid, and rupture occurs also now, but after about 13 minutes.
Time to rupture would change

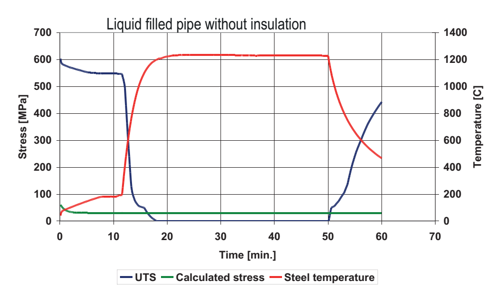

Figure 3 - Rupture of a liquid filled pipe without insulation.

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for another steel quality or wall thickness. Time to rupture would also change with different fire loads.

A common strategy to extend the life of process equipment or pipes exposed to fire is to apply passive fire protection (insulation). The situation in Figure 4 is the same as in Figure 2, except that the pipe has been provided with a fire insulating material.

Vessel Survivability

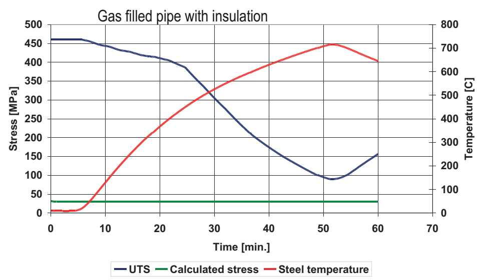

Figure 4 - Effect of fire insulation. The pipe filled with gas (ref. Figure 2) does not rupture.

Many clients are concerned about the integrity of vessels. Experience shows that vessels normally show better performance characteristics than pipes in fire situations.

It is important to note, that it is not sufficient to analyse only the vessel. The pressure relief valves and blowdown valves of a process segment are normally attached to the vessel. This means that also the contents of all pipe-work upstream and downstream of the vessel will have to escape through the vessel's blowdown arrangement. Thus, addressing vessel survivability must include the entire segment of which the vessel is a part. Most, if not all of the segments pipework will also be exposed to fire loads if a vessel is exposed to a jet fire, and it is the background heat load that causes the temperature of the inventory to increase, resulting in increased pressure. The entire segment acts as a huge heat exchanger. The surface of all pipework is thus also significant, including wall thickness, the presence of insulation etc.

Fire loads

Standard fire loads as for instance given in NORSOK S-001 or the Scandpower procedure can be applied. However, it should be observed that plant/installation geometry and topology as well as equipment layout and arrangement may influence the fire scenario.

Fire loads should be assessed for each segment.