A Complete Guideline for Blocked-in Condition

Saeid Rahimi

26-Sep-2011

Introduction

Process piping and equipment content can get blocked-in between two valves during plant operation, maintenance, normal and emergency shutdowns. If the trapped fluid is exposed to a heat source at higher temperature, system over-pressurization may take place. Heat source can be chemical reaction, hot process and utility streams, heating coil, heating jacket, heat tracing, solar radiation, radiation from flares and ambient temperature. The possibility of creating blocked-in condition under different plant operation modes is discussed below:

- Normal operation; there should be no trapped fluid in any process piping and equipment during normal operation but there are particular processes in which system content is shut-in during normal operation and draining is not feasible due to time constraint, nature of operation or cost consideration. One typical example is storage area transport piping where pipe sections are regularly shut-in during product shipping and tanker loading without draining.
- Maintenance and normal shutdown are scheduled activities; they are completed under supervision and according to detailed checklists, procedures and work permits. Equipment and piping are drained as a part of preparation process for maintenance therefore the possibility of forming blocked-in condition is minimum.
- Emergency shutdown; when a piece of equipment or part of the plant is isolated automatically by shutdown valves, it can lead to fluid blocked-in condition. The position of control valves during shutdown should be taken into consideration. As flow stops, some of the control valves go to the closed position which can create isolated section.

Relief Requirement

Figure 1 offers a complete guideline for blocked-in condition in order to specify the relief requirement. This chart assumes that:

- System has been blocked at both ends
- System has been exposed to a heat source at higher temperature

If above mentioned conditions are satisfied, there is a potential of overpressure. Figure-1 recommends the relief requirement depending on system content (liquid, two phase, gas) at relieving condition. The description of each question in this Figure is provided below:

1. System is considered liquid filled if liquid volume is more than 95% of system volume. In two phase systems, small vapor or gas pockets can disappear upon heating because of liquid swelling (due to reduction in liquid density), gas condensation, compression and solubilization when system pressure and temperature increases from operating to relieving. In contrast, multi-component two phase mixtures with a wide boiling range can always have sufficient vapor present to preclude becoming completely liquid-fill.
2. If liquid vapor (bubble) pressure at heat source temperature is higher than system design pressure, heating will lead to liquid thermal expansion followed by liquid vaporization. It is generally believed that PSV sized for liquid vaporization stage (vapor relieving) is adequate to protect the system. This is because density of liquid is several times of gas therefore orifice area required for liquid is much smaller than gas orifice area. Relief rate can be simply calculated by dividing heat transfer rate by liquid latent heat.

   If the liquid vapor pressure at heat source temperature is lower than system design pressure, liquid is so stable that it does not generate vapor even at heat source temperature. It means that liquid thermal expansion can potentially over-pressurize the system. The requirement of TRV can be specified by following Figure-2 flow chart.

   Questions asked in Figure-2 are discussed in paper "<u>What You Should Know about Liquid Thermal Expansion</u>" which is available on paper page of this website.
3. Since system is two phase at relieving condition, if liquid vapor pressure at heat source temperature is higher than system design pressure, heating will result in liquid vaporization. System gas also may expand during heating course which may cause some relief but liquid vaporization is generally governing. Relief rate can be simply calculated by dividing heat transfer rate by liquid latent heat.

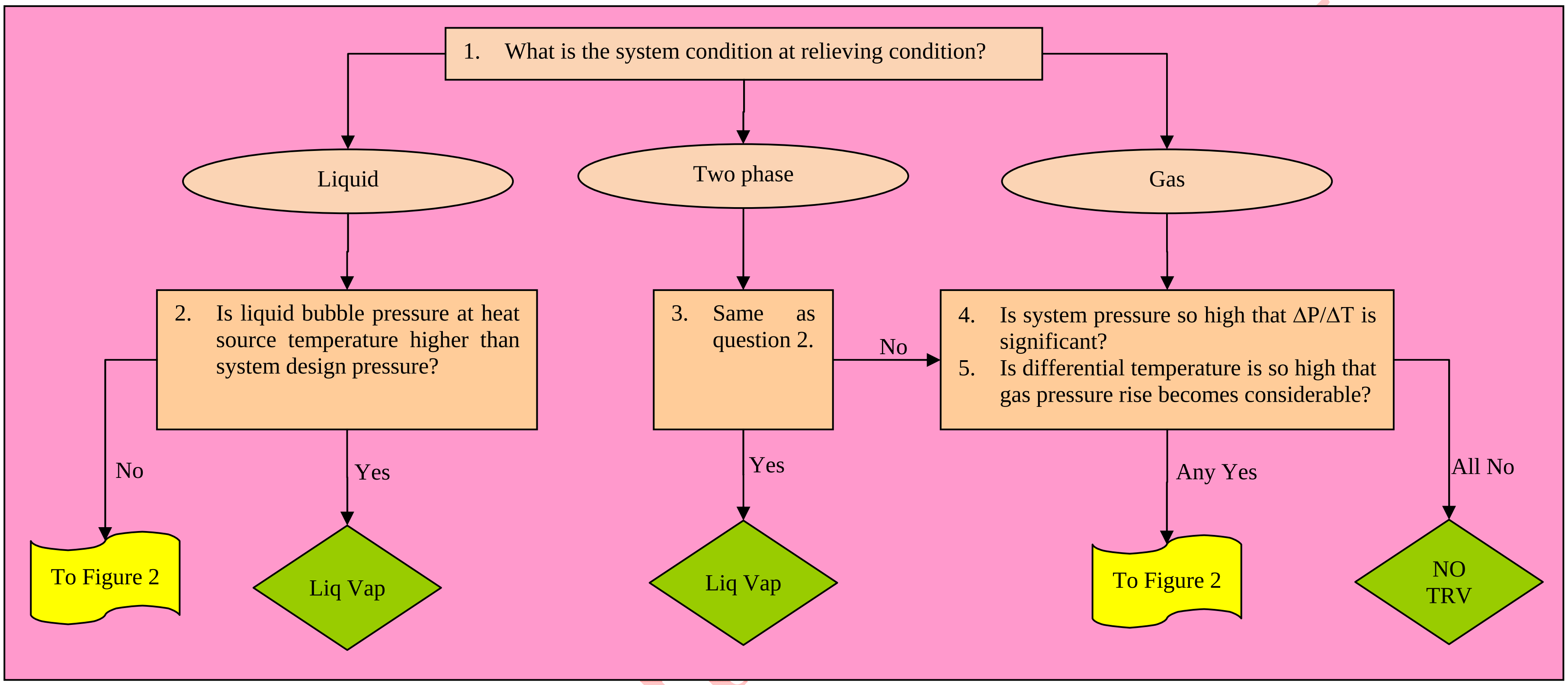

Figure 1 – Guideline for blocked-in condition

If the liquid vapor pressure at heat source temperature is lower than system design pressure, system won't be pressurized because of liquid vaporization. In other words, liquid is stable at high temperature however gas can still expand because of heat input and cause over-pressurization if gas thermal expansion requirements (questions 4 or 5) is satisfied.

4. When system pressure is high, pressure rise due to temperature increase is significant. Gas expansion is considerable at very high pressures and it reaches about 1.5bar/^{o}C at 300 bar. For a system containing high pressure gas or two-phase fluid, temperature variation can cause pressure rise above system design pressure.

5. If there is high differential temperature between heat source and blocked gas, there is a potential pressure rise if the gas is blocked. For example, when 20 bar fuel gas is superheated in a gas-gas heat exchanger using steam at 400, although the gas expansion is too small at low pressures but high differential temperature can easily drive the blocked-in gas to pressure beyond design pressure.

   For further information on questions 4 and 5, please refer to paper "Designing the Correct Pressure-Relieving System" already available on paper page of this website.

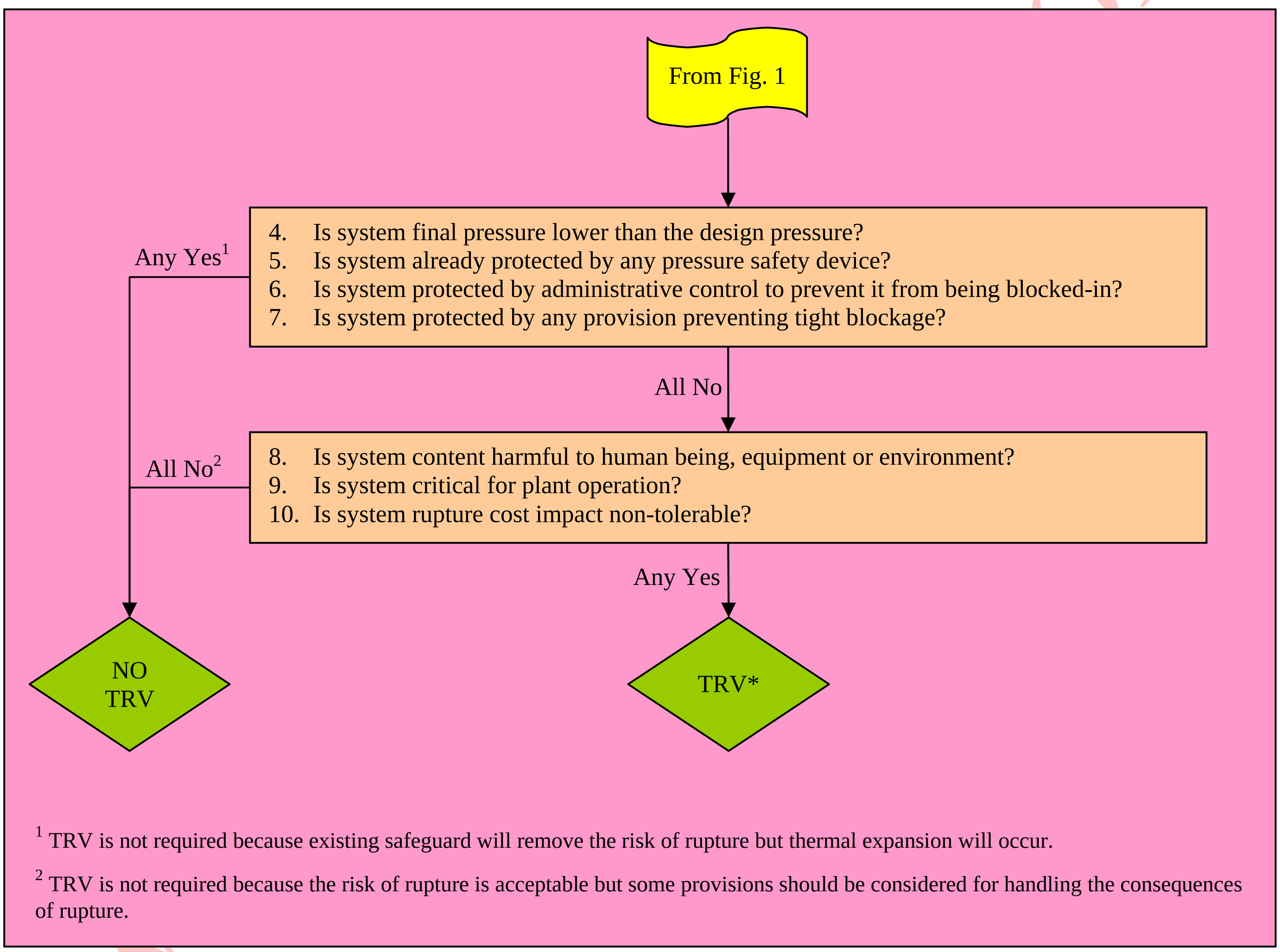

Figure 2 – Thermal expansion requirement flow chart

* if overpressure protection device is required for gas expansion case, most probably typical TRV of ¾"x1" or 1"x1" won't be sufficient. For gas expansion cases PSV with proper size shall be employed.

Contact

Please visit www.linkedin.com/groups/Chemwork-3822450 should you have any comment, question or feedback or feel free to contact S.Rahimi@gmail.com.