

Can a Fail-Open Valve Fail Closed?

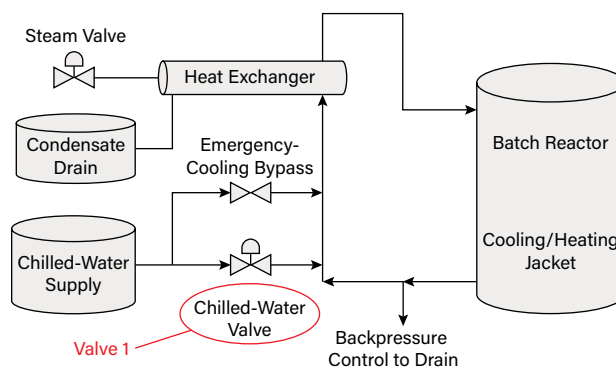
June 2020

Valves are often specified as fail-open, fail-closed, or fail-in-last-position on piping and instrumentation diagrams (P&IDs) or other process safety information (PSI). These designations indicate the valve response in the case of utility failure, such as loss of instrument air or electric power failure.

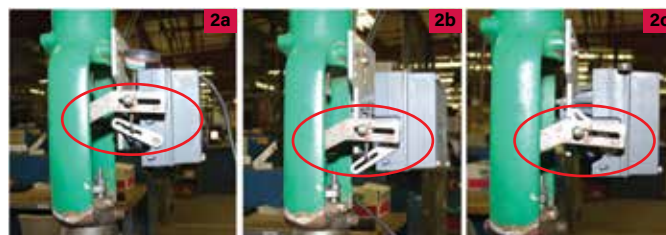
An incident occurred with a batch reactor when a fail-open valve in the cooling system did not fail in the open position as intended. The temperature of the batch reactor was maintained with a heat exchanger and jacket system that used steam as the heat source (Image 1). When the batch contents reached the required reaction temperature, steam was shut off and chilled water was sent to the heat exchanger to control the reactor temperature. The chilled-water flow was controlled by a fail-open valve (Valve 1) that required instrument air pressure to close.

On the day of the incident, the reactor temperature began to increase, signaling a high-temperature alarm. The operator observed that the signal on the control screen to Valve 1 was fully open. However, the reactor temperature continued to increase, eventually triggering another alarm, indicating low cooling water flow. The operator was unable to troubleshoot the problem over a 7-min period and did not open the emergency cooling bypass to increase cooling water flow to the reactor. The emergency shutdown system intervened and dumped the reactor to a containment pit, causing an environmental release. There were no injuries.

Dee, *et al.*, "When the Fail Open Valve Fails Closed: Lessons from Investigating the Impossible," *Process Safety Progress*, 38, doi:10.1002/prs.12031 (2019).



▲ The reactor cooling system controlled the chilled-water flow with a fail-open valve (Valve 1). The valve was designed to fail open so that cooling water could flow even in the case of utility failure.



▲ These images show the chilled-water control valve positions when open (Image 2a) and closed (Images 2b and 2c). In Image 2c, the valve is closed but signalling as open because the mechanical linkage that connected the valve actuator to the positioner was broken.

Did You Know?

- A mechanical linkage connects the valve actuator to the positioner (Image 2, gray box) that receives the control signal.
- When the linkage works, the valve stem moves from the open position (Image 2a) to the closed position (Image 2b) as the air pressure signal changes. When the linkage failed in this incident (Image 2c), the valve remained closed.
- A valve may fail to operate for many reasons other than loss of utilities. A mechanical component could fail or be missing. The material flowing through the valve or dirty or rusty components could cause the valve to stick.

What Can You Do?

- Identify the failure position for safety-critical valves in your plant. Note that P&IDs typically indicate the loss-of-utility (e.g., power, air, etc.) failure state of the valve.
- Observe valve operation in the field to detect and report valve problems.
- If you participate in hazard identification activities such as process hazard analyses (PHA), management of change (MOC) reviews, or design reviews, consider the consequences of a valve that fails to operate as intended. Consequences could arise from valves that fail to operate or fail in a position other than their designed loss-of-utility failure position.

Be aware that valves can fail to operate as intended!