Advanced Process Control

CBEg 6142

School of Chemical and Bio-Engineering
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Chapter 2

Selective Control, Override Control and Split Range Control

2.1 Selective Control

- *Selective control* is used for safety considerations and process optimization.
- Selective controllers have a single manipulated variable and a number of measured process variables.

2.1 Selective Control

Example 2.1

A fixed-bed catalytic tubular reactor with an exothermic reaction may exhibit a "hot spot" along the length of the reactor. The reactor temperature is measured in multiple locations along the length of the reactor (TT-101, TT-102, and TT-103). These measurements are sent to a High Selector (HS-15) which chooses the highest measured temperature and sends it to the controller to avoid the occurrence of a hot spot.

2.1 Selective Control

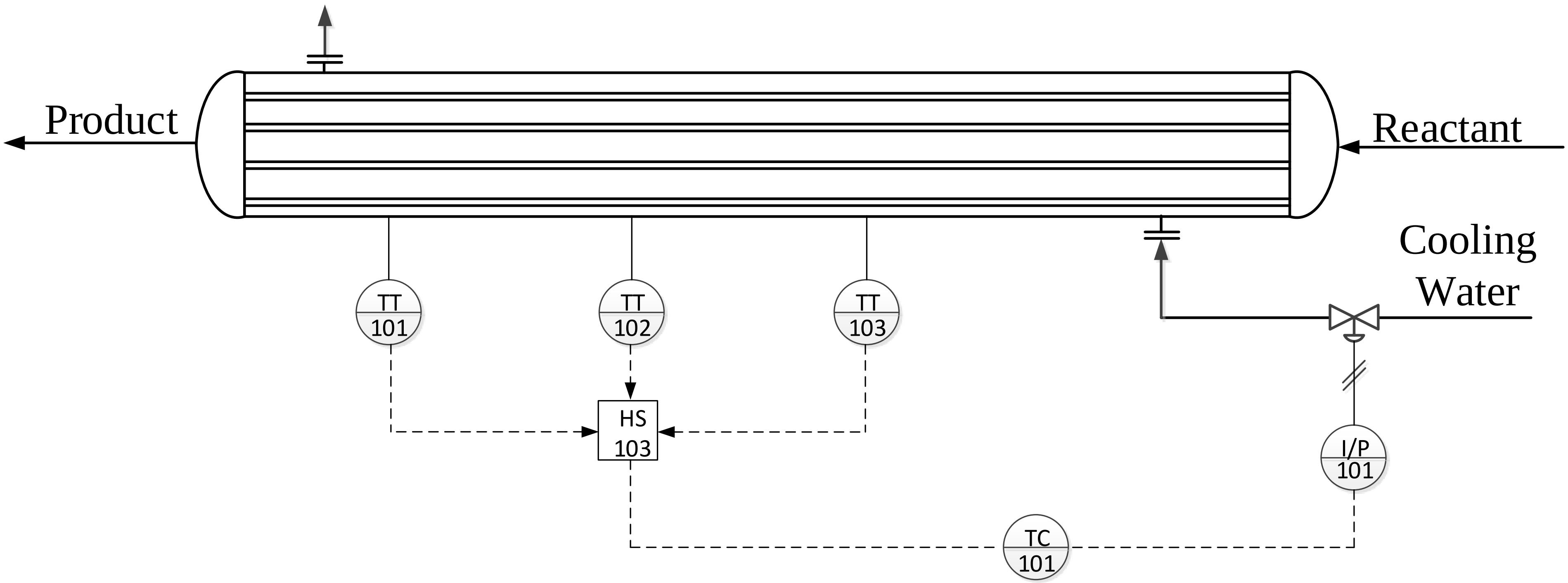


Figure 2.1 A fixed-bed catalytic tubular reactor with an exothermic reaction.

2.2 Override Control

Override Control

- The override control is used as a "protective" strategy to ensure the safety of the personnel and equipment and improve the quality of the product.
- It is not as drastic as the "interlock" control which shuts down the plant or a part of a plant in the case of emergency.
- The override control switches from one controller to another in an abnormal condition.
- The override controller uses a High or a Low Selector switch to implement the logic of switching from the "normal" controller to an "abnormal" or "emergency" controller.

2.2 Override Control

- It is important to have auto-reset windup controllers for both the "selected" and the "nonselected" controllers so that neither of the controllers winds up (their outputs exceed 100%) while they are sitting idle. This is shown as Reset Feedback (RFB) in the following example.

2.2 Override Control

Normal conditions: The level in the tank is controlled by adjusting the pump speed on the effluent stream of the tank.

Abnormal condition: If the level falls below h2, the liquid level will not have enough net positive suction head (NPSH) and cavitation at the pump will occur. Therefore, under such conditions, the control of the pump speed must be switched to the level controller.

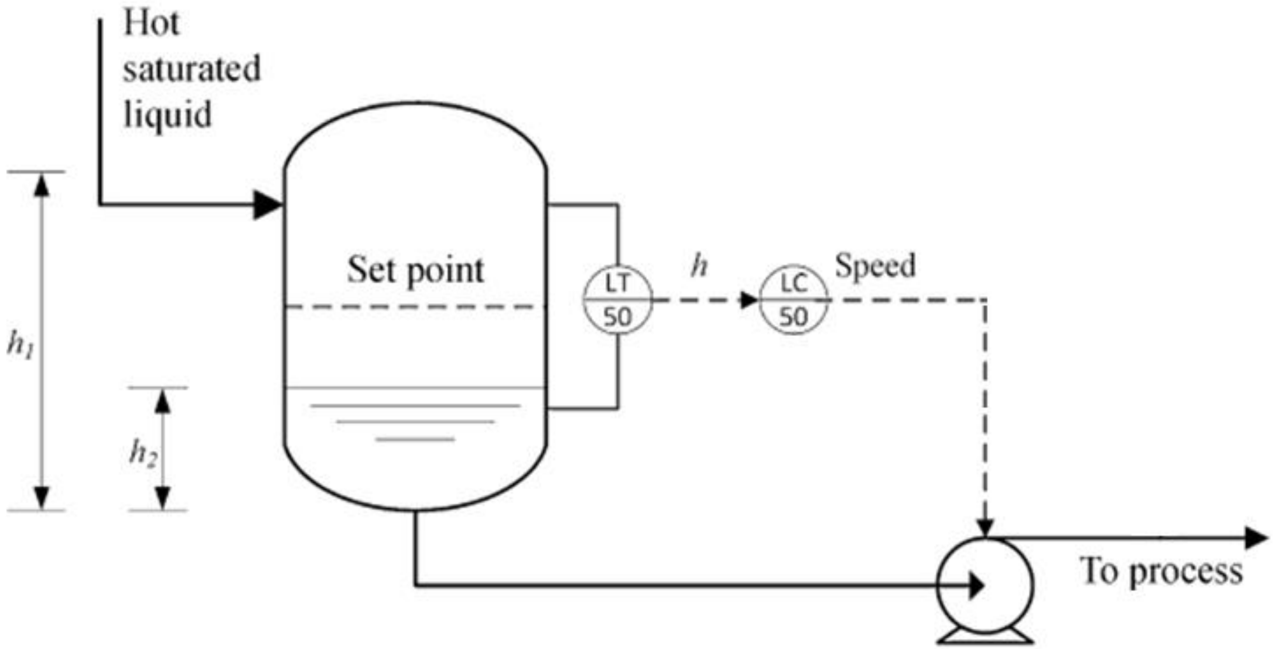


Figure 2.2 Level Control- Feedback

2.2 Override Control

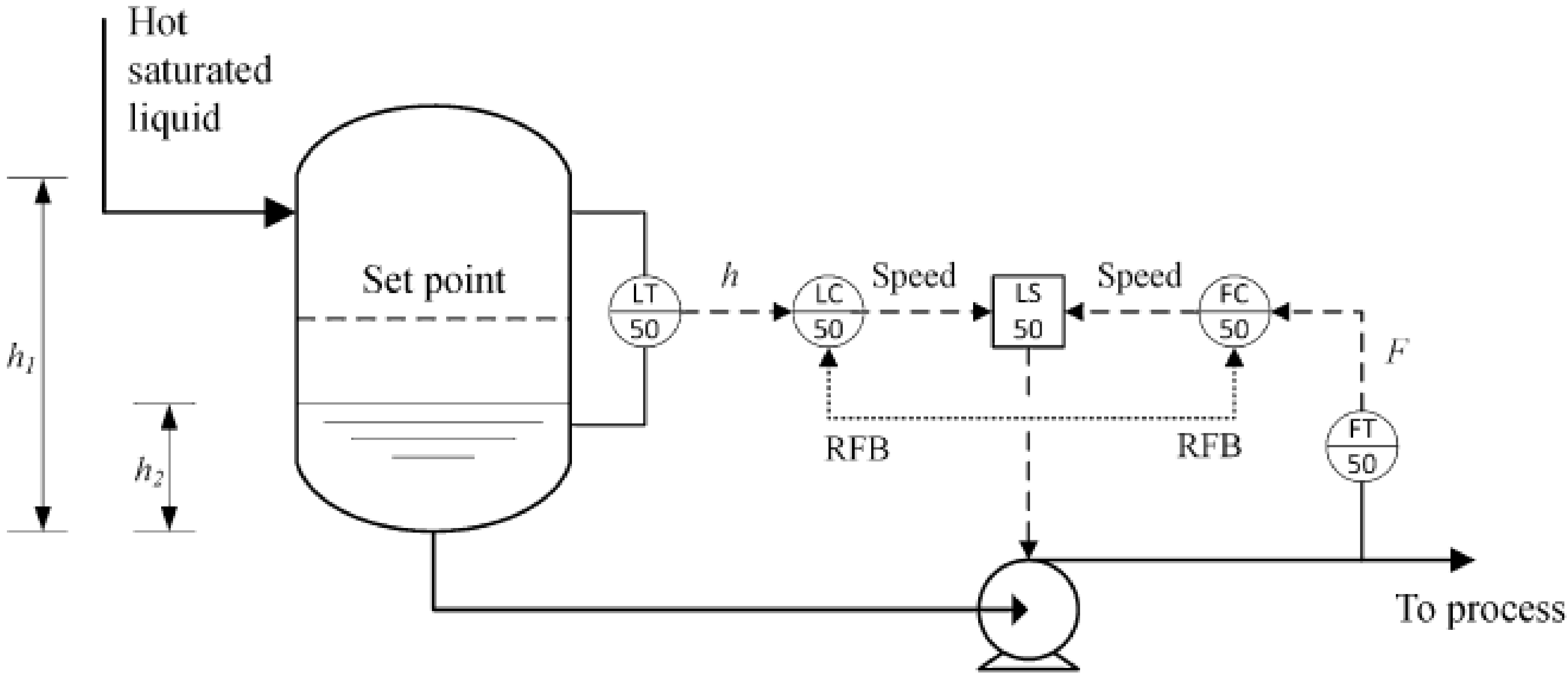
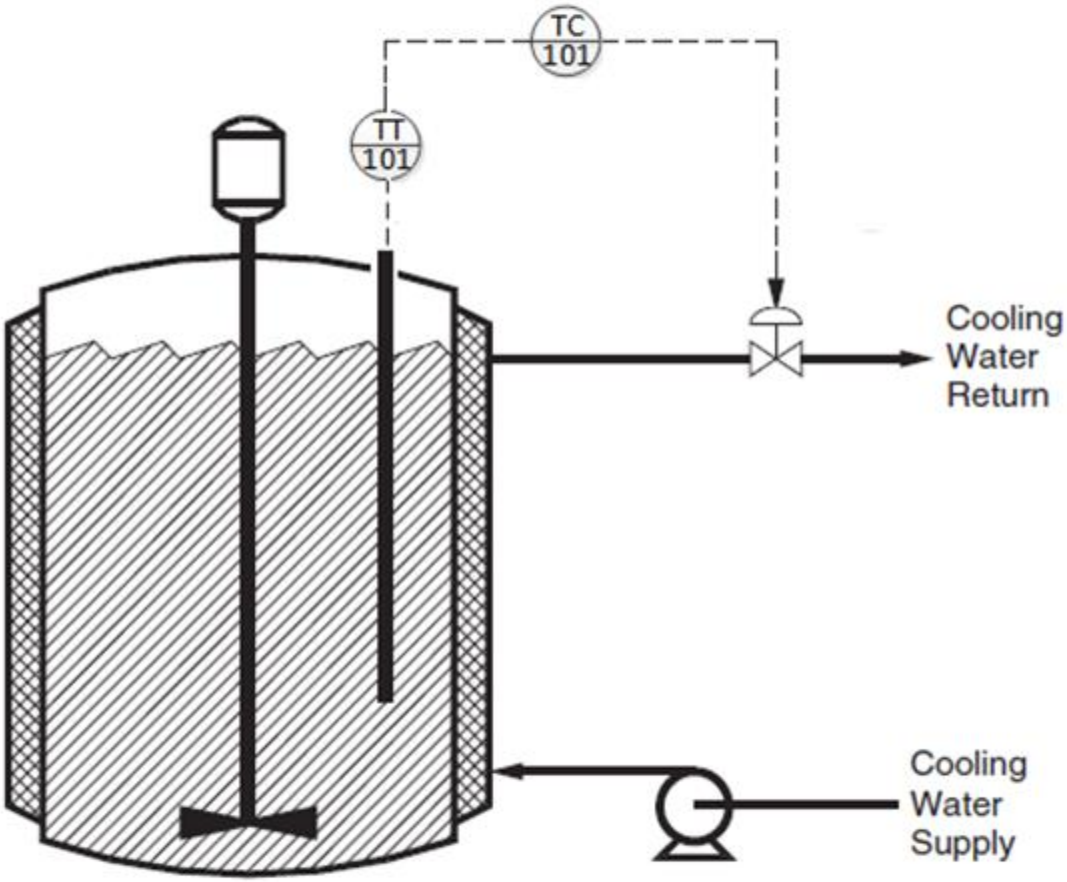


Figure 2.3 An override control strategy.

2.2 Override Control



Normal Operation: Maintain reactor temperature at desired value.

Abnormal Operation: CW exit temperature should not exceed a certain value.

Figure 2.4 Temperature control feedback for a reactor

2.2 Override Control

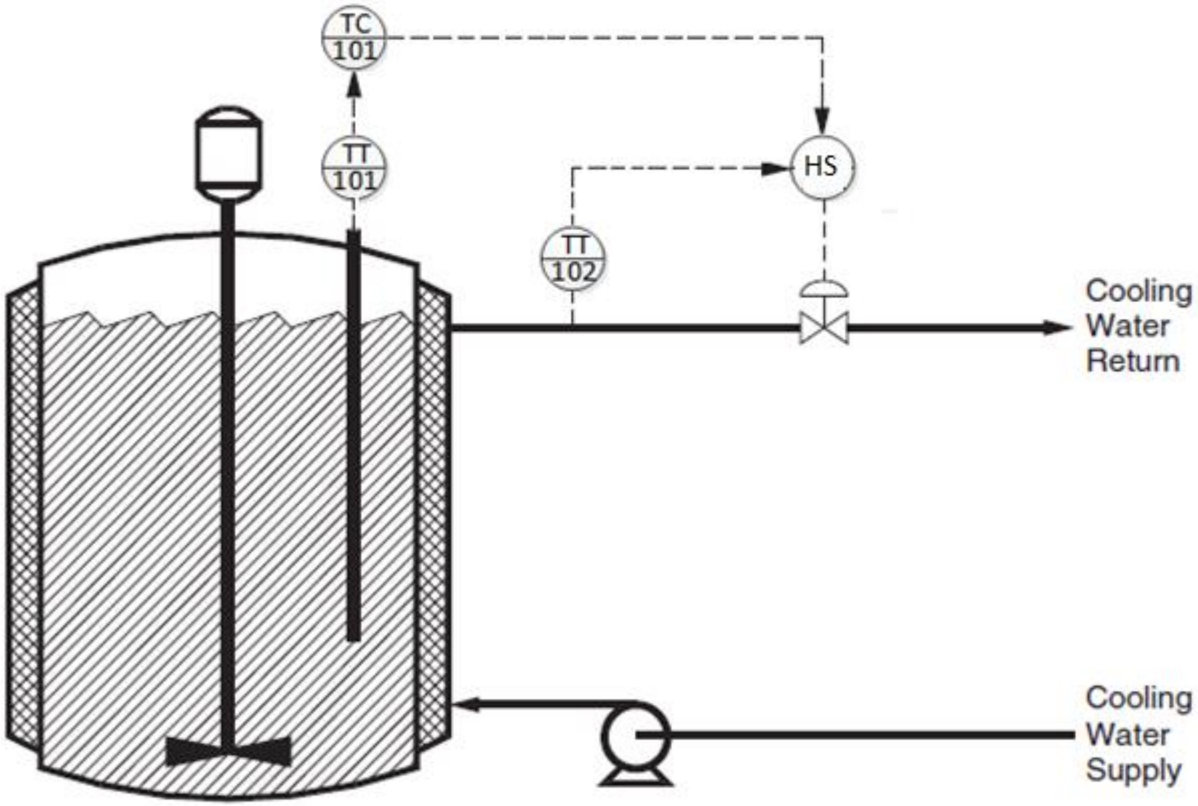


Figure 2.5 Override Control

2.2 Override Control

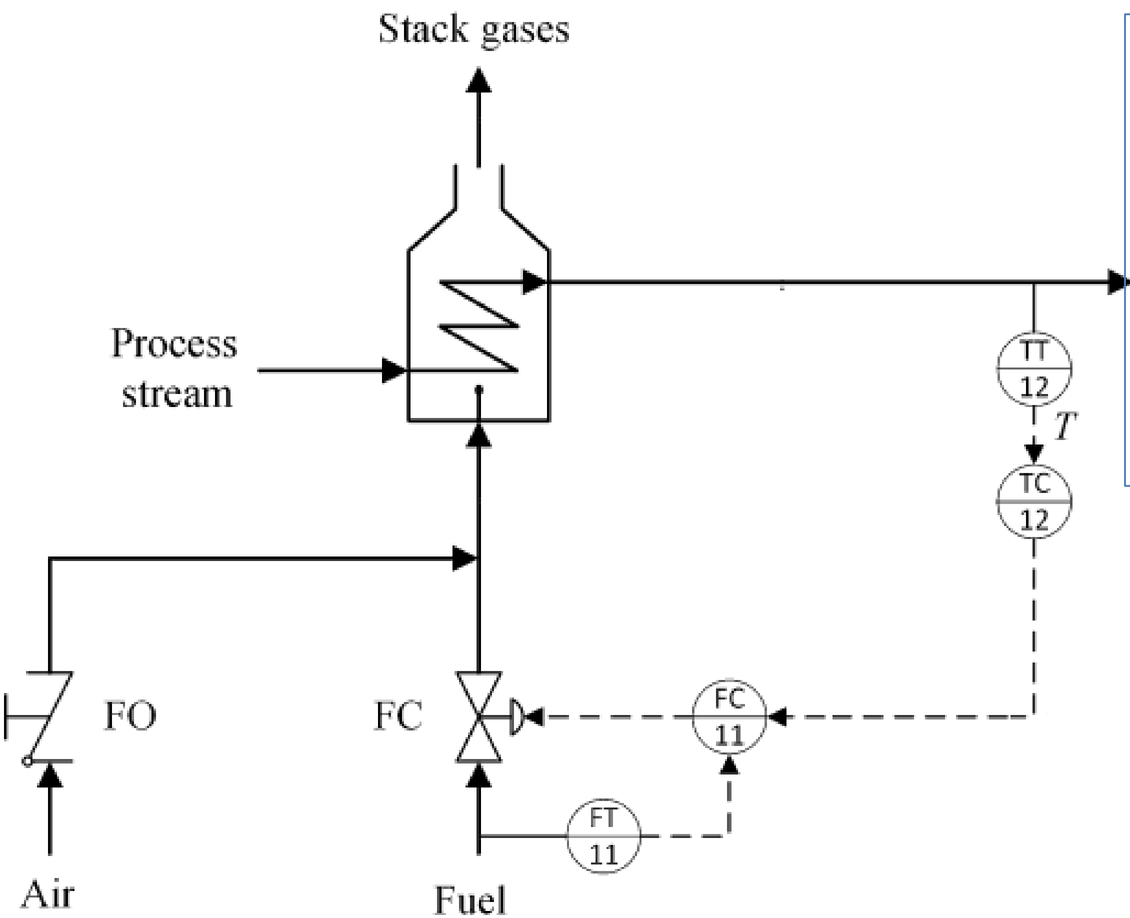


Figure 2.6 Furnace control (cascade)

<u>Safety and Operating Requirements</u>

- Pressure should not be too high to get sustained flame.
- The stack temperature should not exceed the safety limit .

2.2 Override Control

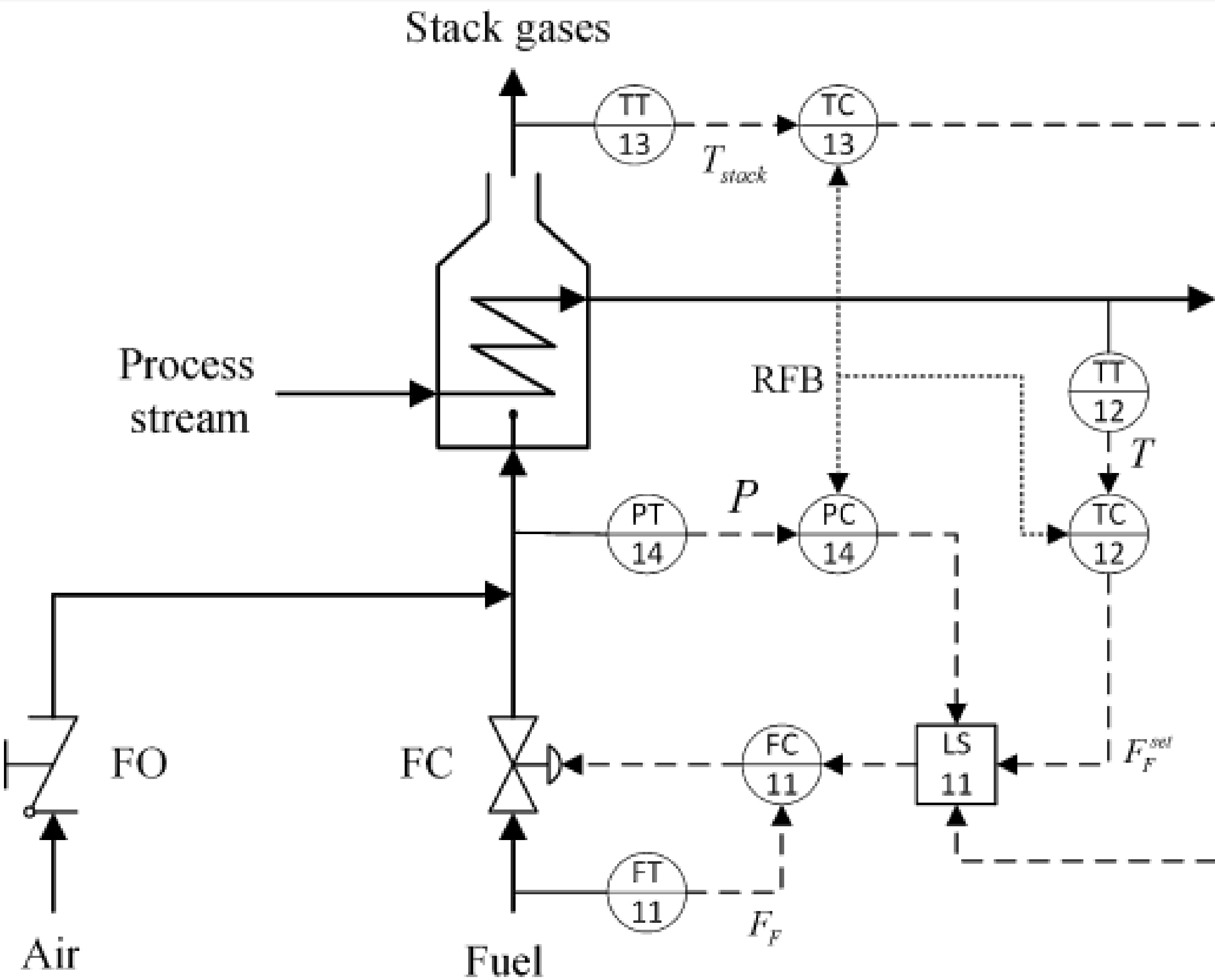


Figure 2.7 Furnace override control

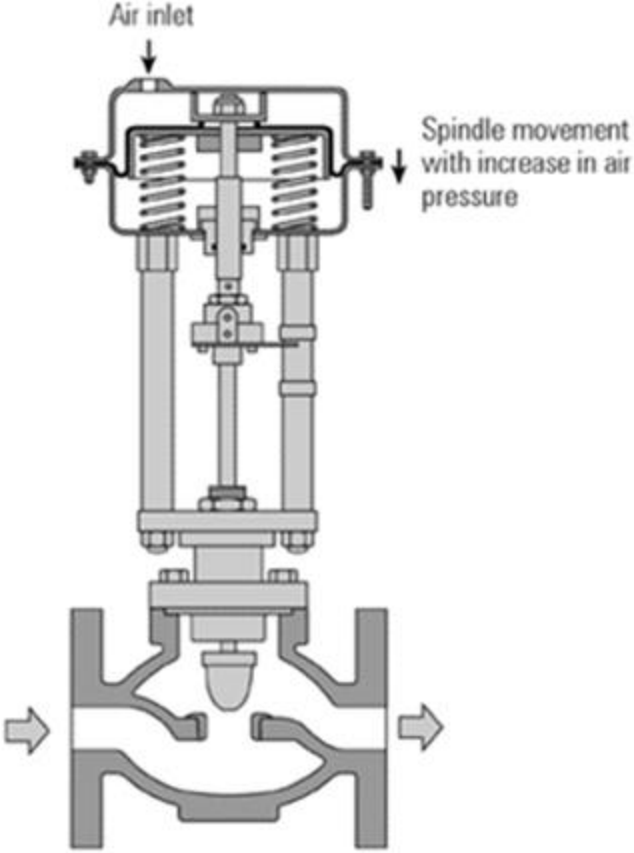
2.3 Split Range Control: Control Valve

Figure 2.8 Control valve

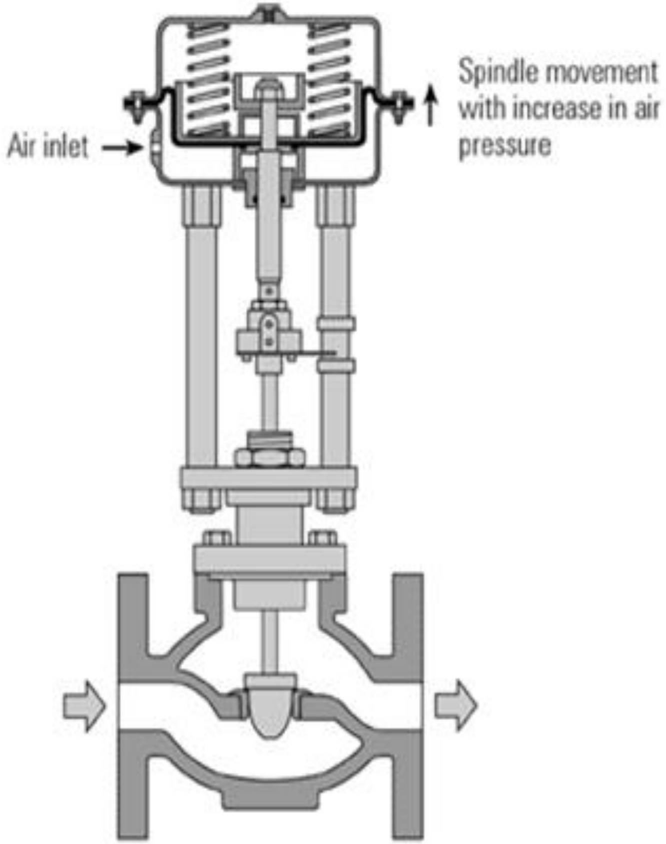
2.3 Split Range Control: Control Valve

Figure 2.9 Control valve

Direct and Reverse Acting Valves



Fail Open (Air to close), reverse acting valve



Fail Closed (Air to open), direct acting valve

Figure 2.10 Direct and reverse acting control valves

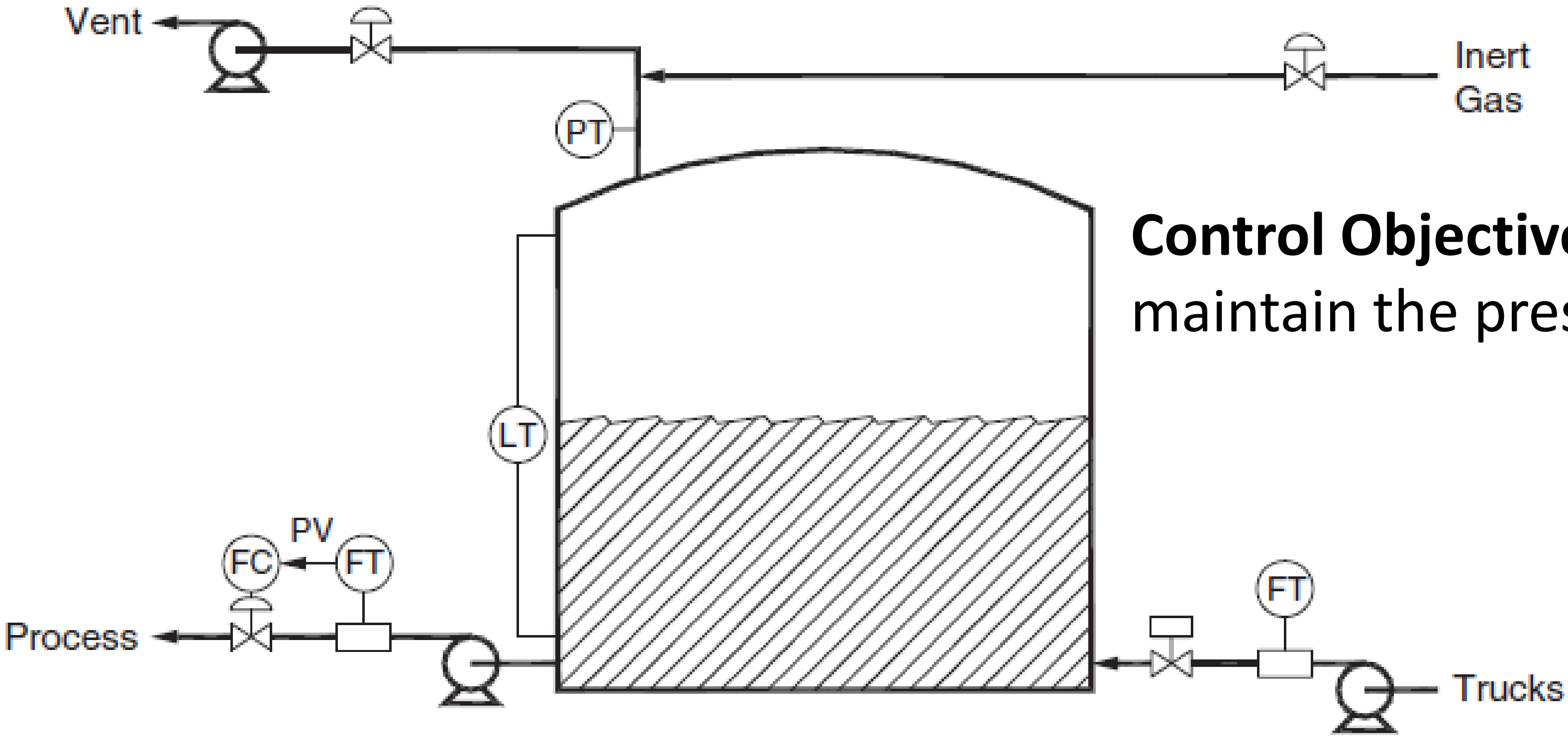
2.3 Split Range Control

- Some control applications involve a dual mode of operation.
- The two that are most frequently encountered are:
  - *Heat/cool.* Sometimes the temperature must be maintained by adding heat to the vessel, but at other times the temperature must be maintained by removing heat from the vessel. Many reactors impose such requirements.
  - *Vent/bleed.* Sometimes the pressure must be maintained by venting gases from the vessel, but at other times the pressure must be maintained by adding gases to the vessel. Such a capability is required for some storage tanks.

2.3 Split Range Control

- There are two approaches to providing control in such applications:
  - *Separate controllers for each operating mode.* This normally requires that the set points for the individual controllers be separated sufficiently so that only one controller is active at a given time, the other having driven its final control element to a limit.
  - *Split range.* A single controller is provided, but its output range is “split” such that one mode of operation is active from 0 to 50% and the other is active from 50 to 100%.

2.3 Split Range Control



Control Objective: To maintain the pressure at SP.

Figure 2.11 Oil storage tank

2.3 Split Range Control

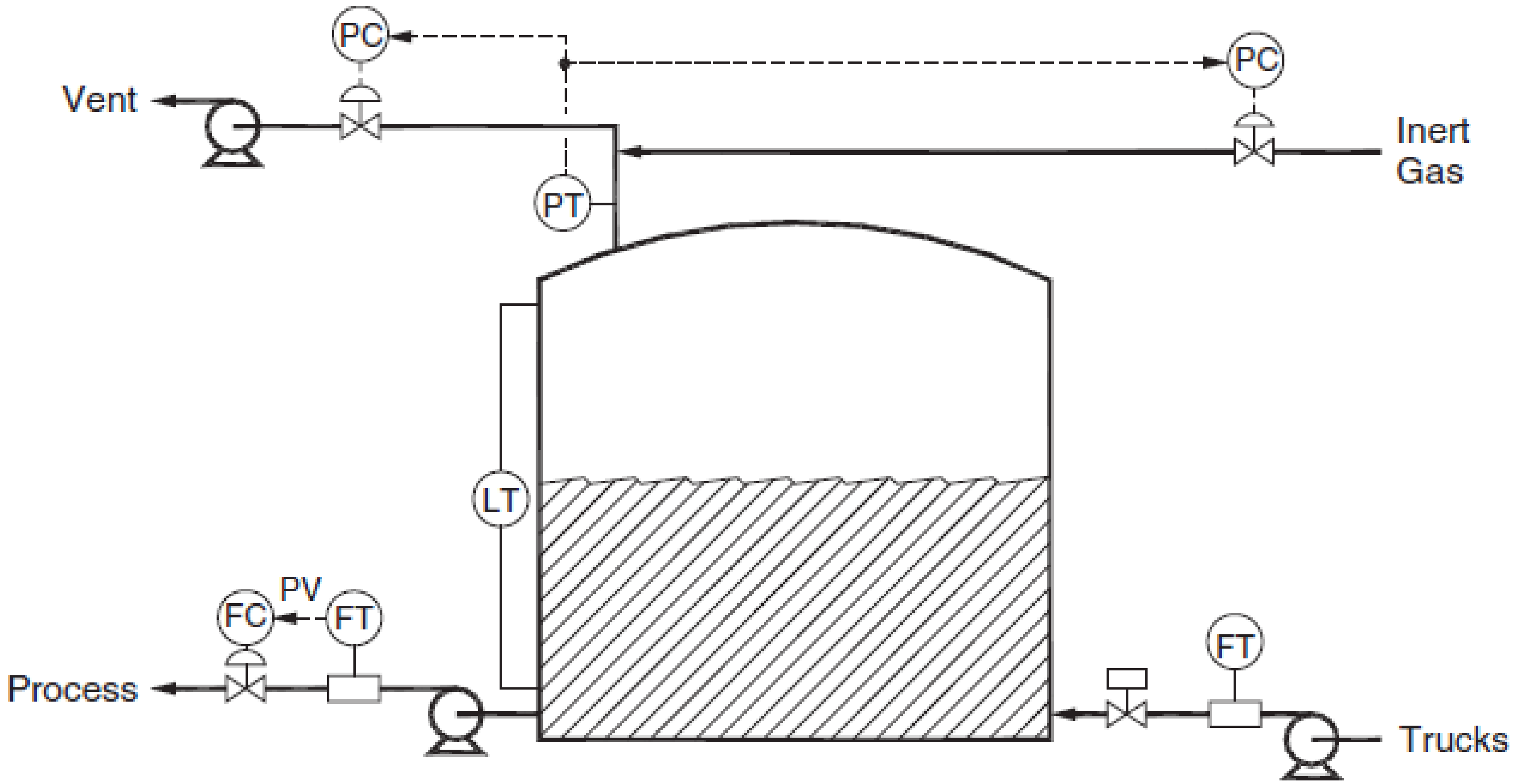


Figure 2.12 Oil storage tank with two feedback controllers

2.3 Split Range Control

- **Ideal Split Range.** The logic for driving two valves using only one controller output the storage tank is as follows:
  - At a controller output of 50% (midrange), both valves are closed.
  - As the controller output increases above 50%, the vent valve opens but the inert gas valve remains fully closed.
  - As the controller output drops below 50%, the inert gas valve opens but the vent valve remains fully closed.

2.3 Split Range Control

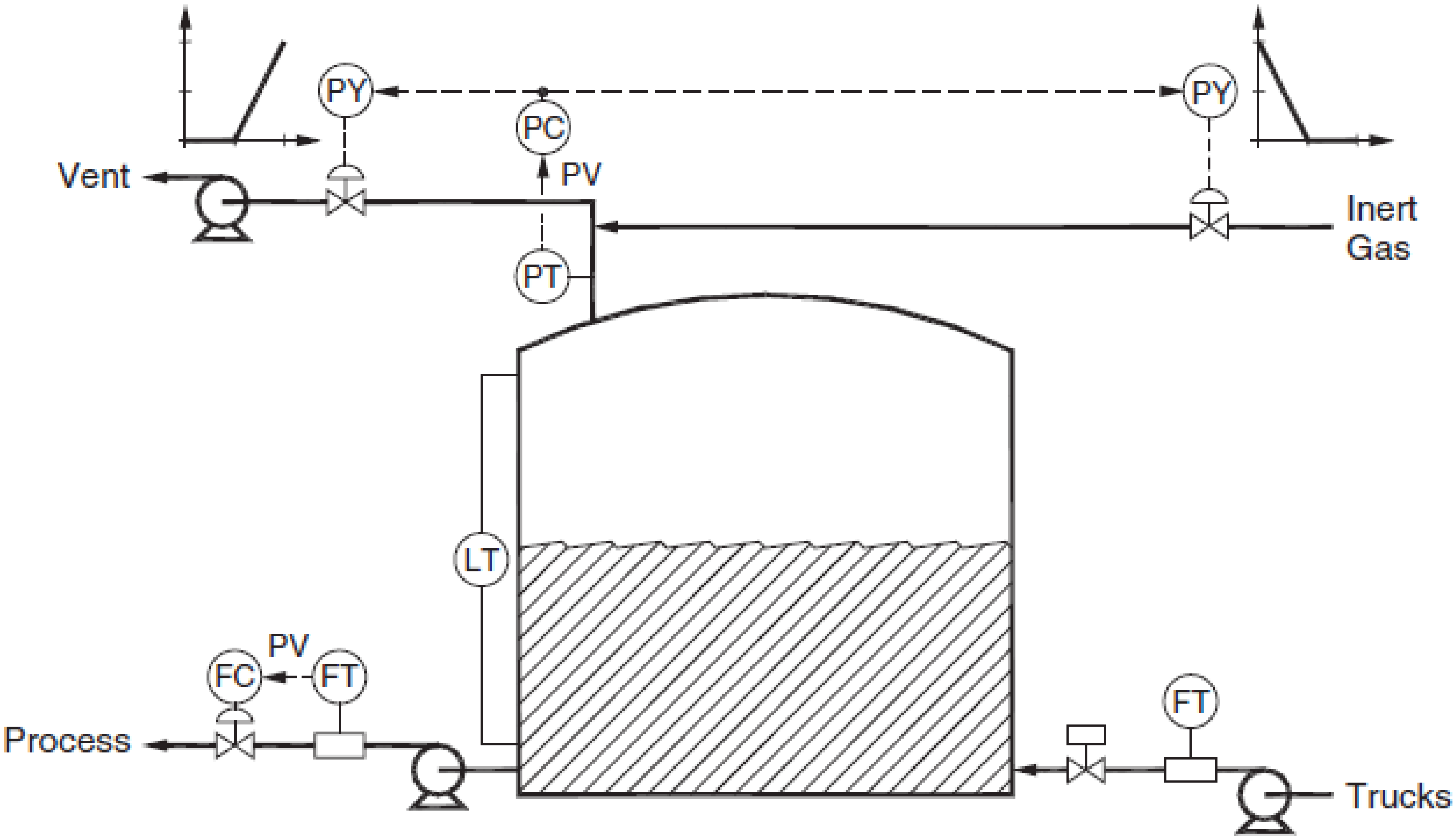


Figure 2.13 Oil storage tank with two feedback controllers

2.3 Split Range Control

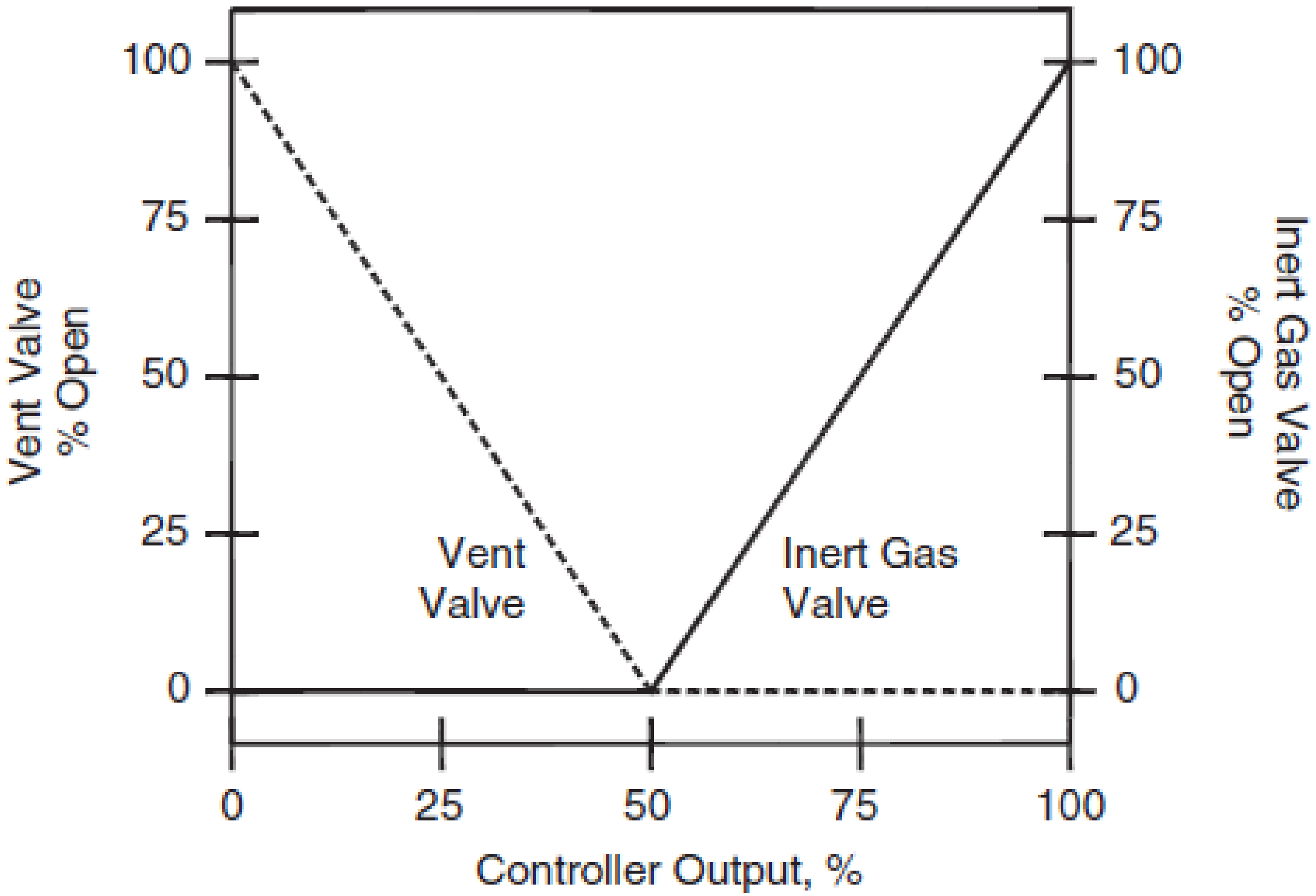


Figure 2.14 Ideal split range logic.