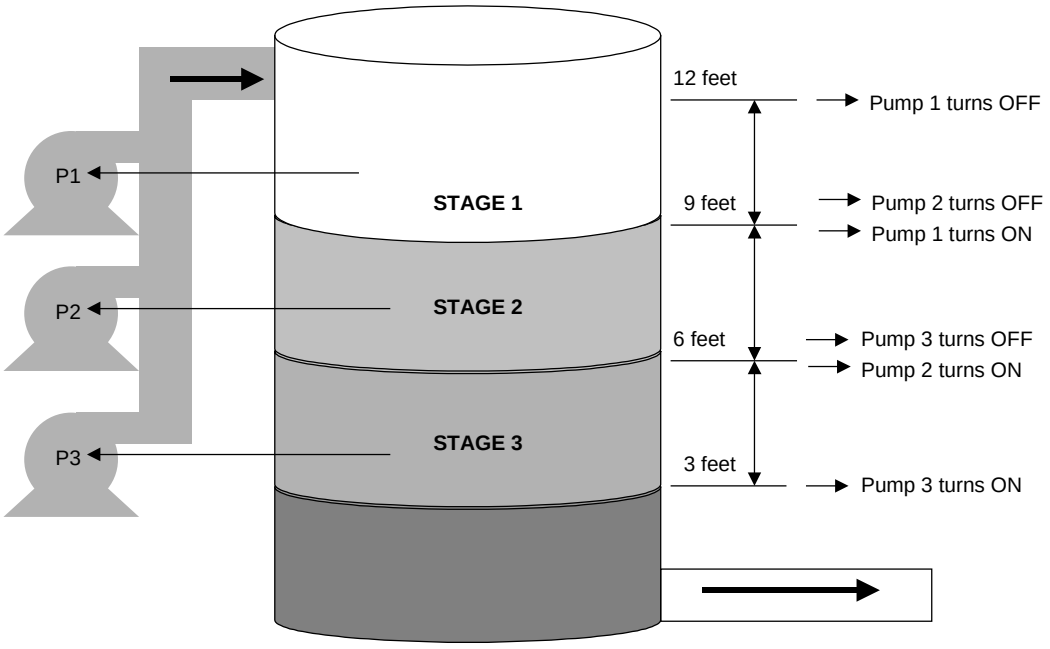
# HC900 Hybrid Controller

*When you need more than just discrete control*

## Stage Function Block – Product Note

**Background:**
Controlling the level in a tank or vessel, particularly when material is being continuously added or extracted at dynamically changing rates requires approaches to control that are significantly different from those used to control such variables as temperature. The purpose of tanks and vessels is to provide reserve capacity to support changing process demands. Controlling the amount of material in these units often requires controlling within a band or range rather than to an exact setpoint value. When the tank or vessel has multiple bands or ranges of control, the control action within the band is often referred to as a Stage. Each Stage typically has its own end element such as a pump or valve that is regulated to control the level in that Stage.

An example of a "Pump-up" tank control with three stages is indicated below. The objective of the control is to maintain a tank level of not more than 12 feet and not less than 3 feet. Stages are setup to activate a supply pump at 9 feet and additional pumps at 6 and 3 feet as the level in the tank decreases. At a level of 1 foot a separate event could indicate an alarm condition.



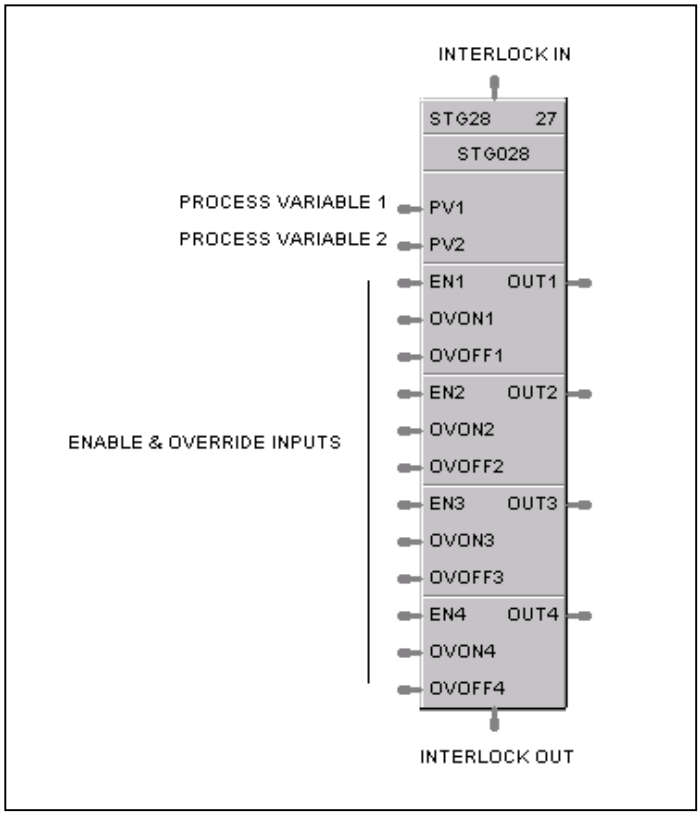

**Problem Statement:**
To control the level of a tank with multiple stages an ON setpoint and an OFF setpoint value is needed for each stage output. To prevent oscillations around stage thresholds, stage setpoints are often set to provide overlap of adjacent stages. In addition to stage overlap to prevent oscillation, some installations require interlocking of pumps to prevent all pumps from being turned ON or OFF simultaneously. Typically all stages within a tank will be controlled from a single variable representing level.

The example above represents a “Pump-up” control system where the material entering the tank is controlled to maintain the tank level within the desired limits. Another type of frequently used tank level control is Pump-down. In a Pump-down control system material enters the tank until a limit is reached which causes a pump(s) to turn ON and pump the material out of the tank. On multi-stage pump-down tanks, additional pumps are enabled if the level in the tank continues to increase after the first pump is enabled. As with Pump-up control, overlapping setpoints and interlocking pumps are also a common requirement.

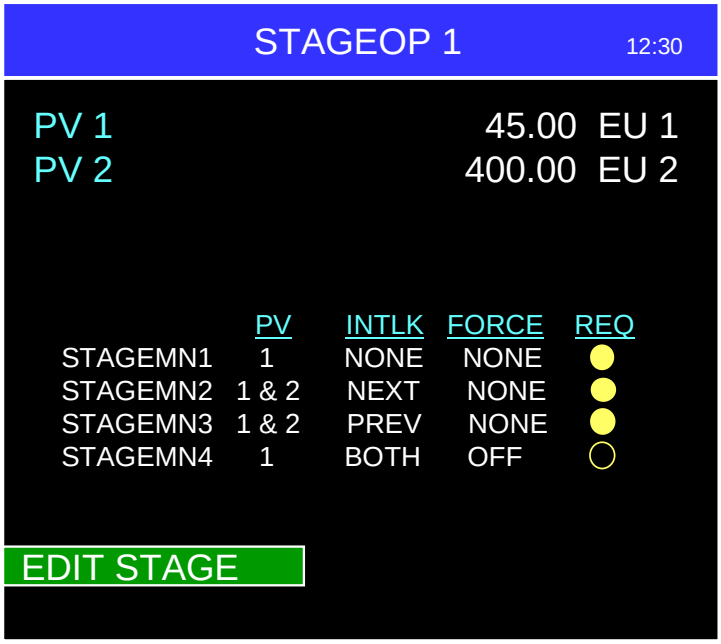
In the event of a sensor failure, if a pump is taken out of service, or for other off-normal conditions, the controls in the Pump-up or Pump-down control systems should provide override capability to allow forcing the output state of a specific stage.

**Solution:**

The HC900 Stage function block provides a method of handling stage control that is both easy to setup and simple to use. A single “Stage” function block supports up to 4 stage control algorithms, each with individual ON and OFF setpoint values and digital outputs. Two process variable inputs are provided which are common to all of the four stage control algorithms. The user may select from standard Pump-up or Pump-down configuration choices that predefine the control action taken on the first PV input. Custom configurations may also be created such as using the value of PV1 to activate a stage output and a different value of PV2 to deactivate the output. Each of the four stages of the function block allow separate Pump-up or Pump-down selections.



The HC900 Controller can support up to eight Stage function blocks. Each algorithm has a dedicated display for operation and monitoring on the 1042 Operator Interface. The Operator Interface supports on-line changes of the setpoints, delay times and interlock selections.




Processes that involve control using large pumps and valves are often sensitive to momentary activation or deactivation. To prevent a momentary process variable deviation from pulsing an algorithm's outputs, On-delay and Off-delay timers are provided for each of the four stage algorithm outputs. In operation, these delay timers require the error signal to exist for a time longer than the delay time before the appropriate action is taken.

Interlocking of stage outputs is often needed during start-up and shut-down operations or during periods of high instability when large error signals may exist which could result in the simultaneous activation of multiple stage outputs. Interlocking selections of Next and Previous are provided for each stage of the stage function block.

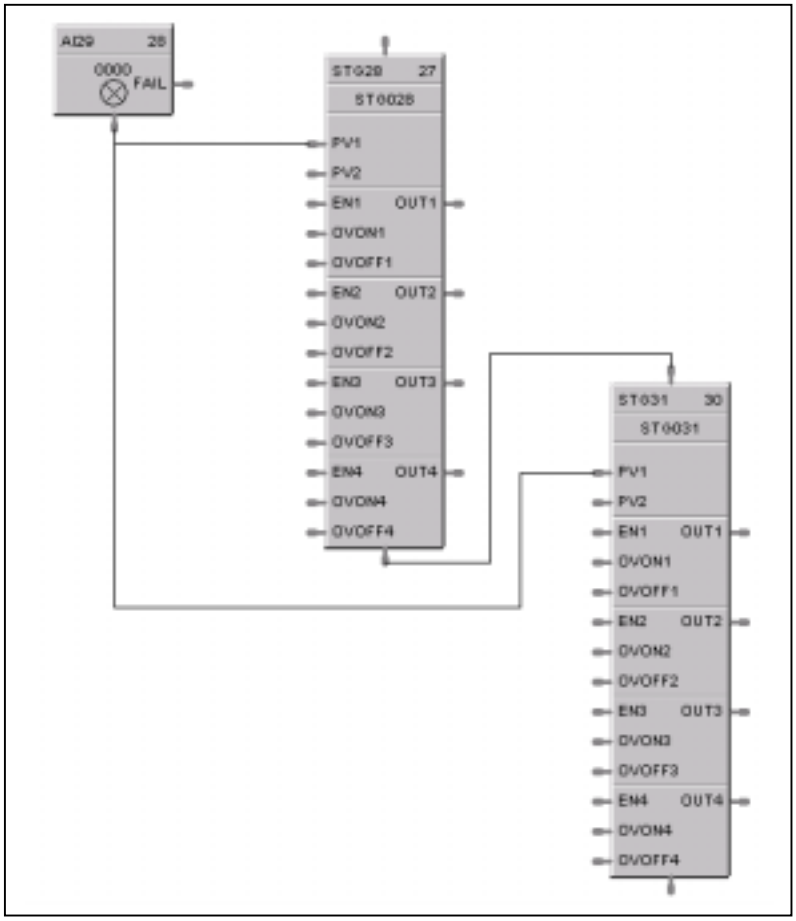
Next-Interlocking - Selecting "Next interlocking" for a stage will require the output of the next stage in sequence to be OFF before the output of the stage with the interlocking enabled can turn OFF, regardless of the stage input value.

Previous Interlocking - Selecting "Previous interlocking" for a stage will require the output of the previous stage in sequence to be ON before the output of the stage interlocking enabled can turn ON, regardless of the stage input value.

The selection of Interlocking can be made on a per-stage basis to allow such configurations as stage 1 is interlocked with stage 2, stage 3 is interlocked with stage 4 but stage 3 is not interlocked with stage 2.

If the number of outputs in a control sequence exceeds 4, multiple stage function blocks can be cascaded as indicated in Figure 2. Interlocking can be continued beyond a single block through the input and output pins

provided at the top and bottom of each function block. Simply connect the interlocking output of the first stage function block to the interlocking input of the second stage function block.




Each stage of the Stage function block has a pair of override input pins. The normal state of the pins is OFF, but if ON, the ON-override pin forces that stage's output ON and the OFF-override pin forces the stage's output OFF, regardless of the PV input value.

Although the HC900 Stage function block provides an ideal solution for controlling level in multi-stage tanks and vessels, the algorithm may also be used to provide a latched digital output that turns on based on one setpoint and turns off based on a second setpoint. Uses for this attribute can be found in many other control applications.

**Summary:**

The HC900 Hybrid Controller Stage Function Block provides a ready to use solution for a wide variety tank level control applications. The built in delay timers, independent override controls and secure interlocking features make implementation very simple when compared to equivalent functions performed in PLCs. The dual setpoints per stage with inherent latching of this function block also supports use in a variety of other non-level control applications.