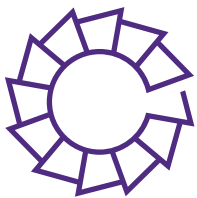
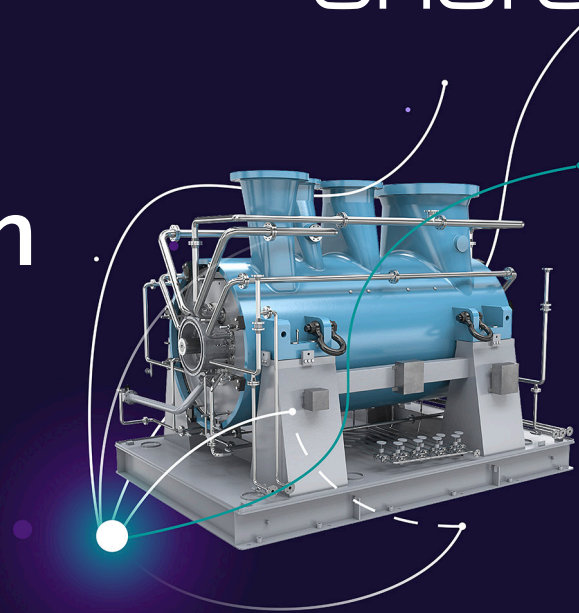


# Compressor Train One Control

## Anti-Surge Control

[siemens-energy.com](https://www.siemens-energy.com)



As a top tier supplier of compressors, Siemens Energy has the domain expertise and experience across the range of several well-known legacy brands of compressors including the Siemens legacy and the Dresser-

Rand legacy. This expertise comprises both the compressors themselves as well as the decades of experience in compressor control. The enhanced Compressor Train One Control (in the following abbreviated as One Control) core functions are used in both the worldwide leading SIMATIC PCS 7/S7 automation product family from Siemens Energy or the well-established Allen-Bradley.

Siemens Energy's One Control anti-surge algorithm is based on a patented universal control map that is used to accurately predict the surge point over a wide range of changing conditions, especially in process applications with variable gas composition.

## Application

The One Control anti-surge controller provides optimum safety of the overall plant as the energy costs, lifetime of the compressor and quality of the overall process depend on closed-loop control. The system is specially designed for compressor applications that can react extremely quickly to changes in volume flow and pressure at the compressor. It protects the compressor from surging in an uncontrolled flow event that invokes large variations in pressure and cyclic reversal of the direction of flow. If excessive surges occur, high levels of vibration and excessive thermal loading will result. Damage to various components of the compressor, such as bearings, seals, impellers, and rotors can occur which can cause significant repair costs and production outages. Even in the absence of any obvious damage, the service life and efficiency of the compressor will be adversely affected.

## Surge Control Operation

Figure 1 illustrates the use of the universal surge control map. The compressor flow setpoint is provided by the control line. The control line is positioned to the right of the surge line which provides a safety margin for the surge controller PI (Proportional & Integral) algorithm. The PI control loop is used to compare the control setpoint to the operating point of the compressor and provides an output to the surge valve to prevent the flow from decreasing below the control line. The optimum control line in relation to the surge line is determined either in a factory in-house test or during an on-site commissioning test.

Under normal operating conditions, PI control is used, and surge control action is initiated at the control line by opening the surge valve as required to maintain forward flow through the compressor. This prevents the compressor operating point from reaching the surge line.

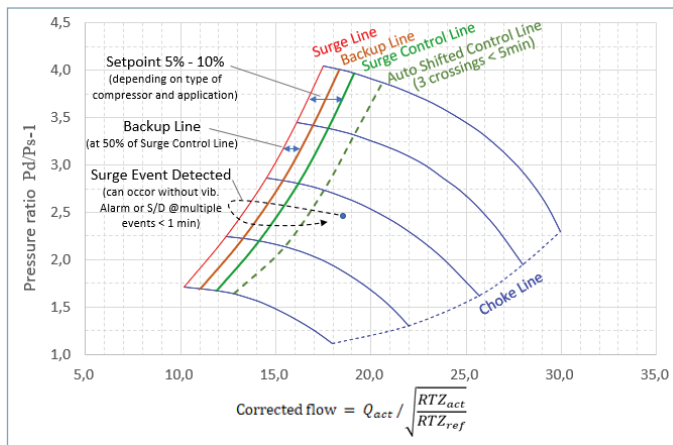


Figure 1: Universal Control Map

However, there are cases where the PI control cannot cope with the operational changes. In the case of rapid reductions in flow, such as process upsets, three additional controls are implemented.

**First**, a backup line, located between the control line and the surge line, is used. If the operating point reaches this line, the One Control's Open Loop Step Logic quickly forces the surge valve open as required to increase forward flow through the compressor.

**Second**, if the operating point of the compressor reaches the backup line a certain number of times within a specified period, the control setpoint will be shifted to the right via One Control's Setpoint Shift Logic.

**Third**, a variable proportional gain action has been added to the control loop to assist in stabilizing the process when rapid de-decreases in compressor flow are encountered.

## Backup Line with Valve Step Function

The backup line is positioned between the surge line and the control line (ref. to figure 1) and provides a basis for additional control action. If the operating point of the compressor de-decreases to flow values less than those defined by the backup line, traditional PI control is overridden by the Open Loop Step Logic control function to facilitate rapid opening of the anti-surge valve.

The anti-surge valve position is forced to increase in discrete, timed steps, thus opening the valve much quicker than possible with conventional PI control. Compressor surge is avoided by this quick incremental control of the surge valve thus minimizing the effects of process upsets.

## Setpoint Shift

If the flow decreases to the backup line a predetermined number of times (adjustable) within a given period (indicating a recurring problem), the surge control setpoint is shifted to the right via the Setpoint Shift Logic. This action establishes a larger margin of safety from the surge line.

The flow setpoint continues to be shifted as necessary until the backup line crossings cease. The intent of the setpoint shift is to prevent surge until the cause of the instability can be corrected. This bias remains in effect until reset by the operator.

## Floating Proportional Algorithm

Derivative action as known from a conventional PID controller would tend to make the compressor control unstable.

Thus, the derivative gain is replaced by a Floating Proportional gain action that takes effect when normal PI control response would be too slow to prevent compressor flow from dropping below the control line during rapid system upsets. To cope with this challenge, the Floating Proportional Control Algorithm is initiated, and anti-surge valves are opened preemptively for fast changes in flow before the operating point reaches the control line. This function is triggered if both the operating point is close to the surge limit line and the flow is decreasing too rapidly.

Normal PI control is resumed when the process upset has been stabilized.

## Adaptive Control

Unlike conventional anti-surge applications, the One Control anti-surge controller automatically adjusts PI gains to optimum values if the default gains set at the time of unit commissioning cannot adequately provide timely control response under changing process conditions.

### Anti-surge control features – in a nutshell

- Universal Control Map (Invariant to suction MW, T, Z)
- Backup Line with Valve Step Function
- Setpoint Shift Logic
- Floating Proportional Algorithm
- Adaptive Control
- Limit Control
- Temperature Correction
- Decoupling
- Surge Protection
- Load Sharing Control



## Limit Control

An additional function of the anti-surge controller limits the pressure ratio thereby ensuring that no undesirable process states occur. In addition, a choke limit control system is also implemented to be activated where required.

Additional limit controllers, such as motor current, discharge pressure or suction pressure limiters can be easily combined to the anti-surge control loop.

## Temperature Correction

For high deviations from the reference suction condition, both the anti-surge controller and the pressure ratio limiter can be temperature compensated. This feature is mostly used for adjustable inlet guide vane compressors with atmospheric inlet pressure conditions and gear-type compressors in general.

## Decoupling

In case of multiple controllers or a multi-variable system, the relation between controller output and input might be coupled, which is a characteristic property. For a control system that has independent inputs and outputs, a decoupling mechanism might be necessary.

One Control has several decoupling mechanisms integrated to decouple the integrated controllers:

- o Decoupling ASC ↔ ASC
- o Decoupling ASC ↔ Performance controller
- o Decoupling ASC ↔ Load sharing controller

## Surge Protection \*)

The surge protection application is used to protect the machinery from damage as a result of repeated surge events. Surge cycles are often accompanied by flow reversals and high variations of process variables. This is why One Control offers two kinds of surge protection.

\*) There is a separate technical flyer available on this topic

### Surge protection - Control Deviation mode

The Control Deviation mode of surge protection is included within the anti-surge controller function. This type of surge protection is monitoring the compressor operation point in relation to the control line. The monitor is activated when the control deviation falls below a preset negative value. The surge cycle is detected, when this preset value is passed again in direction to the control line.

### Surge protection - Gradient mode

The Gradient mode of surge protection is realized by a separate surge protection function block in the same PLC or in external hardware. This mode of surge protection monitors the gradients of up to four process signals (e.g., discharge pressure, flow, motor current or suction pressure). A surge is detected if one of the gradients exceeds the gradient limit that was configured during commissioning.

Both types of surge protection can be configured to create a warning or open an ASV valve before a compressor shutdown is initiated (in general, at the 3rd or 4th surge event).

## Long-term Archive

The One Control system contains a long-term archive for diagnostic and maintenance purposes. This archive contains both data and process variables relevant to the anti-surge controller.

## Process Controller

Many chemical processes demand a high degree of accuracy with regard to process parameters of compressed gas. This is typically a constant suction or discharge pressure or a specified flow to the process. These tasks are performed by integrated process controllers (refer to fig. 2) that are combined with anti-surge controllers and limiters.

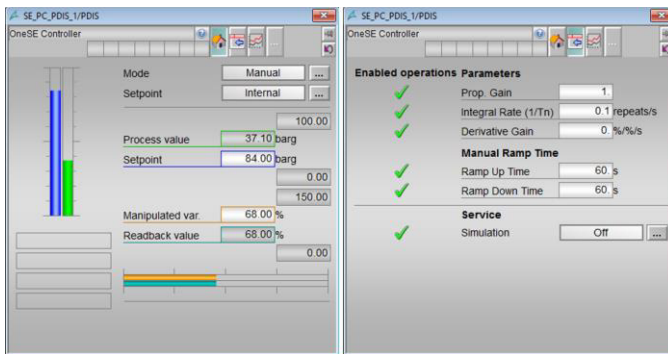


Figure 2: Example of HMI with process controller

## Operating and Monitoring

In addition to the control software running in a PLC system, we provide an innovative HMI (Human Machine Interface) for operator control that is mostly based either on Siemens SIMATIC PCS7®, Aveva Wonderware® or Rockwell FactoryTalk® platforms. All One Control systems incorporate surge control as an integral part of the PLC program without the need for additional external hardware. Compressor inlet flow, suction pressure, and discharge pressure measurements are input directly into the system using standard PLC analog inputs. The tuning parameters are displayed and adjusted from the HMI screen. A live compressor map with the anti-surge control line including limiters, operating point, temperature correction and back-up line is displayed on the HMI monitor as well as system parameter and process variable trends.

Furthermore, it also provides the user with extensive functions for operating and monitoring machines and systems, as it offers a balance between cost-effectiveness and user-friendliness.

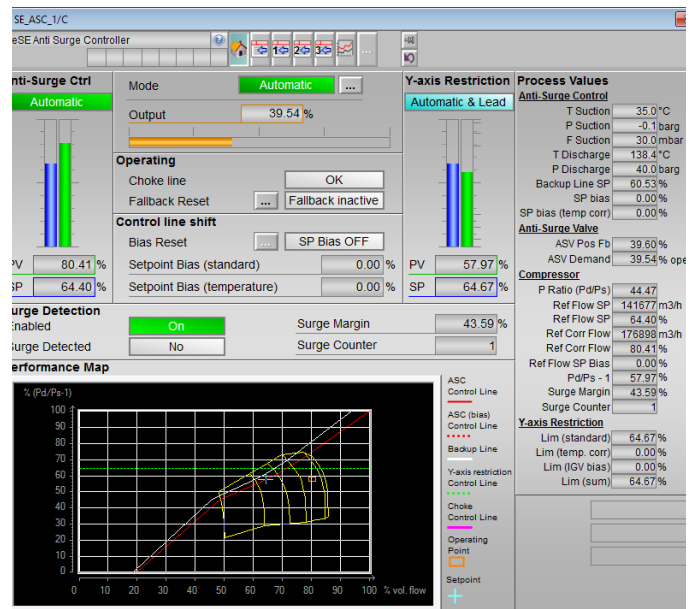


Figure 3: Example of HMI with anti-surge controller



Thanks to the standardized HMI and the pretested interface to the automation system, the benefits become apparent as early as the commissioning phase.

## Load Sharing Control \*

One Control also features a patented load sharing algorithm, which helps equalize surge margins and maximize system efficiency by sharing flow among multiple compressors that are connected to common suction and discharge lines.

Conventional load sharing algorithms are based upon the relationship between compressor inlet flow and the respective flow at the control line. This does not account for any recycled flow. To eliminate this problem, One Control's algorithm uses a Coefficient of Export Flow (CEF). This value accounts for the effective flow to the process instead of considering only the compressor inlet flow. That is the reason we are able to provide effective load sharing even if the compressors are in recycle operation.

\*) There is a separate technical flyer available on this topic

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