OptiComp* Compressor Control Suite
Overview

**OPTICOMP** Compressor Control Suite is GE’s latest comprehensive software package for controlling centrifugal and axial compressors. It improves upon anti-surge control and protection algorithms used in the industry today and effectively and safely matches compressor performance to process demand within the operational constraints of the compressor, its driver, and the process.

*Trademark of General Electric Company*
OptiComp software is a flexible solution, supporting integrated turbine-compressor systems as well as motor-driven machines. It emphasizes integration with process control and helps to optimize plant performance by providing stable and predictable unit control. OptiComp software provides efficient load sharing between parallel and series units, increasing operating region without recycle. When recycling is necessary, it provides stable and effective control. OptiComp consists of standard software modules with interfaces to unit control suitable for both GE and non-GE units. When used with GE compressors, OptiComp embeds proprietary features built on OEM-specific compressor knowledge and modeling capability, resulting in increased performance benefit.

This solution is based on decades of OEM and unit control experience, with over 600 installations controlling centrifugal and axial compressors in many oil and gas applications worldwide.

OptiComp is capable of handling a wide range of applications starting from simple single-stage compressors to complex multi-stage compression trains with series and parallel configurations, including refining, petrochemical, LNG, NGL, and pipeline applications.

OptiComp can be a part of an integrated unit control system with several hundreds I/O points or exist as a stand-alone control system with anti-surge and performance control loops with fewer than 20 I/O points, depending on your application. OptiComp can be implemented using GE’s Mark* VIe turbine control.

Benefits
- Better Protection
- Improved Process Stability
- Improved Efficiency
- Simplification
- Flexibility

*Trademark of General Electric Company

Applications and Options

UPSTREAM
- Gas gathering/process plants
- Gas reinjection

MIDSTREAM
- Pipeline booster compression
- NGL processing
- LNG

DOWNSTREAM
- Chemical/Petrochemical plants
- Refineries
- Ethylene plants
- Ammonia plants and Methanol plants
- Fertilizer plants

PRIME MOVERS
- Industrial and aeroderivative gas/steam turbines
- Electric motors (fixed or variable speed)

COMPRESSORS & BLOWER
- Centrifugal
- Axial

AUXILIARY SYSTEMS
- Lube oil
- Seal oil
- Dry gas seals
- Station control and sequencing
Anti-Surge

WITH OPTICOMP COMPRESSOR CONTROL SUITE

OPTICOMP provides a rich and powerful set of configurable control functions for effective anti-surge control and protection. This comprehensive and flexible solution employs powerful, field proven algorithms to meet your process requirements.

MAIN FEATURES

- Accurately defines the low flow stability boundary of the compressor over the entire range of operating conditions
- Minimizes steady-state anti-surge protection margin using enhanced control algorithms with features such as patented\(^1\) dead time compensation in the anti-surge control loop, rate control for anticipating effects of disturbances, and open loop response with automatic determination of the step size based on a simplified system model of the compressor and recycle line.
- Utilizes recycle valves to minimize effects of process upsets
- Integrates with capacity control via loop decoupling
- Provides basic diagnostics on compressor operation preventing inadvertent closure of the recycle valve due to faulty measurements
- Incorporates reliable surge detection and prevention of successive multiple surge cycles or continuous operation in the stall region
- Prevents nuisance opening of the recycle valve in case of signal failures, while still providing anti-surge protection

\(^1\)Patent US20120103426
SURGE LINE DEFINITION

• Widely accepted non-dimensional Surge Line formulation, which automatically compensates for variations in inlet conditions and changes in gas composition
• For refrigeration machines: more precise calculation of side stream flow utilizing on-line real gas properties estimation

CONTROL ACTIONS

PI Control
• PI control for maintaining the operating point on the Surge Control Line, with:
  — System dead time and valve anti-hysteresis compensation
  — Loop decoupling with other anti-surge controllers for multi-section compressors and with process controllers in the vicinity of the Surge Control Line
• PII Rate Control for opening the recycle valve before the operating point reaches the Surge Control Line based on exceeding allowed rate of approach to the Control Line
  Note: PII is PI with additional integral action

Boost Correction
• An open loop response providing a step change in the output to the recycle valve
• The step size is calculated based on the desired increase in the flow, the valve and compressor characteristics, and on the rate of change of the operating point

PROTECTIVE ACTIONS

Safety Protection can de-energize the recycle emergency opening solenoid if the compressor’s operating point remains in dangerous proximity to Surge Limit, despite open command to the recycle valve

Surge Detection By
• Identifying oscillations of compressor parameters exceeding specified amplitude and frequency, in line with API-670 requirements
• Crossing of the Surge Limit Line

If Surge is Detected, OptiComp
• Increases protection margin with patented relocation logic. The increment is estimated based on where surge has occurred and must be between specified minimum and maximum values. The margin is re-evaluated on every detection.
• Counts surge cycles
• Generates discrete signal used for alarm or trip when a specified number of surge cycles occurs within a specified time period
• Can directly limit closure of the recycle valve if operating point calculation is not reliable. OptiComp can limit increases on every detection.

FALLBACK STRATEGIES FOR SIGNAL FAILURES

• For GE compressors: When compressor geometry is known, the value of the failed parameter is estimated (patented) based on the remaining healthy parameters, through the compressor non-dimensional map and the previously estimated gas properties.
• For non-GE compressors: Last Good Value method is applied. On signal failure, Last Good Value will be used in its place in the calculations until any other parameter deviates from its value at the time of the failure by a specified amount (i.e., system is not in steady-state). Then either high or low default value will be used, depending on the worst case condition. For flow failure valve output will ramp to a specified value.

PERFORMANCE CONTROL ASSISTANCE AND INTERFACES

• Suction and discharge pressure limiting proportional–integral–derivative (PID) control loops for assisting with response to large disturbances
  — Provisions for simultaneous reaction to suction/discharge pressure limit for machines with multiple sections
  — Set points may be coordinated with process controllers
• Provisions for allowing performance control to manipulate recycle valve in order to:
  — Minimize errors of process controllers
  — Prevent capacity control from driving the operating point beyond the Control Line when decreasing capacity

Performance Control

WITH OPTICOMP COMPRESSOR CONTROL SUITE

OPTIMIZE performance without sacrificing reliability. OptiComp Control Suite improves integration between compressor anti-surge protection and performance control, minimizing the effects of process upsets and handling load changes without affecting process stability.
MASTER PERFORMANCE CONTROL (MPC)

- Up to three PID loops with high/low output selection for main and limiting control of:
  - Suction Header Pressure
  - Discharge Header Pressure
  - Export Net Flow
- Control of a stand-alone unit or simultaneous adjustment of the performance of the parallel/series units
- Options for parallel/series compressors:
  - Distributed architecture, where each unit controller incorporates MPC and the control actions of MPCs are synchronized via GE’s fast and reliable Unit Data Highway (UDH)
  - Separate (split) hardware architecture, with a dedicated MPC controller for a group of compressors, communicating to the unit controllers via the UDH

LOAD SHARING FOR PARALLEL/SERIES COMPRESSORS

- Ensure that the operating points of all compressors simultaneously reach their respective Surge Control Lines (SCL) in order to avoid unnecessary recycling
  - SCL-based criterion takes into account the nominal characteristics of the compressor, ensuring that when operating away from the SCL compressor efficiency characteristics affect relative loading
  - When operating on the SCL, the recycle flows are balanced to avoid unequal recycle
- Provide for more efficient operation of the units away from the Surge Control Line by balancing the relative power consumption of the drivers
  - Used when power measurement or other power-consumption related measurements, such as exhaust gas temperature for gas turbines, are available
  - Saves energy compared to the SCL-based loadsharing by avoiding running less efficient units with the same load on the compressor as more efficient units
  - Transition from SCL-based load sharing to relative power occurs automatically, based on the location of the operating points of the compressor
- Use pressure ratio for balancing series machines
- Automatic compensation for a tripped unit, increasing performance of the units that remain on-line
- Standard PID control modules with signal selection logic that can be interfaced with MPC for individual constraint control of a particular unit, or as stand-alone modules
- Sequencing logic and control for automatically loading and unloading of units, avoiding process upsets
- Standard interfaces to turbine control preventing integral wind-up in case of encountering turbine constraints, such as exhaust temperature limit
- Decoupling between PID control modules within OptiComp Performance control, and with antisurge controllers
- Provisions for feedforward control, for example, quench control for refrigeration compressor applications, whereby feedforward signal from the antisurge controller to the quench controller significantly improves the response of the quench controller
HMI AND PERFORMANCE VISUALIZATION

- Display of compressor performance curves, Surge Limit Line (SLL), SCL, Boost Correction, Safety Protection and operating point in real time and in various coordinate systems
  - User can select desired coordinate system from the Compressor Map HMI screen or different map displays are provided for each coordinate system
  - SLL, SCL, Boost Correction, Safety Protection are read from the controller and then recalculated to selected coordinate system
  - Compressor curves are stored in base coordinates on the HMI and then recalculated to selected coordinate system

- Compressor performance calculations, such as polytropic efficiency and shaft power, estimation of power losses due to recycling

- Remote monitoring capabilities via the HMI

USING MARK VIE AND CIMPPLICITY

- Built-in OPC-compliant alarm and event logging and archiving
  - Time stamp on the controller (1msec resolution)
  - Sequence of Events (SOE) with 1msec resolution for I/O and scan time resolution (down to 10msec) for internal events
  - Synchronized process and mechanical information when interfaced to Bently Nevada systems
  - Extensive built-in hardware diagnostics

- Commissioning and Troubleshooting tools
  - High speed trending with scan time resolution

- User configurable critical event archiving (surge or trip) with data collection in the controller and automatic transfer to the HMI
Integrated Controls

WITH OPTICOMP COMPRESSOR CONTROL SUITE

OPTICOMP can be integrated with motor, gas or steam turbine controls in simplex, duplex, and TMR configurations, taking full advantage of sophisticated decoupling algorithms for better coordinated turbine and compressor control responses.

Having an integrated system simplifies troubleshooting, maintenance and repair activities providing common, time synchronized sequence of events and trending functionality. The common control platform also reduces the number of vendors to deal with, spare parts and training requirements, and multiple control system interface issues.
The **OPTICOMP BN** option enables detection of rotating stall and enhances surge detection in combination with Bently Nevada 3500 systems.

Patented¹ algorithms used in OptiComp BN combine traditional measurements used by anti-surge systems, such as flow and pressure, with mechanical measurements of radial and axial vibration and axial displacement of the compressor shaft, enabling detection of rotating stall and improving reliability of surge detection.

*Available with Mark* *VIe and BN3500.*

¹Patent US8342794
*Trademark of General Electric Company*
CURRENT METHODS OF SURGE DETECTION RELY SOLELY ON PROCESS MEASUREMENTS. CHALLENGES ASSOCIATED WITH THIS TECHNIQUE INCLUDE:

- Cannot reliably detect surge precursor (stall)
- Not being able to reliably distinguish between surge and process upsets or signal failures, leading to false detection
- Cannot evaluate the severity of the surge cycle in terms of potential mechanical damage

ROTATING STALL DETECTION

Radial Vibration Measurements
OptiComp BN correlates vibration characteristics (i.e., radial vibration) and thermodynamic measurements (i.e., pressure, flow, temperature) to improve detection of compressor instability. These values are used to identify rotating stall, which is recognized as a precursor to surge. Using patented stall detection, OptiComp BN provides an alarm when rotating stall characteristics are detected in the in the region approaching the Control Line. As a configurable option, OptiComp BN automatically relocates the Surge Control Line to the right of the detected stall region.

ADDITIONAL SURGE INDICATION

Axial Displacement
OptiComp BN utilizes both thermodynamic and mechanical measurements to detect compressor surge. It identifies sudden and large changes in axial rotor displacement, indicative of surge cycle(s). OptiComp BN correlates the axial displacement signal with rapid changes in the process signals to detect a surge event within a defined window. It then initiates the surge recovery response. OptiComp BN also counts surge cycles. This data can then be further analyzed to determine the severity of the surge and potential compressor damage as a result of the surge.

OptiComp BN utilizes process measurements that are readily available in most compressor installations. No additional instrumentation is required.
Features & Benefits

Better Protection
- Reduced Polytropic Head vs. Reduced Inlet Volume Flow calculations provide improved protection with varying operating conditions and gas composition.
- Rate control (derivative response), Boost (open loop response), and normalization of valve response as a function of pressure ratio/gas properties provides improved protection over a wide range of disturbances and process conditions.
- Advanced surge detection using multiple process variables.
- Stall and surge detection using vibration measurements in conjunction with traditional process measurements (OptiComp BN)

- “Boost” open loop response provides additional compressor flow when OP moves beyond the SCL just prior to reaching the surge limit
- Anti-surge control PID positions the recycle valve for steady-state, stable operation on the SCL
- Normalization of valve response as a function of pressure ratio/gas properties
- Real time map showing OP in user selected terms using real gas properties
- High fidelity simulation of the compressor, driver, and process equipment

Improved Process Stability and Uptime
- Suction and discharge pressure override control utilizes the recycle valve to help stabilize the process.
- Improved diagnostics for process signals validity and fallback strategies for failed transmitter inputs, minimizes unnecessary recycle and avoidable trips.
- Decoupling between driver and compressor provides more reliable and stable process capability by reducing unnecessary trips and process swings.

Efficiency
- Parallel/Series Load-sharing parameter selection based on compressor and driver characteristics
- Performance and efficiency calculations using real gas properties provides valuable benchmarking information for evaluating changes in overall train efficiency.
- Improved surge prevention, reducing recycle and improving efficiency.
**Simplification**
OptiComp can be applied with motor, gas or steam turbine controls in simplex, duplex and TMR configurations, taking full advantage of sophisticated decoupling algorithms for better coordinated turbine and compressor control responses. In addition, having an integrated system simplifies troubleshooting, maintenance and repair activities providing common, time synchronized sequence of events and trending functionality. The common control platform also reduces the number of vendors to deal with, inventory of spare parts, and training requirements as well as multiple control system interface issues.

**Flexibility**
In some applications, compressor control issues are unique and cannot always be resolved using “off-the-shelf” solutions. Customers require both a proven approach along with system flexibility in order to address their specific problems. OptiComp provides just that. The core control responses are used for every compressor control application, with the programming flexibility to meet control challenges. OptiComp is scalable from a single compressor anti-surge and performance control to multiple turbine/compressor trains including auxiliaries and overall process control.

**MORE CONFIDENCE**
With GE, you get outstanding compressor protection and control, based on decades of experience as a controls provider and OEM for compressors, backed by one of the most successful providers of turbomachinery equipment and controls in the world.

**PATENTS**
- Dead Time Compensation (US20120103426)
- Margin relocation logic following a surge detection (EP2423514A2) (US 2012/0048387 A1)
- Stall Detection/OptiComp BN (US8342794)
- Patent Pending: Failed Parameter Estimation