



Surge Control Design for Centrifugal Compressor Systems

Three levels of dynamic surge analysis

There are many station events that can cause a centrifugal compressor to surge, such as interaction from other units, reciprocating compressor pulsations, and upset conditions like sudden power loss. To understand, model and evaluate this risk, a complete station surge analysis is often required – even if an OEM has previously evaluated units on an individual basis.

Wood Group VDN (BETA) offers three levels of analysis to assist users in carefully evaluating the optimal design for their surge control system, in terms of machine protection, station functionality, and capital cost.

Purpose of surge control

A well-designed surge control system should effectively sustain positive flow through the compressor in sufficient time to save it from the effects of emergency shutdowns, fast stops, low flow periods and machine start-ups. The piping system, recycle valves, and their controls are integral parts of the surge control system.

Services for Centrifugal Compressor Systems

Surge Control Design

See also:

- ▶ Shell Transverse Acoustical (STA) Analysis
- ▶ Lateral Vibration Analysis
- ▶ Flow-Induced Vibration (FIV) Analysis
- ▶ Pipe Stress Analysis
- ▶ Acoustic Fatigue Assessment
- ▶ Flow-Induced Turbulence (FIT) Analysis

Resources

Visit our website to access these resources:

- ▶ **Service offering**
Surge Control Design for Centrifugal Compressor Systems
- ▶ **Calculator tool**
Free surge sensitivity calculator
- ▶ **Webinar recording**
What Is My Risk of Surge?
New Tools to Prevent Centrifugal Compressor Surge
- ▶ **Case study**
Avoiding Compressor Surge With Multiple Compressors (PDF)



Compressor impeller damaged during surge

Factors affecting surge control design

- 1. Piping system:** The piping system design drastically affects the performance of the surge control system. This has historically been overlooked, because traditional surge control analysis techniques focus only on the overall volume of the piping network, not on the physical length and impedance of the system. Piping layout, placement of valves, recycle loop(s), and control valve functionality are especially important to a reliable surge control system. The piping system is also integral in a multi-unit station where one centrifugal may cause another to surge if the piping system or recycle loops are shared.
- 2. Recycle valve selection and control scheme:** Maximum capacity, flow percentage vs opening percentage (trim), opening/closing delay, and valve travel time must be included and evaluated.
- 3. Instrumentation and surge limit model:** The selection and placement of pressure, temperature, and flow metering will affect surge detection and control system response.

When is a dynamic surge analysis required?

A dynamic analysis is recommended for **new compressor projects** with high risk of surge, when **modifications** are proposed for an existing system, or when the **risk of an existing system** going into surge needs to be determined.

Three levels of analysis

Wood Group VDN offers three levels of analysis, each level increasing in complexity and accuracy. The appropriate level depends on project risk tolerance and surge sensitivity. This analysis should be considered even if the individual unit has been previously evaluated by an OEM.

► **Level 1 – Surge sensitivity analysis:** Calculates a compressor's *Inertia Number* as a non-dimensional value to determine surge risk and sensitivity. Offered as a **free calculation tool**, the accuracy of this assessment depends on the available project data.

► **Level 2 – Time limit analysis (impedance method):** This is a short evaluation of valve capacity and system response times compared to allowable maximum response times, plus a qualitative system assessment.

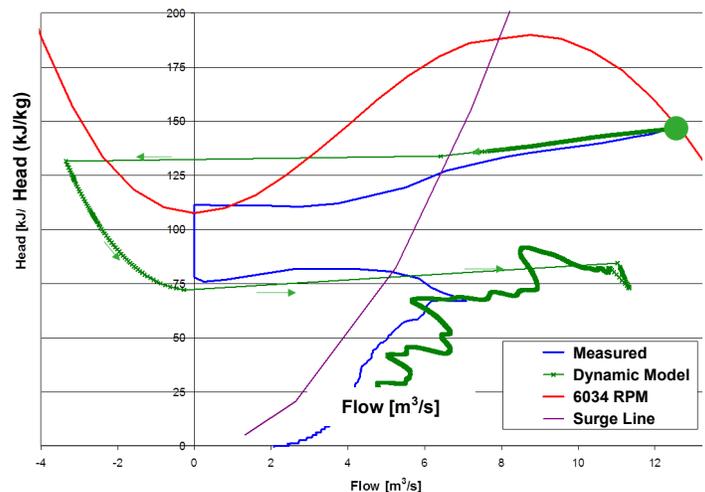
Deliverables include:

- Recycle **valve sizes** (including hot recycle, if required)
- Maximum allowable **valve response times**
- Impedance line plots with a **qualitative assessment of risk**

► **Level 3 – Full dynamic simulation:** This analysis uses a complete dynamic simulation of the compressor, driver, piping system, control valves, and control scheme. The simulation includes the negative flow regions of the operating map to assess each surge cycle and ensure complete machine protection after a successful design is developed. Operators often request the full dynamic simulation in many high-risk cases previously thought to be safe from surge events.

Deliverables include:

- **Most accurate prediction** on the market for surge behavior of facilities
- Detailed **recycle valve sizes, trim types and response specifications**
- Evaluation of **piping layout** and surge system **component suitability**
- Recommendations to address various **surge scenarios**, when required



ESD surge event example: measured data vs dynamic model

See our [website](#) for more details.

Wood Group experience

Wood Group VDN (BETA) has significant experience with centrifugal compressor systems, gas turbine drives (both frame and aeroderivative), electric motor drives, torque converter coupled, and more. Our team are world authorities on surge control design and analysis with decades of research experience on transient flow problems in complex systems, including centrifugal compressor surge phenomena, pressure relief system dynamics, transients of two-phase stratified flows, interface mixing between batches in pipelines, fluid-structure interactions, and flow-induced vibration in heat exchangers and machinery dynamics.

Contact Wood Group VDN to find out which level of surge analysis is required for your facility, and how we can help you build a safe and reliable surge control system.