Control Performance:
An Imperative for Safety

George Buckbee
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Summary
Safety is the primary requirement of any control system. After that comes environmental requirements, stability, efficiency, and optimization. But safety is always the very first concern.

When handling dangerous energy, chemical, and mechanical hazards, the automated control system is the first layer of safety. It can respond more quickly, predictably, and repeatedly than a human operator. Yet few plants are measuring the performance of the control system and its resulting effect on safety. This means that the control system may not be capable of meeting its design requirements, and could fail in the face of a serious safety hazard.

This paper explains the link between control performance and safety, reviewing the minimum requirements for effective control system operation.

Overview

What is Control Performance?
Control Performance is made up of the complete performance of all parts of the control system. This includes the performance of:

- Instrumentation
- Controller Configuration
- Controller Tuning
- Control Valves, Variable Speed Drives, and Actuators
- Control System Operation
- Process & Control Interactions

When any component of the control system fails to function, one or more layers of safety have been removed or disabled. For example, a pressure controller running in manual leaves a pressure vessel with only one layer, the safety relief valve, to handle an unexpected surge in pressure.

Motivations: Some Industrial Examples

BP Texas City
One of the most significant incidents in recent years was the explosion at BP in Texas City, south of Houston. On March 23rd, 2005, a hydrocarbon vapor cloud explosion occurred killing 15 workers and injuring more than 170 others. The
Texas City Refinery was the second-largest oil refinery in the state, and the third-largest in the United States with an input capacity of 437,000 barrels.

US Chemical Safety Board's video of the events concluded what had led to the explosion. The video takes you from the start to the end of the incident, and clearly explains what caused it. It appears to be a combination of bad control system design, poor instrument maintenance, and multiple operator errors.

Fukishima

Friday, March 11\(^{th}\), 2011 a magnitude 9.0 earthquake struck northeast of Tokyo, Japan.

The quake caused serious damage at Tokyo Electric Power Company's (TEPCO) Fukushima Daiichi nuclear power plant, south of Sendai. Three of the plant's six reactors, which came into service between 1970 and 1979, were already shut down for inspection at the time the disaster struck. Those still in operation were designed to also shut down in the event of a quake, with diesel generators pumping water around the reactors to keep them cool.

But when the tsunami hit, flood waters swamped the generators, causing them to fail. The reactors began to heat up, this resulted in the operators' guessing at the level of cooling water, and because they guessed wrong, they drastically delayed the start of cooling by the few emergency means at their disposal, such as by using helicopters, fire trucks and sea water.

The solution to this unacceptable situation is not only to measure the in-core level, but when the fuel rods are about to be uncovered, automatically start emergency cooling by opening the gravity flow from elevated open or from pressurized closed tanks (or from helicopters, fire engines, etc.).

Are These Exceptions?

Unfortunately these are not exceptions. Process plants are in heritably dangerous places. There are serious safety-hazards in just about ever plant whether you are producing oil & gas, pulp & paper, metals, chemicals or food. When your control system is not performing at its best, the probability and seriousness of these hazards can be dramatically increased.

Measuring Control Performance

Measuring the performance of the control system highlights hazards as they develop. As we have already seen, ignoring these hazards can have serious consequences. Yet most plants do not monitor even the simplest aspects of control system performance.

In fact, many plants have collected tremendous data history, fully recording the risk, and yet have never considered looking through the data to address the
issues of control performance. This presents further legal issues of due diligence in case of an incident.

There are over 80 known measures for control performance. These performance measures range from simple to complex, and most can be monitored automatically. Several key metrics for safety are described below.

**Time in Normal**

In North America, as many as 30% of control loops are operating in manual. With loops in manual, the control system is not doing any control. In fact, it is not capable of doing anything until the operator returns it to automatic operation. The system will not respond to upsets. Safety and environmental results may be easily compromised by a process upset condition. The protection provided by the automated control loop is completely gone.

For most effective control, and the highest level of safety, control loops should be operating in their “Normal” mode of operation. This may be automatic, cascade, feedforward, or some other mode of control.

Despite the clear importance of this metric, few plants are monitoring which controllers are in manual. And very few have organized plans to return controls to their normal mode of operation.

**Loop at Limit**

The second most important measure of control performance measures whether the controller is operating at a limit. Examples of loops operating at limit include:

<table>
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<tr>
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<th>Consequences to Safety</th>
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<tr>
<td>Control output at its</td>
<td>This is often an indication of process capacity or constraint. The controller is unable to respond to further</td>
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<tr>
<td>maximum, or valve fully</td>
<td>increases in flow. The operator cannot override this. It is a physical limit.</td>
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<tr>
<td>open</td>
<td></td>
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<tr>
<td>Control output at its</td>
<td>This often indicates that the valve is too large. When a valve is too large, control is poor, resulting in</td>
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<tr>
<td>minimum, or valve fully</td>
<td>stability issues due to overly aggressive moves of the control valve, and an overreaction in the process.</td>
</tr>
<tr>
<td>closed</td>
<td></td>
</tr>
<tr>
<td>Process measurement at</td>
<td>When the process measurement, such as a temperature or pressure, reaches the upper limit of the instrument,</td>
</tr>
<tr>
<td>its maximum</td>
<td>then the operator is running blind. We cannot say the actual condition of the process, and we cannot assess</td>
</tr>
<tr>
<td></td>
<td>the degree of hazard in the situation.</td>
</tr>
<tr>
<td>Process measurement at</td>
<td>Again, the operator is running blind. When an instrument reports its minimum value, this is often a sign</td>
</tr>
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<td>its minimum</td>
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Loops operating at a limit represent a clear and imminent danger to plant safety.

**Unable to Hold Setpoint**

Even if the loop is running in its normal mode and position, the control loop may not successfully achieve its primary objective; to hold the process variable at its set point. There may be problems: process upsets, control strategy, or process capability.

Identifying loops that are unable to hold set point is a critical step in improving the safety of the plant.

**Variability**

When Process has high variability it is more difficult to keep operation in safe bounds. Quality and environmental constraints may also be violated. Improved control performance will stabilize the process, reduce the variability and reduce the risk of safety, quality, and environmental violations.

**Interaction**

Process plants are complex. The true source of upsets and variability may be far upstream in the process. It is important to find the true root cause of all process upsets, rather than treat the downstream symptoms.
How to Implement Control Performance Monitoring

Justifications – Are You at Risk?

A one-time audit or evaluation can help identify the major risks at your plant. This evaluation can used to clarify the scope of benefits from a control performance monitoring solution.

Scope of Control Performance Monitoring

Should you monitor the performance of every control loop? This is a cost/benefit analysis that most plant face. The initial temptation is to monitor only the control loops with the highest safety risk. While this is a good starting point, you should also consider those controllers that have process interactions with these critical loops. Beyond that, it may be important to add some measurement-only instruments to the monitoring system.

One rule of thumb to determine the size of a control monitoring system is to take the number of analog outputs in a DCS, then add 10 to 20% to cover the important measurement-only devices.

All of the performance measures discussed (time in normal mode, are loops at limit, setpoint, variability, root cause) should be monitored continuously to insure the plant does not drift into a dangerous situation.

Prioritizing Corrective Actions

A typical oil refinery may have over 3,000 control loops, if 30% of the control valves have mechanical issues that would mean 900 valve repairs are needed. In the real world, most plants do not have the resources to address this many valve repair issues.

Prioritizing the corrective actions is a critically important task. Control performance monitoring tools allow for automated prioritization of corrective actions based on technical, economic safety matters.

Staffing and Implementation

Today many plants struggle to meet management demands with fewer in house resources. There are a few plants that have the internal resources dedicated to
take on full control performance monitoring on their own. Fortunately, automation suppliers, such as Metso, have recognized the need and are offering control performance solutions. With these offerings many combinations of internal and external resources are possible.

**Sustaining Safety**

If you were somehow to resolve 100% of control performance issues for your plant and then stop monitoring, problems would slowly creep back. In fact, the half-life of control performance problems would return in 12 months. So it is absolutely critical to follow any control performance improvement program with a sustained monitoring effort.

**Summary & Conclusions**

The control system is one of the most important links in the chain of safety of risk management. Monitoring the performance of the control system is essential the minimizing the risk factors in a process plant. Control performance monitoring tools and services are readily available and provide a proven practical methods to improve safety, environmental and quality results.

**Get More Detail**

ExperTune has over 25 years experience in control loop evaluation. If you would like a personal review of your control system issues, please contact us at +1.262.369.7711 for a consultation.
Sponsored by ExperTune’s PlantTriage

This white paper is sponsored by ExperTune’s PlantTriage. This Control Loop Performance Monitoring software optimizes your entire process control system, including instrumentation, controllers, and control valves. Using advanced techniques, such as Active Model Capture Technology, PlantTriage can identify, diagnose, and prioritize improvements to your process.

CONTROL PERFORMANCE

Continuous Improvement Tools

PlantTriage improves performance every day. It monitors the entire facility, looking for the biggest improvement opportunities.

PlantTriage notifies you of the issues, than gives you deep-dive analysis, so you know exactly what the issue is.

Expert Analysis

Every PlantTriage system contains an expert system, developed by industry leaders like F. Greg Shinskey. It’s like having a world-class expert looking at your plant, every day.

Open System Compatibility

PlantTriage works with your control system. For over 25 years, ExperTune has studied process control systems, and learned the intricacies of working with each one. PlantTriage knows how to work with over 700 industrial control algorithms.

Also, PlantTriage is certified OPC-Compliant. It can connect to your control system via OPC, or to your data historian via OPC-HDA.

A Complete System

PlantTriage comes complete, with everything you need, including configuration services and training. You do not need to buy any other software. You will have unlimited users working with the true thin-client interface. Engineers, operators, managers, and technicians can all use PlantTriage to make their plant run better.
About the Author

George Buckbee is General Manager of ExperTune. George has over 25 years of practical experience improving process performance in a wide array of process industries. An experienced manager and instructor, George has also been elected a Fellow at ISA. George holds a B.S. in Chemical Engineering from Washington University, and an M.S. in Chemical Engineering from the University of California.

About PlantTriage

PlantTriage is Control Loop Performance Monitoring software that optimizes your entire process control system, including instrumentation, controllers, and control valves. Using advanced techniques, such as Active Model Capture Technology, PlantTriage can identify, diagnose, and prioritize improvements to your process.

About ExperTune®

ExperTune Inc. is a division of Metso Automation. ExperTune has been in the business of control system improvement since 1986, and has received numerous awards for its PlantTriage software.

References


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