The 6 Most Common PID Configuration Errors: How to Find and Fix Them

George Buckbee, P.E.
ExperTune, Inc.

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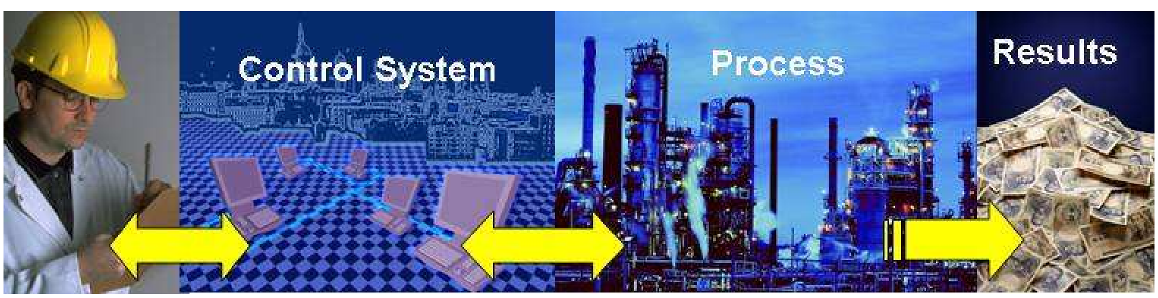
Summary

The PID Control Loop is one of the fundamental workhorses of the process industries. Day in and day out, millions of PID loops strive to keep processes safe, stable, and profitable. But there is a secret, known only to control engineers and technicians…many of these control loops are not properly configured…and the consequences could be devastating. This paper identifies the most common PID configuration issues, and provides techniques to help plant-based personnel to find and fix these issues.

Overview

How Control Systems Deliver Results

The control system acts as the nervous system for the plant. It provides sensing, analysis, and control of the physical process. The control system sits directly between the operator and the process…almost all of the operator's information comes from the control system, and all of the operators commands are carried out by the control system. When a control system is at peak performance, process variability is reduced, efficiency is maximized, energy costs are minimized, and production rates can be increased.



The Role of the PID Loop

Each individual PID control loop is responsible to maintain a single process variable at its setpoint. The control loop consists of an instrument, a controller, and some type of manipulated variable, usually a control valve. The PID loop must respond quickly and appropriately to any process upsets or load disturbances, as well as to operator setpoint changes. The loop may also coordinate its actions with other control loops, as in a cascade, ratio, or feedforward control scheme. Ultimately, the PID loop's role is to reduce process variability.

PID Loop Performance

Surprisingly, as many as 75% of control loops actually **increase variability!** Many control loops simply do not do their job. Setpoints are not followed, valves swing around, creating oscillations, and many loops are disabled by the operator: placed in MANUAL mode.

Poor performance happens in large part due to control loop configuration issues. Studies of control loops in the process industries give some insight into the root cause of these issues. For example:

- 30% of DCS Control Loops Improperly Configured
- 85% of Control Loops Have Sub-Optimal Tuning
- 15% of Control Valves are Improperly Sized

In the sections below, this white paper will show you how to identify and resolve specific issues at the root cause of poor controller performance.

PID Controller Configuration

Consider the Whole Loop

When you think about a control loop, it is *critical* to think about the *whole loop.* This includes:

- The instrument, its parameter settings, mounting, and location in the process
- Wiring, I/O, and DCS/PLC hardware and operating system
- The PID controller itself, and all its configuration settings
- The valve, actuator, and positioner. Their location and installation in the process.

In this white paper, we will focus on the configuration issues. But you should be aware that mechanical issues with the instrument and the valve could play a major role in the performance of the controller. Remember: No amount of tuning can fix a broken valve!

The Most Common Issues

The most common configuration issues include:

1. Choosing the Wrong Algorithm
2. Improper Tuning
3. Over- or Under- Filtering
4. Improper Configuration of Control Strategy
5. Spanning and Scaling
6. Scan-related Issues

In the sections below, this paper will address each of these common configuration issues. You will learn how to identify these issues in your plant, and how to make corrections to improve process performance.

Choosing the Algorithm

The Problem & Its Effects

The choice of control algorithm is crucial to good process control. Over the years, many DCS suppliers have included a wide variety of specialized variations on the PID algorithm. This gives the engineer many great options for those special-case loops. However, many of these special-case algorithms are often applied to the wrong situation.

The effects are widespread. The wrong algorithm choice can lead to:

- Inability to track setpoint
- Creating sustained oscillations
- Excessive wear-and tear on the control valve
- Excessive process movement in response to setpoint changes

At the business level, these problems can have a direct effect on quality, and indirect effects on energy costs and production rate.

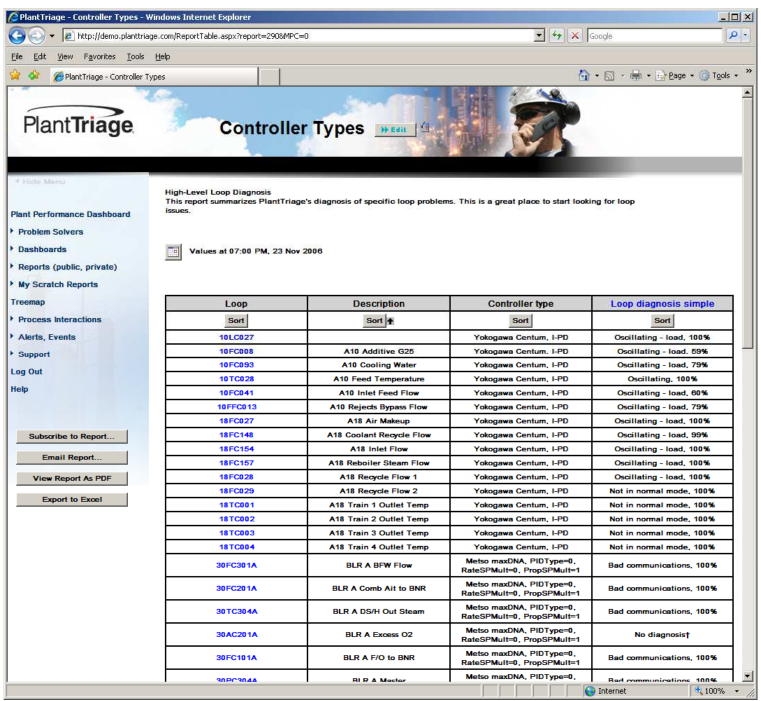


Figure 1. A Report Showing Controller Algorithm Types

Identifying PID Loops with Algorithm Problems

A few general rules can be applied to help find loops with the wrong algorithm. You can start by generating a list of all the control loops in your plant, sorted by controller algorithm. Figure 1 shows such a list, generated by ExperTune's PlantTriage.

The following algorithm choices should be avoided, except in certain special cases.

Algorithms to Avoid

Algorithm Choice	**Why to Avoid**	**Special Cases**
Derivative on Error	Causes "derivative kick" on setpoint changes, excessive wear on valve. Especially damaging when used on the inner loop of a cascade system. Use "Derivative on PV" instead.	Rarely.
PID-GAP	Does not allow PV to track the Setpoint closely. Often leads to a sustained oscillation, or PV offset from setpoint.	If minimizing control valve action is more important than good control. Surge tanks.
Integral-Only	Does not respond quickly to upsets or setpoint changes.	Slow, smooth transitions are required.

There are as many variations on control algorithm as there are control vendors. You should use caution when applying anything other than a "plain vanilla" PID controller, because there could be unintended

Fixing the Problem

First, make sure that the algorithm was not selected for one of the special case reasons. Resolving algorithm issues usually requires some form of "change management" approval. Here are a few tips to make it easier to correct the algorithms:

- To simplify the work, try addressing these issues "in bulk", rather than individually.
- Always make sure that you have a complete control system backup before you start making these changes.
- Make the changes during a shut down if possible. If changes are made while running, hold the control output at a steady value while swapping algorithms.
- Closely coordinate with operations. Make sure that operators are prepared to report any "strange behavior" right away.

Improper Tuning

The Problem & Its Effects

Typically, 30% of loops have tuning that makes no sense whatsoever, and 85% of loops have sub-optimal tuning. We all know why this happens…most plants do not have a standard method, practices, training, or tools for loop tuning. Many plants still “tune by feel”. This leads to inconsistent and often terrible tuning results. It is not surprising that you may find as many as 30% of control loops running in manual!

The effects of poor tuning are:

- Sluggish loops do not respond to upsets, causing disturbances to propagate
- Overly-aggressive loops oscillate, creating new disturbances
- Operators put the loops in manual. The loops are unable to respond, increasing the risk of safety, environmental, and quality incidents.

Identifying PID Loops with Tuning Problems

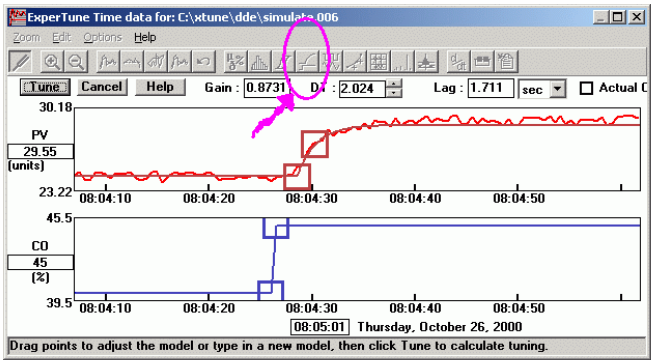
ExperTune’s PlantTriage software automatically finds control loops with tuning problems. Using “Active Model Capture Technology”, the software automatically finds process models, and compares the current tuning against the ideal. The user can receive a list of loops that require tuning, delivered by email.

Fixing the Problem

Good controller tuning requires training, tools, and techniques.

Training should include:

- Process dynamics
- Controller algorithms
- How to distinguish between tuning and hardware issues
- Selection of robust controller tuning



In today’s world, there is simply no excuse for tuning loops without software tools. The tools simplify the work and ensure that the work is properly documented. ExperTune’s software tools have led the industry for over 20 years.

Consistent techniques at your plant site are also an important component. If each person uses different methods, you will always have a mix of results. Spend some time to agree on a consistent approach to controller tuning.

Over- or Under- Filtering

The Problem & Its Effects

Filters can help to reduce the effects of process noise or signal noise. When appropriately sized, the filter helps to keep the process in control, without over-reacting to noise.

In a modern plant, there are many places to implement filters: from the instrument, through the I/O, in the controller software, and even in the PID block itself. Unfortunately, in many plants, there is little consistency in how filters are implemented. Implementing multiple filters for a single loop can lead to additional lags in the control response. Effectively, the controller becomes de-tuned.

An under-filtered loop may have the opposite effect. Random signal noise becomes amplified by the controller, especially if there is a large controller gain or derivative action. This leads to "induced variance" in the process, creating quality and stability problems. In Figure 2, You can see that the over-filtered response appears smooth on the surface, but takes almost twice as long to return to setpoint after an upset.

Identifying PID Loops with Filtering Problems

Compare the filter time constant to the process deadtime. The filter should be approximately 3 times smaller than the deadtime

Fixing the Problem

Step 1: Keep all filtering in one place. ExperTune recommends the DCS.

Step 2: Choose filter size based on the process dynamics.

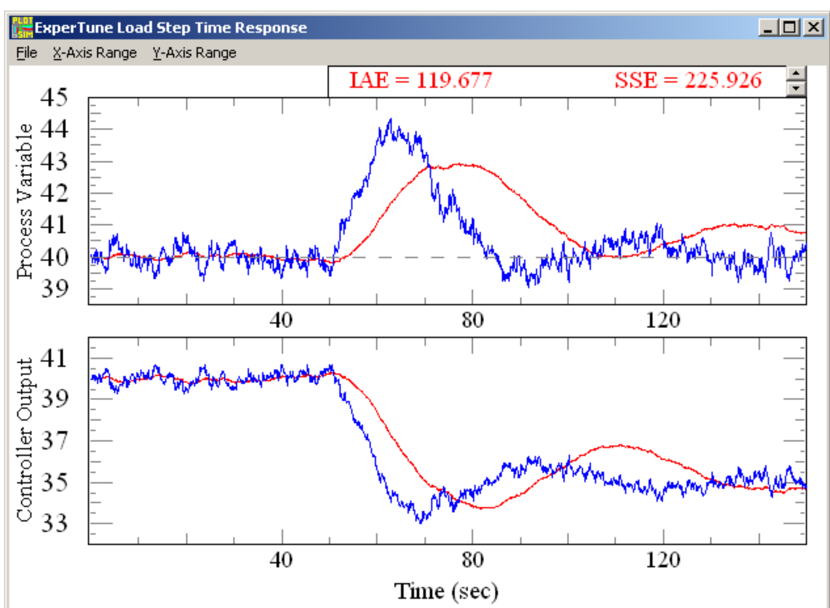
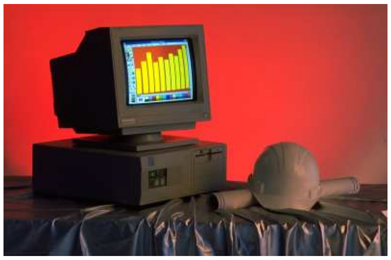


Figure 2. Effects of Over-Filtering

Improper Configuration of Control Strategy

The Problem & Its Effects



Each control loop is not working in a vacuum. Its activities must be coordinated with the process and with the other control loops around it. Cascade and Ratio control loops, for example, may rely on other loops to provide their setpoints and control modes.

When the coordination between loops is not configured properly, then the loops do not perform their design function. This can lead to process upsets, bumpy transitions, or even loss of control

Identifying PID Loops with Strategy Configuration Problems

Start by identifying the loops in each cascade pair. Check that the loop initialization works properly. While this is different in every DCS system, you can usually confirm proper actions by switching the inner (secondary) loop controller modes, and watching the response of both loops.

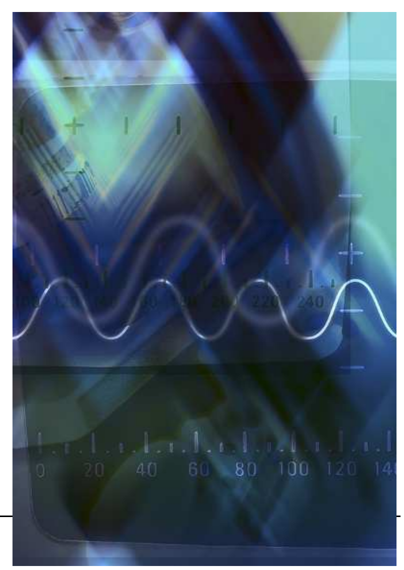
While in Cascade, the inner loop SP should follow the outer loop OP (scaled). While in Auto, the outer loop OP should follow the inner loop's SP. Make some small SP changes to confirm.

Fixing the Problem

Some DCS-specific knowledge is required to fix these problems. Work with the DCS engineer to ensure that the loop is configured properly.

Spanning and Scaling

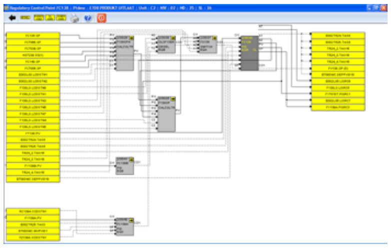
The Problem & Its Effects



The instrument span should, of course, match the DCS span. But beyond that, we find many control loops that are either under-spanned or over-spanned.

When the instrument span is too wide (over-spanned), then resolution is poor. The instrument span should be selected based upon the normal and abnormal condition expected range. For example, when controlling a distillation column at around 250 degrees F, you should NOT span the instrument from 0 to 500 degrees. A span from 200 to 300 degrees might be more appropriate.

Identifying PID Loops with Spanning & Scaling Problems



Again, keeping some simple process metrics can help tremendously. With ExperTune's PlantTriage, we monitor over 70 metrics on every control loop. To evaluate instrument span, we look at percent of time that the PV exceeded the span limits. This quickly identifies instruments that are under-spanned.

For over-spanned instruments, we can look for loops where the PV moves less than 1% of the instrument span. While this might turn up some loops that are simply well-controlled, it will also highlight some span issues.

Fixing the Problem

Fixing this issue involves re-spanning the instrument and the DCS, and updating the associated documentation. Again, change management procedures apply.

Scan-Related Issues

The Problem & Its Effects

When the controller scan time does not match the PID block's configured scan time, strange behavior ensues. This will affect the calculation of integral and derivative actions action. In some cases, even the proportional is affected. The net result is that the controller tuning will not be performing as expected.

The most likely process and business impacts are: increased variability and oscillation, leading to loss of quality and/or efficiency. It also makes the loop very difficult to troubleshoot!

Identifying PID Loops with Scanning Problems

The fastest way to spot this problem is to identify loops where the expected setpoint change results do not match what is observed. In ExperTune's PlantTriage, actual step test results are automatically compared against the expected results, and any significant controller model mismatch is identified.

Fixing the Problem

Resolving these problems take some DCS-specific design and configuration expertise. Be sure to compare the actual PID scan time against the configured PID scan time. Also, in PLC-based systems and some DCS-based systems, you will find a "timescale" parameter, which may convert between seconds and milliseconds, for example. Ensure that this is set properly.

Automate the Identification

You Don't Have Enough Time

In today's business environment, your time is at a premium. If you are managing hundreds or thousands of control loops, it is very difficult to manually evaluate each loop for these issues.

Software Can Do It

Fortunately, many of these common configuration errors can be discovered using control loop monitoring software, such as PlantTriage. This system works 24 hours a day, highlighting issues as they occur. Issues are identified, prioritized, and diagnostic information is reported. Figure 3 shows a "Biggest Payback Loops" display, which can be used to set priorities for control loop performance improvement.

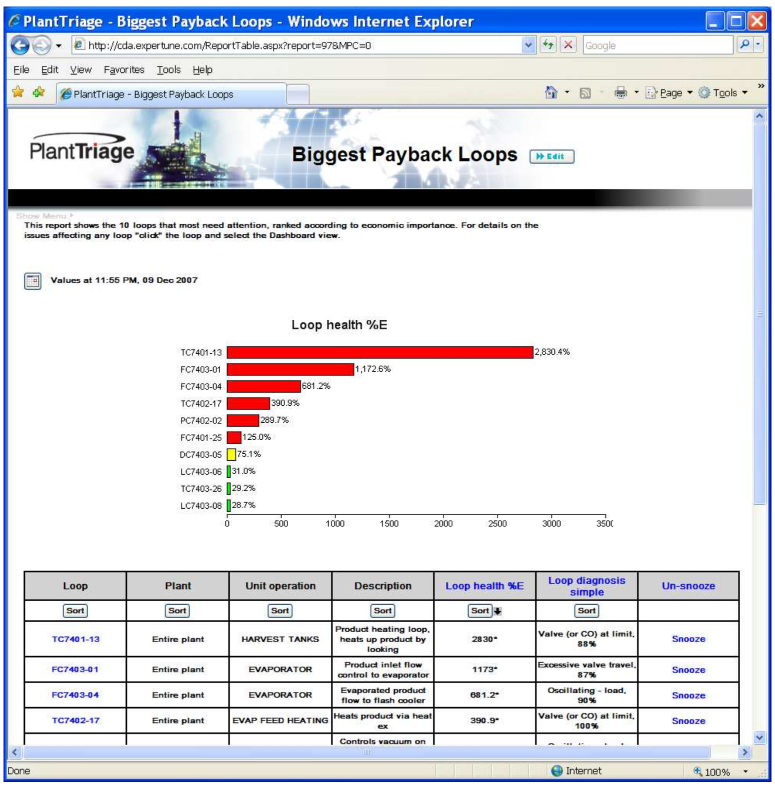


Figure 3. Biggest Payback Loops Helps to Set Priorities

Get Into the Details

After you have identified the problems, be sure that you understand the specifics of the application before applying the fix. You may want to drill down into some details of the loop behavior, as shown in Figure 4. You should also talk with process engineers and operatorsin the area, to ensure that you are fixing the right problem.

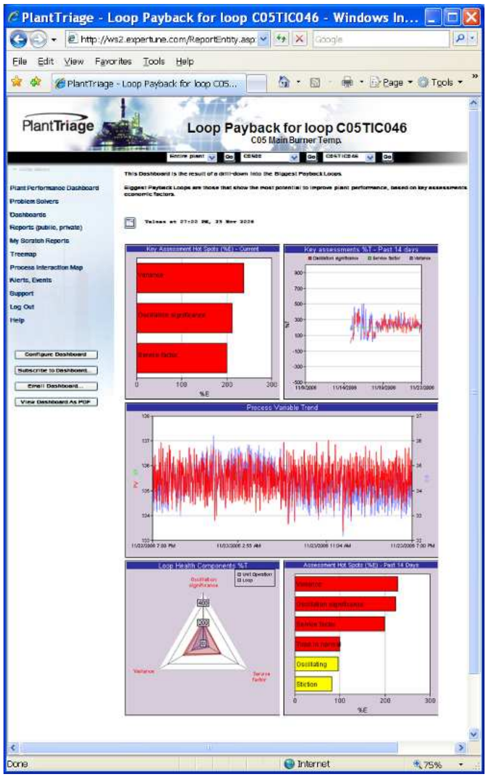


Figure 4. A Real-Time Dashboard

Results & Expectations

In over 20 years doing this work in process plants around the world, I have yet to see the perfect control system configuration. In fact, many of these common configuration errors are readily apparent, and have been overlooked.

What will <u>you</u> find? While it is impossible to guess at the specifics, in a plant of 200 control loops, it is likely that you will find at least one of each of these common errors. If you find that hard to believe, contact sales@expertune.com to arrange for an evaluationof your plant data. Simply send us a set of data from your process historian, and we'll let PlantTriage do the analysis.

Recommendations

1. Look for the 6 common configuration errors in your plant.
2. Use automated software tools to monitor for all of these common problems.
3. Always use change management procedures when resolving configuration issues.
4. Contact sales@expertune.com for an offline analysis of your plant's control system.

About ExperTune

About the Author

George Buckbee is V.P. of Marketing and Product Development at ExperTune. George has over 20 years of practical experience improving process performance in a wide array of process industries, 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 a Plant-Wide Performance Supervision System 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.

Glossary

Term	Definition
DCS	Distributed Control System. A centralized process control system that typically provides data collection, operator interface, and control functions.
I/O	Input & Output.
KPI	Key Performance Indicator. A metric that can be used to monitor overall performance.
OPC	OLE for Process Control. An industry standard communications protocol, allowing
OPCHDA	OPC Historical Data Access. An enhancement to the OPC protocol that allows data to be pulled directly from standard data historians.
ROI	Return on Investment. Measured as the amount of time needed to fully recoup an investment.