EMERSON
Process Management

PlantWeb University

Quality 101
Improving Quality Through Process Control

In this course:

Overview

There are as many definitions of quality as there are process operations. Most of them focus on how well the process delivers the desired results, especially in terms of output. But simply defining quality is a lot easier than figuring out how to improve it.

You have to identify potential sources of quality problems. And—here is the tough part—fix them before too much of your output winds up in scrap & rework.

There are different programs designed to improve quality, such as Six Sigma or Total Quality Management (TQM). These programs incorporate a wide range of tools and methodologies into an organization in order to improve performance and quality. In this course, you are going to look not at the entire organization, but on quality problems introduced by the process itself.

What is the most important source of process quality problems?

It is not raw material quality, human errors, or equipment problems—at least not directly. It is **excessive process variability** or more precisely, the difficulty in recognizing that there is too much variation. This makes it difficult for anything to be done in time before it affects output quality.

Hint

As you go through the topics in this course, watch for answers to these questions:

- What are the financial opportunities for improving my quality?
- What are the causes of variability?
- What steps can I take to reduce variability and thus improve my quality?

Costs of Poor Quality

The benefits of improving quality are enormous. Besides happier customers and fewer headaches, better production quality means more good product to sell, or even the opportunity to make higher-specification, higher-profit products.

But that is only part of the profit-improvement picture. Improving quality also brings opportunities to **reduce costs** associated with off-specification product, such as:

- Reprocessing product to meet specifications—also known as rework.
- Scrapping or flaring product that must be disposed of, leading to possible loss in profits and possible disposal costs.
- Expediting and overtime costs to meet customer deadlines.
- Making price concessions while selling off-specification products to customers. They may agree to accept a second-class product only in exchange for a reduction in price.
- Losing future orders (and profits) because of customer unhappiness with inferior products.

The cost of process variability has a double hit. In addition to the costs of poor quality, the operation also runs slower and at higher operating costs. Operators adjust to process variability by ensuring that a big enough safety cushion exists to keep them out of trouble. For example, set points might be moved further away from product specification than necessary to prevent scrap or rework. This in turn reduces the throughput of the plant.

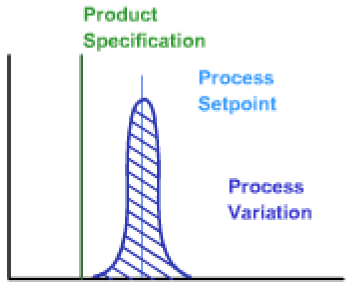
Causes of Variability

All plants have variability. It is created by the dynamic behavior of the process. Noise, friction, deadtime, process upsets, and so on are problems that can create variability. Because process variations often go unseen, **plants unavoidably accept them as normal**. But if these variations are ignored, they can build over time. Worse, they can accumulate from one unit operation to the next, propagating through the process—and into the product.

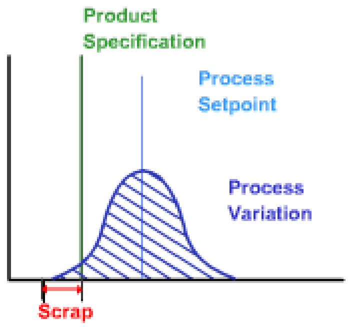
In addition to affecting the end product, process variability has another nasty characteristic: it tends to increase overtime unless active measures are taken to contain it.

How Variability Grows

The culprits behind excessive variability are often hard to detect, and they start to invade your plant the day you start it up. A plant is usually designed based on steady state. Dynamics and variability are not considered. Often, once a plant starts up, control loops are rarely looked at again.



In the beginning, if loops are tuned, variability is at a minimum, and the setpoint is close to the product specification.



Over time, equipment wear and tear increases variability.

This increase in variability can cause an increase in scrap or rework costs.

Sources of Variability

Sources that cause variability are many. For example, many control loops are started up with 'default' tuning values, such as a gain of 1.0 or a reset of 0.5 minutes. These defaults are often left unchanged after startup, leaving the loop poorly tuned, and having high variability that is not seen.

In traditional control architectures using 4-20mA, if the signal is 'live', the reading is considered good and the system will control off of it forever. Until, of course, quality starts to suffer and then a huge troubleshooting process is initiated. Without continuous validation, you do not know if that signal drifted, or is simply wrong.

The dynamic behavior that causes variability can also include control valves that stick or slip. Without proper visibility, these valves can cause large deadtime problems and therefore large variability.

Transmitters might drift or report erroneous readings. They may have been installed in a convenient place for troubleshooting, but a poor place for proper control. This can possibly add deadtime to the loop.

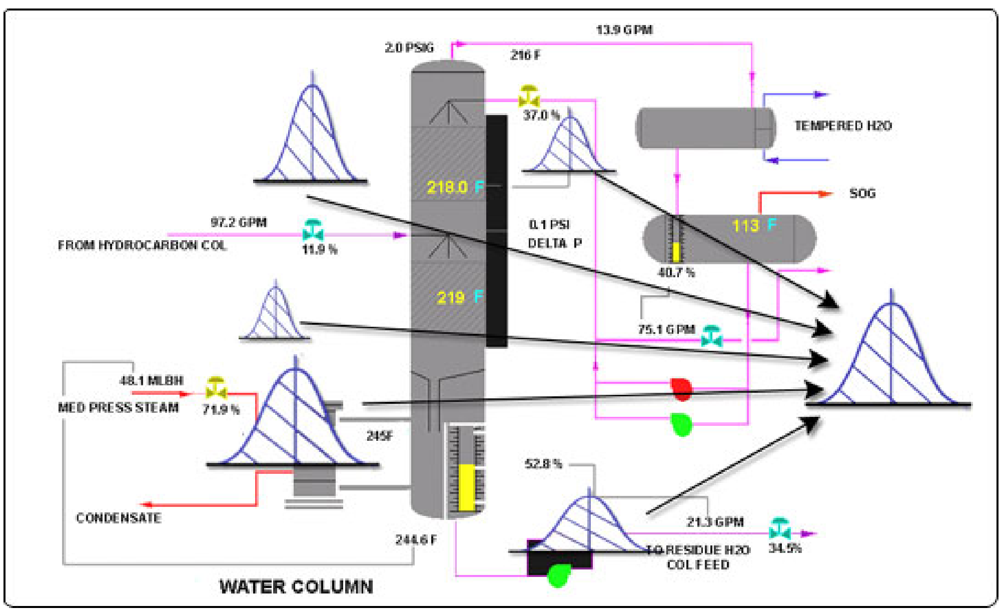
Another large source of variability is the loops themselves being put in manual. It is common for an operator to switch to manual to ‘line the signal out’. This means that the operator saw high variability, but his solution is to put it in manual.

Other common sources causing variability are when:

- Dead time is excessive in transmitter installations.
- Process agitation and mixing is inadequate.
- Air entrainment occurs in liquid flows.
- Control valves are oversized.
- Control valves have excessive backlash and/or stiction.
- Control strategies have excessive interaction.
- Control algorithms and tuning approaches are inappropriate.
- Controllers are inappropriate.
- Sampling rates are excessively slow.
- Anti-aliasing filters are lacking.
- Control loops have default tuning.
- Control strategy design and coding are faulty.
- Source of variability cannot be located.
- Tuning of many loops cannot be coordinated.
- Given disturbances cannot be tuned for.

Effects of Variability

If process variability is ignored, it can propagate through the unit operation and beyond, possibly impacting your product quality. And since it can be hidden in several loops, you may not realize the effects until it is too late.

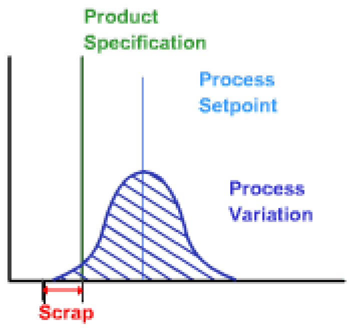


In a typical operating unit, variability can be found in many different places. Every control loop can be a source for variability.

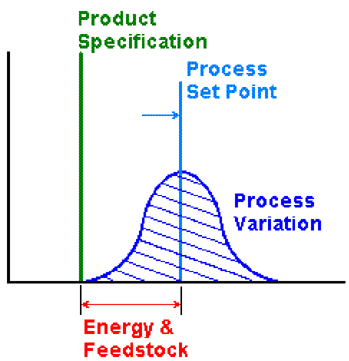
Process streams can act as conduits for variability throughout the process. This allows variability to accumulate to the end product, and possibly affect the product's quality.

Measures to Contain Variability

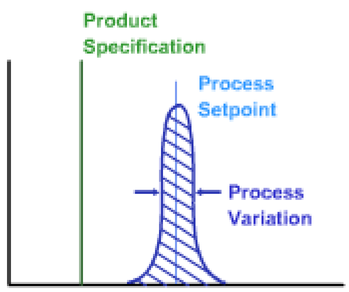
Taking active measures like adjusting setpoints or analyzing all devices and retuning the loop can contain variability.



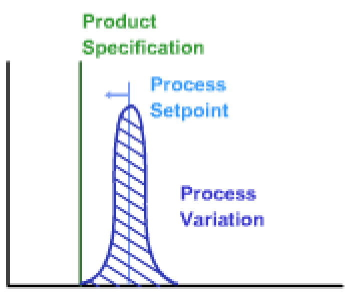
Increase in variability can cause an increase in scrap or rework costs.



One solution is to move the setpoint farther from process specification. This, however, might increase energy and feedstock costs and cause throughput and efficiency loss.



The best solution is to decrease this variation by analyzing all devices and retuning the loop.



Once the loops are tuned, the setpoints can be moved closer to the product specification once again. This will reduce possible scrap or feedstock costs, and improve throughput.

Solutions to Improve Quality

In order to build a profitable plant, it is important to reduce variability. And you cannot build a profitable plant on a poor foundation. That is why quality improvement is important. It begins with ensuring that valves, transmitters, and other equipment consistently provide the performance you need.

One of the solutions is to **start with accurate, reliable field devices**. It makes no sense to develop a control strategy using sensors and transmitters capable of 0.5% or better accuracy, and then team them with control valves offering no better than 5.0% resolution. A well-engineered valve should respond with 1% accuracy or better.

Another solution is **to maintain the accuracy you started with**. The dynamic performance of even the best valves can change over time because of wear or changing process conditions. Keeping all devices well maintained is critical.

Solutions based on traditional DCS-centered architectures can also help. But they are hampered by limited information about what is happening in the process and the equipment running it. Any analog signal between 4 and 20 mA is assumed good, and eligible for use in controlling the process.

In reality, any number of problems may exist. The signal could have drifted. The measurement itself could be wrong, such as a pressure reading that reflects a plugged impulse line instead of actual process conditions. Or a valve may not be responding accurately to its control signal.

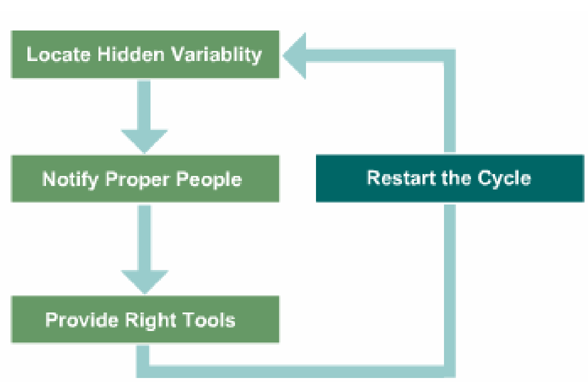
With no way to validate the information, the control system—and any advanced controls or other applications will continue to use this bad data. This will continue until the process is affected, and a quality problem or process upset suggests that the signal should be questioned. In the meanwhile, scrap and rework costs add up.

Steps to Reduce Variability

Even if your plant is perfectly tuned at startup, the laws of physics cannot go away. The dynamic behavior of a process plant will continue to create variability.

Here are the steps you can take to reduce process variability:

1. **Locate hidden variability** by checking all devices and monitoring control loops.
2. **Notify proper people** who understand the process well enough to properly tune the loops.
3. **Provide the right tools** such as diagnostic and loop-turning software.
4. **Restart the cycle** by monitoring variability – online if possible.



The PlantWeb Advantage

PlantWeb Alerts allows the user to monitor status information from the powerful software in Emerson field devices, **AMS Suite: Intelligent Device Manager**, and the **DeltaV automation system**. The user can immediately analyze this incoming information, categorize it by who should be told, and prioritize it by severity and time-criticality. Then the user will not only be able tell the recipients what is wrong but also advise what to do about it.

Emerson automation systems use a good/bad/uncertain status flag to verify that the instrument's signal is valid for use in control algorithms. If it is not, the system can then automatically modify control actions as appropriate, minimizing or eliminating any impact on product quality.

DeltaV Inspect software goes a step further by continuously monitoring entire control loops and automatically flagging any degradation in performance. It includes a Variability Index that can be used to alert operators if transmitter or valve variability exceeds user-set limits.

The **EnTech™ Toolkit** software quantifies the dynamic characteristics of a process and its control system. It aids in the diagnosis of control loop strategy and tuning problems. Additionally, instrumentation performances can be evaluated while the process is running. This software works with traditional and modern digital architectures.

Digital Technology

Digital technology can help to reduce variability. Through digital technology it is possible to access and share new types of information. This information goes far beyond the process variable signals of traditional automation architectures.

Digital technology helps reduce variability by using:

- **Intelligent Field Devices**

  Intelligent field devices—including transmitters, analyzers, and digital valve controllers—use on-board microprocessors and diagnostic software. This software monitors health and performance of these devices. It also monitors the process, and signals when there is a problem or when maintenance is needed. Digital valve controllers with predictive intelligence can help maintain the original performance by detecting deterioration before it causes variability problems.

- **Communication Standards**

  Communication standards like HART, FOUNDATION fieldbus, and OPC instantly deliver the digital information throughout the architecture for analysis and action. This allows you to quickly reduce the variability discovered.

- **Integrated Software**

  Integrated software can take advantage of the predictive intelligence of digital field devices by sending the information to the proper people, and providing the tools needed to correct the problems found, before they affect quality. On-line monitoring software that looks for variability in control loops will help in maintaining and improving your current quality.

The PlantWeb Advantage

In PlantWeb architecture, intelligent field devices—including transmitters, analyzers, and digital valve controllers—use on-board microprocessors and diagnostic software to monitor their own health and performance, as well as the process, and signal when there is a problem or maintenance is needed.

Besides supporting popular protocols from 4-20mA and High-Speed Ethernet to AS-i, DeviceNet, Profibus DP, and Modbus, **PlantWeb is the only architecture to provide a single, integrated environment that delivers the full capabilities of HART, FOUNDATION fieldbus, and OPC**.

To make problem detection even easier, **PlantWeb integrates many types of equipment information in a single browser-based Asset Portal** that is accessible by anyone who needs it—including technicians in the maintenance shop, operators in the control room, or other personnel and applications throughout the plant and business.

Loop Tuning

Loop tuning is an important part of the quality improvement process. Loops can be tuned by using trial and error techniques or by using tuning software tools.

- **Trial and Error**

  Most engineers and technicians tune process control loops using trial and error, observing the response to setpoint changes. Achieving good setpoint response takes a skilled intuitive understanding of the shape and speed of response. Only experienced people are able to achieve good setpoint response this way.

- **Using Tuning Software Tools**

  Using tuning software tools to analyze a loop will give the engineer or technician helpful hints about the process, including equipment performance and interactions with other loops. Software tools also let you select appropriate tuning parameters for the control objective, rather than default values. The tuning method should identify process dynamics and actuator nonlinearities. We recommend Lambda tuning, which is considered to be the most suitable for uniform manufacturing in continuous processes.

  If you have FOUNDATION fieldbus devices, make sure your tuning software can analyze them as well. Many programs only work with 4-20mA loops.

The PlantWeb Advantage

DeltaV Tune is fully integrated into your **DeltaV system**. It determines quickly and automatically the optimal tuning parameters for *PID and Fuzzy Logic control loops*. Based on a patented, field-proven algorithm for calculating control loop parameters, DeltaV Tune minimizes the time required to establish stable, responsive control loops including FOUNDATION fieldbus loops.

OvationTune is a system-wide adaptive tuning package for the Ovation system that quickly and automatically determines optimal tuning parameters for PID and PID feedforward control loops. The user can select whether tuning advice is provided or tuning adjustments occur automatically. The optimized tuning parameters can be archived and documented for future analysis and comparisons.

EnTech Toolkit's Tuner module interfaces with digital architectures via OPC to provide expert tuning of inter-related control loops via a systematic Lambda tuning strategy. Eleven dynamic models are supported.

Getting it Right the First Time

Many variability problems start with the original automation design and implementation. During implementation, valves and transmitters for the same loop may be selected independently, without considering how they will work together. Instruments may be installed in locations that make maintenance easier but increase control deadtime. If startup crews discover that a loop is not working, they may try to tune it quickly "by feel" before moving on to the next one.

The result: control that is ripe for high process variability.

You can reduce this risk by separating a project's automation design, equipment selection, and implementation from the civil works. Then assign them to a single automation contractor.

By doing this, you will get:

- Seamless integration
- Single point of responsibility
- Faster, smoother startup

The PlantWeb Advantage

Engineering services from Emerson's Process Solutions division provide a resource for our customers to raise the performance of the plant to the highest possible levels. In conjunction with our Local Business Partners (LBP), we offer very experienced field service personnel specialized in process variability studies, control system optimization, loop monitoring, and troubleshooting. Our senior consultants can help you plan, design, and implement control improvement and advanced control projects. In addition, they can also help you plan and execute a program to migrate to a modern digital architecture.

[End of course]