Improving quality

with PlantWeb® digital plant architecture

The major source of quality problems in plants, mills, and refineries is process variability. PlantWeb digital plant architecture's predictive intelligence helps you detect and correct potential problems before they can increase variability. As a result, you can keep instruments and other equipment performing at their best, improve control, and sustain the resulting gains – so you can reduce variability and shift setpoints for higher-quality output.

The challenge: Reduce process variability *before* it affects quality

Although there are almost as many definitions of quality as there are process operations, most focus on how well the process delivers the desired results – especially in terms of output. For example, one definition of quality is the percentage of "on-spec" output from the first pass through the production sequence:

$$\% \text{ quality} = \frac{\text{product produced} - (\text{product lost \& rework})}{\text{product produced}}$$

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's the tough part – be able to fix them before too much of your output winds up in the "product lost & rework" part of the equation.

What's the most important source of quality problems? It's not raw-material quality, human errors, or equipment problems … at least not directly. It's **excessive process variability**. Or more precisely, it's the difficulty in recognizing that there's too much variation -- in time to do anything about it before it affects output quality.

Problems often unseen

The culprits behind excessive variability are often hard to detect. You may have control valves that stick or slip. Transmitters that drift or report erroneous readings. Improperly installed instruments. Poorly tuned loops. Inferior control strategies. The list goes on.

Who hasn't seen an operator put a control loop in Manual to line it out? That's proof that control loops on Auto don't always do what they're supposed to do. In fact, variability audits by Emerson Process Management show that 80% of control loops are underperforming.

Because process variations often go unseen, plants unavoidably accept them as normal. But if those 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.

What if you could detect or even predict the causes of this variability – and correct them -- *before* product quality is affected?

Opportunities for better output, lower costs

The benefits of improving quality are enormous. Besides happier customers and fewer headaches, a higher quality percent means **higher output** of good product to sell – or even the opportunity to make higher-spec, higher-profit products.

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

- Reprocessing product to meet specs
- Scrapping or flaring product that must be disposed of
- Overtime and expediting costs to meet customer deadlines

Reducing process variability can also reduce wear on valves and other equipment, for lower maintenance and replacement costs.

How big are the savings? Results will be different for each plant, but a large study by Monsanto in collaboration with a dozen other chemical companies offers a hint.

Reducing variability by moving to best practices in the first three control categories opens the door for additional benefits in the other six.

	Category	Potential savings (% COGS)
1	Final control device performance and basic loop tuning	1.5
2	Unit operations control	0.8
3	Advanced regulatory control	1.0
4	Production management control	0.3
5	Advanced multivariable control	0.4
6	Global online optimization	0.5
7	Advanced advisory systems	1.3
8	Process data access	1.3
9	Manufacturing data integration	0.5

The study projected that bringing process control up to best practices in nine areas, from basic through advanced control, could cut manufacturing costs by more than 7% of the cost of goods sold (COGS). Each of the nine areas must be addressed in sequence, building on the results of the one before.

What's most significant for quality-related savings is that the first three areas – final control device performance and loop tuning, unit operation control, and advanced regulatory control – are directly related to process variability. Together, they offer a projected savings of **3.3%.**

Needed: Better insight into what's happening -- before it's too late

You may have already taken steps to improve quality, from upgrading valves and measurement instruments to adding advanced controls and optimization systems. So what do you do when customers or management demand even higher quality and lower costs?

Solutions based on traditional DCS-centered architectures can help, but they're hampered by limited information about what's happening in the process and the equipment running it. The control system doesn't know much more than the process variable and any associated alarms or trends. Any analog signal between 4 and 20 mA is assumed good, and eligible for use in controlling the process.

That's not always a safe assumption, especially when your product quality depends on it. 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. Even the best-designed processes are affected over time, as equipment wears and conditions change.

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

What's needed is a way to detect conditions like these and get the information to the people and systems that need it, so they can take corrective action *before* product quality is affected.

The answer: Predictive intelligence

With its PlantWeb digital plant architecture, Emerson Process Management offers technology and services that enable you to see what's happening in your process and equipment, identify conditions that cause variability, access the information wherever it's needed, and take action to maintain or improve quality … before it's too late. We call this *predictive intelligence*.

New insights, better results

Digital technology makes it possible to access and share new types of information that go far beyond the PV signals of traditional automation architectures.

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's a problem or maintenance is needed.

PlantWeb then uses communication standards like HART, FOUNDATION fieldbus, and OPC to instantly deliver the digital information throughout the architecture for analysis and action.

For example, AMS™ Suite: Machinery Health Manager software provides diagnostic and analytical information for faster, easier troubleshooting and maintenance of mechanical equipment such as motors and pumps. AMS Suite: Intelligent Device Manager provides similar functions for field devices like valves, transmitters, and analyzers, and AMS Suite: Equipment Performance Monitor for process equipment like boilers, compressors, and heat exchangers. Information from all three is available to technicians in the maintenance shop, operators in the control room, or other personnel and applications throughout the plant and business.

The DeltaV™ and Ovation® automation systems use this digital intelligence about equipment condition (as well as process variables) for regulatory and advanced control. As a result, you can be confident control actions are based on an accurate picture of what's happening -- and never control off bad data. The system also notifies operators, maintenance personnel, and others as appropriate when human intervention is required to correct problems before quality is affected.

In addition, Emerson offers a full range of services -- from variability audits and project engineering through ongoing equipment monitoring, optimization, and maintenance -- to help you take full advantage of

What makes PlantWeb different from other automation architectures?

- It's engineered to efficiently gather and manage the wealth of information available from today's intelligent field devices, including process and equipment diagnostics.
- It provides not only process control, but also asset optimization and integration with other plant and business systems.
- It's networked, not centralized, for greater reliability and scalability.
- It uses standards at every level of the architecture -- including taking full advantage of Foundation fieldbus.
- It's the only digital plant architecture with proven success in thousands of projects.

For more about the architecture and what it can do for you, visit **www.PlantWeb.com.**

PlantWeb's capabilities and sustain improvements over the life of your plant.

In short, PlantWeb architecture's predictive intelligence reaches into the field, validates and predicts the performance of plant assets, and integrates the information into the architecture to

- Maintain and improve equipment performance
- Enable better control
- Maximize these advantages over the life of your plant.

Let's take a closer look at each of these three ways PlantWeb helps reduce variability and improve product quality.

Keeping equipment performing at its best

You can't build a profitable plant on a poor foundation. That's why quality improvement begins with ensuring that valves, transmitters, and other equipment consistently provide the performance you need.

Part of the solution 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% accuracy. A well-engineered valve should respond with 1% accuracy or better. The best control valves – like those available from Emerson as part of the PlantWeb architecture – provide this kind of precision to help you minimize variability.

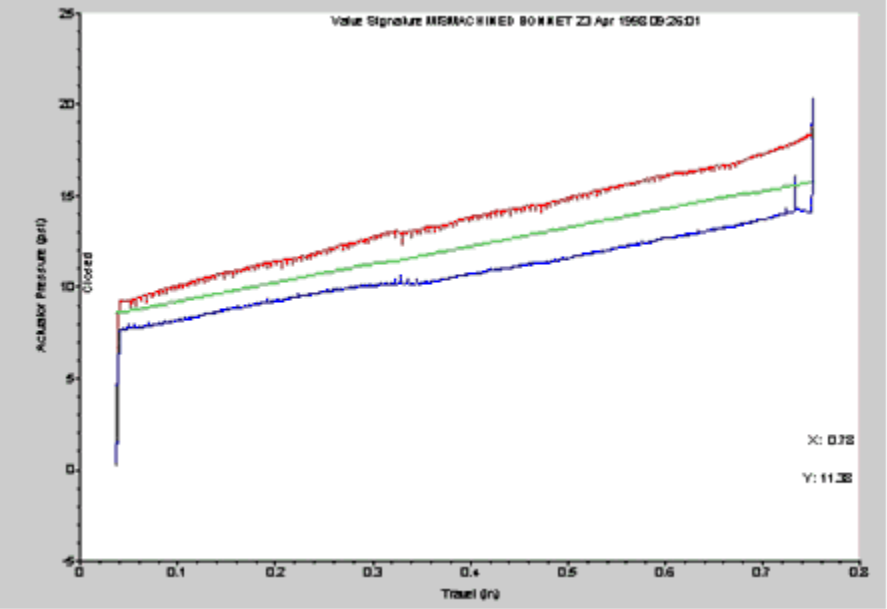
The other part of the solution is to keep getting the accuracy you started with. The dynamic performance of even the best valves can change over time because of wear or changing process conditions. But the predictive intelligence embedded in PlantWeb's digital valve controllers helps maintain the original performance by detecting deterioration before it causes problems.

For example, the ValveLink technology in AMS Device Manager can detect a wear-induced condition called *stiction*. Stiction causes a valve to stick in one position until an inordinately large actuator force is applied. Then the valve suddenly moves as much as several percent of travel at once. As a result, the valve spends much of its time in the wrong position, which obviously increases process variability and quality problems.

The valve signature diagnostic reveals stiction as a series of abrupt movements (rather than a smooth curve) as actuator force changes. With this information, you can detect which valves may be affecting variability

and, for those that are, schedule service before the problem grows large enough to impact quality.

Valve signature diagnostics reveal conditions that – left undetected -- can increase process variability.



In the past, detecting stiction required taking the valve off-line to perform a "bump test." With ValveLink technology, you can check for changes in signature while the valve is still in service, making it much easier to detect problems before they affect product quality.

For measurement and analytical instruments, the same principles apply: Start with accurate, reliable devices, then use predictive intelligence to maintain their performance.

PlantWeb makes this easy. Many of our transmitters offer 5-year "set and forget" stability, as well as fast dynamic response that enables more aggressive loop tuning for tighter process control. Add embedded diagnostics, and you've got the formula for keeping a tight rein on variability.

For example, analytical measurements such as pH can be essential to product quality -- but establishing and maintaining a stable measurement can be difficult, especially in applications that are rough on sensors. That's where capabilities like **sensor fouling detection** make a big difference. This diagnostic in our analytical devices detects fouling that can lead to inaccurate measurements and off-spec product – then helps you avoid those problems by triggering maintenance requests or even automatically initiating cleaning of the sensor.

Other examples include a **high process noise** diagnostic for magnetic flowmeters, and **adaptive digital signal processing** that tracks the signal from vortex flowmeters and makes adjustments to reflect process conditions, so setpoints aren't subject to analog drift.

PlantWeb diagnostics can alert you to potential problems not only with field devices, but also with other process equipment.

For instance, **statistical process monitoring** can identify a wide variety of problems – from leaks in pipes to fouling in heat exchangers, filters, and similar equipment.

The advanced diagnostic capability in Emerson's FOUNDATION fieldbus devices allows up to four control or process variables to be monitored for changes in mean and standard deviation. Statistical process monitoring analyzes how these four user-selectable factors change in relation to each other to detect equipment problems.

As heat exchangers and filters foul and clog, for example, the diagnostics can detect a mean change in the differential pressure across the unit without a corresponding change in the setpoint or flow rate – and alert the operator or maintenance shop so the problem can be fixed before it affects output quality.

Enabling better control

PlantWeb also helps you maintain tight, accurate process control that reduces variability and can even enable setpoint shifting for higher-quality output.

Good control demands good data. That means you need to know immediately if the data you're using is bad or suspect – a capability that's built into PlantWeb architecture.

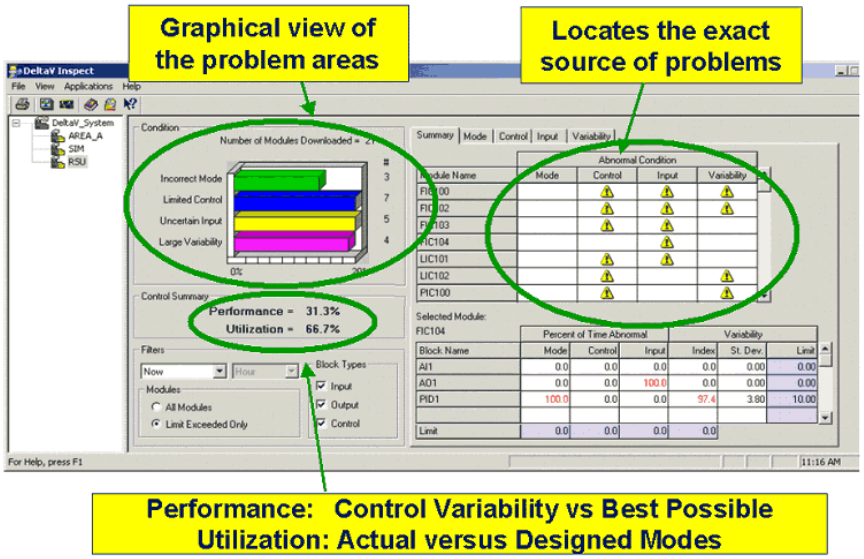
Every FOUNDATION fieldbus instrument from Emerson is designed to check for problems and label the data it sends as good, bad, or uncertain. A **bad** status signal could indicate a device failure, such as a failed sensor. An **uncertain** status means the quality of the data is unknown. For example, a pressure transmitter reading that's 110% of the device's upper limit may be accurate – or it may be inaccurate because the device has saturated high and the actual pressure is even higher.

The DeltaV automation system monitors the status information (something not every control system can do) and notifies the right persons -- operators, maintenance technicians, or others -- if there's a problem. This capability, called PlantWeb Alerts, relies on powerful software in Emerson

field devices, AMS Suite, and DeltaV to immediately analyze the incoming information, categorize it by who should be told, prioritize it by severity and time-criticality, and then not only tell the recipients what's wrong but also advise what to do about it.

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

DeltaV **Inspect** software goes a step farther 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.



DeltaV Inspect software monitors equipment and loop performance to identify potential problems.

OvationTune software also smoothes out variability by monitoring and adaptively tuning loops for optimal performance – not just at startup, but also during ongoing operations.

Once lower-level loops are operating optimally, PlantWeb can help reduce variability even more through **advanced control**. Unlike advanced-control applications that are simply layered onto a traditional DCS-based architecture, these functions are integrated so they have access to the same validated process and equipment data that's available to the rest of the architecture.

For example, the multivariable Model Predictive Control technology in **DeltaV Predict** software uses powerful but easy-to-use function blocks to deal with excessive dead time, long time constants, and loop-to-loop interactions.

Because the technology is embedded in the DeltaV controller rather than a networked workstation, it runs at the controller cycle time – typically 1-2 seconds– rather than the longer cycles common in other MPC systems. And the faster the update, the more variability can be smoothed out. In fact, DeltaV Predict may make it possible to boost product quality by moving setpoints closer to optimum without violating operating or safety constraints. Embedding DeltaV Predict in the controller also makes redundancy easier than with networked MPC controllers.

For Ovation systems, the **Unit Calibration Advisor** continuously monitors complex, feed-forward control schemes and provides revised models to improve process response – further reducing variability.

Maximizing the advantages – and sustaining the gain

Reducing process variability also reduces workloads, because there are fewer problems to deal with. But today's short-staffed plants can have trouble finding the resources needed to make improvements, especially when adopting unfamiliar technologies or work practices.

With PlantWeb, that doesn't have to be a problem. Emerson offers a wide range of services based on our know-how and experience helping customers make the most of the architecture's quality-improvement capabilities.

Get it right. Many variability problems start with the original automation design and implementation. Valves and transmitters for the same loop may be selected independently, without considering how they'll work together. Instruments may be installed in locations that make maintenance easier but increase control deadtime. If startup crews discover a loop isn't working, they may try to tune it quickly "by feel" before moving on to the next one. The result: control that's 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 and assigning them to a single automation contractor. You'll get seamless integration, a single point of responsibility, and a faster, smoother startup.

With Emerson's project specialists, you'll also get the benefit of tools and expertise we've developed in implementing FOUNDATION fieldbus and other PlantWeb technologies in similar applications. Our training services

can help your own engineering, operations, and maintenance personnel shorten the learning curve so they make the most of the new automation, too.

Keep it going. Even when it's easy to detect potential problems, somebody still has to fix them before quality is affected. Maintenance staffs hit hard by downsizing and retirements may have only enough manpower to deal with critical issues -- while myriads of smaller quality-robbing problems pile up.

While PlantWeb helps ease the workload with features like remote diagnostics and automatic documentation of instrument maintenance, Emerson also offers a full range of repair and maintenance services. Depending on your needs, we can monitor equipment health (remotely or on-site), supplement your staff during shutdowns and other peak labor periods, or assume complete responsibility for equipment maintenance and performance.

Make it better. Once new controls have delivered expected improvements, there's a tendency to stop measuring and optimizing results – especially when control and instrumentation departments barely have time to keep the process running.

But as we pointed out earlier, things change. Poor control-system tuning or changing field conditions may prevent transmitters and valve actuators from working as designed. Key input and output variables the controls were optimized for may not be the ones that make the most difference today.

It's therefore important to continuously collect and analyze as much data as possible to determine which factors are affecting variability, which data has become corrupted, and which devices are acting badly. While advanced controls can all but eliminate this need in some plants, others will continue to need assistance.

If you don't have the time or staff to do this yourself, we can help. Emerson engineers with loop-tuning and variability-reduction tools and experience can help you dig in, find problems, and put your process back on course for better product quality.

Real projects, real results

Quality improvement is a key reason users have chosen PlantWeb architecture for thousands of automation projects. Day in and day out, it's helping reduce process variability and improve results in plants, mills, refineries, and other operations around the world.

One example is **Canandaigua Wine Company**'s winery in Madera, California, where PlantWeb architecture helped bring a distillation unit's output up to quality specifications.

Canandaigua had considered tearing down and rebuilding the 37-year-old still. The neutral alcohol spirits it produced were so inconsistent in taste that they had to be trucked to another winery for re-distillation. But inspections showed that the distillation equipment was still basically sound. Instead, all the evidence indicated that aging, unreliable controls were at the root of the problem.

To replace the older controls, the project team chose PlantWeb architecture with FOUNDATION fieldbus. "Fieldbus was selected as the primary communications protocol to minimize wiring, assure the highest speed and the least drift, and enable diagnostics and calibration from the workstations," reported Robert Calvin, Canandaigua's West Coast director of engineering.

The PlantWeb installation provided a new wealth of information for tighter control. For example, fieldbus instruments now monitor plate temperatures in the main column, providing new insights on the amount and distribution of alcohol and other distillates within the column. Coriolis mass flowmeters provide real-time tracking of alcohol content, which the winery previously had no way of knowing until a sample was lab-tested.

The real difference is in the unit's output quality: With the PlantWeb digital architecture in place, tests rated the neutral alcohol spirits from the improved still as the best it had ever produced – and worthy to be included in Canandaigua's highest-quality brandies and fortified wines.

That's just one example. Here's what other PlantWeb architecture users have said about its impact on variability and quality:

- "Since we installed Plantweb and FOUNDATION fieldbus in our elemental potassium plant at the Evans City facility, we are making better quality products at a lower cost. We have cut raw material usage by

approximately 20%, and have 10% greater throughput. We operate more efficiently than ever before."

- Chemical manufacturer

- "Operations have achieved a reduction in process variability due to tighter controls on the process. This has resulted in a more consistent product with respect to quality, yields, and cycle time."

- Pharmaceutical maker

For additional case histories and proofs of PlantWeb architecture's capabilities, visit **www.PlantWeb.com** and click on "Customer Proven."

Taking the next steps

You wouldn't be reading this if you didn't suspect your operation could benefit from improving output quality. So how do you get started?

Begin by using the formula at the beginning of this paper – or one appropriate for your operation -- to calculate your current quality level. Look at past quality data, too, to see if there are any trends. If you have access to data on typical or best-practices quality levels in operations like yours, you can also get an idea of what your process may be capable of.

Next, identify the opportunity. If you could improve output quality, what would you gain? Could you reduce scrap and rework costs? How much? Could you make more salable product? For how much incremental income? Could you shift production to higher-grade products? At what additional margin?

Then look for the ways your current operation introduces variability that prevents you from reaching those goals. How many loops that should be in Auto are being run in Manual instead? What caused your most recent process upset? What equipment or loop needs attention most often? When there's a dip in quality, how long does it take to find and fix the source of the problem? Emerson's variability-audit specialists can be a big help here.

Finally, work with your local Emerson Process Management team to identify the ways PlantWeb can reduce or eliminate these variability problems – and where it offers the greatest benefits.

Other resources

- Improving quality is just one of the ways PlantWeb helps improve process and plant performance. It can also help increase throughput and availability, as well as reducing cost for operations and maintenance; safety, health, and environmental compliance; energy and other utilities; and waste and rework.
  www.PlantWeb.com – click on **Operational_Benefits**

- Quality is also a major factor in Overall Equipment Effectiveness, a structured metric for process performance. Emerson Process Management's free online learning environment, PlantWeb University, offers a 5-course introduction to OEE.
  www.PlantWebUniversity.com

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