# Nuclear plant leverages the power of digital instrumentation

**Florida Power and Light Company (FPL), a utility based in Florida, was faced with a challenge. The company was facing challenges supporting its aging analog control systems in its four nuclear power plants in Florida. The systems were dated and product support and spare parts were becoming more difficult. Because of this, FPL chose to upgrade these systems to more modern designs, based upon digital architecture, that were already being used in most other industries. The nuclear industry is somewhat unique in that plant designs make what would be routine upgrades in other plants much more difficult to implement. Because of obsolescence, upgrades must be made, and plants are looking for approaches that will be consistent with plant designs and are also cost justified.**

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FPL decided to take a more proactive approach to upgrade the control systems and digital field devices. The thinking was that by harnessing the additional capability of the field devices to improve process control and to facilitate a switch to predictive maintenance, the plant would also gain efficiencies as a result of the upgrades. This article will review how FPL went about its digital instrumentation upgrade, and will offer lessons learned in terms of getting the most out of this type of investment.

## Florida Power and Light Company

FPL has a total of four nuclear units in operation in Florida, at two sites, St. Lucie and Turkey Point. Total capacity of these four units is about 3300MW. All four units have been through uprates and have received renewed licenses. An uprate is where the operator makes changes to the plant and receives approval from the NRC to increase the output. License renewals extend the time the plant may operate under its NRC operating license. Most plants were originally assigned a nominal service life of 40 years. Many US plants are coming up on 30 years of service, and utilities have reviewed the costs associated with shutting them down on schedule and their stellar operating performance to date and decided that the safe, reliable, and cost-effective operation of nuclear plants could be continued beyond the original 40-year life.

That is very good news for the industry, but does pose a challenge in that most of the plants are still operating with relatively old process control systems, from the controllers themselves to the field devices like transmitters and control valves. Nearly all of the current fleet of US nuclear plants have obtained or are pursuing 20-year license renewals, which means that the typical plant will operate at least another 20 years beyond the original license term. Continued plant operation will pose challenges with existing process control infrastructure, as support and spare parts will become very difficult to get. There is also the fact that more modern technology can enable much tighter process control, and facilitates a transition to a predictive maintenance approach, both of which will result in safer and more reliable plant operation.

With that as a backdrop, FPL decided several years ago to begin the upgrade process by changing out its process control systems from analog to modern

*Turkey Point Nuclear Power Station*

*St. Lucie Nuclear Power Station, Florida, USA*

digital systems. These types of changes are being considered at most nuclear utilities in the United States that have filed for or obtained renewed licenses. However, many utilities' plans stop with an upgrade to the control system. FPL added field devices, primarily valve positioners, to the scope of the plan. This was mostly driven by concerns with reliability of the existing field devices, but the project team also thought that they could improve the operating performance of the plant by making these changes. In particular, it was sometimes difficult to maintain steam generator levels during startups shutdowns, and transients, which could lead to an unplanned shutdown. An unplanned shutdown (trip) of a nuclear unit is very undesirable. FPL hoped to get the system to operate the way it had been designed to by upgrading to a digital approach across the board.

## Implementation

The very first system where digital positions were upgraded was the Chemical and Volume control system at the two Turkey Point units from 2002 to 2004. This went well, but did not include an upgrade to the control system, only the positioners on the control valves. The first comprehensive upgrade to include all process control elements was the feedwater system. A simplified schematic is shown in Figure 1 that highlights the valves in this system that were destined to receive new digital valve positioners. They included the feedwater regulation valve, the feedwater bypass valve, the dumps to atmosphere, and the dumps to condenser.

At the current time the four units are in varying states of upgrade with respect to the feedwater system, but the two St. Lucie units have been essentially completed with changes to the field devices and new digital control systems. The balance of this article will focus on those two units since they illustrate a comprehensive approach.

As mentioned, this program included a transition to a modern digital control system coupled to digital valve positioners on all key valves in the feedwater system. Before installation, the plant engineers did their homework. They worked hard to make sure they selected the right device and then worked very closely with the vendor to understand all the ins and outs of setup and calibration. Personnel practiced on mockups to cut down on surprises in the field. They also arranged to have the local vendor and factory support on call in case they ran into any unanticipated problems.

## What happened?

Overall implementation went smoothly. Set up and calibration went very well. That is one of the key advantages of digital systems. With two-way communications from the system to the devices on the valves, the devices can identify themselves to the system, and automatically download setup and operating characteristics. This is particularly important to the nuclear industry because time spent in the field comes at a premium, so anything that can cut down on man-hours in the field is a big benefit. Experience to date has

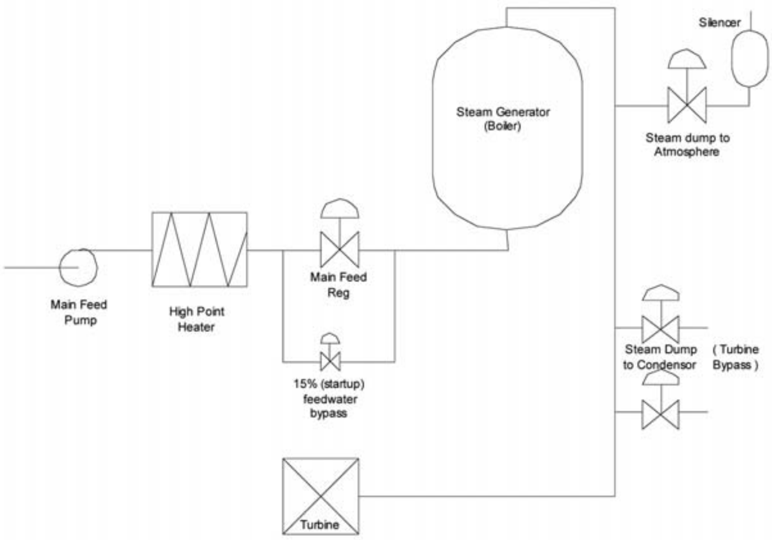



Figure 1: Simplified process schematic showing valves that were upgraded

shown that use of digital devices can cut set-up and calibration time by 40-60%. The plant also discovered that the digital positioners could more quickly port air and could be digitally tuned to optimize valve performance and response times. This resulted in the plant being able to remove many of the additional pneumatic accessories like volume boosters and quick release valves that were originally installed to speed the stroking time to meet system requirements. Eliminating these peripherals simplified the schematics, further reducing setup time, and potentially eliminating several points of failure on the valves, increasing overall system reliability.

One problem arose in the area of tuning sets on the controller and digital positioners. The old controller tuning sets were determined taking into account the performance of the old analog positioners. When the new systems were implemented there was no way to predetermine how the controller and positioner would work together. The new positioner, with its higher flow rates and customized performance settings, can be set up to provide very good control performance at the valve. It is much faster and more accurate than what it is replacing. However, if one does not take this improved performance into account when setting up the controller, one can end up with instability because the new combination is too "hot".

There are two potential ways to address this. One is to de-tune the new positioner to make it look like the old one. This helps assure stability, but ends up bypassing many of the benefits of improved positioner performance.

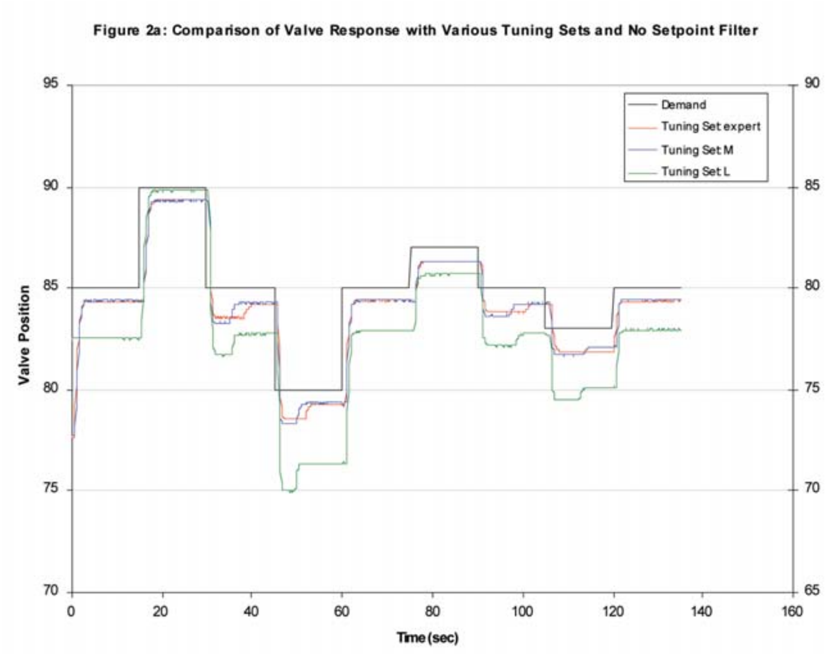
A better approach is to take full advantage of the improved performance of the positioner to get the valve positioned quickly and accurately to get good process control, and then set the tuning parameters on the controller to take advantage of this performance without creating instabilities. Many nuclear plants struggle with this approach because of a lack of experience tuning an active loop. However, it is time well spent and will pay dividends over the life of the plant because the valve works in concert with the loop and keeps the process variable right on setpoint which means a smoother more efficient process. A smoother process means fewer service excursions for the mechanical components, which translates into lower maintenance costs and longer life.

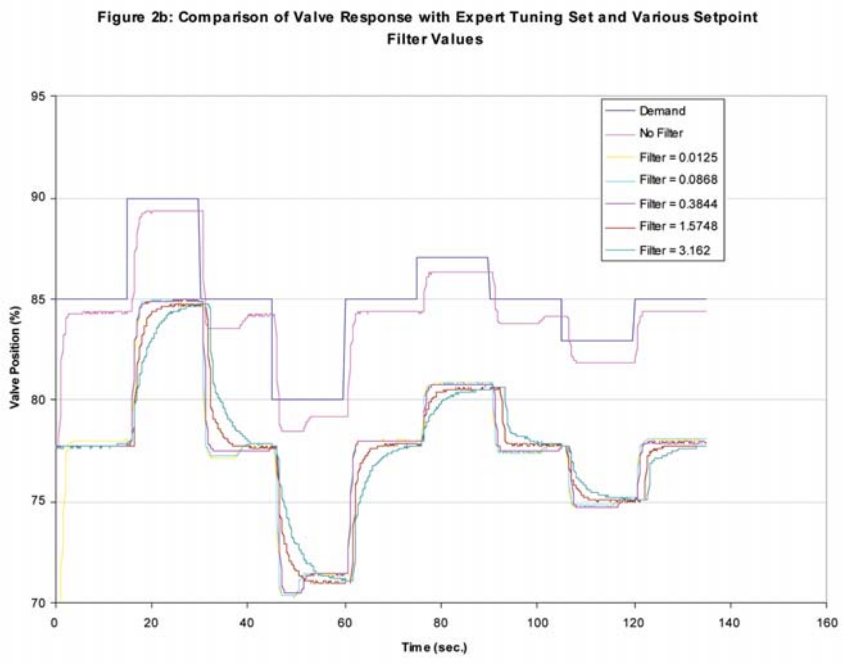
As the industry gains more experience with tuning, it will be able to get it done faster and with less risk to the process, and simulation programs can also be used to get one very close to the right settings right out of the box.

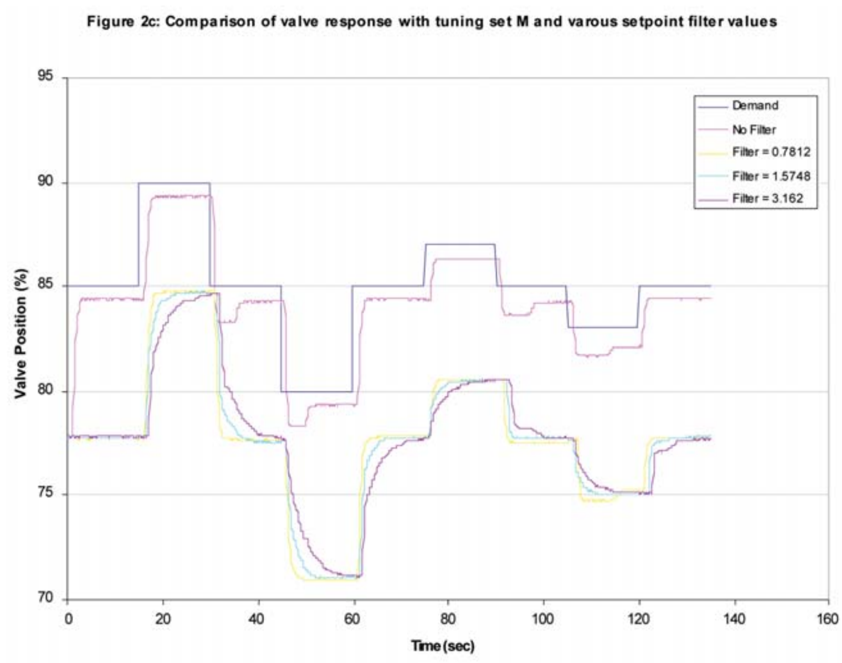
To its credit, FPL took the right approach and did not de-tune the valve. Plant personnel worked through a number of different tuning settings, as shown in Figures 2 a, b and c, until they settled on the one that provided good, stable, but rapid response that met the criteria for the system. Employees have also started to do more formal loop tuning with more modern tuning methods on some of their older analog systems as well, reaping the benefit of more stable operation.

It should be pointed out that the upgrades

*Feedwater regulation valve with panel mounted instrumentation*






did result in a few problems cropping up that needed to be addressed. A bias spring on the new positioner turned out to be susceptible to corrosion in the salt air, as the plant is located near the ocean and the valve is located outside. A switch to a different material was done to correct this problem. The plant has also seen some damage to the feedback mechanism due to valve vibration levels and high temperatures present in feedwater service. A new more robust design for the feedback pot and the linkage is being implemented to address these problems, as well.

## Results

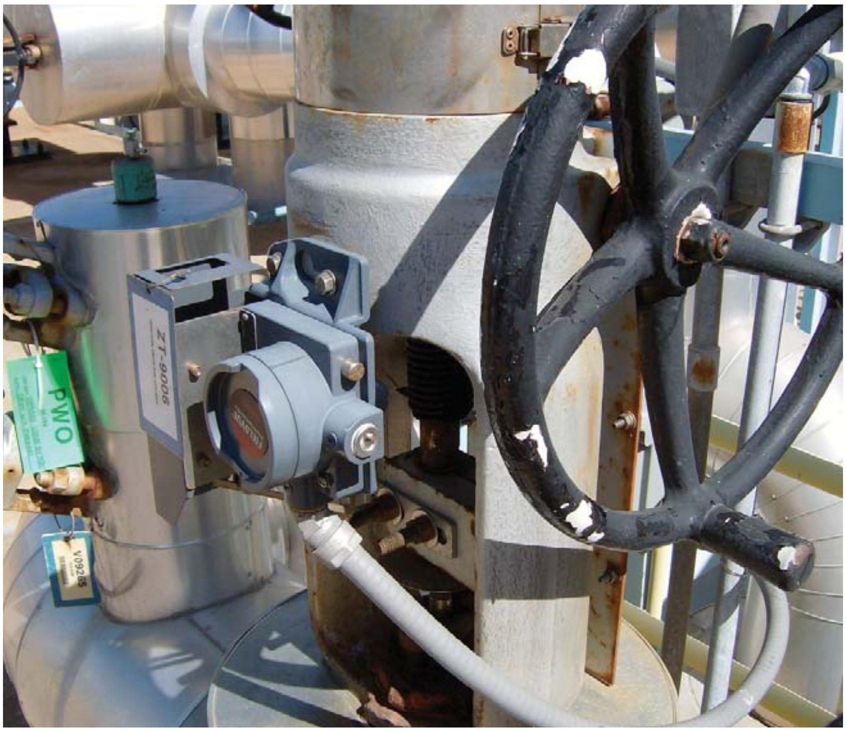
Summarizing the process control results for each valve in the Feedwater system:

- Steam dumps to atmosphere: the improved control impressed operations. The plant was able to eliminate the quick exhausts
- Feedwater bypass (15% valves): process performance is not as critical on these valves; they performed well before and will continue to do so. The replacement was a natural evolution. The plant was able to eliminate the boosters
- Main feed regulation valves: the improved control helped reduce large level swings during startup, shutdowns, and transients. This was a big advantage for the plant in that it eliminated the "babysitting" of the system during these periods and put much less stress on the mechanical components. The system operates with more stable level control in all operational evolutions with the combined digital process controls and digital positioners.
- Steam dumps to condenser: After the modifications, the plant was able to run in automatic control mode. That gave operators very good confidence and allowed them to devote their time to other important functions during startup.

Overall the plant showed improvements in the following general categories:

- The quality of the process control improved. This will positively impact the ability of the plant to operate closer to normal limits, which will

*Feedwater bypass valve with remote mounted feedback sensor*




*Close up of the remote mounted position feedback sensor*

increase output, and will also put less stress on mechanical components, greatly reducing the amount of maintenance.

- The schematics for the valve were simplified, also reducing the setup time required, and will cut down on maintenance due to increased reliability.
- The devices themselves are more reliable, further reducing maintenance.
- Set up and commissioning time was much less on all field devices, cutting down on time spent in the field.
- While the plant has not yet taken advantage of the technology, smart devices permit one to determine the operating condition of the valve while on line, which translates into taking a predictive approach to maintenance and is much more productive than preventive or run to failure.

All of these changes will help contribute to safe, reliable, and cost-effective plant performance.

## Conclusion

Overall, the project was judged to be very successful as evidenced by the changes noted above. Long-term, FPL plans to continue to transition key systems to digital at all of its operating units. In summary, key takeaways and lessons learned included:

- Improved process control will reduce maintenance in the long run by reducing stress on mechanical components.
- To get the full benefit out of a digital upgrade, one should include the field devices along with the process control system.
- Tuning of control systems and field devices must be done in concert to make them work together smoothly.
- Simplified schematics and digital two-way communication greatly reduced the amount of time to set up and commission the loops involved.
- It is absolutely critical that the industry change its work practices to take advantage of the predictive maintenance that digital field devices offer. There is no industry that could better benefit from condition-based predictive diagnostics that come with a digital architecture, but those benefits only accrue if the technology is leveraged by the end-user.


## About the authors

**Bill Fitzgerald** is a Graduate of Iowa State University where he earned a Bachelor's in Mechanical Engineering and Master's in Engineering Mechanics. He has worked with the Fisher group of products, within Emerson Process Management, for the past 30 years, most of which has been spent working in the Power Industry. He earned an Executive MBA degree from SMU in Dallas in the spring of 1998 and is currently the General Manager of the Nuclear Business Unit. He has written many articles and made countless presentations on control valves and control valve maintenance, and in 1994 he completed his first book entitled "Control Valves for the Chemical Process Industries". He holds a number of patents, one of which is for the Flowscanner device, which permits remote diagnostics to be carried out on control valves. He currently makes his home in Marshalltown, Iowa.

**Inman Lanier** is a graduate of the Georgia Institute of Technology where he earned a Bachelor's in Mechanical Engineering. He has been employed by Florida Power and Light since 1978 in a variety of positions, and currently holds the position of Component Specialist in the engineering department. He specializes in valve work and supports the Florida P&L fleet around the country in that capacity. He also serves on the steering committee for the Air-operated Valve User's Group. He currently resides in the West Palm Beach area in Florida.