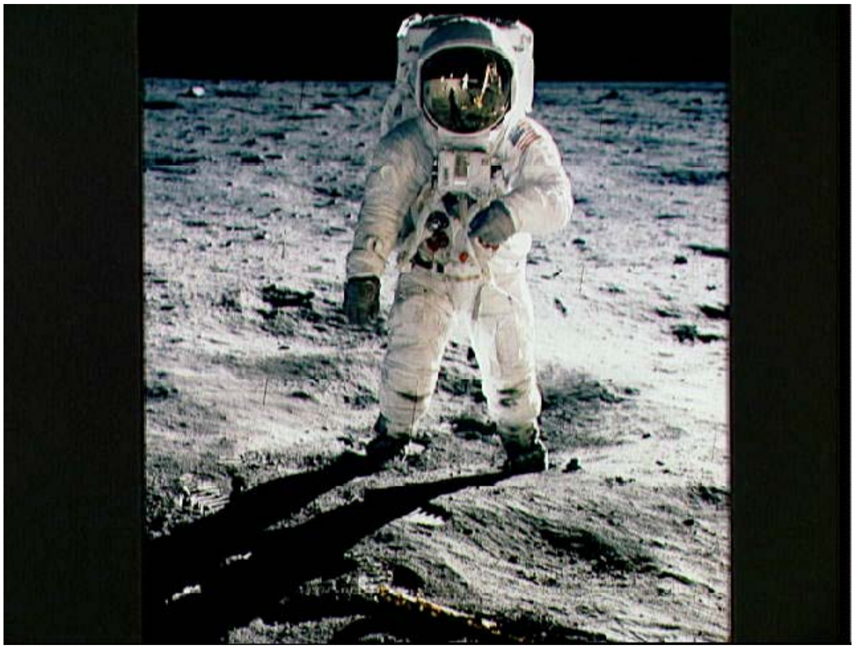

Upgrading to Digital Positioners on Feedwater Regulating Valves

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Abstract:

Fort Calhoun Station experienced reliability problems with the Feedwater Regulating Valves. The Steam Generator Level Control System provides a 10 to 50 ma signal to a Fisher Model 546 positioner. The single pneumatic output of the Fisher positioner feeds into a Bailey Model AV1 positioner to provide a dual output to a Fisher Type 472, Size 80 piston actuator. Similar designs are used in the nuclear industry.

The lever arm in the positioner has a ball bearing mounted on a shaft which rides as a wheel on the positioner cam. The retaining clip which holds the ball bearing in place vibrated off allowing the ball bearing to fall off causing the shaft to ride directly on the cam. A plant shutdown would be necessary to fix the problem.

Positioner problems such as spool valve fretting, feedback arms and linkages have been an ongoing issue in the Nuclear Industry. The decision was made to look at new technology in an attempt to eliminate the problem(s). The option of a digital positioner was selected for the upgrade. Several features such as remote mounting capability, on board diagnostics capability and allow integration to a future Digital Process Control System modification at Fort Calhoun Station. Based on the experiences at Fort Calhoun Station and discussions with plants installing digital positioners on Feedwater Regulating valves many of the challenges were similar. This presentation is important because some of the issues were technical in nature but many revolved around cultural paradigms and work practices. To gain the full advantage of equipment upgrades such as this one, one must be ready to address culture and to change work practices.

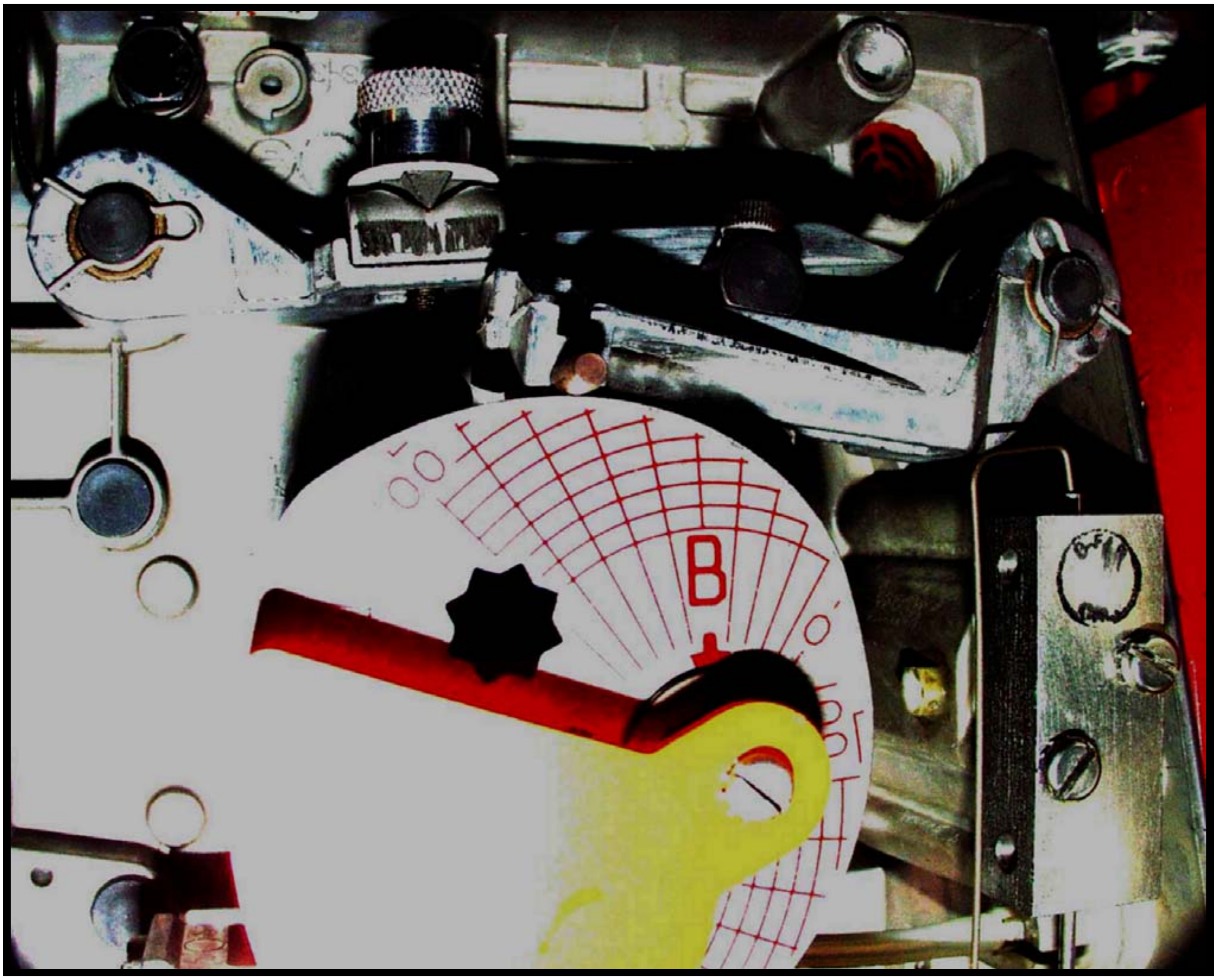
Background:

On January 23, 2001, a reactor operator at Fort Calhoun Station received a RC-2A S/G High Level Alarm. The reactor operator notified his supervisor that the automatic control mode of the flow control loop was not functioning properly. The flow control loop was taken from automatic to manual mode and a plan troubleshoot the problem was formulated. A 22 percent step change in valve position was observed on the Feedwater Regulating Valve (FRV) after trouble shooting. The FRV was returned to automatic mode after the positioner problem was better understood until the next refueling outage. During the refueling outage the positioner cover was removed and it was determined that the retaining clip came loose and cam roller was found lying in the cover.

August 26, 2003, a reactor operator received a RC-2A S/G LOW LEVEL ALARM. It appeared the FRV was not responding in automatic mode. The operator restored level control by shifting FRV control from automatic to manual mode. While restoring steam generator level the plant experienced a slight ***reactor power transient***. This was a second occurrence at Fort Calhoun Station.

After generically looking at common industry operating experience problems with positioners such as age degradation, air leaks, linkage and positioner problems, the decision was made to evaluate upgrading the positioners to enhance reliability. Upgrading a positioner sounds like an easy task on the surface but it is not, this experience provided many interesting challenges which are shared in this paper. The importance of this paper is to acknowledge changes in process control technology that may impact utilities wishing to upgrade to digital controllers in the future.

Positioner Failure



The picture above illustrates typical technology used by many manufactures in the process control industry over the past several decades. A lever arm has a ball bearing (not shown) mounted on a shaft which rides as a wheel on the positioner cam. In this case a retaining clip most likely vibrated loose allowing the ball bearing to fall off causing the shaft to ride directly on the cam. This causes a shift in the feedback within the device which makes the positioner think that the valve is in a different position and results in a corrective action from the positioner. At Fort Calhoun Station this caused the level in the steam generated to shift followed by a slight system transient.

Original Air Operated Valve Configuration:

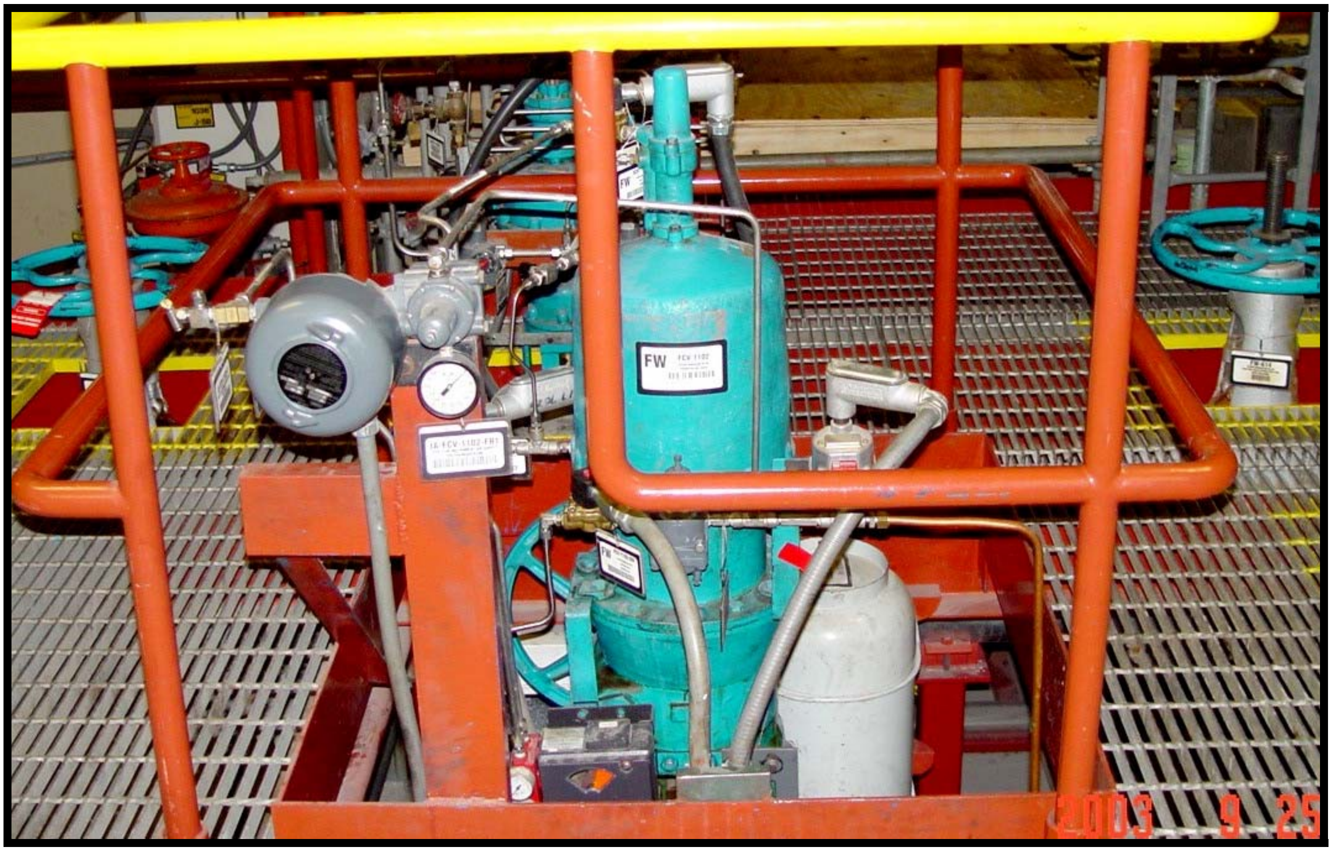
Actuator: Fisher Type 472-1 Size 80, Piston without Spring

Valve: Fisher Model EHD – Size 8 inch with travel limited to 3.5 inches.

Positioner: Fisher Model 546/Bailey Model AV1

10 – 50 ma input
3 – 27 psi output

The pneumatic output signal was feed into a Bailey positioner to convert the single output to a double output for a piston actuator.



Bailey Positioner

Reliability Issue:

FCS experienced valve positioner problems impacting plant reliability. The positioner was subjected to vibration which created continuous problems such as maintaining calibration and cam follower roller bearing failure.   Discussion with other plants in the industry also identified positioner linkage and fretting problems in the sliding spool control valve assembly within the positioner potentially resulting in degraded valve control performance or a possible plant trip.

Choosing a new positioner for the Upgrade:

The decision was made to investigate use of new technology available to increase plant reliability. Challenges for upgrading the positioners existed in many areas so we looked from the inside of the box to the outside.

- **Cultural Changes** (Engineering, Craft and Operations)
  - Site engineering experience with digital technology was very limited and plant procedures were not in-place to evaluate digital modifications.
  - Craft and Operations personal had no experience with the digital positioners or the associated software
  - Training and experience would be needed for everyone. Experienced on site staff did have the appropriate level of knowledge for digital positioners.
  - Culturally there was concern about the **"Digital Scare"** problems heard in the industry over many years and the possibility of malfunctions during the installation of the modification and post maintenance during plant startup & operations.

- **Advantages**

  The digital positioners selected have the capability to perform advanced diagnostics which almost eliminated the need for conventional diagnostic test equipment.

  Historical data could be retrieved after the installation of a Digital Process Control System from a remote location.

  The issue of man machine interface when performing calibration. The results will be the same as long as the same data is used.

  Local and Remote mounting capability eliminates leakage adjustment which could affect calibration.

  Maintenance time required for calibration, and maintenance was significantly reduced. In addition, removal for a remote mounted digital positioner for valve and actuator overhauls takes only a few minutes.

Modification Process:

Evaluation of Digital positioners

- Evaluation Procedures – Outside assistance was obtained to develop procedures to document and evaluate digital process controls that utilize microprocessors, associated software/firmware to perform its intended design function. This process was based on available industry information from EPRI Report TR-102348, "Guideline on Licensing Digital Upgrades."

- Learning new technology – Several digital positioners were considered. The following features were looked at to make a final decision

    - Robust construction and a product the was easy to maintain

    - Positioners with on-board diagnostics capabilities and characteristics that were similar to diagnostic test equipment currently used in the nuclear industry

    - Vendor Support for Training with minimal costs to the station

    - Positioners that would be compatible with new digital plant architectures in the future and that had a significant installed base within the process control industry.

    - Ease of installation, testing and calibration

    - Capable of being remotely mounted to avoid harsh environments during maintenance, normal operation and accident conditions.

- Modification Issues

    - Converting the process control signal from 10 – 50 ma to 4-20 ma.

        - A signal conditioner was installed in remote panels to convert the signal to a 4-20 ma.

    - Testing

        - Testing requirements had to be established

        - Portable diagnostic Test Equipment was used to validate On-Board diagnostic dynamic and ramp test capability of the digital positioner.

        - Plant calibrations procedures were revised.

    - Training and Experience

        - I&C Technicians and Training Department personnel familiar with air operated valve diagnostics were trained by the vendor on digital positioners and associated software.

        - Vendor experience was used during the installation and validation testing. This included pre-outage walkdowns and checking out the positioner in the I&C shop to ensure is operated correctly and familiarize plant personal with test equipment and software.

        - Component Testing and Design Engineers benchmarked similar modifications at a site and participated with the installation of digital positioners with the vendor. This provided engineering knowledge and experience required for preparation, procurement and installation of the digital positioners. In addition, experience was obtained for initial setup and calibration to develop changes to plant procedures and the modification package.

- Diagnostic Testing with On-Board Diagnostics and AOV Diagnostic Test Equipment.

    - The Feedwater Regulating System utilizes a three element control loop with inputs from feedwater flow, steam flow, and steam generator Level. It controls the FRVs at 70% open (Equivalent to 100% Power) to maintain the steam generator programmed level at 65%.

    - In the event of a turbine trip, a ramp signal will close the both FRVs from 70% open (100% Power) to 8% (5% Power) open in 20 seconds.

    - Fisher ValveLink Software was used to setup the digital positioner on the Air Operated Valve. In addition the Hart communicators were used to ensure that the positioner would perform similar tasks, as part of an equipment check.

- Diagnostic tests were compared using Fisher Flowscanner 5000 diagnostic test equipment to validate the signatures from the AMS ValveLink Software.

- The Loop Calibration Procedures were used as a final check for Post Maintenance Testing and returning the loop to operation.

- Diagnostic Testing was performed to verify AOV setup parameters such as:

    - Valve stroke length

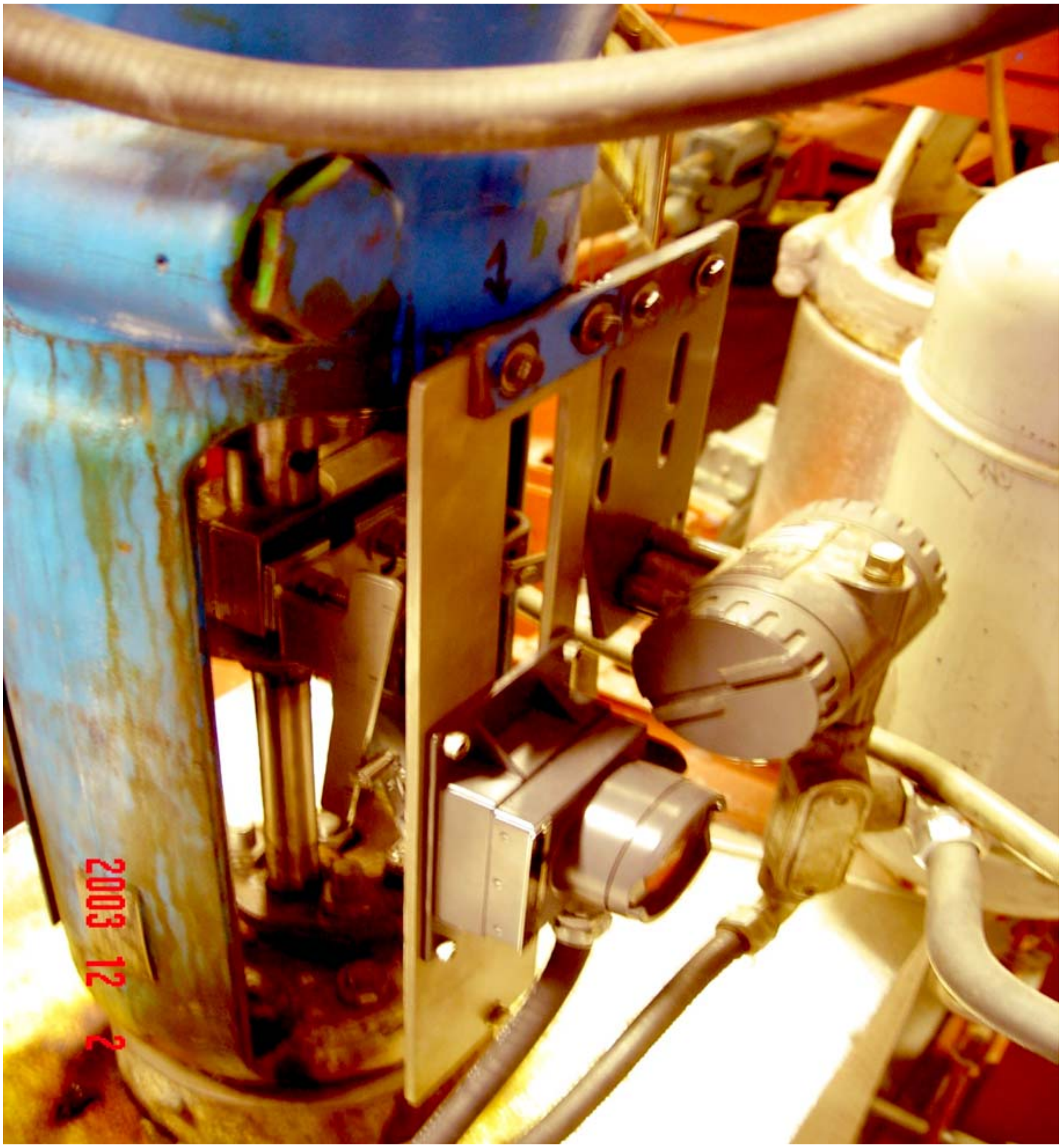
    - Tuning Setup
        - Proportional & Integral gain settings
        - Dynamic error and linearity
        - Zero and Span at full range of travel

    - Packing friction

    - Overall dynamic valve signature comparison between Fisher Flowscanner and AMS ValveLink Software.

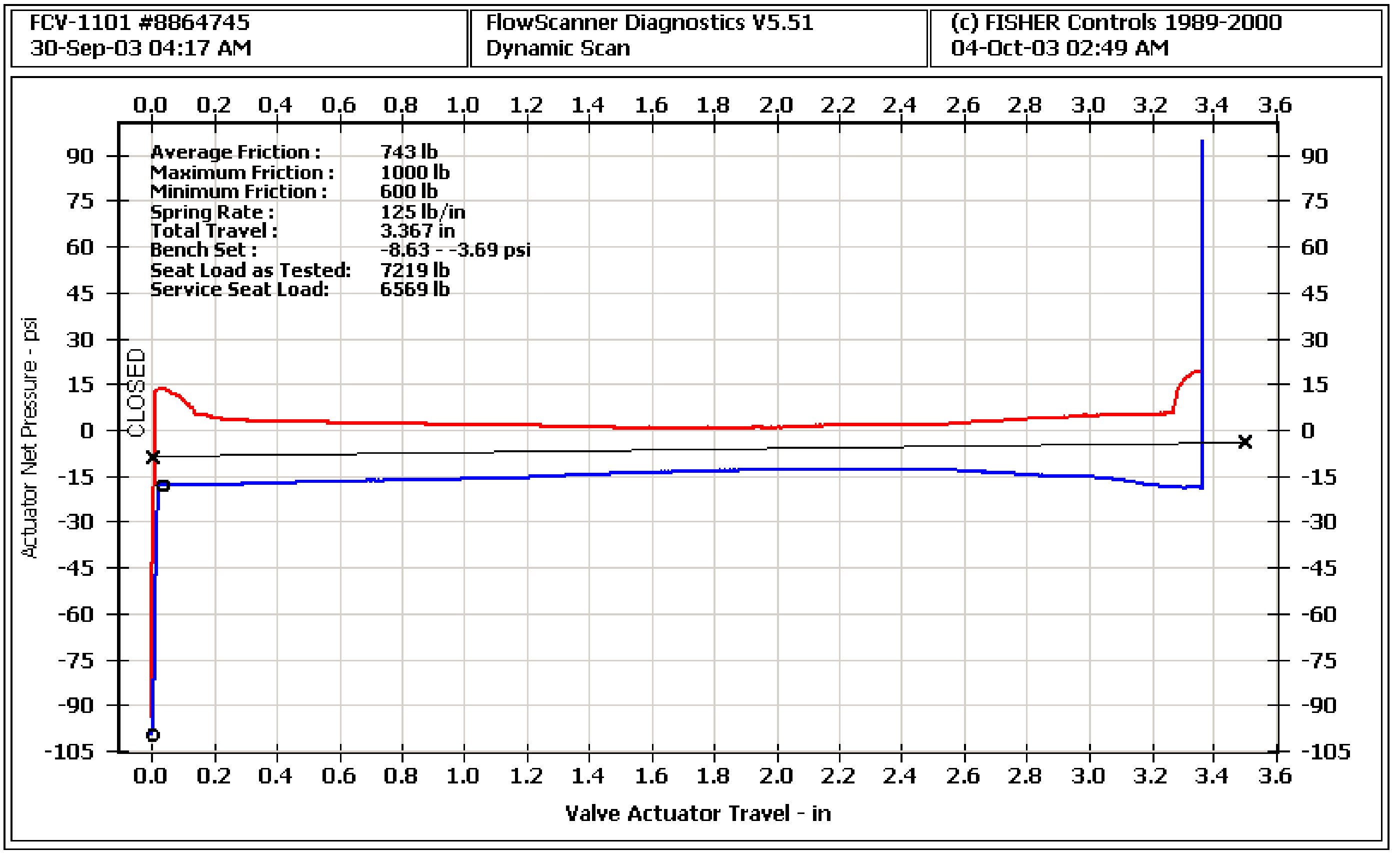
Installation of the Digital Positioner

Installation of the Mounting Bracket and Travel Potentiometer for the Digital Positioner



Installation of the Cam and Travel Potentiometer
for the Digital Positioner
(Side View)

Dynamic Scan Test
Flowscanner Diagnostics



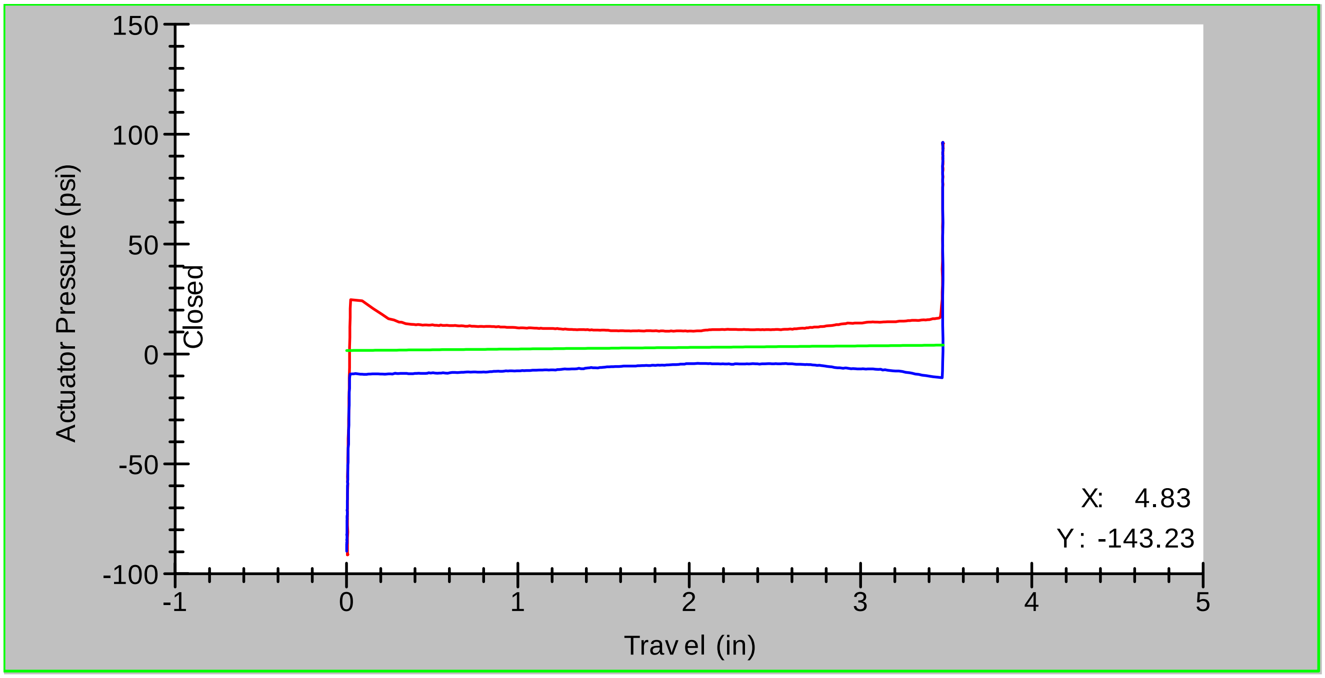
Test Conditions:

Dynamic testing was performed with the Plant shutdown under of Flow conditions.

The "***Red***" Trace going from left to right illustrates the valve going from closed to the full open position.

The "***Blue***" Trace from right to left illustrates the valve going from full open to the closed positioner.

Dynamic Scan Test
ValveLink Diagnostics

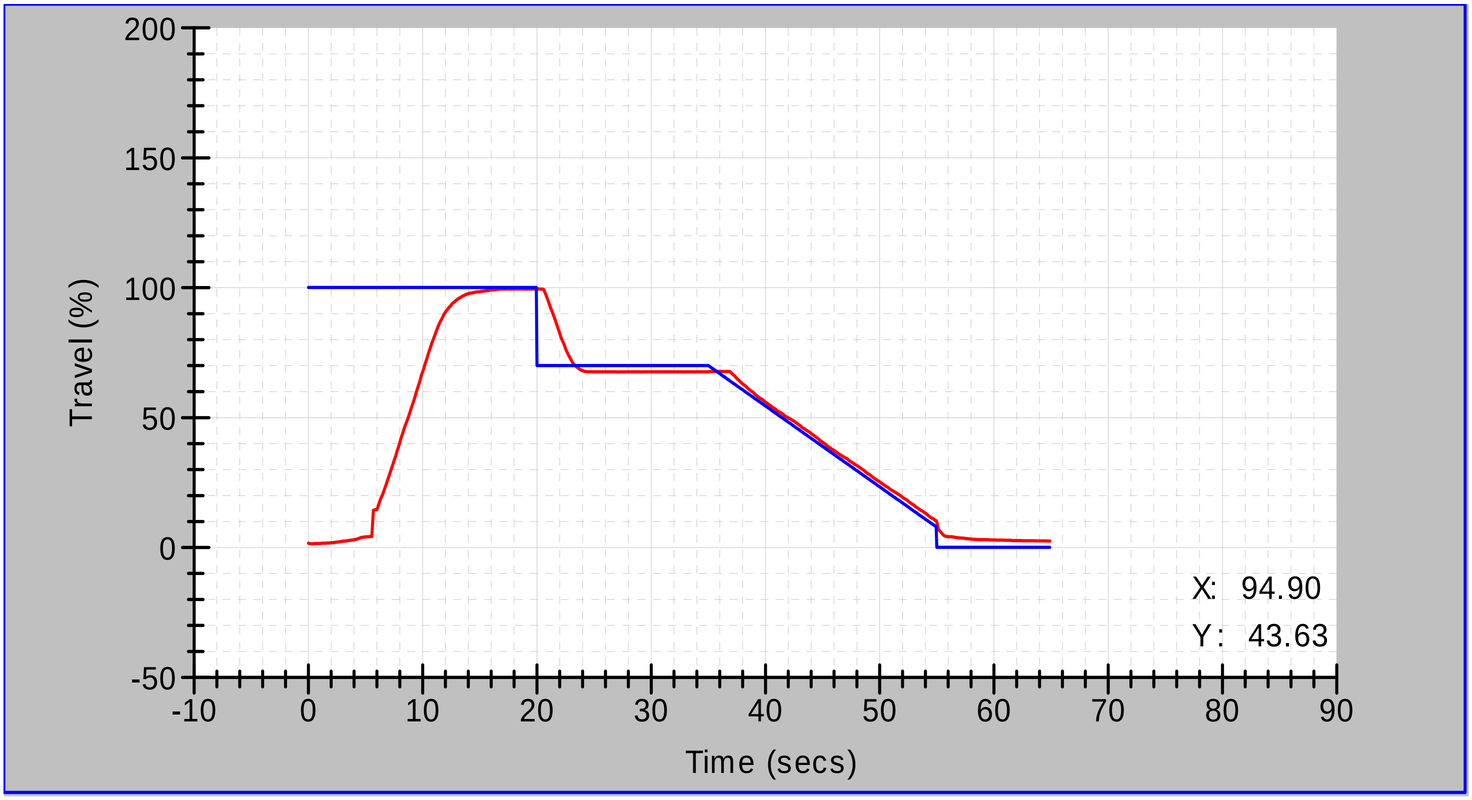


Valve Travel – Closing Stroke Valve Travel – Opening stroke

The profile characteristics of both Dynamic Signatures from the AMS ValveLink and Flowscanner diagnostics were compared. The comparison demonstrated that the on board advanced diagnostics in the digital positioner was functional. The intention is to use the On-Board diagnostics in place of the Flowscanner.

- Calibration time for the positioner was reduced from 4 hours to 5 minutes per valve.
- The need to disconnect tubing and lifting leads was eliminated.
- Repeatability for calibrations no longer a concern with digital positioners. Even when different technicians perform the positioner calibrations.

RAMP Test Simulation from 100% to 5% Power



Ramp Input Signal – Blue Valve Travel - Red

Ramp testing was performed with the plant shutdown and no process flow from 70% to 8% open within 20 seconds was performed using the AMS ValveLink Diagnostics to ensure the valves would respond to a turbine trip.

- This was done by simulating 100% open full valve travel followed by a step to 70% open (100% Power) to set up the test.
- The air operated valve was stabilized prior to initiation of a 20 second ramp signal from 70% open to 8% open (5% Power).
- Each Feedwater Regulating Valve was returned to service after a Loop Calibration and a function check to cycle the valve.

New technology requires new training

- Lack of knowledge and experience was obtained by working with Emerson Process Controls personnel during an installation of digital positioners at Omaha Public Power District's North Omaha Station.

- Vendor manuals for the positioners and software were obtained in advance to assist Design Engineering with the development and planning of the modification package.

- Site Engineering, Training and I&C personnel attended training at Fisher in Marshalltown prior to the development of the modification package. This was very beneficial in helping everyone understand the installation and calibration of the positioners.

- The digital positioner and software was setup in the I&C shop to perform a functional check of the positioners and test equipment prior to installation in the field. This mock up significantly reduced hardware installation and software/hardware setup time. In addition this task verified everything was working before the installation.

Potential Benefits:

While the focus on this project was on increasing hardware reliability, there are additional benefits that can result from leveraging this type of technology. These benefits include:

- Faster more sable valve response will enable loops to be tuned and set up closer to operating limits increasing overall output and efficiency.
  i.e. The plant will generate more megawatts.

- More stable operation of the valves will result, give the capability of the positioner, which will reduce the wear and tear on the valve and major system components that might have to react to variations of flow through the valve. A smoother plant runs better and cheaper with reduced need for corrective maintenance spending.

- Upgrading to modern equipment addresses the issue of equipment obsolesce and technical support.

- Online diagnostics capability will permit a condition-based predictive maintenance approach on the Feedwater System, resulting in better performance at a lower cost.

- Digital equipment can be tuned to match the operating requirements of the system, optimizing process control. This translates into improved plant performance at lower cost as previously mentioned. If necessary, it could be tuned to match the performance of the equipment that it replaces so that the system would not have to be retuned until more experience is gained by the plant.

- Digital upgrade with advanced diagnostics and communications capabilities provides an avenue of transition to future Digital Process Control Systems which will improve plant performance and reduced maintenance. Plant personnel will have remote calibration and monitoring capabilities for component and system performance.

10 Top Things to Consider When Upgrading to Digital Positioners:

1. Develop good communications to ensure the manufacturer understands everything about the application.

2. Make sure all personnel on site participating are familiar with the Digital Upgrade.

3. Ensure your vendor has the knowledge, experience and enthusiasm to work through every phase of the modification.

4. Consider using alternative testing with additional equipment to validate on-board digital diagnostics.

5. Setup and test equipment prior to the installation to ensure everything is operating correctly.

6. The modifications process should carefully address all the issues for digital modifications by using available industry guidelines and practices.

7. Obtain training directly from the manufacturer for various plant personnel, such as Design, Training and Craft personnel.

8. Have spare parts and equipment readily available to prevent delays.

9. Participate with a cross section of personnel for the installation of digital controls at another site(s) to learn as much as possible.

10. Attend industry conferences and use resources for industry operating experience information to understand potential problems associated with conventional and digital positioners.

Quote of the Day: “There are no Bad Positioners,
it’s just that some work better than others.”

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