We Solve Control Valve Problems®

Advanced Digital Valve Controller

By Stan Miller, CCI;

Presented at AUG January 8-12, 2007

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As advancements continue to be made in digital smart positioners, more and more applications are being uncovered in nuclear plants. Nuclear plants are unique as they have all the problems inherent in conventional plants, but add in requirements for AOV testing, radiation, need for precise control and accident conditions. Old-style positioners have been the work horses for many years but have severe limitations on aiding the plant to track the performance of the valve and withstand the harsh operating environment.

Conventional Digital Smart Positioners

Over the past five years, a number of these units have been qualified for nuclear applications. They have been placed through extensive environmental testing as well as validation and verification programs to prove their reliability and stability. The plant operator now has several options to choose from in replacing the old technology and selecting new network protocols. Most of the positioners are compatible with HART® and Field Bus technology and can be easily interfaced with plant DCS systems. The one common thread among these positioners is they were all developed for standard plant applications and are simply adapted for the Nuclear industry. They still have some drawbacks that limit their application and long-term reliability.

Conventional System Drawbacks

Several aspects of the nuclear plant make it very difficult to adapt a conventional smart positioner. The combination of high temperatures and high radiation virtually rule out these devices in many locations. The electronics that are needed for the digital portion of the device will be damaged by relatively low levels of radiation and will certainly not withstand the effects of a LOCA event. Therefore, the electronics must be located in a mild environment and some other method adopted to get signals to and from the control valve. The only available options for most devices are long tubing runs and highly inaccurate position feedback devices that when combined lead to slow response and poor control.

Advanced Digital Valve Controller

One device has been developed with the Nuclear industry as its major target. The QuickTrak™ unit shown in Figure 1 has specific features that allow it to be applied in almost any AOV or electro-hydraulic application. The standard unit uses a magneto restrictive device to obtain an absolute position feedback from the control valve. As shown in the illustration, the device is completely contained inside the actuator and has no moving parts or linkages. As the actuator moves up and down, a magnet on the piston interrupts the magnetic field and provides precise feedback. This unit can be used up to about 50,000 RAD integrated dose. For higher rad levels it would be replaced by a radiation hardened LVDT. The standard LVDT is mounted on the actuator yoke and as the valves moves up and down it drives the core of the LVDT through the magnetic field, also giving very precise position feedback. This device has been used for reliable feedback in the Nuclear industry for the past 40 years. These two solutions now allow the electronics to be moved away from the valve without sacrificing accuracy or exposing the unit to environmental damage.

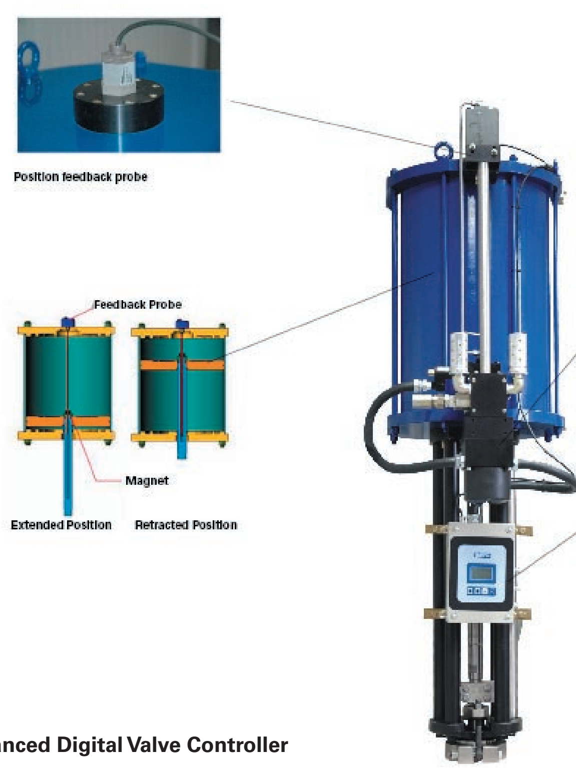

Figure 1: Advanced Digital Valve Controller

Figure 2 shows a typical application where the actuator and position feedback system have been left on the valve, but the electronic valve controller and servo valve are installed 25 feet away. In this application, the feedpump was causing significant vibration in the piping and the conventional positioner could not withstand the vibration. This led to excessive maintenance and poor reactor water level control. Once the new equipment was installed, the vibration problem was eliminated and excellent reactor level control was achieved.

Figure 2: Nuclear Feedwater Regulation…Before

Nuclear Feedwater Regulator…After

This is a very simple example that becomes more complicated when the valve is installed in a high heat, high radiation area. In a typical BWR, the feedwater heater level control valves are in a personnel exclusion area. Since electronics can not be installed in this area, conventional smart positioners will not work. With the advanced system, an LVDT can be used to provide the position feedback and the electronics and the servo valve can be located up to 250 feet from the valve. This will allow the electronics to be accessed by station personnel during operation and virtually eliminate these valves from needing AOV testing during the outage. Using the advanced diagnostics, the AOV evaluation can be completed prior to the outage, and if work is needed it can be scheduled ahead of time.

The other major advantage of this device is the large air capacity of the spool in the servo valve. By delivering 20 times the air volume compared to a typical smart positioner, excellent performance can be maintained even though the servo is located a significant distance from the valve.

Following is a partial list of where the Digital Valve Controller can be applied:

- CVCS Demineralized $H_2 0$
- CVCS Boric Acid Make-Up
- CVCS Charging
- Feedwater Control
- CVCS Let Down
- Start-Up Feedwater Control
- Steam Dump to Condenser
- Heater Drains
- MSR Drains
- Atmospheric Dump Valve

Each application presents slightly different challenges but they can all be addressed with only minor changes.

Special Applications

Atmospheric Dump Valves

The ADV application presents significant challenges because of the severe conditions that exist after a LOCA. The LVDT described above is right at the limits of its capabilities, but will provide the necessary feedback for effective pressure control during the system shutdown. Since the air supply system may be interrupted, the nitrogen back- up system must be used after the LOCA occurrence. The electronic controller and the servo valve will be located in an adjacent mild environment area up to 250 feet from the valve. In addition, a special nitrogen lock-up system is available which completely shuts off the nitrogen flow when the valve is stationary. This allows the valve to perform as long as necessary after the accident without draining the nitrogen bottles. Figure 3 shows a schematic diagram of this system.

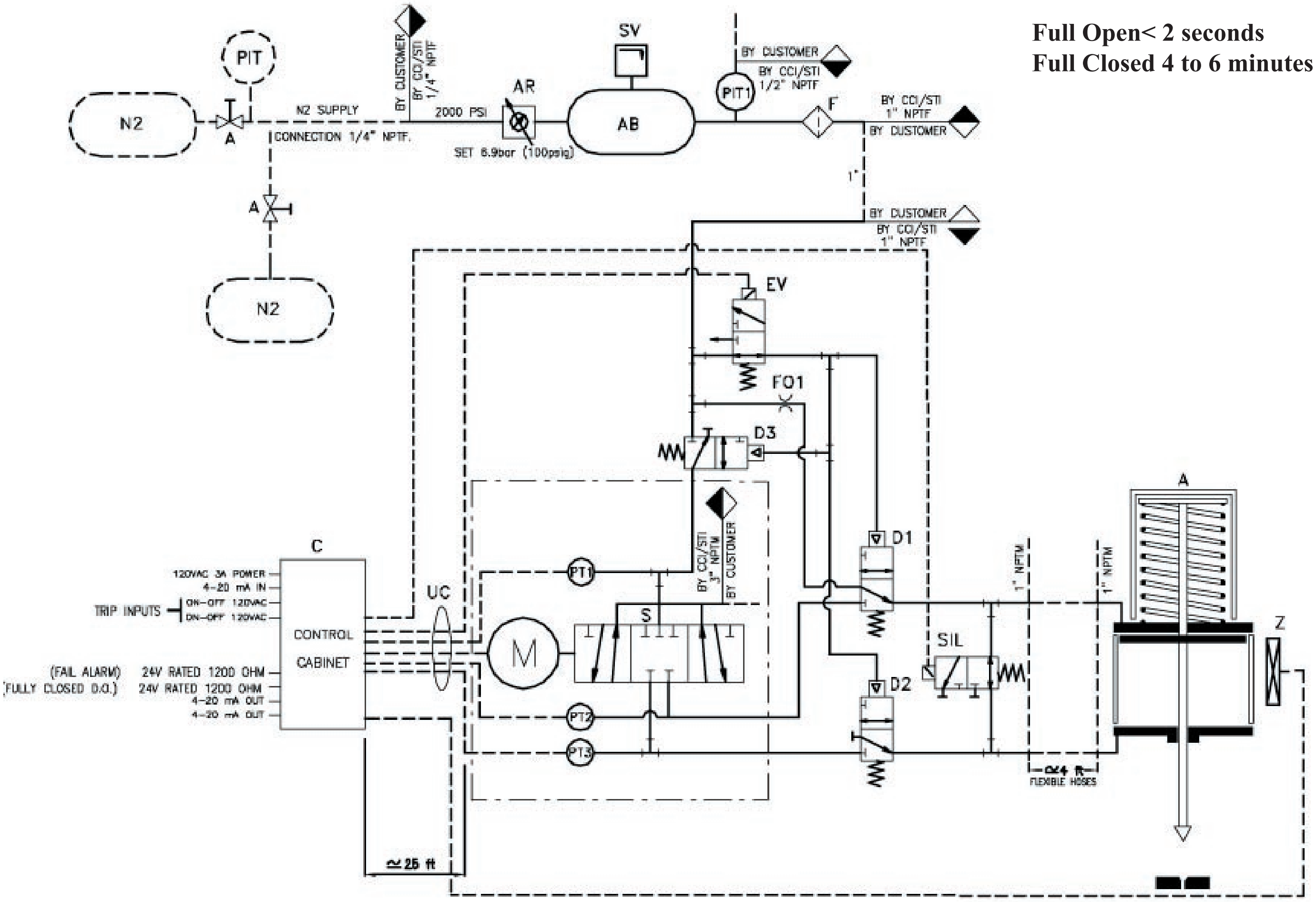

Figure 3: Nitrogen Lock-Up System

The controller also allows tremendous flexibility in configuring the system. In the above example, the unit will open in two seconds and is adjustable from four to six minutes in closing.

Dual Control System

Previously the only way to supply this option was a very complex linkage system with extensive manual intervention required. As shown in Figure 4, the Advanced Smart Positioner provides a very effective solution to this problem. To avoid a single mode failure, the magneto restrictive probe can be used in combination with an LVDT to provide two independent feedback mechanisms with no linkages and very precise control. The two controllers are set up in a primary and a secondary mode control which allows seamless transfer from onto the other if a problem is encountered. This allows the station to continue operating while the fault is corrected.

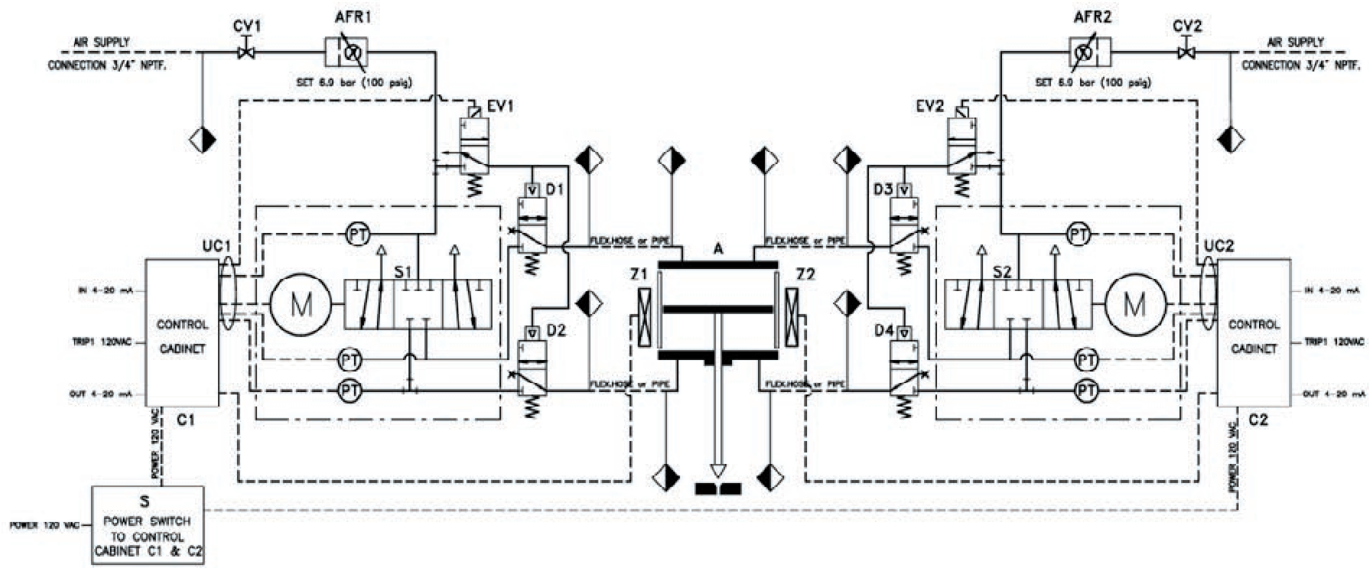

Figure 4: Advanced Smart Positioner

Boric Acid Make-Up System

As shown in the Figure 5 schematic, an existing conventional control system can be modified with only minor changes to the plant control system. This system had been in place for a number of years and had proved inadequate in providing the necessary control. The new system uses the QuickTrak™ to provide the precise control and still uses the trip modes of the original system.

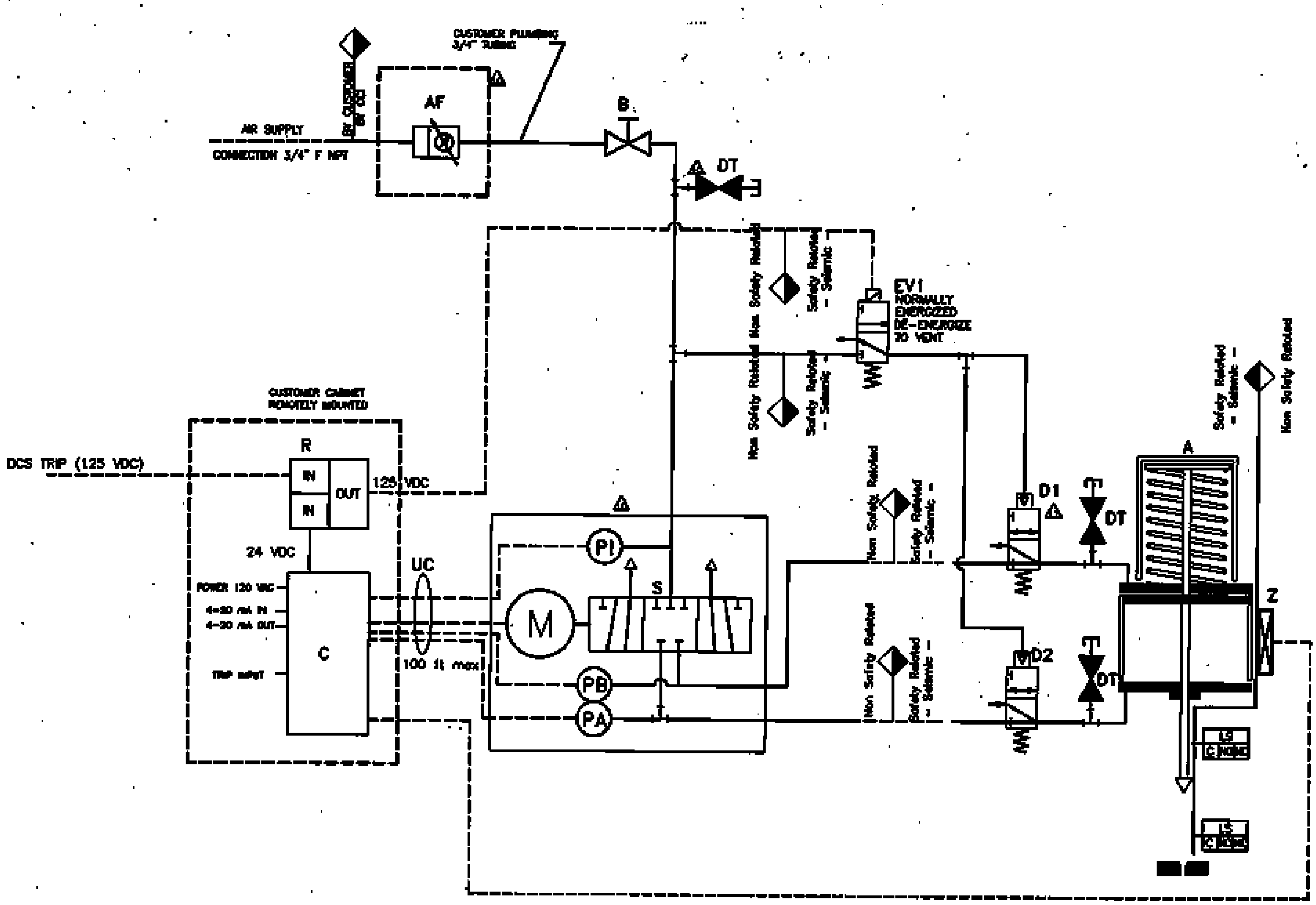

Figure 5 – Boric Acid Make-Up System

A Truly Configurable System

The following is how the Advanced Digital Valve Controller can address these unique applications:

- Next generation DSP processors with HW "watch dog" and 64Kx16 RAM
- 6 digital outputs (3 can provide PWM mode solenoid control)
- 4 free contacts digital inputs
- Additional feedback signals accepted i.e. start/stop, LVDT and 4-20 mA
- CanBus connection for external sensors
- LEDs on the PCB for visual trouble-shooting

The user is not limited to a set of standard routines but can have the system configured to meet their exact needs. By using the powerful processor logic can be included that makes the dual control system feasible without any external controls. The free contacts and additional IO's allow the system to mimic existing control schemes and provide additional options. The large memory allows the AOV program to be easily implemented without any external computer requirements. The advanced diagnostics will allow the user to configure the device for their specific program and interface it with their existing AOV electronic equipment if necessary. An added feature of the device is to perform internal diagnostics on the controller and servo on a continuing basis. Any problems that are detected will be recorded and can be transmitted to the control room if desired.

In summary, the Advanced Digital Valve Controller offers nuclear plant operators a system that is truly flexible and can be used in a number of critical applications.