

INTRODUCTION

Part I of this report discusses advantages gained when a new boiler feed pump (BFP) recirculation control valve design was used at an Illinois Power Co. installation. One author, Mark Liefer, Baldwin Power Station engineering coordinator, (page 24) provided the following separate comments on the experience.

Installation of the new design BFP recirculation valves has been quite successful. When the 1A and 1B turbine-driven BFPs on Unit I were put into service on March 28 and March 30, 1995, the pumps and valves had no vibration or cavitation at any point in the speed ramp." During tests, the pumps were held for a short time at 4,400 RPM, which is just below the pumping speed needed to move water into the BFP header. Both pumps never ran quieter or smoother at this speed and the flow was 800,000 pounds per hour (lb/hr). Under these conditions, the flow with the original valves and capillary tubes in place would have been much less at 375,000 lb/hr.

Reduced noise and cavitation also is attributed to the higher flows made possible by the new valves. "The modulating control for the recirculation flow is smooth and consistent, which allows operators to keep the BEP controls in the automatic control mode when starting or stopping the turbine-driven BFPs."

A new generation of technology also is the theme in the article on motor operated valves that begins on page 27. The author discusses how New England Power achieved significant cost savings and improvements in efficiency using new valve actuator technology on a flue gas desulfurization (FOD) system at its Brayton Point power plant. According to plant engineers, the new technology was less expensive to install than traditional methods and has helped to increase reliability.

Actuators and standardization

Details on advances in valve controls, such as actuators, is premium information wherever and whenever it is available. Sometimes discussions on the subject can go far beyond just the controls. As an example, the Valve Manufacturers Association of America (VMA) presented an interesting variety of papers during its 1994 Technical Seminar. Among these was one by Leon J.

Niessen of Mekanotjanst International UK titled "Development of the Quarter Turn Pneumatic Actuators for Global Markets."

Niessen listed burdens faced by the power generation and other industries that are all too familiar to industry engineers. Demands to reduce costs, yet boost productivity and efficiency are shared by all industries. Power plants also suffer the highest costs for maintaining operation while the pressures of possible deregulation and seemingly growing numbers of independent power producers (IPPs) is increasing. We say 'seemingly' because signs of attrition among the weaker IPPs has appeared.

Demands to
reduce costs, yet
boost productivity
and efficiency
are shared by
all industries

According to Niessen, the average maintenance costs, expressed as a percentage of total operating costs, are 20 percent for a cogeneration plant, 25 percent for a fossil plant and 40 percent for a nuclear plant.

The author relates the high cost of maintenance to his discussion of the value of standardization in valve actuator technology. He explained, as an example, that standards for quarter-turn pneumatic actuators were introduced in Europe as a result of efforts by various end-user industries. However, "to date, this standardization program has been ignored by U. S. industries." He said that legislated safety standard continues to grow and, hence, the demand for automated valves increases. More automation translates into higher maintenance costs.

Niessen reviewed five stages of actuator development. He began with the mid-1930s when the linkage arm and clevis pin arrangement that converted linear motion to rotary motion was introduced. In 1950, the first quarter-turn pneumatic actuator had a vane with off-centered drive shaft. The "last of all current 'parent' design quarter-turn pneumatic actuators," introduced in 1970, combines the rack and pinion (vintage 1960) and scotch yoke (1961) features.

"None of these actuator designs are directly interchangeable on a valve." They also

have no common way to mount accessories.

The author's conclusions on the need for and advantages of global harmonization of valve standards include a common base for valve automation worldwide, including valve/actuator mounting details, common mounting configuration for solenoid valves, and mounting standard for positioners and feedback devices. His suggestions would lead to component interchangeability worldwide, shorter ordering lead times and down times, and would allow a common in-house parts stock; all of which leads to lower costs.

Unless or until standardization is realized, either through manufacturer-induced technology transfer or under the urgency of valve user groups, there is another development that will cut costs for in situ testing and non-intrusive condition monitoring of power plant valves.

Modern test equipment cuts costs

Advanced versions of vibration, acoustic, ultrasonic and other techniques avoid unnecessary valve disassembly when used to monitor/test selected valves, according to M.K. Au-Yang of B&W Nuclear Technologies. The variety of valve used in power plants present a challenge to monitor and maintain. Predominant among these are check valves, air-operated valves, and motor- and solenoid-operated valves. More specifically, observed Au-Yang, many of the 1,000 or more valves commonly found in a nuclear power plant are crucial to reliable performance of safety functions. Hence, most recently developed techniques in valve condition monitoring, non-intrusive and in situ testing, and preventive maintenance were developed by the nuclear industry.

"Now that development costs are absorbed, other power plants can take advantage of this modern test equipment. Its use to monitor valve performance can reduce their operating and maintenance costs as it did for nuclear power plants," concluded Au-Yang. Speaking of testing, cooperative activity already had accelerated in the world of valve testing in 1989 at a symposium sponsored by the Board on Nuclear Codes and Standards of the American Society of Mechanical Engineers (ASME) and the Nuclear Regulatory Commission (NRC). The power generation industry enjoyed cooperative dialog at the time, as best"~ described by John J. Zudans of Florida Power & Light: "The ASME/NRC symposium brought together representatives of

INTRODUCTION

utilities, vendors and the NRC in an effort to clarify ASME code requirements and gain NRC guidance on how to prepare programs." Suffice it to say that considerable progress has been made since then in the form of adjusted codes and advanced guidelines. (For background information on early generic letters and codes see "The dynamic world of valve testing." *Power Engineering*, January 1990.)

AOV maintenance guide

Illinois Power Co. benefited when its staff used the *Air Operated Valve Maintenance Guide* to upgrade procedures. Produced by the Electric Power Research Institute's (EPRI) Nuclear Maintenance Applications Center, the guide helped improve the quality of maintenance at Illinois Power's Clinton Power Station. Recommendations from the guide were used in a pilot test program to identify the type of valves that needed diagnosing and to implement an air-operated valve (AOV) testing program. The effort resulted in annual savings of \$275,400 for maintenance and scaffolding (\$10,400), as low as reasonably achievable

(\$15,000) and energy savings of 2.5 MW (\$250,000), according to a report from Doug Koons at Illinois Power. Steps taken in the Clinton power plant program included testing 12 known leakers. The ease of this diagnostic procedure allowed 16 more valves to be tested during one outage.

Slurry valve progress and application

A new generation of design figures strongly in the toughest of all duty for the world of valves—slurry valves. Three utilities gained advantages by seeking better design criteria in their slurry valves. However, another major element, improved maintenance techniques, contributed to greater reliability.

One utility eliminated all but 10 percent of its valve problems by using the combination of design and maintenance factors. This company also reduced maintenance labor costs by up to 15 percent. Another power plant boosted slurry valve life in its scrubber towers by 2.5 times before needing a replacement.

A third power plant chose its valve design carefully and introduced a quality predictive maintenance system. The combination extended the life expectancy of some valves in the roughest service from as little as 30 days to at least 10 years.

Not enough has been heard about recent improvements in slurry valves. In the upcoming August issue, we document some recent improvements to slurry valves in the article "Design, maintenance extend slurry valve life." In the article, the authors examine experiences of power plant's with slurry valves in Texas, Oklahoma and Florida. Most experiences relate to FGD systems.

Meanwhile in Nebraska

In Nebraska, however, another power plant's experience with control and isolation of water in a sparging and screen wash application for an intake system shows the advantages of knifegate valves over the butterfly valves that

they replaced.

The original butterfly valves failed three months after installation at this 800-MW unit, partly due to the sand content of the river water used. These valves were replaced with air-operated pinch valves that also failed. When the pinch valves closed, the water's high velocity slashed the rubber and weakened the valve. Pipe erosion also accelerated because the high velocity of sandy water breached the leaking valves and deteriorated the piping.

The knifegate valves that were installed in 1984 have performed reliably ever since. Their gates and sleeves need replacement about once each year compared to every three months for the butterfly valves. Maintenance costs have dropped and system outages are greatly reduced because the knifegates are out of contact with the water flow when open and the valve bodies are not exposed to water.

Whether the subject is slurry valves or valve controls, the industry now has many guidelines available to help power plants improve their valve selection and maintenance needs. These are examined regularly at conferences, such as VMA Technical Seminar (November 1994) and EPRI's recent Fifth Valve Symposium (June 1995). Considerable evidence of the benefits gained also can be found in the reports that follow.

END

References

The Gypsum Industry and FGD Gypsum Utilization by L. M. Luckevich and R. E. Collins of Ortech and Dean Golden of EPRI. (EPRI TR-103652)

Processing and Potential Applications of Fly Ash-Aluminum (Ashalloy) Composite by P. K. Rohatgi et al of University of Wisconsin, D. M. Golden of EPRI and D. Odor of PSI Energy. Contact Dean Golden, EPRI, Palo Alto, Calif.

Ash Handling Conversion: Lahadie Plant by J. C. Morgan of Union Electric, and G. L. Flandermeyer of Burns & McDonnell at POWER-GEN Americas '93.

Investigation of High-Volume Fly Ash Concrete Srstems EPRI TR-103151, Final Report, Oct. 1993, 156 pages (Project RP3176-06). Contact D. M. Golden, project manager.

EPA. Miracle Concrete, Nonhazardous Wastes, "Environmentally Speaking," October 1993, *Power Engineering*.

Supreme Court Decision has Implications for Power Plants, "Environmentally Speaking," July 1994, *Power Engineering*.



Developments in valve condition monitoring and testing continue apace with innovations coming largely from the nuclear power industry. Photo courtesy of Liberty Technologies Inc.

Recirculation control valve replacement cuts maintenance costs

Replacement of boiler feed pump recirculation control valves solves a maintenance problem on Baldwin Unit 3

By Mark E. Liefer, *Illinois Power Co.*, and Herbert L. Miller and Robert E. Katz, *Control Components Inc.*

All three of Illinois Power's Baldwin power plant Units had the same boiler feed pump (BFP) valve design when they went into commercial operation. The original BFP recirculation valves were a top-guided plug, single-port cage design using a tapered plug and seat arrangement. This design failed in Unit I during the first year of operation, so a redesigned set of internals was installed in 1973. The new internals used a drilled-hole cage and were designed to resist cavitation and erosion. This same design was initially installed in the Unit 2 and Unit 3 valves.

The BFP recirculation control valves were 90-degree angle body valves with pneumatic actuators mounted below the valve bodies. The actuators were designed to allow the valves to operate in fully open or fully closed ("open/close") positions. The plug-and-cage design valves did not provide the pressure reduction needed to allow the recirculation flow to be discharged into the deaerator storage tank. Most of the pressure drop was absorbed in two 1 1/2-inch diameter capillary tubes that carried the flow between the recirculation valves and the deaerator. These 65 feet- (20 m) long capillary tubes acted as a fixed orifice to provide the required pressure drop. Erosion of the tubes was not a problem because they were fabricated from 1 1/2-inch diameter, 304 stainless steel XXS pipe. Taking the pressure drop through capillary tubes was much quieter than taking the full pressure drop through a plug-and-cage design valve.

During initial unit startup and throughout the years, cavitation and erosion of the valve internals resulted in leaks. The valve leakage frequently increased to the point that

the unit power output was reduced. The BFPs could not generate enough flow to compensate for the leakage which was returning to the deaerator. Therefore, the valve required an overhaul; the stem, plug assembly, cage and seat ring were replaced due to the heavy erosion. Several different valve stem, plug and seat materials were tried with no significant improvement in repair costs or repair frequency.

These BFP recirculation valves required replacement of internals on at least an annual basis. Replacement parts used during a valve overhaul were expensive and so were labor costs. Scaffolding had to be built to access valve internals and working overhead to repair the inverted valves was awkward and tedious. In addition to the erosion, which always was present on the replaceable parts, significant valve body erosion also became a problem. The valve bodies were welded and machined several times before the valves were replaced with a different design.

Unit 3's BFP recirculation valves were replaced first, because its drum design boiler

had more low-load operation than the on- through units. As a result, the recirculation valves were overhauled more frequently and the valve bodies were in worse condition than those on Units I and 2. The staff chose to use a valve specifically designed with velocity control trim that had successfully replaced four valves in the startup/bypass system on the Unit I boiler.

The boiler feed pump manufacturer recommended increasing pump recirculation flow and, by designing the replacement valve to specific plant conditions, the volume of BFP recirculation flow could be increased. In addition, by using feedback positioners tied into the control logic for the boiler feed pump, the flow could be modulated, resulting in a smoother transition from recirculation flow to no recirculation flow.

New modulating BFP valves

The new globe-type 4-inch by 4-inch BFP recirculation valves (Figure 1) replaced the old "open/close" angle valves and the pressure-reducing capillary tubes. The top-entry valves are arranged with their actuators on top.

These new valves are an ANSI 2500 pressure class design. The normal flow rate is 945,000 pounds per hour at a design pressure differential of 3,735 psi (3,960 to 225) and a temperature of 350 F (120 kg/s at 25.8 MPa drop, 27.3 to 1.5, 175 C).

Multi-stage pressure reduction

The new multi-stage valve trim (Figure 2) incorporates a stack of tortuous-path disks,



Illinois Power's Baldwin Power Station

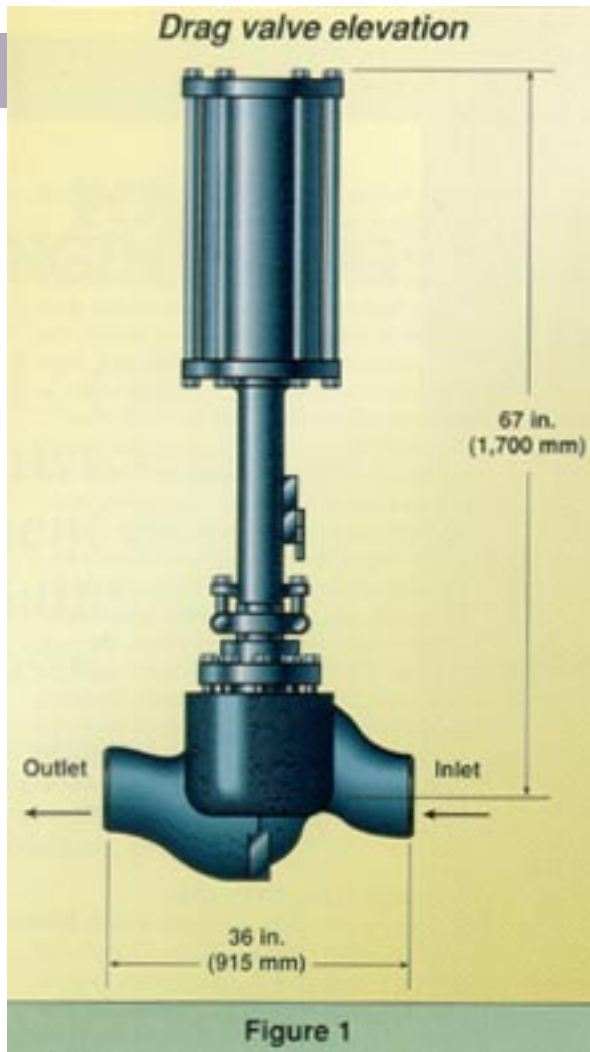


Figure 1

similar to Figure 3, whose built-in right-angle turns permit multi-stage pressure angle reduction over the entire valve stroke. Each disk involves multiple flow paths with 24 pressure-drop stages in each flow path. Boiler feed pump discharge pressure is continually dissipated with a controlled velocity of less than 75 feet per second (22.9 m/s) by being forced through turns etched into the discs.

In addition, each disk in the stack incorporates a pressure-equalizing ring (PER) on its inside diameter to assure that equal pressures act radially around the circumference of the plug at any position in its 6" (152 mm) stroke. The design keeps the plug centered at all loads and prevents plug vibration. These valve features hold noise levels to below 85 dBA at three feet (0091 m).

Stacks of tortuous-path disks produce a linear stroke vs. valve coefficient. Therefore, for this application, the flow rate is a linear function of valve plug position and control signal.

Pressurized-seating construction

To ensure absolutely tight shut-off, these multi-stage BFP recirculation valves are provided with pressurized seating as shown

in Figure 2. When the valve is closed, upstream pressure is applied above the main plug by way of a multi-stage bleed pin which controls flow to the bonnet. This provides a seating load equal to the inlet pressure times the full area of the main plug. Shut-off provided is in accordance with MSS-SP61 (block-valve leakage requirements).

When a signal to open the valve is received, the actuator lifts the stem, opens the pilot plug and allows the main plug to be hydraulically balanced with downstream pressure. There is a step on the main plug's outside diameter that creates a differential area.

When upstream pressure acts on the main plug differential area, it provides an axial biasing force that causes it to remain on the main seat. As the stem continues to move in the opening direction, the pilot-plug shoulder engages

Baldwin Power Station

Illinois Power's Baldwin Power Station is a mine-mouth coal-fired plant with three 600-MW units. Units 1 and 2 are once-through, cyclone-fired units and Unit 3 is a drum design, pulverized coal fired unit. All three Baldwin units are 2,400 psig (16.6 MPa), 1,000 F/1,000 F (538 C/540C) with two steam turbine driven BFP's per unit. The six pumps are identical with a rated capacity of 2,270,000 pounds per hour (286 kg/s) at 3,580 psig (27.7 MPa) at a design speed of 5,850 rpm. Baldwin Unit 1 began commercial operation in 1970, Unit 2 in 1973 and Unit 3 in 1975.

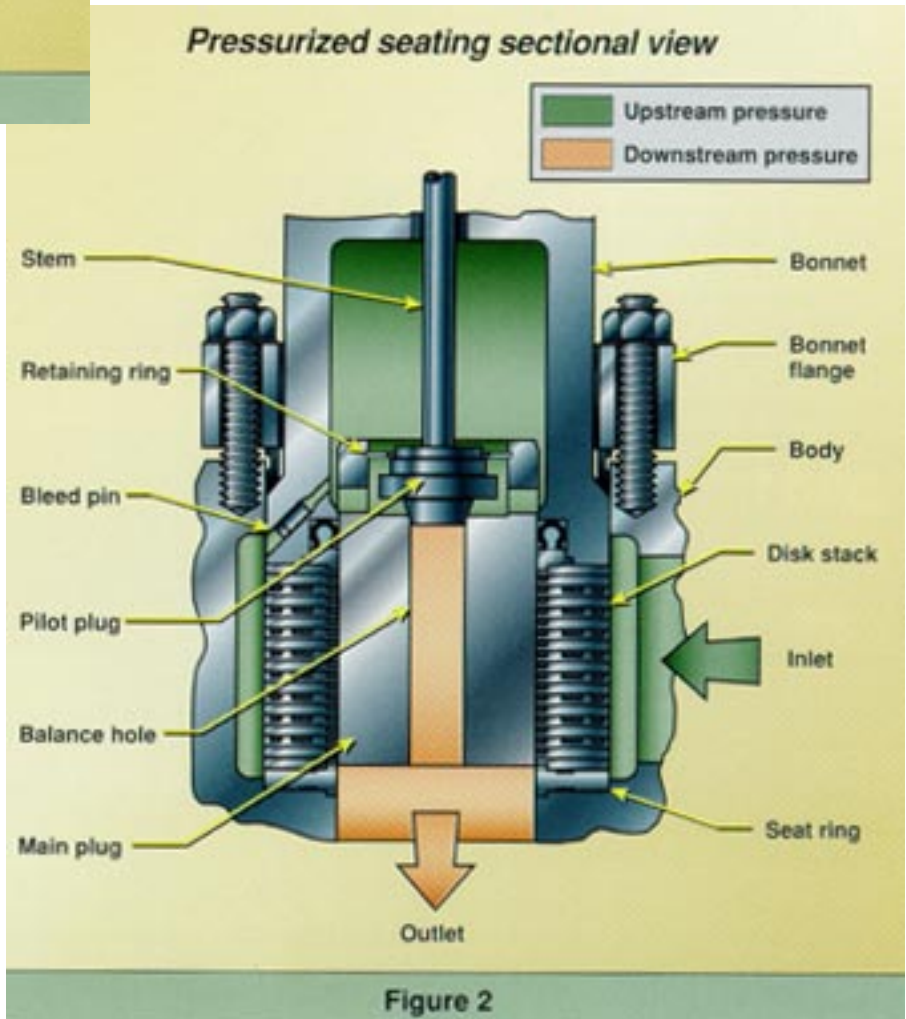


Figure 2

Tortuous path disk

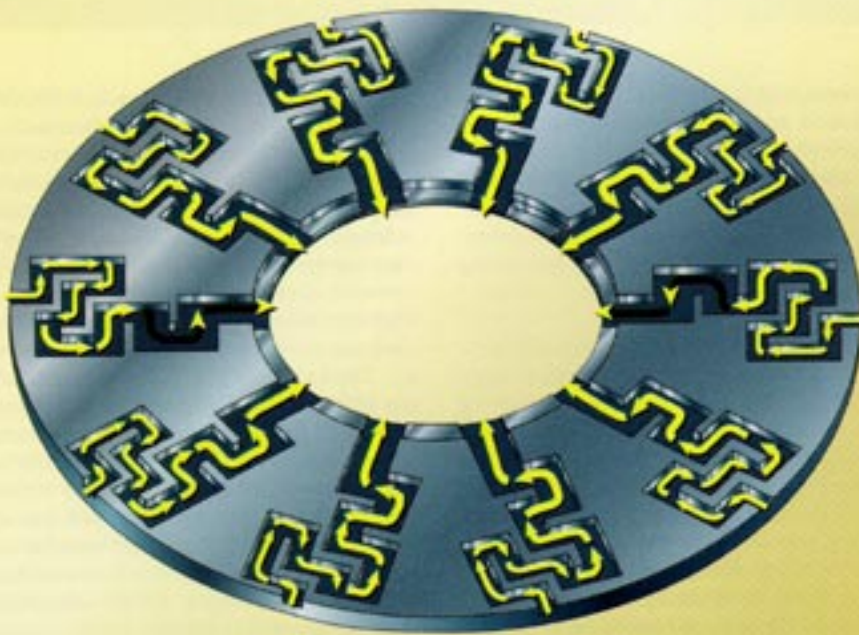


Figure 3

the main-plug retaining ring to lift it off the main seat. This axial biasing force causes the pilot-plug shoulder and the main plug to remain in contact under all operating conditions. When a signal to close the valve is received, the actuator moves the stem in the closing direction. The biasing force on the plug causes it to move with the stem until the main seat is contacted. The stem continues downward to seat the pilot plug, restore upstream pressure above the entire main plug diameter, and assures a tight, leakproof seal. The new pneumatic-actuator control systems (Figure 4) operates on 70- to 100-psig (0.5 to 0.7 MPa) supply air and produce input/output signals of 4 to 20 milliamps. Upon power failure, the recirculation valves open fully in

Recirculation-flow modulation

The original system design had flow transmitters on the discharge line of each boiler feed pump. The recirculation lines did not have a flow transmitter. The control system was set up to close the recirculation valve at 35 percent of rated flow, 800,000 pounds per hour (100 kg/s) during a pump startup. It would open the valve at 33 percent of rated flow, 750,000 lb/hr (95 kg/s) when the pump was being taken out of service. The flow through the recirculation valve was 750,000 pounds per hour (95 kg/s) at these conditions. The opening or closing of the recirculation valve had a significant effect on the feedwater flow going to the boiler. Operators had to anticipate this change and often put the feed pump controls in manual during this transition. The pump manufacturer recommended changing minimum flow through

the boiler-feed pump to 45 percent of rated flow 1,000,000 pounds per hour (126 kg/s). The new valves were designed to pass this flow in the fully open position. The valves have a linear flow characterization curve that allows the flow through the valve to varied by changing the position of the stem and plug assembly. By using this ability to modulate flow, the energy loss in the boiler feed pump could be minimized. The modulating valves would look at the combination of pump recirculation flow going to the deaerator and pump flow which was going to the boiler. The valves would open or close to maintain a total flow of 1,000,000 pounds per hour (126/kgs).

Valve replacement

The new design boiler feed pump recirculation valves were installed during a four-week Unit 3 scheduled outage in the Spring of 1992. At that time. The valves were set up to operate in the "open/close" mode. During the scheduled outage in the Spring of 1994, a new control system was installed on unit 3. The control system was set up to operate the valves in the modulating mode. This was accomplished by adding flow orifices and flow transmitters to the recirculation lines. The signal from these new transmitters was tied into the control system. Position feedback from the valves is used to position the recirculation valve stem and plug assembly so that the combination of recirculation flow and flow to the boiler equals 1,000,000 pounds per hour (126 kg/s). This has proved quite successful and has made the tran-

sition from recirculation to no flow nearly undetectable. The valves have provided reliable, leak-free service since their installation. During the Spring of 1995 scheduled outage on Unit 1, the recirculation valves on both turbine-driven boiler feed pumps were replaced with identical new design valves set up for modulating control. The Unit 2 boiler feed pump recirculation valves will be replaced during its Spring 1996 scheduled outage.

END

Control schematic

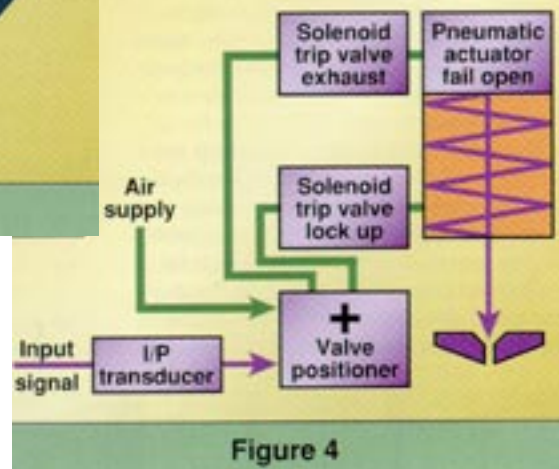


Figure 4

AUTHORS

Mark E. Liefer is an engineering coordinator for Illinois Power. Graduating in 1976 with a bachelor's of science in mechanical engineering from University of Missouri-Rolla, Liefer began working for Illinois Power's Baldwin Station in May of that year. He has held several positions with the company and currently supervises performance and project engineers at Baldwin Station.

Herbert Miller is vice president of operations at Control Components Inc. Miller holds a bachelor's of science in mechanical engineering from Ohio Northern University and a master's of science in mechanical engineering from Northwestern University.

Robert E. Katz is a product standardization manager at Control Components Inc. Katz holds a bachelor's of science in mechanical engineering from Carnegie-Mellon University and a master's of business administration from Pepperdine University.