Technical paper:

Solving McGuire Station's air supply system challenge

In the fall of 2009, Duke Energy, owner of the McGuire Nuclear Station, needed to solve a problem that the plant had regarding an air supply for some critical valves on the raw water strainer backwash system. Duke had to add a back-up air supply system to address concerns about not being able to operate these valves in case the main air supply system was not available.

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The valves concerned are nuclear safety-related and the "defense in depth" concept applied for the plant needed additional assurance that the valves would always be able to stroke when needed. The plant decided to proceed with a feasibility study aimed at designing a system that would operate in place of the normal system if it went off line. This independent backup system needed a separate source of air, and it was decided that the basic design would use a reservoir charged to 350 psi, operating through regulators to step the pressure down to the operating pressure required for the air operated control valves.

The backup system needed to be large and with a regulated output stable enough to guarantee that the air operated control valves would have between 70 - 75 psi available as the reservoir pressure dropped (over an 8 hour period with the valves stroking every 15 minutes). The backup system would be engaged automatically in case of a significant loss of supply pressure in the main (normal) air supply system.

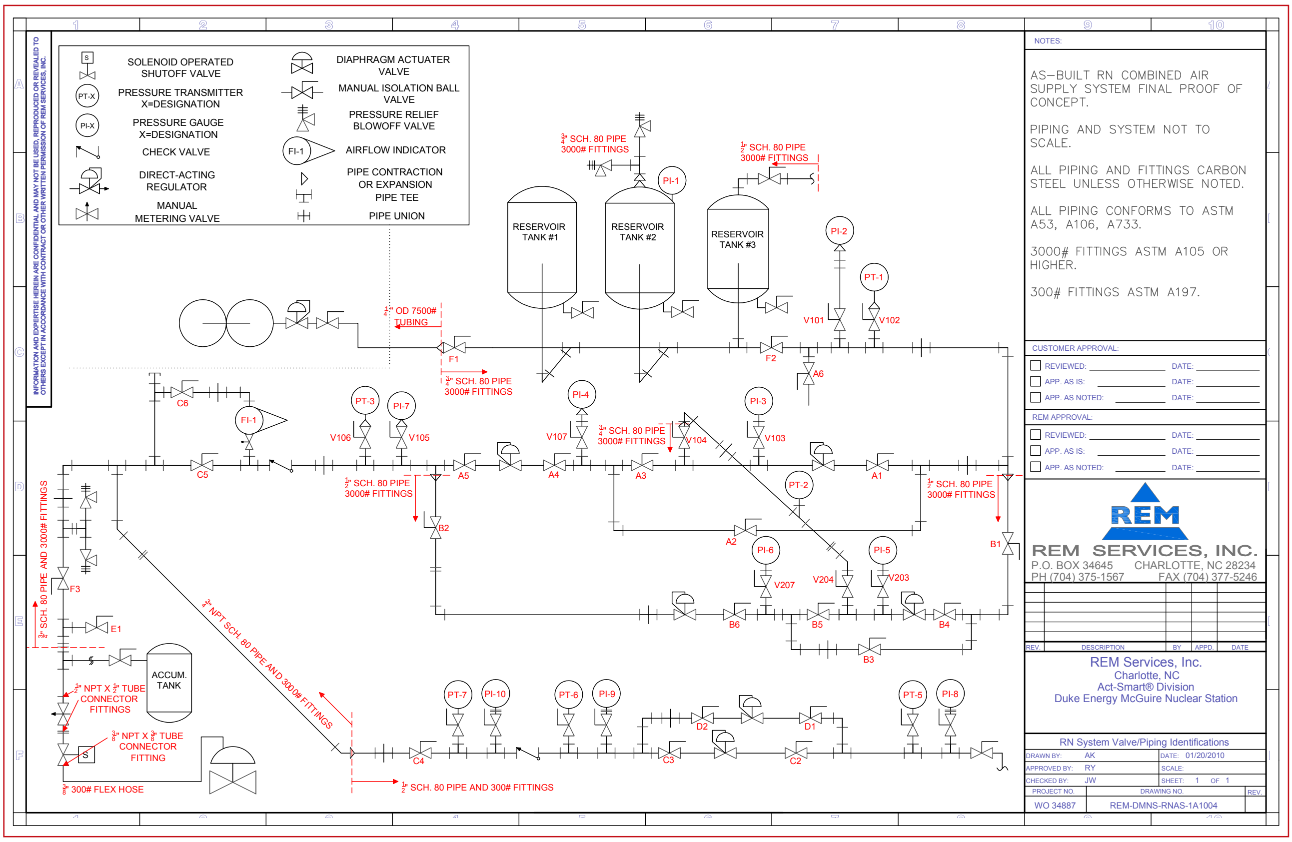

Figure 1. Schematic showing layout of piping and components.

Duke committed to have this new system installed by the end of August of 2010, less than 9 months away at the time. After considering the scope and timing of such a project, the responsible engineers decided to enlist the aid of the RE Mason Co, and the Fisher Division of Emerson process management to help them design and test the system and to then supply the critical nuclear safety related components necessary to meet the specification. They felt that was the only way of meeting the very tight delivery requirements for the project overall.

Figure 2. Overall test set up highlighting the normal air supply circuit

Major design challenges

The major design challenges for the study and the questions that needed to be answered on the final system design included:

- Confirm that the back-up air supply system reservoir pressure can decrease from 350 psig to below 100 psig, while the back-up system output pressure remains steady between 70-75 psig, plus or minus 2 psig. While everyone knew that the regulator output pressure was subject to "droop" (dropping in pressure) when the supply pressure was reduced, there was no way to predict how much droop would occur in this particular system. The 70-75 psi window was required to keep the pressure above the minimum required to operate the valve while never going above the maximum casing pressure of 85 psi for the actuator.

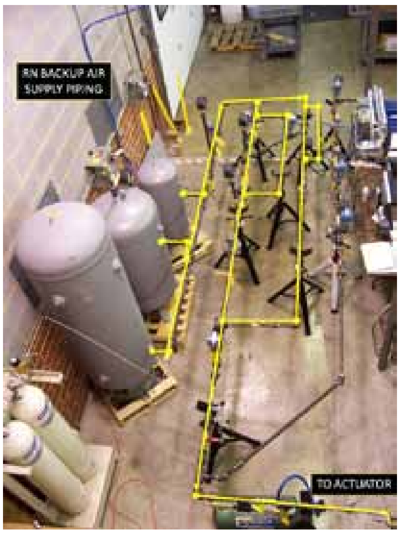

Figure 3. Overall test set up, highlighting both the 1/2" and 3/4" air supply circuits

- Determine how many stages of pressure regulation are needed for the back-up system to maintain this stability, and determine the size of the pressure regulators in question. .
- Determine the droop characteristics of the normal supply regulator, such that the normal air supply system can supply adequate air flow without engaging the back-up air supply system during normal operating conditions. That is, they wanted to make sure that the backup system would not be abnormally engaged while operating on the normal air system.
- Determine whether a metering valve is required to slow the normal air flow to the actuators,to compensate for the normal supply regulator's "droop" characteristics
- Confirm that a 30 ft3 reservoir tank is properly sized to meet the stroking requirements as defined.

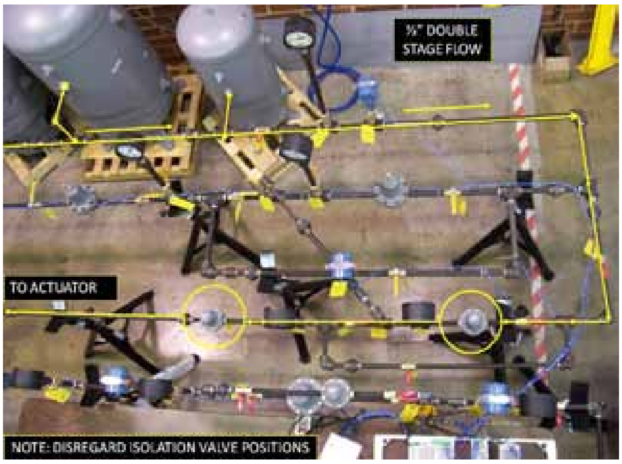

Figure 4. Close-up showing flow from reservoirs through 1/2" double stage flow circuit

Customized test platform

Duke and the design team from RE Mason determined that the best way to get these questions answered was to put together a test platform that simulated the operation of the normal air supply in parallel with the backup system. A schematic of the system is shown in Figure 1. As shown, it included the valve and actuator that were being used in the plant, coupled to both the normal air supply and two alternate backup system loops, one featuring two Fisher 1/2" 95HP regulators, and one featuring two 3/4" 95HP regulators. The backup supply regulators could be operated independently or in series (i.e., as one or two stages), and the backup supply could be operated independently or with the normal air supply system.

The system employed Rosemount Model 3051 smart transmitters and a 6 channel recorder to monitor and record pressures in the system as the various alternatives were evaluated. A rotameter was employed to indicate when the standard air supply system was in use and to verify that its performance was sufficient to avoid inadvertent engagement of the back-up system. See Figures 2-5 for pictures of the system in use in the RE Mason facility.

After a series of test sequences, the following information was summarized in a report to Duke:

- The two stage regulator design provided a more stable output supply pressure than the single stage design over the full 350 - 75 psig supply reservoir pressure, as the reservoir pressure dropped. It was determined that the use of a single regulator caused regulator output pressure to decrease approximately 8 psig as tank pressure dropped from 350 - 75 psig.

- There was no significant difference in performance with the larger 3/4" regulators, so the smaller model was selected to reduce seismic loading concerns since the smaller model was considerably lighter.
- The normal air supply pressure system operated properly and there was very little risk of inadvertently tripping the backup unless there was a real loss of air in this system.
- A metering valve was determined not to be needed to prevent the actuation of the backup supply; however it was still installed in case plant characteristics proved different from test simulation.
- The 30 cubic ft reservoir provided ample capacity to operate the valves as required.

Overall, all objectives for the tests were achieved and RE Mason submitted the report to the Duke Plant Review Committee, who approved it and the plan for installation of the system. The next major challenge for the project was to get the components of the system designed and built in time for the outage.

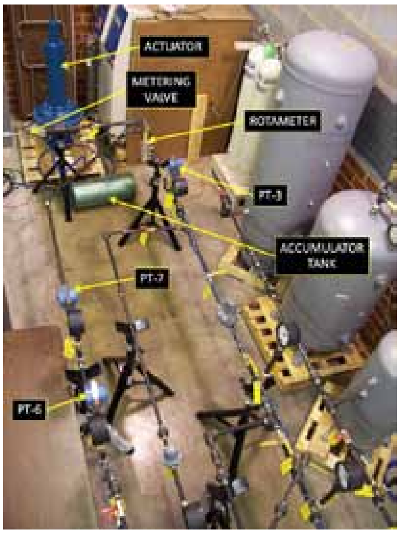

Figure 5. View of test set up showing Pressure transmitter locations and valve and actuator

Working to strict specifications

That is where the Fisher Division of Emerson Process Management stepped up. Once the system design was approved, they met with the Duke project engineers in two days of meetings to go over in detail the requirements for the regulators, to discuss the design specifications, and to review the overall schedule. We were now in February, and the first batch of regulators would need to be delivered by June 1st, only 4 months away.

The major complicating factor in this part of the project was that the regulators needed to be nuclear safety-related and designed to ASME B&PV Code, Section III. That meant that a special design was required. All the requirements for this order were finalized and the team kicked off the manufacturing portion with a revised purchase order that was issued on March 11. It was a tribute to all three members of the team involved, Duke, Fisher, and REM, that the outstanding issues were resolved in very quick fashion in meetings and phone calls that kept things moving. Even with this good effort, the team still had less than 3 months to design and fabricate a nuclear grade, safety-related

The project team from RE Mason and Co. Left to right: Alex Kidd, Jake Henault, Ray Young

component. That type of delivery window is normally unheard of in the nuclear industry.

Sub-suppliers were contacted and commitments made for delivery of the raw material. The project managers were checking daily on progress and communicating on a weekly basis with the Duke team to insure that they understood the status and to enlist their aid as open items came up. A lot of very good work was accomplished over this period by all 3 members of the team. Fisher's project manager worked very closely with the specialists within the Nuclear Value Steam to keep things coordinated and moving quickly.

In summary, the first batch of regulators was delivered on June 7th of 2010. That was actually 6 days later than anticipated, but still in time to support the first work in the outage. The last batch was delivered on July 26th, about 3 weeks early. At last report, everything has been installed and is working exactly according to design.

In closing, this is a great example of what can be achieved in a very short period of time when the parties that normally work in isolation, like end-users and vendors, break down the walls that separate them and work within a framework of trust and cooperation. There is some risk in this approach if the parties don't have a very solid, long term relationship based on trust and performance, but the dividends it pays, as seen here, can be considerable.

The Fisher team