



**SYSTECH**

9014 Heritage Parkway, Suite 304  
Woodridge, IL 60517-4939  
Ph: 630.515.0200 Fax: 630.515.0214  
www.systech-inc.com



## 24 VDC Wiring and 'Smart' Pneumatic Valves on a Control Bus in a Ready Mixed Concrete Control Application

### Purpose

The purpose of this paper is to introduce the reader to advanced technologies that are available and have not been traditionally used to control Ready Mixed Concrete plants.

### Introduction

This object of this paper is to examine the benefits of utilizing 24 volt DC electrical plant devices and intelligent pneumatic controls in the operation of a traditional ready mixed concrete plant. The electrical plant devices on a typical ready mix concrete plant are those that generate signals such as limit switches, liquid meters, and analog devices (IE: temperature controls, load cell signals, etc.). Control devices utilized in ready mixed plants usually consist of pneumatic valves that open/close gates or operate other mechanical plant components; and motor starters that drive conveyors, screw feeders, mixers, etc. This report will compare a traditional plant setup with a plant setup versus a ready mix plant using current 24V DC and intelligent valve technology. The paper will show the operational, safety, and cost benefits of newer available technology both long and short term.

### Historical Perspective

Early concrete plants were controlled with human powered lever actuated gates and dial scale heads for weight readings. The environment for the operator was harsh and extremely hazardous. The quality of the product was inconsistent and production was slow. Decisions were entirely under the control and responsiveness of a single operator who had to react to mechanical issues as well as variations in material flows with split second timing. The quality of the end product was inconsistent at best, and a myriad of safety issues posed a constant danger to anyone in proximity of a plant. These early plant control systems provided no method of recording what went into each load of concrete, any method of knowing what should have gone into each load, or any method of analyzing these results for the purpose of improving subsequent loads or controlling material inventories.

The next step in their control evolution was to 120 VAC push-button manual control stations that controlled pneumatic valves to operate the gates. Often the dial scale lever based scale systems remained in place but started to be replaced by digital readouts via the introduction of load cells placed within the mechanical lever and draft rod system that powered the dial scales. Some models of control panels in this era even provided methods of indentifying standard mix designs to provide the plant operator with consistent target weights for specified product designs. This environment was much improved for the operator and hazards to the operator greatly diminished. The product still remained inconsistent and production was slow. The issue of accurately recording the actual amount of materials utilized in a particular load, and any subsequent analysis had not changed however.

The majority of ready mixed concrete plants today operate with computer control systems that require 120 VAC pneumatic valve control to the gates and 120 VAC input and output signals to devices on the plants. These computer-based control systems provided a method of pre-defining the components and correct quantities required for each load, while automating the response necessary to accurately deliver the target quantity of each component in a prescribed sequence. These computerized control



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systems resolved the issue of recording the actual results of each batch of concrete, and provided a mechanism of subsequently analyzing those batch results for performance and plant operational purposes. However, these new computerized control systems relied on the same sensing devices and pneumatic valve technology that had been utilized for many years. The pneumatic valves in use required regular maintenance for the control to function properly, as well as regular lubrication which was difficult (and many times dangerous) to maintain. Though the control systems and plant electrical devices commonly used today have proven to be somewhat reliable and functional, they require extensive quantities of 120V wiring and are prone to problems, like surges, associated with AC power. Production and quality were greatly improved because the computer systems could predict and react to plant and material conditions faster than an operator could with an older style manual control, and there was far less time spent making small corrective steps to get as close as possible to the desired results in each load of concrete.

With the extensive number of connections required and the harsh environment (corrosive materials, vibration, wide temperature fluctuations, exposure to lightning, etc.) encountered, these 120V wiring systems require substantial amounts of regular maintenance and can be dangerous to work on because of the heights involved and exposure to powerful mechanical apparatus. While working knowledge and experience with 120V wiring circuits is readily available and well understood, problems with these controls often prove hard to diagnose because it is a tedious process to test each leg of a circuit and trace it throughout the entire plant. Non-standard proprietary control boards used in most control panels, and complex software adjustments that are customized on each plant added to the difficulties. The operator was required to have more technical, non-industry related knowledge to accurately diagnose and trouble shoot these computerized control systems.

## Application of 24 VDC control on a control bus

Advancements in control and pneumatic technology have been introduced and are widely accepted in many industries that have only recently been made available to the ready mix concrete industry. This new technology now makes it possible to connect an integrated batch control system to a ready mixed concrete plant via one communication bus. To implement such a system only a network cable to the plant is necessary, replacing the myriad of wires and connections associated with current 120V wiring. The network will connect to a node (electrical device or control valve) or nodes located in the plant. This network can be run wirelessly or via fiber optics for isolation purposes. Each node contains a communication module that is responsible for controlling its individual functions. Functions including pneumatic valves, analog devices, or input or output signals can be connected at each node. These functions operate on or below 24 VDC, which has become the standard environment for industrial controls in many other industries. This 24V DC network greatly reduces the number of wires and connections required resulting in substantially less maintenance, while also greatly simplifying the design and installation of the entire electrical system. The cables utilized in a 24V DC system are typically premade and resemble network cabling within an office or home - complete with a connector at each end that may resemble an RJ-45 plug. Each node has built in intelligence that can identify (typically via a remote Internet-based software application that immediately identifies any broken signal path on malfunctioning node component) to the operator or technician if there is a problem. In this manner, a centralized technician can monitor, troubleshoot and direct repair activity for ready mix plants on a global basis much faster and far more accurately than was previously possible. Each node is designed in such a way that components that fail are "plug and play" and can be replaced in minutes, thus greatly reducing the time for both diagnosis and repair/replacement. Plants utilizing 24V DC wiring have less down time due to low to no maintenance than those wired with 120V wiring, and therefore maintain higher levels of production. Because of the lower voltage and the resulting lower levels of heat generated by 24V DC, electrical devices (sensors and switches) running on 24V DC typically experience life cycles in excess of 10X their 120V counterparts, which further reduces maintenance activity



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associated with the control system. These lower voltage systems and devices are also far safer for maintenance people to work on, which is of great concern given the location of many of these devices on a typical ready mix plant. Typically, 24V DC systems are not required to be run inside conduit. Due to the nature of DC wiring, control signals sent via a DC circuit are much faster and more accurate than is possible with any AC based wiring system. A key disadvantage to DC wiring, however, is that DC signals are limited to short (40' to 60' maximum) distances. Therefore 24V DC systems must be designed to incorporate power boosters when overall control segments in a network require longer operating distances.

These 24V DC wiring systems are available from several major suppliers of electrical and control system suppliers, including: Murr Electronics, Eaton, Schneider, and Siemens. Further, they can be utilized with any computerized ready mix plant batch control on the market today. Obviously, it is easiest to design and implement a 24V DC wiring system when constructing a new plant, but they have also proven to be economical to install when an existing plant requires an extensive amount of re-wiring.

## Programmable Logic Controllers (PLC's)

It is common knowledge that Programmable Logic Computers (PLC) have been in use in industrial environments for many years.



PLC's now control almost all manufacturing in the world, including batch plants. Most PLC manufacturers sell the hardware, and also keep their computer programs proprietary (also called "closed" - so they can charge registration fees for service and updates). But, in the long run, most PLC's, like valves, share essentially the same basic technologies.

There is a core unit that is the central computer, and then modules are added on to the central computer unit. The most common modules are input and output modules. The I/O can be either 120vac or 24vdc. The outputs from the PLC on a concrete batching plant blow the alarm horns, start the conveyor, and actuate valves that open or close mechanical gates and energize the valve to run the vibrator. Inputs are devices that send information to the PLC so that it understands the machine environment, and makes logical decisions based on that information. Typical inputs on a batch plant would be bin indicators, scale weights, and cylinder proximity sensors. PLC based controls is currently very popular in the concrete batch industry. Until Serial Interface became available, the only option was using a PLC, terminating all the inputs and outputs in a central location with banks of relays or I/O devices - typically in one main enclosure junction box. In this design, every input and output uses a separate wire. This is called "centralized I/O".



*An example of a wiring junction box that has been modified over the years.*

Serial Interface offers distributed I/O as opposed to centralized I/O described above. By using serial controls and I/O modules, it is possible to reduce the wiring substantially.

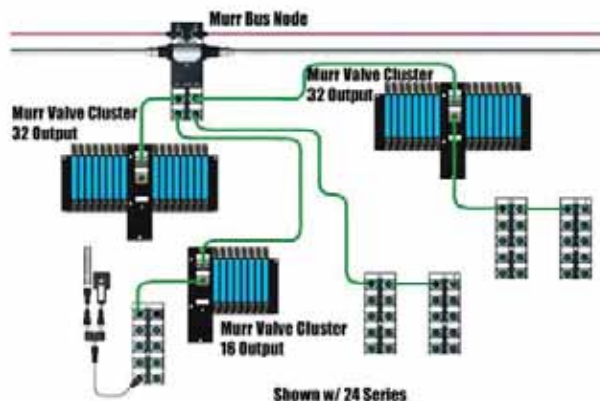


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Serial Interface I/O's use 24vdc exclusively. 24vdc is the world standard for manufacturing and automation applications. Data is carried through serial cables as bits of information. These bits are a series of ones and zeros. The ones and zeros contain data such as the "address" of the I/O it needs to find, and whether or not to turn on an output or check the status of an input. The data goes through the wires one after the other, hence the name "serial". Due to the digital format of this data, the use of fiber optic cable is ideal to connect the controlling PLC or computer to the valve bank control unit. One wire can carry thousands of bits of data, and it does this very quickly, even as it isolates the controlling PLC or computer from any electrical surges (lightning, shorts, voltage fluctuations, etc.) from the plant. The time required to wire an entire Batch Plant can be reduced dramatically, along with a reduction in the amount of wire needed.

Serial Interface requires a "Bus Node". The Bus Node is like a traffic cop, directing the data sent by the computer to each I/O Module.

**MAC/MURR Serial Interface System**



The Bus Node operates using a selected protocol, or software. There are several available, but Ethernet is proving to be the most popular. The I/O Modules can be placed yards away from the Bus Node, which is why it is called "Distributed I/O". The I/O modules are placed close to the devices.



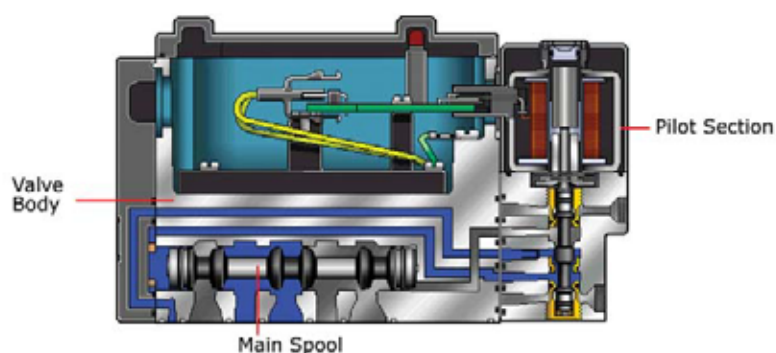
*An addressable valve bank can be connected directly to the process control computer without the need for a junction box and all of the associated wiring.*



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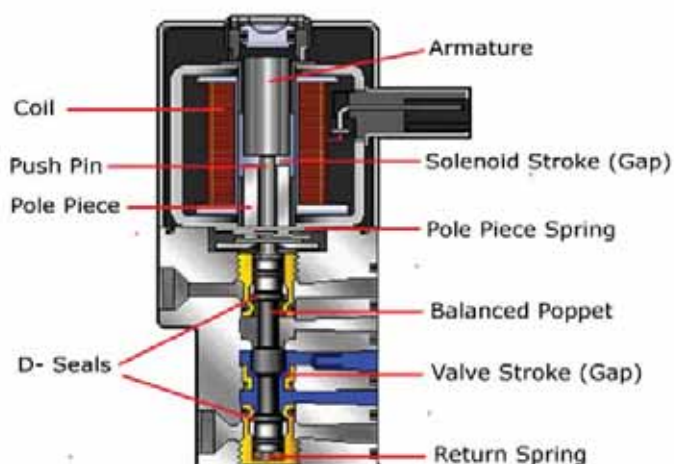
## “Smart” Pneumatic Valves

A separate, yet complimentary technology is that of addressable “smart valves. These addressable valves provide a number of advanced technology features in industrial applications that have proven to be ideal for use on ready mix concrete plants. As the name indicates, these addressable pneumatic valves contain a serial control component within the valve assembly that eliminates the need for a relay or other control device to communication with the control computer or PLC. Originally designed to work in conjunction with the Device Net communication protocol developed by Rockwell (Allen-Bradley), these addressable valves can now operate via an Ethernet communication network.



### MAC 93 Series 4 way, two position pneumatic valve

While these types of valves are available from all major valve manufacturers, the illustrations and references contained within this paper reference the addressable valve product line designed and manufactured by MAC Valves, Wixom, MI, who have established a leadership position for this type of product based upon their (many patents pending on unique design characteristics) and proven product quality.



*The design and components of a typical MAC pilot assembly*



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The MAC pilot assembly has many patented design features. There are many design features to the MAC pilot, but the main features are;

- Very small gap between the armature and pole piece. This “short stroke” feature allows for high forces to be generated when the valve coil is energized.
- Balanced Poppet. MAC does not use a seal on the end of the armature, which is a very popular method for many valve manufacturers. The air pressure applied to the “unbalanced poppet” has a direct affect on the valve’s shifting speed. More air, more speed, less air, less speed. The MAC “balanced” poppet has the same area on both sides of the sealing surfaces. A MAC valve will always shift with virtually the same speed regardless of air pressure. This is extremely important in applications where timing is critical, such as opening of aggregate gates when batching concrete, or applying glue to a container moving at a high rate of speed.
- Poppet D-Seals. The seals are molded to a unique shape that resembles a “D”. Once again, better sealing and less friction.
- Movable Pole Piece. MAC Valves, with the correct voltage applied, will never burn out. Coils normally fail when the armature sticks in place, does not complete the circuit between the pole piece and the armature, in-rush current exceeds the rating of the coil, and the coil burns out. Especially in A/C applications. With the movable pole piece design, MAC coils are guaranteed for life against burning out.

So where did this term “Smart Valve” come from? When Serial Interface technologies became popular, several pneumatic valve manufacturers started offering valve “packages” that included the valves, and the serial interface components required to “talk” to the controls. This is where the term “smart valve” came from.

Pneumatic valves on this system are designed to be “no maintenance”. Due to use of high quality assembly grease, serial valves such as those manufactured by MAC require no lubrication (eliminating the need for self oilers and their associated maintenance issues) while having an expected life cycle that can far exceed the life cycle of other types of valves. This is an important feature in a production environment like ready mix concrete that requires no down time.

The PLC or computer control system “talks” to a control module at the end of the valve manifold. Valve banks need to be placed within proximity (20-30 feet) of the solenoids so that any variations in system responsiveness due to air pressure fluctuations are minimized. Valve banks can easily be daisy-chained together via a single cable. The pneumatic connection from each valve to the actuator is made via plastic air hose (typically 1/2”, but sized per the specific requirement) and built-in, quick fit connections. This scenario eliminates the myriad of electrical connection points that can corrode or vibrate loose, and provides for remote diagnosis of valve failures or performance issues.

## Conclusion

The technology incorporated in the complimentary components of modular 24V DC wiring systems and the addressable “smart” valves described within this paper provide a host of operating advantages that are ideal for the control, maintenance and operation of ready mix concrete plants in a cost effective manner. By reducing plant maintenance, improving operator and maintenance personnel safety, reducing plant down time, and improving control accuracy and responsiveness; these technologies should be strongly considered for any ready mix plant operation.

Tom Wright, The Hartfiel Company  
Ben Gordon, Elite Batch Systems LLC  
John Rabchuk, Systech, Inc.

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