Productivity is more reliable when equipment can be monitored to detect incipient failures and take corrective action before the plant goes down. But many devices, such as analog control valves, pneumatic valve terminals and field sensors, often do not offer diagnostic feedback, or it is not being used. This white paper describes how this problem is being addressed, and includes an example of pneumatic valve terminals that can monitor, among other things, open load or coil currents at the specific valve, pressure inside the valve terminal, and when a manual override has not been reset.
Information about the health of a control system, the I/O systems, field devices and final control elements can be critical for plant operation and uptime. Timely diagnostic information can mean the difference between a quick repair and hours or days of unplanned downtime. This is especially true of pneumatics and solenoid valves used as air pilots, which are often the forgotten parts of a modern control system.

In the past, and in many plants even today, diagnostic information is captured in many ways, including manually, using clipboards, Excel spreadsheets, barcode readers, and by laptops carried into the plant. Much of this data winds up being unused and discarded. The information isn’t available in real time to allow real time decision-making on the part of operators, engineers, and maintenance managers.

**The Connected Plant**
The concept of the Internet of Things, developed a decade ago by a group of visionary companies including Cisco, provides a way to think about organizing the information in a plant, from operating variables to maintenance and diagnostic information.

Originally called Machine to Machine (or M2M) Communications, the Internet of Things posits that every sensor, every controller, and every final control element, whether valve or variable frequency drive, be connected in real time to every other device on the manufacturing network, and from there to the rest of the plant and enterprise networks throughout the enterprise.

There are both benefits and negatives to the Internet of Things, as with most technological advances, but the benefit to manufacturing is that it is becoming almost ridiculously easy to connect all the devices in a plant to a real time network.

The minute you can get information from all the devices in a plant in real time, you have the ability to operate the plant, and maintain the plant in a significantly different way from the past. Real time operations data enables the plant to be “tuned” to operate in the most efficient or most profitable manner (they are not always the same) and provides the ability to apply the techniques of the other new information technology, Big Data. For maintenance and operations, being able to get information to and from all the devices in the plant in real time makes asset management practical in a whole new dimension.

**Benefits of Asset Management**
The basic benefits of asset management are clear. Proactive asset management can prevent extremely costly unplanned shutdowns. How costly is “extremely costly”? A catastrophic failure of a master pump in a refinery could cost not only the entire production of the refinery for the length of the downtime, but also additional costs from cascading failures of additional components. A failure of a temperature sensor in a biotech plant could cause the spoilage of literally millions of dollars worth of product. A missing additive in a batch, caused by the failure of a single solenoid valve, could result in scrapping the entire batch, at a cost of possibly millions again.

What you need to do is to see a failure coming, before it occurs. It is necessary to get the data in real time to be able to see those potential failures. The problem is that while that information does exist, getting it to plant operations and maintenance personnel in real time can be truly difficult.
Both PLC and DCS control system vendors such as Emerson Process Management and Rockwell Automation promote diagnostics based asset management systems. It is possible to seamlessly interface any controller, I/O terminal, or pneumatic solenoid manifold into these systems but not all devices offer the same level of diagnostic feedback. Emerson's CHARM I/O connects HART compatible field devices and communicates diagnostics back to the control system and the asset management system. Other Emerson I/O does the same for Foundation Fieldbus. But CHARMs are not designed to handle control and diagnostics of solenoid pilot valves mainly because for many valve manufacturers that technology is lagging.

Another common platform is Rockwell Automation's RSLogix systems which can connect with various brands of I/O and field devices using Ethernet/IP, but when you start talking about pneumatics valves the same issue arises. Similar to the Emerson example, manufacturer technology in most cases limits the functionality of pneumatic pilot valves mainly because for many valve manufacturers that technology is lagging.

The solution is to specify pneumatic solenoid valves with diagnostic capability, whether used for handling automation or piloting.
Advent of Diagnostics on Solenoid Air Pilot Valves

This is much more important than it may first sound. In a typical Pharma plant doing API production, there may be literally thousands of solenoid pilot valves in control panels, mounted on machines, and mounted on walls. While a typical solenoid lasts seven to ten years in an API plant, if any one of these valves fails, there may be a cascading failure that may ruin the process or batch that is being run. Having predictive diagnostics on these valves may save thousands of dollars, or even more, in the event of failure.

It doesn’t help to keep the plant from going off line if you have all the analog sensors and all the analog control valves producing diagnostic information, but the diagnostics from your plant’s population of solenoid air pilot valves can’t be seen. What inevitably happens is that the solenoid valve will be the point of failure that shuts down the plant or the batch reactor train, or the entire process, because predictive maintenance cannot be applied if the diagnostics from the solenoid valve cannot be seen.

It is good practice, then, to purchase solenoid valves, I/O, and controllers that have rich diagnostics built in. In most control systems a pneumatic solenoid valve appears merely as a digital output and a local LED.

Pneumatic valve terminals are available today which can supply open load or coil current monitoring at the specific valve, pressure monitoring inside the valve terminal and even detect in a manual override has not been reset.

A solution is to consider the Festo CPX/MPA. This product will integrate with most leading PLC and DLC platforms and deliver uniform control and diagnostic information from the field, including I/O, I/P and pneumatic solenoid valves. The diagnostics is already built in due to an internal bus that runs thru the backplane of the pneumatics and I/O.

The Festo MPA series of solenoid valves offers full pneumatic diagnostics when used with the CPX controllers, including cycle count, line pressure, and failed solenoid indication. It also enables the designer to install up to 128 solenoids on a single manifold. This is four times the density of competitive manifolds. This reduces installation footprint, and more.

Example of Performance and Value:

Versatile CPX/MPA integrated I/P is able to both pilot process valves and control inert gas flow directly to reactor vessels.
On the electrical side, the CPX terminal has combined five different I/O connection technologies for digital and analog I/O, and multiple I/P transducers can be mounted with the pneumatic valve and electrical I/O. Festo offers an option for IP20 high density digital I/O for cabinet installations, as well as the ability to support redundant bus control with embedded controller and isolated power zones for safety.

Detailed diagnostic functions are needed to locate the causes of errors in the electrical installation and reduce plant downtime. The Festo design begins with optionally color-coding valves and LEDs, which Festo believes simplifies validation and troubleshooting. Festo calls this on-the-spot diagnostics. Further point diagnostics are available from the manifold, or through the bus connection to the control system via explicit messaging. Festo on-the-spot diagnostics include undervoltage monitoring, fieldbus status, controller and I/P transducer status, and module specific diagnostics as well as valve-specific diagnostics and solenoid coil status.

Short circuit detection for sensors, outputs and valves is supported. Open load detection finds missing solenoid coils.

Festo's CPX series terminal also has on-board history, which can store the last 40 causes of errors, along with error start and end times.

Diagnostics can be also retrieved using a hand-held terminal, or by using Festo's maintenance tool software on a laptop, and are capable of being read out on the fieldbus interface and historicized to evaluate the causes of errors and failures. The series offers optional access via the integrated Ethernet interface for remote maintenance using PC or Web applications.

Selecting the Festo CPX series can provide a whole new level of diagnostics when the end user is specifying the I/O and solenoid air pilot valves for a skid or integration project.

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**Diagnostics and the Connected Plant**

As the Internet of Things becomes more of a reality, and penetrates the industrial process and discrete manufacturing operations, the value of diagnostics will increase exponentially. Diagnostics will be critical to the acquisition of process data, and will provide the device health data that is necessary to fully enable predictive maintenance throughout the plant.

Most vendors of control systems have integrated diagnostics for electronic sensors and electronically-actuated control valves. Simple on-off valves, like solenoid air pilot valves, have often been overlooked because it has been a standard assumption that these valves are not as important as control valves, or field sensors. Pneumatic solenoids have been bypassed or ignored for diagnostic purposes for years.

But this will need to change, as all of the sensors and field devices in a plant become connected and smart.

In the pharmaceuticals and biotech industries, validation and GMP issues have increased the demand for real-time diagnostic information. At the same time, the increasing use of skid-mounted production processes has made the use of dissimilar control systems a near certainty. This means that end users must insist on diagnostics in every I/O terminal, in every sensor, and in every final control element on their skid. I/O must have easy diagnostic information transfer using fieldbus. Festo's CPX/MPA series provides a way to produce that as a plant standard.

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**Undervoltage per module**
- Electronics
- Load -10%.
- Emergency-stop ≤10V.

**Short circuit selectable**
- For each channel.
- For each module.
- For each valve.

**Wire break selectable**
- For each channel.
- For each module.
- For each valve.

**Upper/lower limit value**
- For each analogue channel.
- Voltage.
- Current.
- Temperature.

**Error memory**
- Last 40 messages.
- With a time stamp.
- Recognising of sporadic errors.

**Condition monitoring**
- Setpoint specification for each valve.
- Monitoring of downstream mechanics/processes.
- Preventive diagnosis/maintenance.

**Undervoltage per valve manifold**
- Additional supply for valves monitored separately.

**Monitoring of space required control**
- Pull current.
- Coil clamped.
- Manual override not reset.

**Pressure-monitoring**
- Threshold value.
- Comparator.
- 16-bit numeric.

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