

CONTROL

F O R T H E P R O C E S S I N D U S T R I E S

FIELDBUS IN BIOPHARMA, PART 2

More on how Genzyme's multi-bus platform handles an entire manufacturing suite. **by William T. Dolan, PE, Genzyme Corp.**

Genzyme Corp. recently installed a multi-bus control system platform at its 12-year-old pharmaceutical facility in Allston, Mass.

This was our first introduction to bus technology at Genzyme, and our subsequent selection of bus technologies was based on the process equipment needs within a cell-culture and protein-purification manufacturing environment. Bus technology is used in process areas electrically rated General Purpose and Class 1, Div. 2.

[“Fieldbus in Biopharma, Part 1,” *Control*, July '06, p.58, focused on why Genzyme decided to use fieldbus, how and where it was deployed, and what architecture was used. Part 2 continues coverage of how Genzyme's fieldbus segments were designed.]

More Segment Design

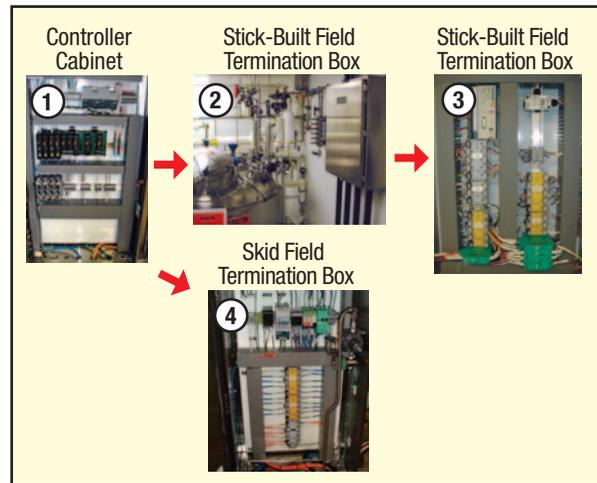
The buses selected included powered buses FF and AS-i, while the unpowered buses are Profibus-DP and DeviceNet. The goal was to have the stick-built process equipment use an identical segment design. This allowed us to develop segment design standards that were followed by our engineering design contractor and the skid vendors.

In the third picture in Figure 1, you can see green modules near the bottom of the panel. These are discrete I/O modules that are attached to the AS-i segment in this cabinet enclosure. Transfer panel proximity switches are hard-wired from the transfer panel location to these modules. There was a concern about not exceeding the AS-i bus segment length, and so the segment length was minimized by placing the I/O modules in the field termination box (FTB) and not at the individual transfer panels. Today, this may not be a concern because segment length is less restrictive with AS-i segment tuners, which didn't exist when our project was implemented.

It's typical in biopharmaceutical facilities to use portable equipment for more than one process unit, such as a bioreactor, because of the clean-in-place (CIP) process, which requires manual setup with transfer panels and hoses to

ready a process unit for cleaning. The cleaning process is highly automated with sequencing of various piping flow paths done by manipulating open/close diaphragm valves. Cleaning bioreactor units requires a portable valve cart (Figure 2) to be hose-connected manually to various process piping headers on the bioreactor. This particular cart

FIGURE 1
FIELDBUS SEGMENT DESIGN



Segment design includes the following components: 1) host control system cabinet with the various fieldbus I/O cards along with their respective segment power supplies; 2) stick-built field termination boxes (FTBs) distributed in the process area; 3) interior view of typical FTB; and 4) interior view of typical skid FTB.

includes five automated diaphragm valves that are part of an AS-i segment. The AS-i protocol immediately recognizes these valves by their unique addresses. The single bus connection represents five discrete outputs for the valve actuator solenoids and 10 discrete inputs for the open/close limits for each valve. If this weren't a bus design, then potentially

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there would have been the need to wire 15 cable pairs or 30 conductors to a larger portable connector.

Unpowered Buses

Profibus-DP and DeviceNet have very straightforward wiring practices. They both follow a multi-drop wiring or daisy chain wiring schema. Wired in a similar fashion to each device is the required 24-VDC power supply. As mentioned earlier, DeviceNet is used to interface variable-speed and single-speed motors. Our motor-control center is scattered about the facility and tends to serve more than one process unit. For example, two bioreactors and one seed reactor have all their respective motors in the same motor-control center (MCC). To maintain independent process units, three separate DeviceNet trunks feed this MCC, including one from each of the two bioreactor trains' controllers and one from the seed reactor controller. Since each unit has its own separate controller, it follows that the MCC interface should be unique for each.

Fieldbus in Hazardous Settings

Most of our purification space is classified as Class 1, Division 2, Group C and D. Our first introduction to fieldbus was in the cell culture side of the facility, and this space is electrically rated as General Purpose. Moving segment designs already in place for general-purpose areas into an electrically classified environment required changing which buses we could employ from those used in cell culture. Immediately, AS-i wasn't appropriate due to its high power levels. However, FF can be used in a Class 1, Div. 2 electrical environment and in a Class 1, Div. 1 space.

Added to the market at the time of our implementation was FF's Fieldbus Intrinsically Safe Concept (FISCO). It has many desirable attributes, such as eliminating the requirement for entity parameter calculations, less documentation to develop and maintain, instruments that can be added later to the segment without the need for further segment analysis, and higher power lev-

FIGURE 2
CIP CART



Cleaning bioreactor units requires a portable valve cart to be hose-connected manually to various process piping headers on the bioreactor.

els that allow more devices per segment. Before FISCO, segment device count usually couldn't exceed four devices for an Entity IS segment, but the count could be as high as 12 with FISCO.

Because it was new, our design presented a concern regarding the availability of field devices certified for a FISCO implementation. We found all the devices we used on the cell culture side of the facility that would be used in purification were FISCO-certified, and so we could continue to use the same suppliers and devices. Though the FISCO implementation is designed for a Class 1, Div. 1 electrical environment and our space classification is Class 1, Div. 2, we decided to pursue the FISCO design because it meant that all segment and device maintenance and troubleshooting could be accomplished with a powered segment or device.

Shortly after FISCO was introduced, another non-incendive design appeared. This Fieldbus Non-Incendive Concept (FNICO) is intended specifically for Class 1, Div. 2 electrical environments. There was a comfort level in the facility with intrinsically safe (IS) implementation, which ensures that facilities personnel never have to think about powering down instrumentation

prior to performing maintenance or troubleshooting.

Figure 3 depicts a Foundation Fieldbus segment design that has the same look and feel as Foundation Fieldbus used in general purpose areas.

Earlier, we mentioned that AS-i wasn't appropriate for IS applications. Therefore, another solution was sought for the discrete devices in the electrically classified space. An IS implementation with FISCO and an IS solution were envisioned for the discrete devices. We tried to keep host controller cabinets in safe-area spaces, and only allow I/O subsystems in process spaces. IS remote I/O was installed in the process space to interface to low-power solenoid operators for valve actuators, valve position limit switches, rupture disk indicators and transfer panel proximity switches. The remote I/O modules are intrinsically safe, but the communications, Profibus-DP, to each is not. Profibus-DP can't be implemented intrinsically safe though it's a non-incendive design.

Fieldbus Instrumentation Attributes

Our experience with fieldbus shows there are some fieldbus devices that lend themselves nicely to biopharma applications. A few instruments can illustrate this point.

The first is the Rosemount 848T temperature transmitter, which also allows for other input types besides RTD and thermocouple. Steam-in-place (SIP) is a common process in biopharmaceutical facilities for sterilizing process vessels and piping. SIP is usually automated with multiple temperature elements at various low-point condensate drains, and usually has five to eight temperature elements per vessel. In the case of a bioreactor, the temperature element count can approach 30 or more. In the early design stages of our cell culture facility, there was some concern about how to handle the many RTD inputs with a bus system. Certainly, a Foundation fieldbus transmitter for each input would be unwieldy from a construction standpoint, not to mention the cost. Fortunately, 848T

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allows up to eight inputs per instrument, which reduces the device count. We also use this device to convert conventional 4-20 mA/DC devices to Foundation fieldbus.

Likewise, Micromotion mass flowmeters are used extensively in our facility, for example, on chromatography skids. From one fieldbus connection to the device, we can realize all four process variables measured or calculated by the mass flowmeter. These include mass flow, volumetric flow, fluid temperature and fluid density. Typically, volumetric flow is the primary value of interest and is a calculated value from the device (mass flow/density). Volumetric flow is used as the process variable for the flow control loop on the chromatography skid. Initial running of the skid requires priming the inlet buffer lines.

While executing the prime phase, we've noticed that when two-phase flow is introduced through the meter, the density will drop in proportion to the two-phase mixture, causing the volumetric flow to read high. Since we prime the various buffer lines based on passing a certain liquid volume, it's important to totalize only liquid flow and not two-phase flow. To prevent totalizing of two-phase flow, we use the density input, detect when it's no longer that of a liquid and then turn off the totalizer. In this case, the host controller is actually writing to a parameter in memory in the fieldbus device. This ensures that all buffer lines have had the predetermined liquid volume transferred and shows the two-way communication available with fieldbus devices.

In addition, Gemu manufactures valve actuators for on/off diaphragm valves. These valve actuators communicate to the host by way of AS-i bus. The valve actuators have a solenoid valve and open/close limit switches in the actuator's topworks. It's not unusual to find diaphragm valves open for SIP and then indicate "valve not closed" when commanded "close" at the end of SIP. This is due to the diaphragm being more malleable when heated, which allows the actuator stem to drive the diaphragm slightly deeper into the weir of the valve body past the pre-

viously set or cold diaphragm-closed position. This device includes a programmable hysteresis for the open and closed limit switch that allows for process condition. Typically, it's the closed limit switch we're interested in confirming in the case of sterile boundary valves.

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IMPACT OF FIELDBUS AT GENZYME

Fieldbus helped us in five areas:

- **Expanded view for operators, engineers and technicians.** From any operator workstation, it's possible to drill down to the instrument configuration and quickly assess current instrument operating status.
- **Reduced wiring and installation costs.** Our qualitative sense tells us that, because of the reduced number of home-run cables and associated conduit size reductions and quantities, our installation cost must be less.
- **Reduced I/O equipment and control cabinet size.** Though our controller cabinet sizes are reduced, we may have more cabinets compared to a conventionally wired system because of the added cabinet count for field termination boxes.
- **Reduction in man-hours for commissioning and start-up.** We believe the effort is essentially identical for fieldbus and conventionally instrumented system. Perhaps we haven't optimized this activity because there are many proponents that advocate this point.
- **Reduced total cost of ownership.** We believe this will be true when we eliminate "run to failure" or scheduled maintenance. Cell culture production can run for months at a time, so it's imperative that the instrumentation platform be robust so bioreactor runs aren't terminated early due to instrument problems. We have evidence to date that the fieldbus platform has enabled us to remedy imminent device failure before the start of a production run.

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