Volume 2 • Issue 3
MAY – JUNE 2001

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the EXTENSION
A Technical Supplement to control NETWORK

IMPLEMENTATION OF A CONTROL PROJECT

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In the last Extension article entitled, "Introduction to Control," we introduced some basic control systems concepts. We discussed the topic of measurement and the role of input and output transducers within either an open or closed-loop control system. Now we will examine how control systems are actually implemented in industry.

THE SYSTEM INTEGRATOR

A company that develops a control system or automation project is called a system integrator (SI). The SI company can be small (one man) or large. SI assists end-users (clients) who lack adequate in-house resources for designing and implementing automation and control projects themselves. A SI is a specialist with a good knowledge of automation equipment, computers and programming. Most clients do not possess many of these skills; therefore, the SI supplements the engineering department (or lack of a department).

Twenty years ago clients in the various discrete manufacturing or process industries would have had large resident engineering staffs incorporating specialists with titles such as process engineer, control engineer or instrumentation engineer. By having the resources to manage and implement their own automation projects, the client was able to keep secret proprietary processes or systems as a competitive edge. However, those days appear to be over. With the "downsizing" and organizational "flattening" movement, the technical resources have been outsourced. The client is no longer the automation expert. Instead, the automation expert role has been passed on to independent SI companies whose employees may have gained their experience while employed at client firms.

THE CONTROLS PROJECT

We are going to examine the activities involved in implementing an automation or controls project. Key to the project is the client who wants to either build a new plant, build a new process line, renovate a process line or automate a process. The client does not have the in-house resources to accomplish the project so he seeks outside services. Depending upon the size of the project, the client may seek a contractor, architect/engineering (AE) firm or a system integrator. For the sake of discussion, we will assume all are needed.

In the May 2001 issue of Control Engineering, Vance Van Doren wrote about the issues of selecting a SI. The Control System Integrator Association (CSIA) at www.controlsys.org offers a guide entitled, "Guide for Selecting & Working with a Control System Integrator." Within the two-volume set is information on the steps that must be taken to implement an automation project. We will examine some of these steps.

Request for Proposal

For our automation project, we will assume the client has minimal in-house engineering resources and is only assigning a small project management staff to the project. Someone from the client must be identified as the project manager. This person is usually referred to as the client engineer, PM or owner. The client wants to build an addition to a building in order to house some tanks used in a cooling water application. There will be a cold well, a hot well and pumps to recirculate the water to the process in an adjacent building. Usually your system integrator cannot design buildings so the client contracts with an AE firm in order to design the building, design the process and to develop a bid package in order for a general contractor to bid the project. This bid package would be the Request for Proposal (RFP).

Since the client is a company and not a public utility, he may pre-approve the general contractors he wants to invite to bid on the project and only send them the bid package. Or he may decide to simply put an advertisement in the paper and solicit bids from anyone. Again, depending upon the project's size, the client may conduct a pre-bid meeting with all potential bidders present to clarify any issues. The representative from the AE firm, usually referred to as the consultant or architect, will be present. Unless the AE firm is also a contractor (design and build firm), the AE is not directly involved in the actual construction. The AE firm is probably required to "observe construction" and not to "supervise construction." There is a big difference in this distinction. Therefore, the AE firm answers questions and clarifies specifications or scope of work. The AE firms contract is solely with the owner and not with anyone else.

The Bid Set

On behalf of the client, the AE develops a bid set consisting of a project overview, scope of work, design specifications, project schedule and performance requirements. Along with the "specs" will be a set of architectural, mechanical, electrical, piping and instrumentation drawings referred to as the "drawings." One general contractor is going to bid the complete project, but he will subcontract out portions of the project to others. The SI will try to determine where they can participate in this bid. The general contractor has probably already determined his mechanical and electrical subcontractors. The SI will probably be working for one of

the subs but which one? In the specifications the SI notices sections entitled Electrical and another Controls and Instrumentation. The SI reads both to learn what is required. The SI will probably find the most relevant information in the Controls and Instrumentation section. Under this section is found a Scope of Work. Basically, the Scope of Work says that everything is specified on the accompanying drawings. The remainder of the Specification is a discussion regarding piping, location of instruments, location of valves, workmanship standards, fittings and valves. Much of this information will be "boilerplate" which means a very general specification that is appended to all projects. However, it is very important not to miss a key item. For example, a requirement that all pilot lights must have "push to test" functionality may be written in the specifications, but may not appear on the accompanying drawings. There is a cost added for a "push to test" pilot light. Therefore, both documents must be totally reviewed so that no aspect of the project is missed in the bid.

It is also important to decide who is responsible for what. On a retrofit job, the client may take responsibility for part of the changeover since production schedules must be altered. However, it is usually the contractor who commissions the system to the "satisfaction of the owner representative." The owner representative could be the owner himself, another consultant or a member of the AE firm. There may also be some requirement for training the owner's operators once the system is functional. How much time should be bid? This takes experience. Start-ups can be slow and painful with circumstances out of the SI's control.

Also in the specifications will be a list of approved control vendors. The client may restrict the number of vendors because of spare parts or equipment familiarity. The AE may want to limit the number of vendors to some well-known names in order to minimize its liability or minimize the time to approve alternate sources. In these circumstances the words "or equal" become very important as non-approved vendors try to have their equipment bid. The SI may receive pressure from a vendor to have their equipment specified instead. It is best that the SI stay out of this fray and refer all equipment substitutions to the AE.

A particular vendor's programmable controller may be specified which the SI has had no previous experience with this equipment. There could be a learning curve associated with this equipment. The job could take longer than the time being bid. This is another source of risk to the SI.

The SI will choose those aspects of the project in which it feels comfortable participating. The drawings make reference to a control panel which houses much of the controls. This panel must be designed and constructed. Inside the control panel will be a programmable controller (PLC) and its associated input/output (I/O) modules. On the front of the panel must be mounted some controllers, instruments, an annunciator and some push buttons and switches. However, nowhere is there any schematic of the required control wiring. In the specifications the SI notices the following paragraphs under the subsection Submittals and Shop Drawings.

"Schematic controls diagrams giving specific data on all settings, ranges, action, adjustments, normal positions, etc. Although schematic, these diagrams shall, as closely as possible, represent the actual systems with all significant equipment and devices identified and located relative to each other. These diagrams shall also show detailed multi-line wiring and instrument piping with all terminals and ports accurately identified. Wiring diagrams shall be detailed to the degree required for field construction and shall include all related wiring."

"Detailed panel construction drawings including description of all materials and finishes, complete internal wiring and piping schematics and complete data on all mounted components."

"Drawings, schedules and written sequences of operation shall be submitted in the form of reproducible prints."

Basically, the Specifications say the contractor must implement the generalized design requirements shown in the drawings. The contractor must provide a set of detailed drawings so that a custom control panel can be produced, equipment purchased and installed and a program written that would execute the required control strategy by the PLC. This is not uncommon. The AE firm may not go into great detail in specifying the control system. They may only provide the overall control scheme. The SI is probably more experienced in the particulars of implementing the actual controls than the AE firm, so this is where the SI can participate. The SI will carve out this portion of the project by taking responsibility for the control panel design, generating all drawings, supervising the panel's construction, dealing with control system equipment vendors, developing any programming and, this is important, assist in the commissioning of the system. The SI submits a bid, probably to the mechanical subcontractor, which is included in the general contractor's bid. With luck, the SI may actually get the job (see figure 1).

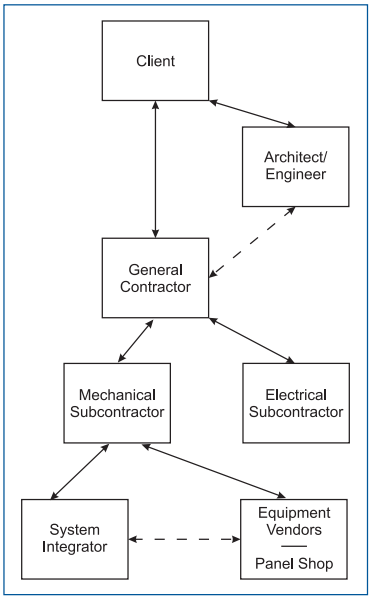

Figure 1. Depending upon the size of the project, the system integrator may be low man on the totem pole. The SI may have a contract with one of the subs, but he must deal with others on the project. The SI becomes very visible during the commissioning phase.

P&IDs

In general, the SI will not purchase any equipment for the job itself. The contractor or subcontractor will purchase all the equipment. Still the SI is required to specify the proper equipment based upon the drawings in the bid set.

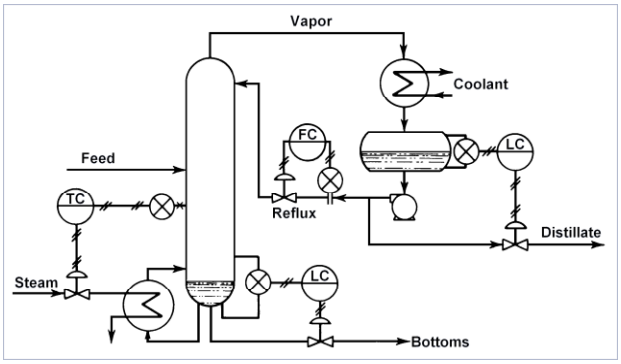

Figure 2. Example of a P&ID depicting two level loops, one temperature loop and one flow control loop. The SI is required to make submittals and shop drawings for these devices before purchasing and installing the equipment.

The AE firm will generate a Piping and Instrumentation Diagram called the P&ID (see figure 2). The Instrumentation, Systems and Automation (ISA) Society has developed a standard set of symbols and graphics that are universally used by AE firms. A P&ID is a schematic. It represents the overall process with little or no construction detail. However, the P&IDs are very important since they will be the diagrams that define the system for the client, AE firm and contractor. There is one detail, however, that is in the drawings and that is the instrument tags. The P&ID diagram will show several control loops and each one will be given a loop number. An instrument within that loop will be given an associated number. For example, a temperature-indicating controller in loop 102 could carry a tag TIC102 and its associated process valve could be PV102. These tags will be unique for the project. When that valve is delivered to the job site, it will be tagged by the valve supplier as PV102.

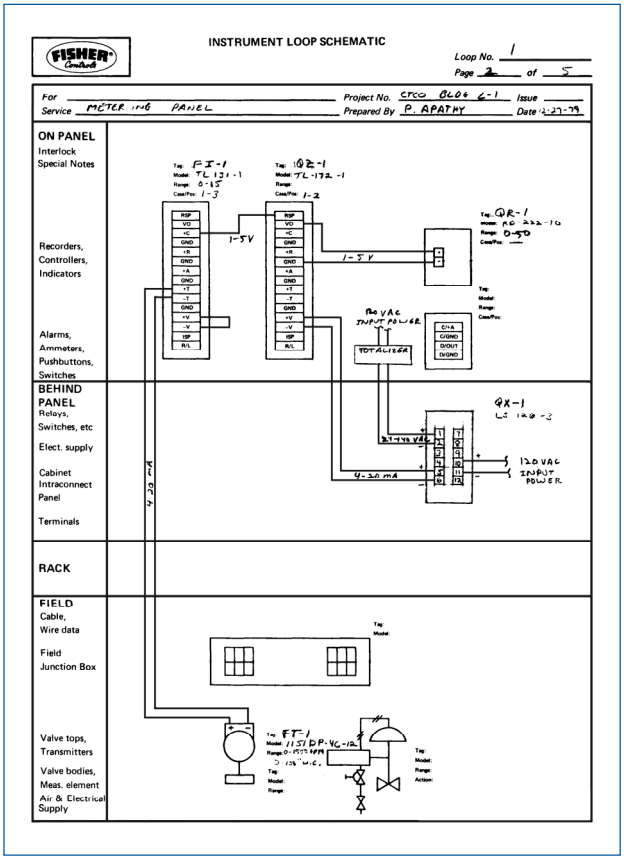

Figure 3. Example of a shop drawing. Loop diagrams must be generated from the P&ID.

Submittals and Shop Drawings

Before any equipment is purchased or brought to the job site, it must be approved through the submission of what is called a shop drawing. One large rubber stamp with the name of the project, general contractor, architect/engineer and possibly the subcontractor will be made and used to acknowledge approval of the drawing. The submitted drawing will be stamped and signed off by the various firms. This step is important to verify that the proper equipment, identified in the bid, is actually being supplied. If the equipment is simply a purchased item, a photocopy of the catalog page, called a catalog cut, is submitted. If the equipment is an instrument, process valve or controller, the equipment vendor will provide a standardized "spec sheet" with all the particulars including the required tagging for the job.

Based upon the P&ID, the SI will provide a "take off," first identifying all the long lead items to make sure they are approved and placed on order quickly. The control panel must be designed and a panel shop or panel fabricator selected. A panel fabrication drawing would need to be made with the proper cutouts for all the instruments and devices. Schematics and wiring diagrams would need to be made as well. From the P&ID, loop sheets will need to be produced. This is another form of shop drawing depicting the wiring of devices in a particular loop (see figure 3). All these drawings must be submitted for approval before construction of the control panel begins. The SI is not concerned about the actual programming of the PLC. That will be done while the control panel is being constructed.

Factory Checkout

During the panel construction phase, the SI may make visits to the panel shop to verify that construction is progressing and to answer any questions (see figures 4, 5 and 6). Generally workmanship is not an issue. Most panel shops do a professional wiring job. The SI should require the panel shop to do a point-to-point wiring check against the schematics and wiring drawings. This will save the SI time in the end. The SI may want to participate in this checkout. To test the control panel with power while simulating the process by manipulating inputs and outputs is difficult. Sometimes only a point-to-point checkout is accomplished before the control panel is shipped to the job site. It is usually the electrical subcontractor who is screaming for the panel in order to complete his piping and wiring. At this time, the SI may not have even loaded his program into the PLC or may not have even completed the program. The program will have to be loaded in the field.

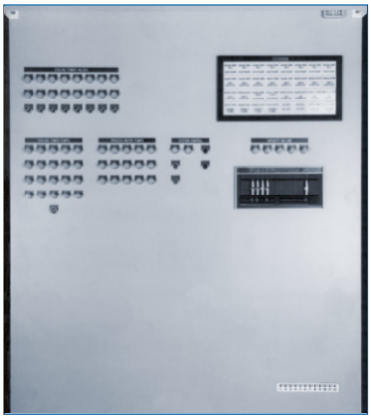

Figure 4. Custom control panel front showing illuminated push buttons and switches for the various pumps and valves. A 32-position annunciator is used to display fault conditions. A 12-position instrument case houses both controllers and indicators.

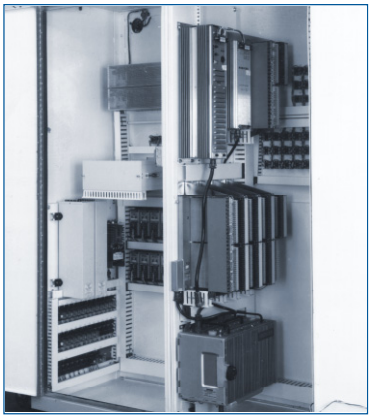

Figure 5. The control panel rear shows the programmable controller and its associated I/O racks. Also mounted in the panel are interposing relays and panel-mounted signal conditioning modules.

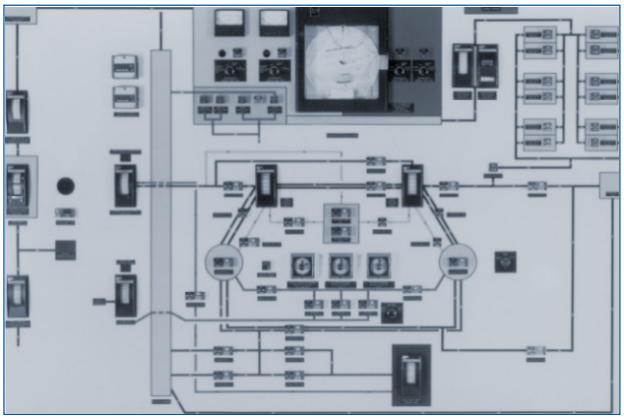

Figure 6. Some control panel fronts will contain a graph of the process being controlled. In this sewage treatment application, the controllers, indicators and switches are mounted adjacent to that part of the process they control.

Site Checkout

At this point the project becomes more interesting as the SI travels to the job site in his work clothes and hard hat to marvel at what has been accomplished from just a set of drawings. The SI verifies that proper power has been provided to the control panel and that field connections have been properly terminated. Instruments will require calibration. The SI may be called upon to assist both the mechanical and electrical subcontractors. In order to "stoke" valves and "bump" motors, it is easier if the SI did this from the control panel. Although this part of the checkout is not strictly the SI's responsibility, it is best to help in order to speed the checkout process. There is one caution, however; the SI must be certain that his actions are safe and that someone knowledgeable with the equipment is participating in the checkout.

Commissioning

In this phase the actual process is put into service. Probably at this time the project is late and overspent, and there is much pressure on receiving owner acceptance of the system. Most of that pressure will be on the SI since he is the last guy on the job. He cannot do all his testing and tuning until all the leaks are found and real process conditions are created in the system. No matter how much planning and testing has been accomplished, there will be some surprises. The PLC program may require modifications in order to compensate for quirks in the system. Control loops will require tuning to compensate for actual process conditions. It could be the experience of the SI that ultimately makes the project successful.

Project Close Out

Since changes were made to the system during commissioning, they should be recorded on the drawings. While on site, the SI should maintain a master set of "marked up" drawings. Once the job is complete, the original drawings are revised to indicate "as built" or "as installed" status. They are then given to the owner. After the project is completed, the SI is in a good position to receive a direct contract with the owner in order to maintain the system and to make process improvements. It always pays to do a complete and thorough job.

CONCLUSION

The role of the SI is interesting in a control systems project. His fees are probably insignificant compared to all the equipment that must be purchased and installed. Yet he is the one that makes everything work together. The SI's job satisfaction occurs the first time the client's process stabilizes with control valves properly modulating and all indicators are signifying that all process variables are near setpoint. This is the culmination of the SI's efforts.