INTRODUCTION

The installation and commissioning of a distributed control system impact the cost and schedule of a new plant or the expansion of an existing plant. Also, the work done during this part of construction can have a long-term impact on the plant operation and system reliability. The steps associated with installation and commissioning are much the same whether the control system is provided for new plant construction or as an upgrade to an existing system. However, the implementation details of installation and commissioning are dependent on the technology incorporated in the control system, for example, fieldbus vs. traditional actuators. Also, in some cases the manner in which the implementation is done will be dependent on the design of the control system and field equipment. Thus, the steps advised in this section may be used as a guideline in examining the detailed requirements at each key step of installation and commissioning.

In most cases the system configuration is completed before installation begins. Even if the system hardware is not available, modern control systems allow the complete system configuration and execute simulation including input-output (I/O). Using this capability, the control logic, alarm setup, and operator displays may be checked out in advance. Also, using process and control simulation, it is possible to train plant operators on the system interface, the value of which will much depend on the quality of the process model. Thus, all efforts should be made that by the time the system is ready to install, the operators are familiar with the control system and the operator interface. Also, there should be good confidence that the system configuration is complete except for the I/O assignment, which must be verified during installation using the actual field devices.

Commissioning and startup will benefit if the design is well documented, particularly in the area of electrical and instrument (E&I) drawings and supervision, and if the commissioning team is well trained and the operators are experienced on the particular process. It is particularly important that the various software packages used in the intelligent workstations be fully understood and that the communication
between intelligent devices from different manufacturers, including analyzers, be fully tested.

**INSTALLATION**

System installation is of prime importance for personnel safety and system availability. The steps involved in the installation of a distributed control system include the following:

- Power and grounding
- System assembly
- Heating, ventilating, and air conditioning (HVAC) and heat tracing
- Field wiring and checkout
- Bus installation

During control system installation, multiple steps are executed in parallel to reduce the time required for installation. The teams assembled for electrical and instrumentation checkout work closely with the engineering firm responsible for system design and documentation. Work during installation acts as further training for the operators as they participate in the control system checkout and correction of any problems found in the installation. During commissioning, the loop sheets, piping and instrumentation diagrams (P&IDs), and documents showing further details on the installation will be marked up. Where the changes impact the system configuration, these will also be noted and implemented so installation may be verified.

**Power and Grounding**

If a process is critical to plant operation and process interruptions must be minimized, secondary power sources should be included in the plant design. Electrical noise effects can be minimized by using isolated AC power sources, grounding at single points, minimizing undue influence on signal wiring from stray magnetic fields, and selecting appropriate cables and pathways, including adequate separation. Proper earth grounding is important to user safety and efficient operation of a control system. Installation methods to obtain good power and grounding are defined by industry-accepted standards. A typical ground network is shown in Figure 4.8a.

During the installation, checks should be done to ensure the quality of the power and ground for the control system. This will include verifying the voltage levels, designed load on isolation transformer, and noise level.

**System Assembly**

In many cases the components of the distributed control system are shipped directly to the construction site for assembly. The control system may be designed to allow controller, I/O, and associated wire trays to be wall mounted, see Figure 4.8b.

Also, specific varieties of enclosures are used when the control system is installed in harsh environmental conditions. System assembly should follow manufacturer guidelines on heating considerations and device placement in the enclosure. In particular, placement of the enclosure or equipment on a wall should take into account the space needed to service, remove, or replace components. During installation, the temperature in the enclosure or room in which the equipment is mounted should be monitored to ensure proper dissipation of internal heat.

System cabinets and components assembled during installation should be labeled for quick identification during

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**FIG. 4.8a**

Typical, single-point ground network for a single enclosure.

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installation. Once the system is fully assembled, the correct operation with the plant configuration should be verified. Any system problems should be addressed to avoid delays in using the system for I/O checkout.

**HVAC and Heat Tracing**

Environmental conditions can affect the operation of electronic equipment. Temperature, humidity, dust (including carbon), and corrosive vapors can cause gradual performance degradation, intermittent failures, and malfunctions.

To ensure maximum system efficiency and reliability, the air conditioning system including air filtering or scrubbers, if required, should be fully in place before the control system is installed. During installation, care should be taken to avoid open doors to the process, which could allow contaminate to enter the rack room or control room area. All environmental conditions must be maintained in accordance with the manufacturer’s recommendations.

Where controllers are to be mounted in the field, care should be taken to ensure that enclosures remain closed and that any purge air or heat tracing required to maintain environmental conditions are in correct working order.

The standard described in Reference 2 defines the environment for control system operation. Such conditions include ambient temperature, relative humidity, and electromagnetic interference.

**Field Wiring and Checkout**

Field wiring should be properly installed to negate electromagnetic interference (EMI) and other electrical noise that can adversely affect the instruments controlling the process. Signal cabling should be kept away from AC power lines, transformers, rotating electrical equipment, or other high-power machinery to reduce the possibility of electromagnetic interference being induced on analog and discrete signals. Industry standards describe noise identification and recommended wiring practices.

After field wiring is installed, continuity checks should be made from the field device to the I/O terminal strip. In addition, electrical isolation checks should be performed between the signal and ground wiring.

Injecting a signal at the transmitter end and observing the measured value at the operator screen may check the operation of traditional transmitter wiring. For traditional valves, the specified valve position should be verified in the field to ensure the software setting for increase open/close is correctly set to deliver implied value position.

As part of the instrument checkout, it should be verified that the alarm setting and the configured control setting match those specified on the loop sheet. Also, as part of the control checkout, the operation of the control after power failure or system download should be verified.

**Bus Installation**

To achieve optimum system operation, digital I/O bus systems, such as AS-Interface, DeviceNet, Foundation Fieldbus, and Profibus, must be properly installed. Otherwise, EMI and other electrical noise can adversely affect the capabilities of the instruments controlling the process.

Once a bus wiring is installed, its operation should be verified before commissioning. Most manufacturers provide a verification checklist that includes such things as a measuring of cable voltage and current capacity and verifying of
terminators on each end of the segment (Figure 4.8c). After these checks, each fieldbus device may be quickly commissioned and its operation status determined at the operator station using the device diagnostics.

**Installing HART Networks**

The HART signal is a modulated analog signal, and HART communication is designed to be compatible with existing or new 4- to 20-mA analog process control systems. The HART signaling occurs in a separate frequency band from the 4- to 20-mA analog signal and therefore, in most cases, does not interfere with the operation of the analog control loop. While HART uses modems designed for analog telephone networks and therefore is forgiving, the capacitance of the wire does limit the maximum allowable cable lengths (Table 4.8d).Depending on the type of transmitter, final control element, or handheld tool used, the HART signal is modulated by varying the loop current or by directly modulating the voltage of the power supply into the loop, as shown in Figure 4.8e.

On a three-wire or multi-drop transmitter loop the current sense resistor is 250 ohms. For DCS, final control elements and handheld tools, the power supply voltage drop is used as the HART signal. For impedance and other requirements of the process control system installation to guarantee reliable HART operation, refer to Table 4.8f.

**COMMISSIONING**

The commissioning of the control system occurs once process construction is complete. Often this work is staged to each process area or piece of major equipment to be commissioned. The steps involved in the commissioning of a distributed control system generally include the following:

- Training and preliminary checkout
- Fieldbus testing
- Process startup
- Tuning process control loops
- Safety systems
- Advanced control

The plant operators play a key role in commissioning. During this phase of the startup, the engineering firm that designed the plant, the E&I contractor, plant engineering, the operators, and equipment suppliers work as a team to find and correct any process or instrumentation problems. Control loop commissioning early in the startup plays an important part in getting the plant to a sustainable level of operation. Any mistakes in system configuration should be corrected during commissioning and reflected in the final documentation of the system. In some cases, these configuration changes are automatically traced to allow the time and person who made the change to be documented.

**Training and Preliminary Checkout**

Training is important, particularly if digital communication systems are used and the E&I contractor and/or the commissioning team has no experience in troubleshooting a fieldbus system. In that case, they have to learn unfamiliar definitions, understand unfamiliar drawings, devise check procedures, and devise configuration software and the approach to troubleshooting a communication network. Training is the only way to overcome the defensiveness of the inexperienced, which in the long run will save a lot of rework. On some critical processes, it is
possible to initially test the system using water as the process fluid. During this time, initial loop tuning constants should be determined, and control loop operation and interlock or permissive limit functioning should be verified. Such testing may reveal process or control problems that can be corrected before startup.

**Fieldbus Testing**

The testing of fieldbus-based process control systems is done in three steps. The first level of testing is called bus segment testing. This testing requires specialized equipment and troubleshooting skills and serves to check the physical installation of the system, including power supplies, terminations, and wire lengths. Prior to starting the testing, it is advisable to identify a qualified contact at each hardware vendor whose field device is part of the system, so that when (not if, when) integration issues requiring expertise arise, one knows whom to call.

The second step is to confirm that the field devices are correctly wired and addressed, their I/O is functioning, and they are communicating on the bus. If some of the field devices perform control or logic functions based on the application software, these too should be checked. When final control elements or other field devices are supposed to provide such information as on/off status and fault or diagnostic information using a data map, which must be unmapped by the other devices on the bus, data-map testing is also part of this second step. The third and last step is operational testing, which confirms that the bus and the PLC, DCS, and other devices that are connected to it are capable of operating as a unit and performing the required control and logic functions. The operational test should also include the checking of cycle times and the testing of all backup systems, data server connections, and bus redundancy.

**Process Startup**

The startup of a process requires that a person, such as the chief operator, together with a process engineer who is fully familiar with the process and the control system, are both present to coordinate the start-up activities. During the initial phase of a startup, the production rate is usually low and process limitations may dictate that operating conditions be
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gradually ramped while the process control loops are in manual. During this phase, it is possible to once again verify the operation of the process I/O and the associated field measurements and actuators.

If the quality of prior testing was inferior, at the time of control system startup it is possible that a safety subsystem or control interlock will initiate false trips or that interlocks may hamper the startup. In such cases the source of the problem should be addressed rather than attempting to bypass the input that initiated the trip or interlock.

For this reason, fieldbus devices are designed to allow I/O simulation to be enabled only if a physical key is present on the device. Similar protection is provided in many process control systems through the administration of system security that requires a certain level of authorization to change a critical parameter.

Commissioning of Control Loops

During startup, the process control loops may be commissioned once the process loads reach normal operation and therefore the controller set point and dynamics are close to normal. Before switching any loop to automatic or initiating self-tuning in the automatic mode, it is essential to check the response of the final control element. Therefore, before switching to on-demand tuning, it should be checked that the final control element responds to a change in the controller output when initiated in the manual mode.

Also, such a test may be used to verify that the PID Direct/Reverse setting is correct. Similarly, it is advisable to verify that the final control elements are not sticking and that their hysteresis is not excessive.

Advanced control tools for process and control monitoring are available to determine which loops have been commissioned and have performed as expected. Information collected on control utilization and variability index may be used to determine which loops may need to be closely examined to detect why the loop is unstable, is noisy, does not hold its set point, or is not being used as designed.

Advanced Control

Only after a process has been successfully started up, base loops fully commissioned, and production fully established, is it possible to commission the advanced control features of the system used for process control. A key step in commissioning various optimized, multi-variable or model-based control (MBC) systems is to make sure that the process variable measurements used are reliable and repeatable. Similarly, it is important to verify that the speed of response, characteristics, and dead time of the final control elements are all acceptable for proper loop performance.

CONCLUSION

Long-term reliability of DCS systems may be improved by paying attention to the power and grounding, environmental, and field installation requirements. Industrial standards or manufacturer’s guidelines exist for such purposes. Advanced control tools such as on-demand self-tuning and process and control monitoring can be used to quickly commission the control loops and to identify loops that require closer examination.

References


Bibliography


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