Start-Up and Commissioning Considerations for Water Treatment Plants by

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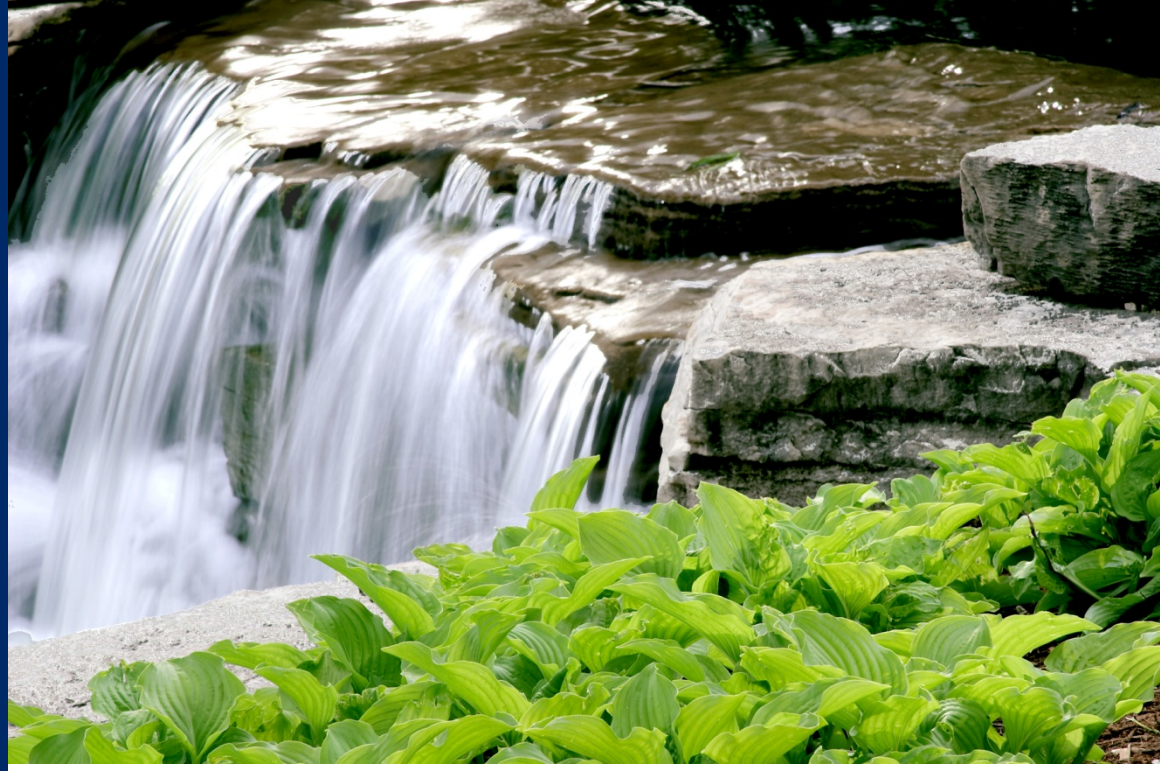

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Why do We Commission?

- Commissioning has several basic roles

  (a) Owners Perspective- Is what we paid asked for in terms of an improvement what we actually got once the project was constructed?

  (b) Engineers' Perspective- Can we prove that we delivered on the promises made during design?

  (c) Contractor's Perspective- Did we do what we were asked to do per plans and specifications?

  (d) Regulator's Perspective- Is a regulatory concern addressed?

Scope of Presentation

- Discussion will focus on items added during the construction of improvements in an existing facility
- Improvements are often multi-faceted and involve multiple engineering and contractor disciplines. For this presentation we will focus on basic commissioning principles in process mechanical, electrical and I&C systems.

Conventions Used in this Discussion

- “Process Control Network” is assumed to include all of the hardware, software and network connectivity associated with a PLC or SCADA system in a plant.

Basis for Commissioning

- Any system must have a clearly defined function. (Example: an HVAC/R system may be used to ventilate an area to provide a certain number of air changes per hour or maintain a certain temperature)
- To commission equipment, we must have a clearly defined plan outlining:

  (a) Components

  (b) Means to verify system effectiveness. (Example: A chlorine feed system must be capable of putting out a certain chlorine residual and a means by which we measure the output of our metering pumps via an analyzer)

  (c) Means by which we can check all modes of monitoring and control. Example: Control of pumps in the “local mode” or via a process control network

  (d) Ability to simulate abnormal modes of operation- discussed later in the presentation.

Basis of Commissioning Operational Perspective

- Operationally, we are concerned with several basic areas:

  a. What is the item's function (disinfection/conveyance/control/monitoring/etc.)?
  b. How much redundancy do I have? How critical is the item if it fails to work?
  c. How do I turn on/open a piece of equipment?
  d. How do I shut off/de-energize a piece of equipment?
  e. What are the cues (from instruments, visual inspection, manufacturer's instructions, etc.) that the device or system is working correctly or incorrectly?
  f. What are the steps I need to take to perform a shut down in an abnormal situation?
  g. What are the steps I need to take to perform a start-up or how do I recover after an abnormal situation?
  h. Do I have people with the proper skill sets on staff to handle maintenance issues or abnormal situations? Do I need contractors or special testing equipment/training for certain tasks?

  ALL of these questions must be addressed in 1 form or another by conscious choices made during design and procurement of equipment

Basis of Commissioning- Contract Documents

- The most important basis of commissioning for any new component or system is the set of contract documents prepared.
- From a commissioning standpoint, contract documents include:
  a. Detailed description of components and overall work scope
  b. Means of testing or guarantee in a shop environment (where practical) and in the field
  c. Definitions of acceptance
  d. A detailed set of requirements for testing in the field with controls (where applicable)
  e. Training plan
  f. Definition of warranty and when warranty “clock” starts
  g. Detailed sets of plans and sections showing how the pieces fit together, special installation requirements, special materials of construction, etc.
  h. Post installation support plan

Suggested Basic Commissioning Principles

- Ensure that documents are complete and address operational issues during design and pre-construction
- Ensure that a commissioning plan is developed prior to turning on any piece of equipment
- Ensure that the commissioning plan is matched to the sequence of proposed construction and any demolition.
- Commissioning should start at the “field” end of a system and then go up through the hierarchy of control and monitoring functions physically further away from the field.
- Demonstration of operations is critical to plant staff. They get supplementary training that is invaluable to system acceptance and continued reliable operations
- Documentation needs to be continually updated to ensure that what we have done during the commissioning process accurately reflects what was installed and any configuration changes to software/firmware have been adequately recorded
- All personnel should be confident that they understand how to maintain and take equipment out of service.
- Ensure that notes and a detailed list of corrective actions is kept.
- Ensure that all items in the list of corrective actions are checked prior to considering everything finished.

What We Commission

- Process Mechanical- Rotating equipment (pumps and motors), chemical feed systems, tanks, and piping/piping accessories, valves
- Electrical- Switchgear, generators, motor controls, low voltage distribution equipment
- Instrumentation and Controls for Process Equipment
- (HVAC/R is also commissioned but is outside the scope of this presentation)

Commissioning Process Mechanical

- Process Mechanical Falls into (2) basic categories:

  (a) Equipment that is field fabricated or stand-alone (piping systems, valves, etc.)

  (b) Equipment that is furnished by a vendor as a package and it typically involves multiple pieces of equipment tied together by 1 person.

- Equipment that is field fabricated has several basic items that must be examined when we commission:

  (a) Field inspection- Conformance to contract documents or specifications for pressure, flow, leakage

  (b) Integration with other disciplines- Electrical and I&C typically are part of integration of stand-alone devices into improvements

  Example: A motor operated valve will typically require some form of power source (electrical, hydraulic or pneumatic) and may require monitoring of valve position (and possibly control of valve position) from some form of process control network.

- Equipment that is furnished in vendor packages for chemical feed systems may consist of vessels to hold raw or finished product, some form of conveyance system (pumps, conveyors, etc.) to move material around, instrumentation, valves, piping and possibly a vendor furnished control panel.

  Example: A polymer system may consist of a storage tank, a day tank, an agitator, and a set of transfer pumps, and metering pumps to deliver the chemical to its application points.

How We Commission Process Mechanical Equipment- Stand-Alone

- Identify the desired flow and pressure ranges the equipment needs to meet
- Identify mechanical integrity testing (pressure testing, checking for noise, vibration, alignment, temperature) as required. Example: Piping support and vibration might be checked to ASME B31.3
- Identify the desired modes of control and how the modes of control will be verified(examples include control in the field vs. control through a process control network)
- Identify what modes of failure apply- Covered later in the presentation

How We Commission Equipment in Vendor Packages

- Vendor packages are a unique challenge because vendors often rely on a standard design to help them achieve economies of scale. Sometimes that design must be customized to meet operational or maintenance needs. Some basic operational needs include:
  - Need for process mechanical equipment standardization (use the same metering pump for every chemical feed system)
  - Need to standardize process controls/look and feel of controls
  - How items are to be removed from service for inspections or maintenance
  - How various types of changes (pressure/flow from a process perspective, temperature from an ambient room perspective, changes to power supply, etc.) will effect equipment operations and performance.

How We Commission Vendor Equipment- Continued

- Address process mechanical issues 1st- pumps, valves, interconnecting piping.
- Pumps- Ensure that flow conditions are clearly understood. For “specialty” applications ensure that items such as vibration and alignment are adequately understood by both installers and inspectors
- Interconnecting Piping- Ensure piping is adequately labeled and supported and ensure that the layout includes routing to drains as needed.
- Issues such as connections to existing parts of a process and the means to isolate one portion of the facility or process from another must be addressed for the purposes of both testing and operational needs.
- Valves- Ensure that valves operate correctly and are tested for intermediary as well as full open and full closed positions.

How We Commission Vendor Equipment Continued

- Electrical- Ensure that any form of motor starter has its protection (over load and over current) correctly set. Ensure that any form of interlocking between components on the skid are correctly understood and tested in all modes of operation
- Field Instruments- Ensure that field devices have some proof of calibration. Ensure that any valves or accessories associated with instruments have been operated and can be removed for inspection or maintenance.
- Controls- Ensure that equipment can be operated in the intended manner required. Example- A vendor control panel may allow the operator to perform some functions in the field while other functions can only be performed through the vendor's controls and/or a process control network furnished as a separate part of the contract.

How We Commission Electrical Equipment

- Switchgear
  a. Ensure that gear is reviewed and approved by the utility
  b. Ensure that protective relaying functions are confirmed with all parties
  c. Ensure that the source of power for all protective relaying and monitoring has been checked
  d. If operating a system with more than 1 source of power, ensure that proper switching can be done between 1 source and another source
  e. Ensure that all of the connections and cables between the switchgear and various loads are checked

How We Commission Electrical Equipment Continued

- Ensure that any form of passive testing (insulation resistance testing as an example) is done prior to making final connections (this is to save time and prevents un-needed shut downs)
- Ensure that the utility is informed as to when you want to energize equipment
- Ensure that equipment rotation has been verified prior to turning equipment on

How we Commission Electrical Equipment- Continued

- Generators-
  a. Ensure that all equipment connections between items supplied by the customer and the generator manufacturer are clearly understood
  b. Ensure that equipment is load bank tested
  c. Ensure that equipment is tested with “live” plant load
  d. Ensure that any form of permitting issues for air quality and the associated operations of equipment are clearly understood during the commissioning process
  e. Ensure that it is clearly understood how “live” plant load will react upon loss of utility power, start-up of the generator, and return to utility power. Have adequate time delays been built into equipment operations?
  f. Ensure that protective relaying (undervoltage/synchronizing, etc.) and generator protective functions (loss of cooling water as an example) are tested.

How Do We Commission Electrical Equipment- Continued

- Motor Control Centers and Motor Starters
  a. Ensure overcurrent and over load protection are matched to load characteristics
  b. Ensure that all hardwired and process control interlocks are checked
  c. Ensure that any special protective relaying functions (ground fault as an example) and associated settings are checked on larger process critical loads.

How Do We Commission Electrical Equipment Continued

- Ensure that equipment grounding connections have been made and are tested
- Ensure that panels are balanced (where multiple phases are used)
- Ensure that any special instructions for installation (such as vendor furnished terminations on special cables have been followed)

How do We Commission Instrumentation and Control Systems

- We have to start with the instruments and final control elements (valves, motor starters)
  a. Are they mounted correctly?
  b. Are they scaled correctly?
  c. Do they have all of the I/O required to connect to the process control network
  d. Are they communicating correctly back to a PLC or process control network?

How do We Commission Instrumentation Continued

- We next turn our attention to I/O check out- You can't escape checking each I/O point
- Once we are confident that I/O operates correctly, we examine our connection from a local controller to the process control network
- After we are sure that we've got correct communications, we can examine the effectiveness of our process control strategies. Each strategy must address what happens in a local mode of control and all other modes of control whether initiated by the process control network or "other" means.

How Do We Commission Instruments- Continued

- Process Control Validation- This represents the “capstone” event within the commissioning activity as we’ve already looked at the items from the field all the way back.
- Basic means of checking process control descriptions
  a. Start with the monitoring functions from instruments
  b. Check the monitoring functions from motor control and/or local control panels
  c. Check the control functions from motor controls and/or local control panels
  d. Check the interlock functions at the process control network
  e. Check the regulatory functions (examples: level regulation in a clearwell)

Process Control Common Mode Failures

- This represents the hardest portion of our commissioning efforts. One suggested sequence is as follows
- Test for the failures unique to a given system without process control network intervention at the field
- Test for failures unique to a given system using local controls only
- Test for failures unique to a given system using the process control network.

Because the process control network has so many components, some of the following common mode failures must be examined:

(a) Loss of energy source (normally electricity but it could be hydraulic or pneumatic)

(b) Loss of system communications with all or part of a process control network

(c) Loss of PLC/RTU processor

(d) Loss of process mechanical equipment in a redundant equipment train

The ONLY means by which this can be done is to compel the team (Owner, Contractor and Vendor) to address these items during submittals. While microprocessor based controls provide more flexibility than older components which were “set and forget”, this flexibility comes at a price as changes to software and firmware have an impact on reliable operations.

Conclusions

- Commissioning starts in design and is not completed until all items are resolved
- Commissioning is a team effort that requires input from multiple stake holders
- Commissioning should be done with the active participation of operations and maintenance personnel
- Documentation control is critical
- Ensure that all contracts build commissioning discussions into the effort