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IACPE No 19, Jalan Bilal Mahmood 80100 Johor Bahru Malaysia	Commissioning Steps (Plan, Construction Completion, Pre Commissioning, Commissioning, Start Up) CERTIFIED PRACTICING COMMISSIONING SPECIALIST PROGRAM (CPCS) TRAINING MODULE	

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INTRODUCTION

Scope

Commissioning is a collaborative, quality-driven, systematic process that focuses on verifying and documenting that a building and all of its systems are planned, installed, inspected, tested, operated and managed as designed. Commissioning has five steps; plan commissioning, construction completion, pre-commissioning, commissioning, and startup.

The commissioning plan is the covering strategy document that describes actions, roles and responsibilities, the commissioning program and risk mitigation measures. Activities to be taken to set commissioning up, gather information, select the commissioning team, develop the schedule and create documentation.

Any installation issues identified at the construction completion stage will obviously be quicker, easier and cheaper to correct. Therefore, it is of the highest importance that a good working relationship is created with the construction management team. Pre-commissioning, activities carried out during construction that prepare and enable the unit to move to the main commissioning phase. Commissioning, here the various systems and items of equipment are first put into initial operation. Start-up, the plant is brought into actual operation. These phase, traditionally perceived as “commissioning”, examines the facets that address the installation, checking and start-up of the new equipment.

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General Design Consideration

Commissioning is the process of bringing equipment and systems into operation. It is a systematic process of ensuring that all systems perform interactively according to the design intent and the Owner's operational needs. Whilst testing and certification is required through the construction and installation process, this is not adequate to demonstrate that the infrastructure will operate as intended. The commissioning process validates the operation against design parameters and is used to complete the configuration before it is handed over to client for operation.

This is achieved by beginning in the design phase and documenting design intent and continuing through construction, acceptance, and the warranty period with actual verification of performance. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training.

Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:

- a. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
- b. Verify and document proper performance of equipment and systems.
- c. Verify that O&M documentation left on site is complete.
- d. Verify that the Owner's operating personnel are adequately trained.

The following framework demonstrates the high level stages of commissioning. The stages can be expanded on in a specific commissioning plan to suit the project requirements.

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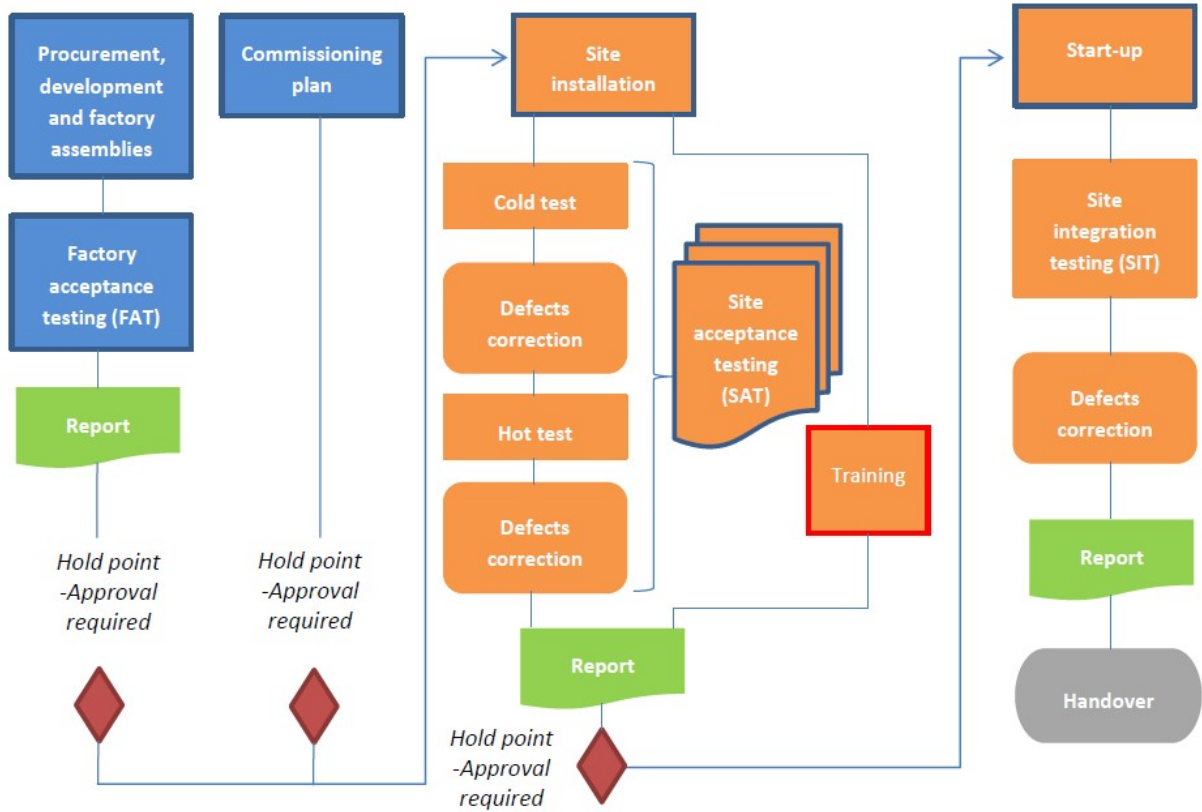


Figure 1. The high level stages of commissioning framework

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The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.

1. Commissioning during construction begins with an initial Commissioning meeting conducted by the Commissioning Authority where the commissioning process is reviewed with the commissioning team members.
2. Additional meetings will be required throughout construction, scheduled by the Commissioning Authority with necessary parties attending, to plan, coordinate, schedule future activities and resolve problems.
3. Equipment documentation is distributed by the design engineer to the Commissioning Authority during the normal submittal process, including detailed start-up procedures.
4. The Commissioning Authority works with the Contractor in each discipline in developing startup plans and startup documentation formats, including providing the Contractor with construction checklists to be completed during the installation and startup process.
5. In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with construction checklists being completed before functional testing occurs.
6. The Contractors, under their own direction, will execute and document the completion of construction checklists and perform startup and initial checkout. The Commissioning Authority documents that the checklists and startup were completed according to the approved plans. This may include the Commissioning Authority witnessing start-up of selected equipment.
7. The Commissioning Authority develops specific equipment and system functional performance test procedures.
8. The functional test procedures are reviewed with the design engineer, Commissioning Authority, and Contractors.
9. The functional testing and procedures are executed by the Contractors under the direction of, and documented by the Commissioning Authority.
10. During initial functional tests and for critical equipment, the Engineer will witness the testing.

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11. Items of non-compliance in material, installation, or setup are corrected at the Contractor's expense, and the system is retested.
12. The Commissioning Authority reviews the O&M documentation for completeness.
13. The project will not be considered substantially complete until the conclusion of Commissioning functional testing procedures as defined in the Commissioning Plan.
14. The Commissioning Authority reviews and coordinates the training provided by the Contractors and verifies that it was completed.
15. Deferred testing is conducted as specified or required.

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DEFINITIONS

Air Blowing - Similar to inert gas cleaning, with the motive force being supplied by high volume air compressors. Air blows usually involve paralleling several air compressors and air receivers. Air pressure is established in the pipe/receivers then suddenly released to remove debris from internal pipe surfaces. Permanent plant air compressors, rental units, or a combination of the two can be used as appropriate.

Acid cleaning - The addition of acid, usually hydrochloric (HCl), to the boiler water to dissolve scale and other deposits on the inner boiler tube surfaces. It is usually recommended for high pressure boilers and in some cases may be deferred until after full load operation

Boiler - The boiler system includes the wetted portions or water side of the boiler including economizer, steam drums and waterwalls (downcomers and risers) of a boiler. In some types of chemical cleaning, the steam side of the boiler, such as the superheater and reheater sections, may also be included

Calibrate - An activity in which an instrument will be operated in a manner that best emulates its installed operating conditions, if feasible. Adjustments are made in accordance with the manufacturer's specifications, to match the desired operating range or set points. This can be either electrically, mechanically, pneumatically or a combination thereof. Adjustments should be made and documented by the Test Technician to achieve the required settings.

Check - A verification process to confirm that instruments and instrumentation systems meet the required manufacturer's design parameters and project specifications.

Contractor - The persons, firm or company whose tender has been accepted by the "Employer", and includes the Contractor's personnel representative, successors and permitted assignees

Controller - The hardware that monitors and affects the operational conditions of a given dynamic system based on a set of logic instructions that reside in it. In installations where there are redundant controllers (processors) the primary controller is the one currently processing and the secondary controller is the backup.

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Component - A single piece of equipment, such as a run of pipe, valve, protective device, instrument, cable, breaker, heat exchanger, pump, turbine, etc.

Component Testing - The inspection, checkout, setup, and functional verification of an individual piece of equipment to verify that it performs in accordance with vendor documentation, project design requirements, and system needs.

Commissioning Plan - An overall plan, developed before or after bidding that provides the structure, schedule, and coordination planning for the commissioning process

Controller -- The hardware that monitors and affects the operational conditions of a given dynamic system based on a set of logic instructions that reside in it. In installations where there are redundant controllers (processors) the primary controller is the one currently processing and the secondary controller is the backup.

Distributed control system (DCS) - a microprocessor/computer-based assembly of components in which process parameters are converted into digital signals at the process input interfaces. The data received is then processed in accordance with the user program and appropriate output signals are generated to control the process from the output interfaces.

Dry out - A process associated with removal of moisture from the internals of piping and equipment by introduction of a drying gaseous medium. Dry out typically removes the final small amounts of water within a system. This is usually accomplished at less than design pressure.

Factory Acceptance Test (FAT) - Testing to be performed at suppliers workshop to verify the equipment's performance/functionality.

Hydrostatic Test - The controlled introduction of fluid to a filled and vented system in order to demonstrate the structural integrity of the associated piping and pressure vessels. A hydrostatic test pump is used to produce a selected pressure, generally 1-1/4 to 1-1/2 times the design pressure. The test pressure will be maintained a minimum of 10 minutes prior to final inspection, with strict adherence to the piping's or component's specified temperature requirements to prevent brittle fracture. Specific requirements should be verified from the applicable codes for each project

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Inert Gas Cleaning - An operational cleaning method using inert gas as the cleaning medium. For optimum cleaning, it is necessary to have a mass flow rate equal to, or greater than, the maximum operating flow rate in all parts of the piping system. This can be accomplished at less than design pressure, but at increased fluid velocity, or at design pressure and velocity.

Licenser or Licensor - A company duly organized and existing under the laws of the said company's country and as referred to in the preamble to the contract.

Loop - Device(s) or instrument(s) along with the associated wiring and/or tubing comprised to make a "system loop" that is designed to measure, manipulate and/or control a specific process.

Loop Check - A testing practice where a qualified Technician will activate or simulate (either pneumatically, electrically, or manually) each device or instrument in a system loop to show that each device or instrument functions correctly within that loop and the loop functions per the design intent.

Mechanical Completion - That point in time when systems are essentially complete but startup activities may not be finished and performance tests have not been performed. The precise terms for mechanical completion are usually defined in the contract.

Mechanical Completion Certificate (MCC) - A MC Certificate issued by the Executor to document that his MC scope has been carried out. The MC Certificates shall be used per MC package.

Pigging - Blowing a mandrel (pig) through the pipe to mechanically clean internal pipe surfaces. The pigging evolution can use a single pig, or more commonly, an arrangement of several types of pigs to remove water and debris out the pipe end. Air or inert gas can provide the motive force for the mandrels (pigs).

Pneumatic Test - A pressure test performed with oil-free air or inert gas to demonstrate the tightness of a system. As a rule, the maximum test pressure shall not be greater than the lesser of 100 psig or 1.10 times the design pressure. The test pressure may be applied with an air compressor or with inert gas from pressurized storage and must be maintained for a minimum of 10 minutes prior to final inspection. Specific requirements should be verified from the applicable codes for each project.

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Project - The equipment, machinery and materials to be procured by the "Contractor" and/or "company" and the works and/or all activities to be performed and rendered by the "Contractor" in accordance with the terms and conditions of the contract documents.

Punch List (PL) - A Punch List describes incomplete work or malfunction of equipment or construction

Purging - The process used to inert the space within the pipe and vessels

Static Test - A hydrostatic test of an open system or vessels such as atmospheric tanks or condensers by filling with water or system fluids to a level equal to the highest available point within the system.

Startup System - A scoped grouping of components designed to perform a specific function within the configuration of the facility. A startup system may consist of one or more engineered systems and may cross engineered system boundaries. Startup systems are generally based on startup and operational considerations.

Startup/ Commissioning - The process of placing a facility or equipment in operation for the first time. The process starts with the checkout, test, calibration, demonstration, and verification steps on individual items of mechanical, electrical, and instrumentation equipment, and ends with acceptance of the facility for normal operation by the Owner.

Test - An activity being performed to prove the functionality or suitability of a component, group of components or system and is covered by a procedure either generic or specific in nature. Testing can occur as an activity during construction, commissioning or startup.

Trip – The placement of a component in a safe condition (e.g. shutdown, de energized, depressurized, closed) as the result of the activation of some protective device or logic interlock.

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THEORY

PLAN

The commissioning plan is the covering strategy document that describes actions, roles and responsibilities, the commissioning program and risk mitigation measures. The Commissioning Plan, provided as part of the bid documents, is binding on the Contractor. The commissioning plan provides guidance in the execution of the commissioning process. The Specifications will take precedence over the Commissioning Plan.

The commissioning plan is a live document that requires updating as the site conditions evolve during the installation. These changes may affect the commissioning procedures.

The content of this document should include:

- Commissioning scope
- Confirmation of standard testing requirements from Watercare construction standards
- Commissioning objectives and performance requirements set by the designer and/or contract
- Operational protocols and procedures
- Integration procedures to integrate new system with the existing system to minimise impact
- Risk assessment and mitigation strategies
- Site health and safety requirements such as exit plans, environmental controls and emergency contact
- Identify specific skill requirements, resources or temporary plant
- Provide logical sequencing of work that considers interfaces and constraints
- Effects on adjoining processes

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- Identify the level of testing at the various stages of commissioning

The commissioning plan is updated regularly whenever there are observations affecting the planned process. The commissioning plan should be coordinated with the project schedule to ensure that dedicated periods are assigned for commissioning activities. The commissioning organization specifies the meeting frequency and expected time consumption for all players. This information should be included in the tender documents, so dedicated resources can be allocated to commissioning activities.

CONSTRUCTION COMPLETION

As construction activities commence, vessels start to be installed and major piping runs established, it is advisable for the commissioning team to start making regular site visits to closely monitor and follow the build progress. Any installation issues identified at this early stage will obviously be quicker, easier and cheaper to correct rather than waiting for the punchlist process to become established and then for the rectification work to take place. Therefore, it is of the highest importance that a good working relationship is created with the construction management team so that a common understanding is gained that the commissioning team, whilst not interfering in any way with the construction progress, does have a vital role to play in early issue identification and therefore efficient correction work.

During the construction phase items of equipment do get installed incorrectly. Examples of this include:

- Vessel being installed in the wrong location
- Vessel being installed in the wrong orientation (e.g. needs to be turned 180°)
- An installed valve handle protrudes into a walkway creating a trip or injury hazard
- Pipe runs installed too low (head hazard)
- Pipe runs have created a low point which cannot be drained down
- Liquid-filled pipe runs installed with no high-point vent

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- Control valves and non-return valves installed in the wrong orientation for the required direction of process flow
- Pipes to be insulated have been installed too close together and insulation cannot be fitted
- Pipe installed with wrong fall direction (flows away from low point not to it)
- Installed insulation covers a valve handle
- Metal insulation cladding or fixing bands have sharp edges presenting a cut hazard
- Incorrect gasket material being installed.

Towards the latter stages of the construction effort within a system (to be agreed with the construction manager but normally ~80% complete) it would be normal practice for the commissioning team to be invited to compile a “preliminary punchlist”, where the build is checked against the project P&IDs. Any resultant issues are then captured on the punch-list to be rectified before mechanical completion of the system.

Factory acceptance testing (FAT) describes the final check performed on vessels and major equipment prior to delivery to the job-site. Here the emphasis for the commissioning team is not on the design and fabrication of the unit, but more on its cleanliness, the test installation of major components and suitability of the equipment to travel.

The key points to consider at a vendor shop acceptance test for vessels and package equipment are:

- Correct finish on flanges as stipulated on the vessel drawings
- Is the unit clean, dry and oil-free?
- Checks that all internals are secure and open ends are covered for transportation
- Are all spare parts, including gaskets and internal components, available for inspection and present ready to be shipped?
- Can a low-pressure leak test be considered and therefore witnessed?