International Association Of Certified Practicing Engineers	**www.iacpe.com** **Knowledge, Certification, and Networking**	**Page : 1 of 59** **Rev: 01** **Rev. 01 – Feb 2023**
IACPE **No 19, Jalan Bilal Mahmood** **80100 Johor Bahru** **Malaysia**	**INTRODUCTION TO COMMISSIONING ACTIVITES** **CERTIFIED PRACTICING COMMISSIONING SPECIALIST PROGRAM (CPCS) TRAINING MODULE**	

The International Association of Certified Practicing Engineers is providing the introduction to the Training Module for your review.

We believe you should consider joining our Association and becoming a Certified Practicing Engineer, or a Certified Practicing Commissioning Specialist. This would be a great option for engineering improvement, certification, and networking.

This would help your career by

1. **Providing a standard of professional competence in the practicing engineering and management field**
2. **Identify and recognize those individuals who, by studying and passing an examination, meets the standards of the organization.**
3. **Encourage practicing engineers and management professionals to participate in a continuing program of personal and professional development.**

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INTRODUCTION

Scope

Commissioning is a series of checks and counterchecks that confirm a newly constructed chemical plant is fit for purpose and suitable for ongoing operation. These checks being made at all stages of a project's life, not just after construction is complete. Chemical plant commissioning has developed significantly and at some pace over the last 25 years, as the constraints of primarily cost and schedule bore heavily on project management teams. A methodology had to be developed that no longer had the luxury of distinct and separate construction, commissioning, and handover to the operations group phases.

The objective of commissioning is to ensure that the plant is brought into production without risk to 1) the personnel, 2) the environment and 3) the equipment. Schedules must be considered and constructed in a way that sufficient time is allocated to each and every commissioning activity, as in the heat and intensity of the commissioning and start-up phases, this is the most critical time when safety implications can be neglected and therefore need to be strictly adhered to and enforced.

As construction develops, commissioning systems and potentially individual items of equipment will take place and introduction of energy to the plant will start. The various process areas must be clearly identified, and clear communication made with them all, especially the construction and operations groups, prior to operation and testing of the equipment to make known the change of status and the new safety implications to the construction and commissioning site.

General Design Consideration

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. Contractor shall pre-commission, commission and carry out the Performance Tests on the Works including all the facilities of the Well Platform, associated pipelines, and Modification Works listed in Description of Work in the Bid Package.

A Commissioning or Pre-commissioning activity shall be considered to be complete only when it has been witnessed and the procedure and the results of successfully carrying out that procedure have been signed off by both Contractor and Company. Company may also require Vendor's representative to witness and sign that document.

General Requirements

1. Commissioning shall start from the point at which steps are taken to bring the Unit/facility up to operating pressure and temperature and to cut in the feed. It shall be complete when the Unit/facility is operating at design capacity and producing products to specification.
2. For a project involving a number of process Units and facilities, it shall be agreed between the Contractor and Company in the earliest stages of a project the sequence of the commissioning of the Units. It shall be necessary to commission utilities and some of the Units in advance of others, because of their interdependence from a process point of view.
3. The responsibilities of the Contractor and Company during commissioning stage should be clarified for the provision of labor, operators, specialists and service engineers, and also for the correction of faulty equipment, etc.
4. The general requirements outlined in this Standard for testing of equipment/lines shall be followed. The detail procedures for testing of equipment and lines and other precommissioning steps are not included in this Standard and shall be prepared in accordance with the Company's Engineering Standards by the Contractor and submitted to the Company for approval. However, on completion of testing, vessels, equipment and piping should be vented and drained, and where necessary cleaned and dried to the satisfaction of the Company.

Spades, blanks and other equipment installed for testing shall be removed on completion of testing. Wherever a flange joint is broken after testing, e.g.,on heat exchangers, pipework, fired heaters and at machinery, then the joint rings or gaskets must be renewed. Particular attention must be given to heat exchangers employing solid metal or filled gaskets, and great care should be taken to ensure that all gaskets renewed after testing of heat exchangers and are correctly fitted before tightening flanges.

Where required, valves are to be repacked with the appropriate grade of material.

Any temporary bolting which has been used shall be replaced and any temporary fittings which may have been installed to limit travel, e.g., in expansion joints and pipe hangers, shall be removed.

5. Prior to commissioning, each item of equipment should have its name, flowsheet number and identification number painted and/or stamped on it according to the Company's Specifications.

Commissioning has three categories:

1. Pre-commissioning, activities carried out during construction that prepare and enable the unit to move to the main commissioning phase. The range of pre-commissioning activities include: installation of filters, packing of distillation columns, filling a reactor with catalyst, cleaning pipes and equipment, vendor and factory acceptance testing, punch listing and instrument, electrical and motor loop testing.
2. Commissioning, here the various systems and items of equipment are first put into initial operation. Utility systems, instrument air, cooling water and general-purpose water are made live and the core process systems are first made operational, typically with safe chemicals, air or water. The unit is leak tested, started up, shut down, distillation column sand scrubbing columns put into use, all to gain the confidence that when process chemicals are introduced the plant will operate as designed and intended.

3. Start-up, the plant is brought into actual operation. The following is a general list of plant startup systems and activities:

    1. Prior to Mechanical Completion

        - Main power activated
        - Instrument air system operational
        - Plant checkout
        - Piping Blow Downs and Flushes Complete
        - Initial Leak Testing completed
        - Instrument & Electrical Checks and Loop Checks Complete
        - DCS/Safety System SAT (Site Acceptance Test) Complete
        - ESD and Safety System fully functional

    2. After Mechanical Completion

        - O_2 Freeing / Gas purge
        - Pre-operational Leak testing
        - Close All block valves in the plant
        - Commission drain and general flare system
        - Commission steam system
        - Commission cooling water system
        - Pressurize Systems
        - Some systems can be started simultaneously to reduce overall plant startup

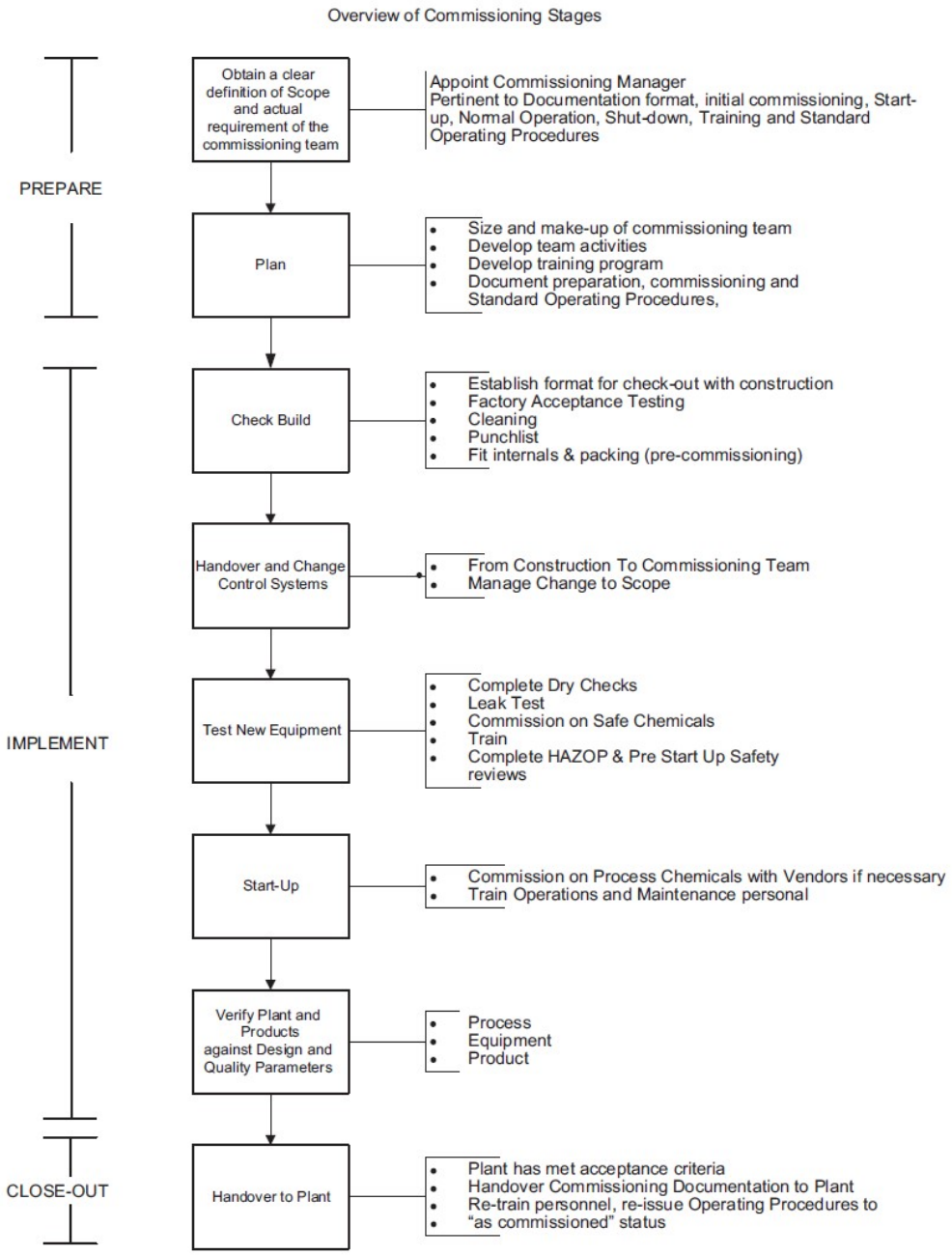

Figure 1. A Simplified Commissioning Logic

The subject of commissioning any chemical plant asset with the fundamental approach divided into three main stages.

1. Prepare. Activities to be taken to set commissioning up, gather information, select the commissioning team, develop the schedule and create documentation.
2. Implement. This phase, traditionally perceived as “commissioning”, examines the facets that address the installation, checking and start-up of the new equipment.
3. Close-out. The final stage of the commissioning process and the one most neglected, ensuring that all paperwork systems and trials are complete, and that the plant or equipment has met its acceptance criteria, enabling the plant to be handed to the ongoing operations group.

Table 1. The subject of commissioning

Phase	Activities
PREPARE	• Define the commissioning scope • Systemize the plant utilizing the project Piping and Instrument Diagrams (P&IDs) and other relevant documents including layout drawings and mechanical flow diagrams, into commissioning systems • Integrate commissioning systems into the engineering documents, line tables, instrument index, P&IDs, equipment lists and procurement plans • Input to design:The commissioning team upon agreement with the Project Manager and Commissioning Managers will attend the following reviews: P&ID, Piping isometric, Plant Layout, Constructability, 3-D model, Schedule, SIL, LOPA and action upon alarm • Compile the Commissioning Schedule • Compile the Commissioning Estimate/Budget • Agree interface/handover procedure with project, client and construction groups • Obtain pertinent and relevant documents and establish electronic libraries • Attend Hazard Study • Compile Initial Commissioning Plan • Set-up site base and compile commissioning consumables list • Determine initial fill chemicals, simulants and procure • Create Commissioning Manual • Compile Standard Operating Procedures (SOPs) • Compile training packages • Agree Safe Systems of Work with all interested parties • Compile Commissioning Procedures • Give input as required to the User Requirement Specification (URS) for a Distributed Control System (DCS) • Compile Decontamination Procedures •

IMPLEMENT	• Attend factory equipment acceptance and pre-delivery tests • Computer Hardware Factory Acceptance Tests (HFAT), Software Factory Acceptance Tests (SFAT), review • Functional Design Specification (FDS) for the DCS • Attend Site Acceptance Tests (SAT) for a DCS control system • Be involved with management and decommissioning and/or decontamination of existing plant if required • Check construction progress and quality • Start commissioning log • Test and clean pipe work • Punch list • Commence training of plant and maintenance personnel • Manage handover construction to Commissioning and/or Operations • Attend and/or manage pre-start-up safety checks • Complete all leak testing • Pre-commission the systems • Manage post-start-up modifications • Manage the introduction of safe and process chemicals • Move team to shift management role if required • Issue first draft of the Standard Operating Procedures (SOPs) • Start-up plant
CLOSE-OUT	• Update to “as commissioned” all commissioning documents and Standard Operating Procedures • Manage post-start-up modifications • Update to “as commissioned” training documents • Run and manage plant to pre-determined design production rates and initial output for the required duration

Table 2. Commissioning Items

Commissioning Items	Constructor	Operations	Advisors
1. Leak and Pressure Test	Perform	Witness	
2. Equipment Inspection (Towers, Reactors, Ect)	Perform	Perform	Witness
3. Flushing, Chemical, Mechanical Cleaning		Perform	Witness
4. Temporary Screens, Strainers and Blinds		Perform	Witness
5. Purging and Inerting		Perform	Witness
6. Drying Out		Perform	Witness
7. Instrumentation Verification	Perform	Perform	Witness

The team of Advisors will include three categories;

1. Commissioning Manager
2. Commissioning Engineer
3. Commissioning Operator Specialist

Commissioning Manager

The Commissioning Manager typically is a Chemical / Mechanical Engineer with greater than 15 years operations experience. They will have been though several grass roots start-ups.

Responsibilities;

1. Be a liaison between the operating company and the Technology Licensee. Manage and work toward building a cohesive team for the most successful start up possible. Encourage open communication between all parties in the organization.

2. Attend meeting as required, typically there is a morning meeting to track progress. Answer and give guidance as required.
3. Issue written guidelines for planned task. The operating company can utilize these guidelines to develop the daily orders.

4. Manage the commissioning engineer and operator.
5. Ensure that site processes are monitored and controlled to achieve safe and economical operation while developing all operators to their full potential.
7. Coach the operators to complete the maximum possible amount of follow-up on their own when items are not as per normal operation. Be an approachable coach to those on your team. Help the operators learn and grow by enthusiastically sharing your knowledge with them and helping them solve problems.
8. Provide technical leadership and expertise to facilitate safe, reliable, and economical operation of the site processes.

Commissioning Engineer

The Commissioning Engineer typically is a Chemical / Mechanical Engineer with some design and operations experience. The Commissioning Engineers contribute to the team by performing a technically oriented service function. They must remember to respect the supervisory role of the operations supervisors and work through them on all issues related to operations. The Commissioning Engineer will record and track the Acceptance Test Run procedure data and make recommendations where and when adjustments need to be implemented. They can be utilized on shift or on a straight day mode.

Responsibilities;

1. Encourage open communication between all parties in the organization. Communication is essential to the success of any organization. Continually strive to develop a positive relationship with open communication with the operators as well as the Production Supervisor.
2. Record Acceptance Test Run data.
3. Develop recommendations to improve Acceptance Test Run.
4. Ensure that site processes are monitored and controlled to achieve safe and economical operation while developing all operators to their full potential.
6. Coach the operators to complete the maximum possible amount of follow-up on their own when items are not as per normal operation. Be an approachable coach to those on your team. Help the operators learn and grow by

enthusiastically sharing your knowledge with them and helping them solve problems.

7. If on shift;
   a. At the beginning of each shift exchange information - be inquisitive; fully understand the state of operations, problems, etc.
   b. Initiate any immediate action needed (recommendations for Maintenance, Operators, etc).
   c. Review the operation soon after shift change and several times throughout the day.

      Inside – review board operations and product specifications

      Outside - review outside route via round sheets immediately after completing each route. This helps to detect trends that may not have been noticed while collecting data.
   d. At end of shift be sure to effectively verbally communicate to your relief, be sure and record all significant items in the logbook.

Commissioning Operator

The Commissioning Operator typically is an operations personnel with greater than 10 years operations experience. They will have seen several chemical plant grass roots start-ups. They must remember to respect the supervisory role of the operations supervisors and work through them on all issues related to operations. The Commissioning Operator will record and track the Acceptance Test Run procedure data. They are typically utilized on shift mode.

Responsibilities;

1. Encourage open communication between all parties in the organization. Communication is essential to the success of any organization. Continually strive to develop a positive relationship with open communication with the operators as well as the Production Supervisor.
2. Record Acceptance Test Run data.

3. Ensure that site processes are monitored and controlled to achieve safe and economical operation while developing all operators to their full potential.
5. Coach the operators to complete the maximum possible amount of follow-up on their own when items are not as per normal operation. Be an approachable coach to those on your team. Help the operators learn and grow by enthusiastically sharing your knowledge with them and helping them solve problems.
6. While on shift;
    a. At the beginning of each shift exchange information - be inquisitive; fully understand the state of operations, problems, etc.
    b. Initiate any immediate action needed (recommendations for Maintenance, Operators, etc).
    c. Review the operation soon after shift change and several times throughout the day.

        Inside – review board operations and product specifications

        Outside - review outside route via round sheets immediately after completing each route. This helps to detect trends that may not have been noticed while collecting data.

    d. At end of shift be sure to effectively verbally communicate to your relief, be sure and record all significant items in the logbook.

DEFINITIONS

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 there of. 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.

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

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.

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.

Distributed Control System (DCS) - A digital processor based control system in which the controller elements are not located centrally, but are distributed throughout the system with each component subsystem controlled by one or more controllers and interconnected by a communications network for monitoring and integrated control.

Engineered System - A designated grouping of components designed to perform a specific function within the configuration of the facility. A system identifier (two-letter alpha code*) is used by the project to identify a system for engineering, construction, startup, and planning purposes.

Facility Startup (Commissioning) Milestone Schedule A list of systems with startup completion dates presented in a logical sequence to permit a smooth and orderly startup. The sequence is based upon system prerequisites, historic information from other projects, and manpower logic loading. The startup schedule projects scheduled activities in terms of weeks before turnover to the Owner for commercial operation.

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

In-Service Test - Pressurization of a system or component with normal system fluids by placing the system in service to demonstrate the tightness of flanges, manholes, and other mechanical closures of piping and equipment. The pressure may be increased to the shutoff head of system pumps but shall be less than installed relief device settings.

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 Check - A testing practice where a test technician will activate or simulate each device or instrument in a control loop to confirm that the device or loop has been correctly configured and that each device or instrument functions correctly within that loop. Many individual DCS I/O points may need to be verified in order to complete a single loop check. Loop checks do not normally verify internal DCS logic.

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.

Permissive - A specific prerequisite condition (e.g. tank level, lube oil temperature, vibration level, valve position) that must be met before a component may leave a safe condition. A permissive function may not cause a trip but a trip function will usually act as a permissive since the component cannot operate until the trip is cleared.

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.

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.

Shift Engineer - A startup engineer assigned the responsibility of directing or guiding operations personnel in the operation of the facility for a particular shift. He/she also coordinates the activities of the various system startup engineers as they affect facility operation.

Startup Inspection and Testing Phase - This period starts at turnover from Construction to Startup and consists mostly of component-level testing and checkout. **Initial System Operation Phase -** This period consists of major component and system cleaning and testing and intersystem tuning and adjustment. 3.4.7 Initial **Loading/Reliability Run Phase -** This period consists of systems operation on an integrated facility basis including performance tests, transient tests, and emissions compliance tests, and culminates in facility acceptance by the Owner.

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. 3.2.4 **Subsystem -** A division of an engineered system used by Startup for planning, scheduling, and turnover requirements. The subsystem associates its function with the operation of the engineered system. The subsystem carries the same system identifier followed by one or more suffix digits. 3.2.5 Scoping Defining engineered or startup system boundaries by marking piping and instrument diagrams (P&IDs), electrical single-line drawings, electrical schematics, and other engineering documents to relate and identify specific mechanical, electrical, and instrument components. Micro-scoping is the breakdown of engineered systems into subsystems to the extent that the original purpose of system scoping has been totally defeated.

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.

System Startup Engineer - A startup engineer assigned the responsibility for the startup of a system. He/she coordinates the activities of the various discipline startup engineers that may be called to work on the system. He/she may be of any discipline although generally, mechanical systems will have a mechanical startup engineer and electrical systems will have an electrical startup engineer

System Testing - The cleaning, checkout, operation, and tuning of components as an integrated system to verify that the system performs in accordance with vendor documentation and project design requirements.

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

Test - An activity being performed to prove the functionally 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.

Unit or Units - One or all process, offsite and/or utility Units and facilities as applicable to form a complete operable refinery/ and or plant.

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