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Related Documents

ICA-001 Phases of the Commissioning Process

ICA-002 Terminology

ICA-003 Roles & Responsibilities

ICA-004 Commissioning Strategy & Planning

ICA-005 Commissioning Engineering, Manufacturing, Construction Completions

ICA-006 On-Site Testing

ICA-007 Handover, In-Service, Closeout

ICA-008 Safety & Risk Management

ICA-009 Lessons Learned & Continuous Improvement

1 Introduction

1.1 Purpose

The purpose of this document is to define the framework and best practices for conducting on-site testing during the commissioning process. On-site testing serves as a critical phase in the commissioning process, where installed systems, equipment, and components are validated to ensure they meet design specifications, safety requirements, and operational performance goals.

This document outlines the strategies and methodologies necessary to:

- Conduct systematic on-site tests to verify system functionality and readiness for operation.
- Ensure safety and compliance during all testing activities.
- Identify and address deficiencies prior to startup, minimizing risks and delays.
- Align testing activities with project commissioning objectives and milestones.

1.2 Scope

This document applies to all stakeholders involved in on-site testing, including commissioning engineers, project managers, contractors, vendors, and quality assurance teams. It is relevant to industrial plant process and energy system projects, regardless of size or complexity.

The scope includes:

- Guidelines for preparing and executing on-site testing activities, including functional and performance testing.
- Establishing protocols for test documentation, reporting, and closeout of deficiencies.
- Managing safety, risk, and compliance during on-site testing.
- Coordinating testing schedules and resources to align with project timelines and milestones.

By standardizing on-site testing practices, this document ensures that systems are validated effectively and ready for safe and reliable operation. It emphasizes collaboration among stakeholders and adherence to safety and quality standards, reducing risks and ensuring that all systems function as intended.

1.3 Use and Disclaimer

Any group, organization, or individual is free to use this Global Commissioning Standard as a reference when working on projects. This standard is provided for informational and guidance purposes only. It is not intended to replace or override local laws, regulations, or specific contractual requirements. While every effort has been made to ensure the accuracy and relevance of the content, users are solely responsible for verifying that the information in this standard is appropriate and applicable to their specific projects.

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The ICA Global Commissioning Standard is a living document and may be subject to updates. Users are responsible to make sure they have the latest version.

2 Document Templates

The ICA Global Commissioning Standard references several templates to be used when creating documentation and gathering information. All templates are provided in the Member's Area of the Institute of Commissioning & Assurance. Log in to access and download these templates so you can create your project-specific documentation to define your commissioning process. The Membership Portal is available at www.icxa.net.

3 Static Commissioning Phase

3.1 Purpose

The Static Commissioning Phase focuses on verifying the functionality of individual equipment and groups of equipment before system-level testing begins during the dynamic commissioning phase. The primary goal of static commissioning is to demonstrate that all equipment is installed correctly, operates according to design specifications, and is mechanically and operationally ready for dynamic commissioning. This phase minimizes the risk of failures during dynamic commissioning and guarantees that all systems are prepared for the more rigorous operational tests.

3.2 Definition

Static commissioning is the process of conducting equipment-level tests and verifications to confirm that individual equipment, instruments, and control systems function as intended. It involves mechanical, electrical, and instrumentation tests, such as loop checks and instrument calibration, confirming that all components meet the necessary

operational standards before transitioning to full system testing during dynamic commissioning.

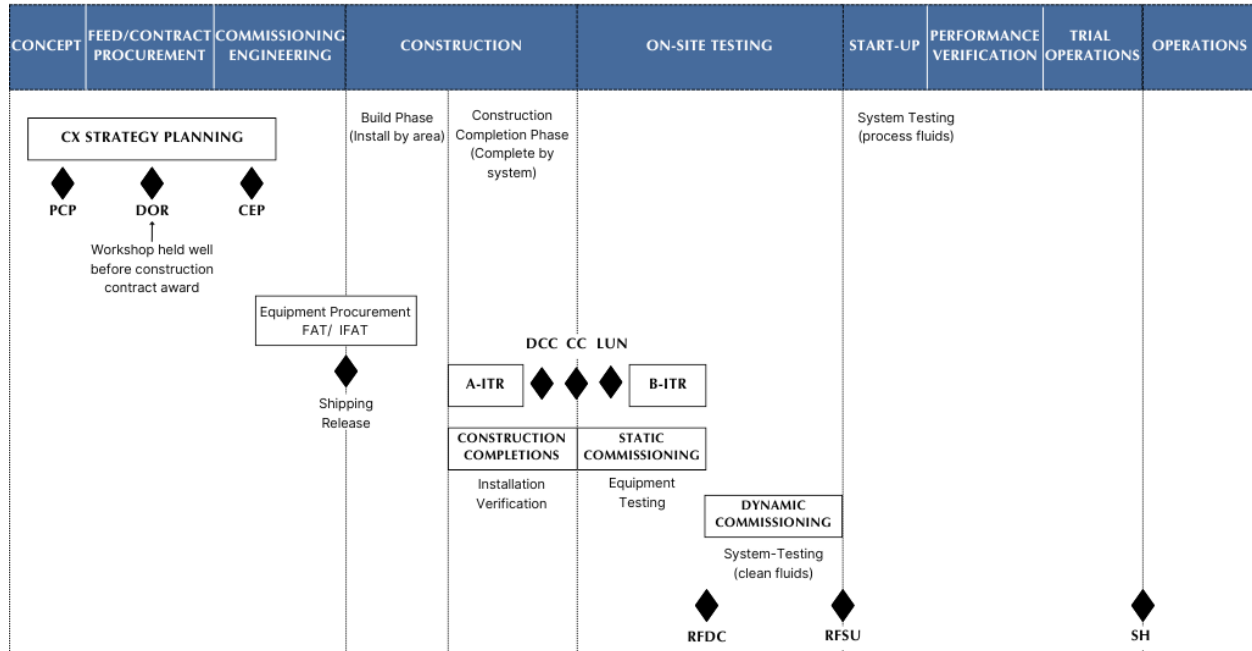


Figure 1 Commissioning Phases & Handover Model

The static commissioning phase starts once each system's Construction Completion Certificate is issued. The commissioning team then proceeds with static commissioning tests, such as loop checks for control and protection systems, hi-pot tests for electrical systems, and bump tests for mechanical rotating systems.

The static commissioning phase concludes once all equipment-level tests are complete, prior to the start of system-level tests during dynamic commissioning, once the Ready for Dynamic Commissioning (RFDC) milestone is achieved.

Keep in mind that there are multiple static commissioning phases taking place concurrently on different systems. While one static commissioning phase ends on one system, another static commissioning phase may start on another system. In this way, multiple systems are at various stages of completion through the commissioning process, as each is completed concurrently.

3.3 Objectives of Static Commissioning

3.3.1 Verification/Energization of Utility Systems

- **Objective:** Verify air, oil, water, and power utility systems as some of the first systems transitioned from construction groups, as these systems will be needed for

subsequent static commissioning and dynamic commissioning activities. These utility systems are often referred to as balance of plant systems, and are the support systems needed for further testing.

- **Key Actions:** Verify that utility systems are complete, accurate, and safe for first energizations or use.
- **Outcome:** Fully functional utility systems or balance of plant systems that are ready to support the next stages of testing.

3.3.2 Instrument Calibration and Functional Testing

- **Objective:** Ensure that control systems and instrumentation (e.g., sensors, actuators, control loops) are fully calibrated, functional, and ready for operational use during commissioning.
- **Key Actions:** Perform calibration of instruments, functional tests, and loop checks to validate the accuracy and performance of individual control systems and automation components.
- **Outcome:** Fully calibrated and operational instrumentation systems, ensuring accurate data collection and control during the commissioning phase.

3.3.3 Equipment-Level Functional Testing

- **Objective:** Verify that individual equipment (e.g., pumps, motors, control panels) operates as intended prior to system-level commissioning.
- **Key Actions:** Power up and test equipment to confirm that each component operates according to specifications and can function independently as required.
- **Outcome:** Verified functionality of all equipment, confirming it meets the operational criteria for commissioning.

3.3.4 Loop Checks and Control System Verification

- **Objective:** Test and validate the functionality of connected equipment through loop checks and control system interactions, confirming accurate signal transmission and feedback.
- **Key Actions:** Conduct loop checks for connected instrumentation and control devices, confirming proper communication between field instruments and control systems.
- **Outcome:** Successful loop checks and control system verifications, confirming that all connected equipment is ready for integrated testing in the commissioning phase.

3.3.5 Safety Checks and Regulatory Compliance

- **Objective:** Ensure that all equipment complies with safety regulations and industry standards, confirming readiness for commissioning and operational use.
- **Key Actions:** Perform safety checks on equipment, review interlocks, and verify compliance with safety and environmental regulations.
- **Outcome:** Verified compliance with safety and regulatory standards, confirming safe operations during the commissioning phase.

3.3.6 Documentation of Static Commissioning Results

- **Objective:** Record all static commissioning activities, including test results, inspections, and certifications, to provide a comprehensive reference for the commissioning phase.
- **Key Actions:** Compile detailed records of static commissioning tests, equipment verification, and system readiness.
- **Outcome:** Complete and accurate documentation of all static commissioning activities, for a smooth handover to the commissioning team.

3.3.7 Ensure Equipment Readiness for Dynamic Commissioning

- **Objective:** Confirm that all equipment is prepared for the more complex, system-level tests and performance checks during the commissioning phase.
- **Key Actions:** Perform final equipment checks and verify that all relevant operational manuals and documentation are available.
- **Outcome:** Equipment ready for commissioning, with all preliminary tests and verifications completed, for a seamless transition to system-level testing.

3.4 Static Commissioning Document Deliverables

The Static Commissioning Phase requires detailed documentation to confirm that all systems, equipment, and processes have been inspected, tested, and verified before transitioning to the dynamic commissioning phase. Comprehensive and accurate documentation is essential to confirm that all static commissioning activities have been successfully completed and that systems are ready for the next stages of dynamic commissioning. The following are the key documentation deliverables from the static commissioning phase.

3.4.1 Instrumentation and Calibration Reports

- **Description:** Detailed reports documenting the calibration of all instrumentation and control systems to ensure accuracy and operational readiness.

- **Purpose:** To confirm that all instrumentation systems are accurately calibrated and connected to control systems, providing reliable data for commissioning.

3.4.2 Functional Test Results

- **Description:** Reports detailing the results of functional tests performed on mechanical, electrical, and control equipment to verify operational readiness.
- **Purpose:** To confirm that all equipment operates as designed and is ready for full commissioning.

3.4.3 Safety Inspection and Compliance Reports

- **Description:** Reports documenting the results of safety audits and inspections, confirming compliance with safety regulations and industry standards.
- **Purpose:** To confirm that all static commissioning activities comply with applicable safety guidelines, minimizing risks during commissioning.

3.4.4 Static Commissioning ITR Checklists (B-ITR)

- **Description:** Comprehensive Inspection Test Record (ITR) checklists that document all static commissioning tasks and confirm that each activity has been completed successfully.
- **Purpose:** To provide a detailed record of all static commissioning activities, ensuring nothing is overlooked before moving to commissioning.

3.4.5 Handover Documentation

- **Description:** A complete package of all static commissioning documents, including test results, certificates, and inspection reports, to be handed over to the commissioning team.
- **Purpose:** To ensure that the commissioning team has all the necessary information to proceed with the next phase of the project.

3.4.6 Stakeholder Sign-Off

- **Description:** Official sign-off records that confirm stakeholder approval of the static commissioning results and readiness for commissioning.
- **Purpose:** To obtain formal approval from key stakeholders, confirming that all systems are ready to transition to commissioning.

Static commissioning documentation ensures that all equipment, systems, and activities are verified, tested, and properly documented before the dynamic commissioning begins.

4 Dynamic Commissioning Phase

4.1 Definition and Objectives

The Dynamic Commissioning Phase is where systems, equipment, and infrastructure are thoroughly tested as a system to confirm their operational readiness. During this phase, utility systems (air, oil, water, heating, cooling, etc) as well process systems (pre-treatment, refinement, coagulation, etc) are tested using clean fluids before process fluids are introduced in the startup phase and before full megawatt transfers in energy systems. The primary goal is to demonstrate that all components function as designed, safely and reliably, under normal and abnormal operating conditions, preparing the project for the transition into the startup phase.

4.1.1 Definition:

During dynamic commissioning, systems are tested with clean fluids (e.g., air, water) where possible to simulate operational conditions, verifying that they are ready to handle process fluids and full operational loads in the startup phase. Testing with clean fluids may not always be possible, but this is a prudent risk mitigation strategy to protect against bigger issues during startup. For example, testing with clean fluids is typically done prior to introduction of wastewater or hydrocarbons, since removing and cleaning hazardous fluids from piping is difficult and time consuming should an issue be discovered after startup that requires investigation within the system.

Dynamic commissioning includes testing of both normal and abnormal operating conditions to verify system readiness prior to full-scale operation.

4.1.2 Objectives of Dynamic Commissioning

Validate System Performance Across All Operating Modes

- **Objective:** Demonstrate that all systems, equipment, and components perform according to design specifications under normal and abnormal operating conditions, using clean fluids prior to introducing process fluids.
- **Key Actions:** Execute system-level tests, simulate various operational modes, and observe system behavior during startup, shutdown, and fault conditions using clean fluids, using a step-by-step System Commissioning Procedure developed in the commissioning engineering phase.
- **Outcome:** Verified system functionality in all expected and abnormal scenarios, confirming readiness for the introduction of process fluids and the startup phase.

Ensure Safety and Risk Management:

- **Objective:** Confirm that systems meet safety standards and are prepared for full-scale operation, safeguarding personnel, equipment, and the environment during future operational phases.
- **Key Actions:** Perform safety checks, validate protective systems, and test emergency shutdown mechanisms while using clean fluids to verify that systems can safely handle process fluids.
- **Outcome:** Safe systems with mitigated risks, ready for the introduction of process fluids and full megawatt transfers in energy systems.

Test System Responses to Abnormal Operating Conditions:

- **Objective:** Confirm that systems perform reliably under abnormal conditions, such as overloads or emergency shutdowns, using clean fluids.
- **Key Actions:** Simulate abnormal conditions, validate system responses, and test fail-safes and backup systems to confirm proper functionality in emergencies.
- **Outcome:** Demonstrated reliability and safety during unexpected scenarios, ensuring the system is prepared for operational challenges in later phases.

Optimize System Settings and Configurations:

- **Objective:** Fine-tune systems to verify they are operating at peak performance and efficiency prior to introducing process fluids and transferring full megawatt loads.
- **Key Actions:** Conduct system tuning, calibrate control systems, and make necessary adjustments to optimize performance with clean fluids.
- **Outcome:** Optimized systems ready for efficient operation during startup, ensuring a smooth transition to handling process fluids and full operational capacity.

Test Control and Automation Systems:

- **Objective:** Verify that control systems, automation sequences, and instrumentation are fully operational and ready to manage processes effectively before process fluids and full loads are introduced.
- **Key Actions:** Test programmable logic controllers (PLCs), distributed control systems (DCS), human-machine interfaces (HMI), and SCADA systems to confirm they function correctly in all operating scenarios using clean fluids.
- **Outcome:** Fully operational control systems, prepared to manage processes during the startup phase and full megawatt transfers.

Document Commissioning Activities:

- **Objective:** Maintain thorough documentation of all commissioning activities, including tests performed with clean fluids, performance data, and any issues resolved during the process.
- **Key Actions:** Compile test reports, performance evaluations, and inspection results, documenting system readiness for the next phase.
- **Outcome:** Complete documentation provides a clear record of system functionality and readiness for the introduction of process fluids and operational startup.

Engage Stakeholders for Final Review and Approval:

- **Objective:** Involve key stakeholders in reviewing commissioning results and securing approval to proceed to the startup phase.
- **Key Actions:** Present results, address any concerns, and confirm that systems are ready for the introduction of process fluids and full operational capacity.
- **Outcome:** Formal stakeholder approval, confirming that systems are ready for startup and subsequent full-load operations.

4.2 Dynamic Commissioning

Dynamic commissioning is essential to confirm that all mechanical, electrical, and automation systems work together seamlessly to operate as one integrated plant process or energy system. This stage focuses on validating the interactions between different systems, confirming that they are not only functioning correctly on an individual basis but are also fully synchronized to operate efficiently and reliably as a unified process.

4.2.1 Integration of Mechanical, Electrical, and Automation Systems

- **Objective:** Ensure that mechanical systems (pumps, compressors, rotating machinery), electrical systems (power distribution, transformers, motor control centers), and automation systems (PLCs, DCS, SCADA) are fully integrated and communicate effectively with each other.
- **Actions:**
 - Verify that electrical power is correctly supplied to all mechanical components and that the systems can operate within the required load capacities.
 - Verify control signals between automation systems and mechanical equipment are accurate and respond in real-time to commands.

- Test the integration of automation and control systems with electrical equipment, ensuring seamless operation during start-up, shutdown, and system interlocks.
- **Outcome:** Integrated systems that communicate effectively, confirming that mechanical, electrical, and automation systems function as a unified process.

4.2.2 Functional Testing of System-Level Operations

- **Objective:** Validate the ability of the plant to operate as one cohesive process by simulating typical operating conditions and observing how systems perform together.
- **Actions:**
 - Conduct system-level tests where all subsystems (mechanical, electrical, automation) are activated simultaneously, replicating operational scenarios.
 - Simulate normal operations such as startup sequences, process load changes, and shutdown sequences to observe system coordination.
 - Verify that system-level safety interlocks and emergency procedures operate across all systems, ensuring plant-wide safety.
- **Outcome:** Proven functionality of the integrated plant process, with all systems operating in harmony under real-world operational scenarios.

4.2.3 Communication and Data Flow Testing

- **Objective:** Ensure seamless communication and data exchange between mechanical, electrical, and automation systems, enabling effective monitoring and control of the plant process.
- **Actions:**
 - Test data flow from sensors and field instruments to control systems (PLCs, DCS) and verify that all data is accurately processed and displayed in human-machine interfaces (HMIs).
 - Confirm that control commands issued by the automation system are correctly transmitted and executed by the mechanical and electrical systems.
 - Validate alarm and notification systems for abnormal conditions, ensuring that any deviations from expected operations are detected and reported across all systems.

- **Outcome:** Reliable communication and data flow between all systems, for accurate monitoring, control, and response across the plant process.

4.2.4 System-Level Safety and Emergency Testing

- **Objective:** Confirm that all systems are integrated to respond effectively during emergency situations, ensuring plant-wide safety.
- **Actions:**
 - Simulate emergency shutdown (ESD) procedures, verifying that mechanical, electrical, and automation systems work together to safely shut down operations in an emergency.
 - Test interlocks and safety systems to confirm that they trigger the appropriate responses across all subsystems, preventing unsafe conditions.
 - Conduct safety drills to demonstrate all integrated systems respond in unison to hazardous conditions or alarms.
- **Outcome:** Fully tested and compliant safety integration, confirming that the plant process can handle emergency situations and respond effectively to safeguard personnel and equipment.

4.2.5 Punch Closeout During Dynamic Commissioning

- **Objective:** Ensure all remaining punch items are resolved during dynamic commissioning to prepare for startup.
- **Key Actions:**
 - Use CMS software to track punch items during dynamic commissioning and confirm that any new A-punch items are resolved before system start-up.
 - Schedule regular punch item reviews to confirm all issues are closed out in line with commissioning milestones.
 - Finalize punch categorization and closeout.
- **Outcome:** Punch items are tracked and closed out efficiently during commissioning, ensuring no delays in the handover process.

4.2.6 System Documentation and Stakeholder Sign-Off

- **Objective:** Provide detailed documentation of system-level testing results, so all stakeholders are informed and approve the integration of systems.
- **Key Actions:**
 - Document all system-level tests, including the results of integration, load performance, safety checks, and any identified issues or adjustments.
 - Provide a comprehensive report that highlights system functionality, compliance with design specifications, and readiness for the next phase.

- Review and present system-level testing outcomes to project managers, engineers, and other key stakeholders for approval.
- **Outcome:** Complete system-level testing documentation, providing clear evidence that all systems are fully integrated and functioning as a unified plant process, with formal approval from stakeholders to proceed.

4.2.7 Commissioning Test Report

- **Description:** A comprehensive report that consolidates the results of all commissioning activities, including system-level testing, load and stress tests, safety system verifications, and calibration of instrumentation and control systems.
- **Purpose:** To provide a clear and complete record that all systems have been tested and are functioning as designed, ready for operational startup and long-term use.
- **Key Components:**
 - **System-Level Testing Results:** Summary of the integration testing for mechanical, electrical, and automation systems, confirming they operate as a unified process.
 - **Load and Stress Testing Data:** Documentation of performance under full operational loads and stress conditions, verifying system stability and capacity.
 - **Safety System Testing:** Verification of emergency shutdowns, alarms, interlocks, and other safety protocols to ensure compliance with safety standards.
 - **Calibration Reports:** Confirmation that all control systems, sensors, and instrumentation are calibrated and providing accurate data.
- **Outcome:** A complete commissioning report, signed by project stakeholders, certifying that all systems are tested, operational, and ready for the startup phase.

5 Startup Phase

5.1 Definition and Objectives

The Start-Up Phase marks the transition from dynamic commissioning to full operational mode, where systems, equipment, and processes are run under real-world conditions with live inputs for the first time. This phase focuses on gradually ramping up operations, including the introduction of process fluids, ramping up to full electrical loads, verifying system performance in real-time, and confirming systems can sustain continuous

operation. The Start-Up Phase involves close monitoring to detect and resolve any early-time operational issues before the project moves to full-scale production.

Due to the complexity of the startup phase, the transitions and responsibilities must be clearly documented in the Division of Responsibility (DOR) matrix and associated plans and procedures.

5.1.1 Definition:

This phase focuses on confirming that systems meet performance, safety, and reliability standards as they transition into stable, continuous operation.

5.1.2 Objectives of the Startup Phase

- **Pre-Startup Safety Review**
 - **Objective:** Ensure all equipment and systems are in a safe condition prior to startup, as well as confirm that the necessary safety protocols are in place prior to startup
 - **Key Actions:** Develop a PSSR checklist and circulate it for review by all stakeholders. Complete the review of PSSR checklist items to confirm all actions have been taken. Meet to review with all stakeholders to confirm all safety protocols are in place and all hazards have been mitigated prior to startup.
 - **Outcome:** All stakeholders are in agreement that the planned startup is safe and can proceed.
- **Initiate Live Operations**
 - **Objective:** Transition systems from dynamic commissioning to live operational mode by introducing real-world inputs, including the first introduction of process fluids, and running systems in their intended environment.
 - **Key Actions:** Activate systems using operational parameters such as live power supply, process fluids, production materials, and control inputs, so they start smoothly.
 - **Outcome:** Systems are successfully initiated and can operate under live conditions, including process fluid introduction, without failure or disruption.
- **Ramp-Up to Full Operational Conditions with Process Fluids:**

- **Objective:** Gradually increase system loads, including the introduction of process fluids, to full operational capacity while monitoring performance and stability.
- **Key Actions:** Incrementally introduce process fluids and other operational loads, such as throughput, power demand, or production rates, while closely observing system performance at each stage.
- **Outcome:** Systems are tested at full capacity with process fluids, confirming their ability to handle long-term operations at their designed output levels.
- **Monitor System Stability and Performance:**
 - **Objective:** Continuously monitor all systems during the start-up phase to demonstrate stable operation and address any issues that arise.
 - **Key Actions:** Use monitoring tools to track key performance indicators (KPIs) such as temperature, pressure, flow rates, energy usage, and system response times, especially during the introduction of process fluids.
 - **Outcome:** Stable system performance is achieved, with any deviations or issues addressed promptly to prevent operational failures.
- **Identify and Resolve Operational Issues:**
 - **Objective:** Detect and resolve any early-stage operational issues or inefficiencies that could impact long-term performance.
 - **Key Actions:** Analyze system performance data to identify areas of concern, such as equipment malfunctions, inefficiencies, or performance bottlenecks, and implement corrective actions.
 - **Outcome:** All identified issues are resolved, and systems are optimized for continuous operation with process fluids and full operational loads.
- **Validate System Integration in Live Environment:**
 - **Objective:** Show that all systems and subsystems are integrated seamlessly under live operational conditions, functioning as a cohesive unit.
 - **Key Actions:** Test the interaction between mechanical, electrical, control, and safety systems in the real operational environment with process fluids, confirming they work together without conflicts or failures.
 - **Outcome:** Fully integrated systems that operate reliably and safely under live conditions, confirming that all components function as intended.
- **Confirm Safety and Regulatory Compliance During Operation:**
 - **Objective:** Confirm that systems continue to meet all safety and regulatory requirements during live operations, including the handling of process fluids.

- **Key Actions:** Perform regular safety checks and audits, monitoring systems for compliance with safety standards, and verifying that protective measures are functioning properly, especially during fluid transfers and operational ramp-up.
- **Outcome:** Systems remain compliant with safety and regulatory requirements, protecting personnel, equipment, and the environment during the start-up phase.

5.2 Ramp-Up to Operational Conditions

The Ramp-Up to Operational Conditions phase during start-up involves gradually increasing the operational load on both electrical and mechanical systems to bring them to their designed capacity under live conditions. For mechanical systems, this includes the introduction of process fluids, while for electrical systems, it involves progressively increasing the power load. The primary goal of this phase is to establish stable and continuous system operations, confirming that systems can function at full capacity in preparation for performance verification in the next phase.

5.2.1 Gradual Increase of System Load

- **Objective:** Introduce and progressively increase system loads for electrical and mechanical systems, bringing them to full operational capacity.
- **Key Actions:**
 - For **electrical systems**, start with reduced loads and gradually increase toward full capacity, monitoring system behavior for any signs of instability.
 - For **mechanical systems**, gradually introduce process fluids, monitoring flow rates, pressures, and other important parameters as they are ramped up to full design levels.
 - Conduct observations at each incremental load stage, focusing on key metrics such as temperature, pressure, flow rates, and power consumption.
- **Outcome:** Systems are smoothly ramped up to full capacity, with stable operations under increasing loads and process fluid introduction.

5.2.2 Monitoring Key Performance Indicators (KPIs)

- **Objective:** Continuously track and analyze key performance indicators (KPIs) during the ramp-up to verify that systems are functioning within acceptable ranges.
- **Key Actions:**

- Use real-time monitoring systems to track KPIs such as electrical load, flow rates, pressure, and energy usage as loads are increased.
- Compare observed data against expected values to confirm that systems are operating within acceptable limits at each load stage.
- Monitor for any early signs of instability or system deviations and make adjustments as needed to confirm stable operation.
- **Outcome:** KPIs confirm that systems are functioning correctly and within design parameters as they approach full operational capacity.

5.2.3 Documentation and Reporting

- **Objective:** Document the ramp-up process, capturing performance data, system adjustments, and the overall progress towards stable operations.
- **Key Actions:**
 - Record all relevant performance metrics and system observations during the ramp-up phase, noting any incidents or adjustments made.
 - Compile detailed reports summarizing system behavior, ramp-up activities, and results achieved at each load stage.
 - Submit these reports to project managers and stakeholders for review and sign-off, confirming the successful completion of the ramp-up phase.
- **Outcome:** Complete documentation of the ramp-up process, providing a clear record of system readiness for the performance verification phase.

5.2.4 Stable System Operations Report

- **Description:** A comprehensive report documenting the process and outcomes of achieving stable system operations during the start-up phase, including any issues encountered and resolved.
- **Purpose:** To provide clear evidence that systems have been successfully brought online, ramped up to full operational load, and are operating continuously under live conditions.
- **Key Components:**
 - Confirmation that the system has reached full operational capacity with live inputs and process fluids.
 - Documentation of any issues encountered during start-up and the corrective actions taken to resolve them.

- Verification that safety systems and protocols have functioned correctly throughout the start-up process.
 - Evidence that the system is stable, safe, and ready for continuous operation.
- **Outcome:** A complete and signed-off report confirming that the system is fully operational, stable under live conditions, and ready for handover to the operations team.

6 Performance Verification

6.1 Definition and Objectives

The Performance Verification Phase is where systems are rigorously tested and validated under actual operational conditions. The primary goal of this phase is to confirm that systems meet the performance, safety, and regulatory criteria specified in the project design. This phase demonstrates that the project is fully functional, efficient, and reliable, preparing systems for long-term operation and providing stakeholders with confidence in system performance.

6.1.1 Definition:

Performance verification is the systematic process of testing, monitoring, and validating the performance of systems, equipment, and processes under full operational loads and real conditions. It validates that all systems meet the required output, efficiency, safety, and regulatory standards before final handover for continuous operation.

6.1.2 Objectives of Performance Verification

- **Confirm Compliance with Design Specifications**
 - **Objective:** Validate that all systems and equipment meet or exceed the performance criteria outlined in the project's design specifications, including capacity, efficiency, and reliability.
 - **Key Actions:** Compare actual performance data with design specifications, confirming that systems are operating within acceptable parameters.
 - **Outcome:** Systems are confirmed to be compliant with design specifications, confirming they function as intended.
- **Validate System Performance Under Real Operational Conditions**
 - **Objective:** Ensure that systems can sustain performance targets under real operating conditions for extended periods.

- **Key Actions:** Continuously monitor systems during operation, assessing key performance indicators (KPIs) such as energy usage, output levels, and system stability.
- **Outcome:** Systems are validated for continuous operation, demonstrating their ability to meet operational demands in real-world conditions.
- **Ensure Efficiency and Resource Optimization**
 - **Objective:** Evaluate system efficiency and identify opportunities for optimization, ensuring that energy use, resource consumption, and operational costs are minimized while maintaining productivity.
 - **Key Actions:** Analyze energy consumption, output, and operational data to identify inefficiencies and optimize system performance where necessary.
 - **Outcome:** Optimized systems that operate efficiently, reducing energy consumption and operational expenses without sacrificing performance.
- **Assess System Reliability and Stability**
 - **Objective:** Confirm that systems operate reliably and maintain stability over extended periods, without interruptions, failures, or degradation in performance.
 - **Key Actions:** Conduct long-duration tests, monitoring system behavior for potential issues such as overheating, wear, or control system malfunctions.
 - **Outcome:** Proven reliability and stability of systems, confirming they can operate continuously without significant disruptions.
- **Ensure Regulatory and Environmental Compliance**
 - **Objective:** Verify that all systems meet regulatory standards and environmental guidelines, protecting personnel, the environment, and stakeholders.
 - **Key Actions:** Perform regulatory audits, environmental assessments, and safety inspections to confirm that systems comply with all legal and industry requirements.
 - **Outcome:** Verified compliance with safety, environmental, and regulatory standards, confirming the project operates within all applicable frameworks.

- **Document and Report Performance Findings**

- **Objective:** Compile a comprehensive record of all performance verification activities, including test results, performance data, and any necessary system adjustments.
- **Key Actions:** Prepare detailed reports summarizing performance findings, highlighting deviations from expected results, corrective actions taken, and overall system performance.
- **Outcome:** Completed performance verification reports that provide stakeholders with clear evidence of system readiness and reliability.

- **Obtain Final Stakeholder Approval**

- **Objective:** Secure formal approval from stakeholders, confirming that the systems meet all performance, efficiency, safety, and regulatory requirements.
- **Key Actions:** Present performance verification results to stakeholders, address any concerns, and obtain their formal sign-off on system readiness for long-term use.
- **Outcome:** Final stakeholder approval, confirming that systems are fully verified and ready for operational handover.

6.2 Performance Verification

The Performance Verification phase demonstrates that all systems, equipment, and processes perform according to design specifications under real-world operational conditions. This phase involves detailed testing, data collection, and analysis to confirm that system outputs, efficiency, and reliability meet the established performance criteria. The primary objective is to validate that systems are capable of sustained, consistent, and efficient operation over extended periods.

6.2.1 Real-Time Performance Monitoring

- **Objective:** Continuously monitor key performance metrics to confirm that systems operate within expected parameters and maintain steady performance under live conditions.
- **Key Actions:**
 - Use real-time monitoring tools to track important indicators such as energy consumption, temperature, pressure, flow rates, and system output.

- Record operational data at regular intervals to detect trends, deviations, or inefficiencies.
- Monitor system alarms and alerts to detect and address performance anomalies promptly.
- **Outcome:** Comprehensive real-time data confirming that systems are operating within design specifications and performing as expected.

6.2.2 Functional and Output Testing

- **Objective:** Verify that systems achieve the required functional outputs and maintain operational capacity during peak and off-peak conditions.
- **Key Actions:**
 - Conduct tests to measure system outputs, including production rates, energy efficiency, and throughput under varying load conditions.
 - Simulate different operational scenarios to assess how systems respond and adjust to varying demands.
 - Ensure that systems can sustain peak output levels without performance degradation or excessive wear.
- **Outcome:** Verified system functionality and output, demonstrating that systems meet operational targets and are capable of consistent performance.

6.2.3 Efficiency and Energy Consumption Analysis

- **Objective:** Assess system efficiency and confirm that energy consumption is within acceptable limits, reducing operational costs and environmental impact.
- **Key Actions:**
 - Analyze energy usage data and compare it with system outputs to calculate overall system efficiency.
 - Identify inefficiencies or excessive energy consumption and implement corrective actions to improve performance.
- **Outcome:** Optimized energy consumption and improved system efficiency, for cost-effective and environmentally friendly operation.

6.2.4 System Stability Testing

- **Objective:** Confirm that systems remain stable during extended periods of continuous operation, without significant fluctuations or performance degradation.
- **Key Actions:**

- Perform long-duration tests under normal and peak load conditions, monitoring for signs of instability such as overheating, pressure drops, or system slowdowns.
- Conduct failure mode and effects analysis (FMEA) to assess how systems handle faults or unexpected failures during normal operations.
- **Outcome:** Validated system stability, confirming that systems can operate reliably over extended periods without major disruptions.

6.2.5 Verification of Control and Automation Systems

- **Objective:** Verify that all control and automation systems are functioning correctly, providing accurate and reliable responses to system inputs and changes.
- **Key Actions:**
 - Test control systems such as programmable logic controllers (PLCs), distributed control systems (DCS), and human-machine interfaces (HMIs) to verify that automated processes respond as expected.
 - Simulate abnormal conditions (e.g., equipment failures, load shifts) to verify that control systems respond correctly and adjust operations as needed.
- **Outcome:** Fully functional control and automation systems, confirming that systems can be monitored and controlled accurately under live operational conditions.

6.2.6 Comparison to Design Specifications

- **Objective:** Compare actual system performance to the original design specifications to confirm compliance with project goals.
- **Key Actions:**
 - Analyze test data and operational metrics against design criteria, such as output capacity, efficiency, and reliability.
 - Identify any deviations from design specifications and investigate the root causes of discrepancies.
 - Implement corrective measures to bring system performance in line with design expectations.
- **Outcome:** Confirmed compliance with design specifications, confirming that systems meet operational requirements and perform as intended.

6.2.7 Identification and Resolution of Performance Issues

- **Objective:** Detect any performance issues, inefficiencies, or bottlenecks and resolve them before full-scale operations.
- **Key Actions:**
 - Use performance data to identify areas of concern, such as suboptimal efficiency, excessive wear, or inconsistent outputs.
 - Investigate the causes of performance issues and apply corrective measures such as recalibration, control adjustments, or equipment maintenance.
- **Outcome:** All performance issues identified and resolved, confirming that systems operate efficiently and smoothly.

6.2.8 Final Performance Validation Report

- **Objective:** Provide a detailed report summarizing the results of the performance validation phase, including all tests, data collected, and any adjustments made.
- **Key Actions:**
 - Compile a comprehensive report including performance data, comparisons to design specifications, and documentation of corrective actions.
 - Highlight any remaining issues or areas for further optimization and provide recommendations for ongoing performance monitoring.
- **Outcome:** A complete performance validation report documenting that systems have been tested and validated for long-term operational readiness.

6.2.9 Punch Item Closeout

- **Description:** Resolution and closeout of all remaining A and B punch items before trial operation.
- **Purpose:** To confirm that any outstanding issues identified during performance verification have been addressed, so systems are fully ready for continuous operation.
- **Key Actions:**
 - Review and resolve all remaining punch items related to performance, safety, and operational readiness.
 - Document corrective actions taken to address each punch item, confirming that no priority issues remain.

- **Outcome:** A completed punch item closeout report, confirming that all issues have been addressed and systems are ready to proceed to trial operation.

6.2.10 Handover Documentation Package

- **Description:** A comprehensive package containing all relevant documentation, including performance test results, compliance certificates, safety protocols, and operational manuals.
- **Purpose:** To provide the operations team with all necessary information and documentation for managing and maintaining the systems during trial operation and beyond.
- **Key Components:**
 - Final performance verification reports and compliance certificates.
 - System operating manuals, safety procedures, and maintenance requirements.
 - Closeout documentation for all punch items and stakeholder sign-offs.
- **Outcome:** A complete handover package, formally delivered to the operations team, ensuring they are equipped to take over system management.

6.2.11 Stakeholder Sign-Off

- **Description:** Official sign-off records confirming that all project stakeholders, including engineers, project managers, and regulatory bodies, approve the performance verification results.
- **Purpose:** To formalize stakeholder approval and confirm that all parties are satisfied with system performance and readiness for trial operation.
- **Outcome:** Signed stakeholder approval records, providing formal confirmation that systems are fully verified and ready for trial operation.

7 Trial Operation Phase

7.1 Definition and Objectives

The Trial Operation Phase is the period during which systems, equipment, and processes are tested under live operational conditions for a specific period of time before final handover to the operations team. This phase involves running the systems continuously under real-world conditions to demonstrate they can operate reliably over time. The trial operation period can last 3 days, 30 days, 90 days, or as specified in the contract, with clear definitions of what constitutes a restart. If an operational upset occurs as defined in

contracts, the trial period must restart, and it only concludes once completed without any unintended restarts.

7.1.1 Definition:

Trial operation refers to the operation of systems under actual working conditions, replicating real-world demands. This phase allows the project team to verify that systems can handle continuous operations without failure. No performance verification or tuning is done at this stage, as those activities were completed earlier. The focus is on demonstrating system stability and readiness for long-term operation.

7.1.2 Objectives of Trial Operation

- **Continuous Operational Conditions**
 - **Objective:** Operate systems continuously under live conditions, replicating the full demands they will face during long-term use.
 - **Key Actions:**
 - Run systems for extended periods under actual working conditions, monitoring performance under typical and peak demands.
 - **Outcome:** Systems successfully operate under real-world conditions, demonstrating they can handle continuous usage without failure.
- **Monitor System Stability and Reliability**
 - **Objective:** Demonstrate that systems maintain stable performance and reliability throughout the trial operation period.
 - **Key Actions:**
 - Continuously monitor system behavior, tracking key performance indicators (KPIs) such as output levels, energy usage, and system response times.
 - **Outcome:** Proven system stability and reliability over the entire trial operation period, confirming systems can perform without degradation or unexpected issues.
- **Evaluate Long-Term Operational Efficiency**
 - **Objective:** Confirm that systems can maintain efficient operation over time, sustaining performance while minimizing energy consumption and operational costs.
 - **Key Actions:**

- Track efficiency metrics such as energy consumption, resource utilization, and system output to confirm systems operate within expected efficiency targets.
 - **Outcome:** Validated operational efficiency, confirming systems operate effectively and meet long-term operational goals.
- **Address Operational Upsets**
 - **Objective:** Respond to any operational upsets during the trial operation phase, addressing the issue and restarting the trial period as required.
 - **Key Actions:**
 - Monitor systems for signs of an operational upset, such as equipment failure, unexpected shutdowns, or process deviations.
 - Implement corrective actions to resolve the issue and restart the trial operation period once systems are restored.
 - **Outcome:** Operational upsets are resolved, and trial operations restart until the trial period is completed without further interruptions.
- **Trial Period and Restart Conditions**
 - **Objective:** Define and manage the duration of the trial operation period, ensuring it meets contractual requirements and that any unintended restarts are handled appropriately.
 - **Key Actions:**
 - Set the trial operation period based on contract terms (e.g., 3 days, 30 days, or 90 days).
 - Define what constitutes an unintended restart, requiring the trial operation to restart, and that the trial concludes only when the period is completed without interruptions.
 - **Outcome:** A completed trial operation period without unintended restarts, confirming systems are fully ready for long-term operation.

7.1.3 Completion of Trial Operation

- **Description:** A system that has successfully completed the trial operation period without any operational upsets, confirming its readiness for continuous and long-term operation.
- **Purpose:** To demonstrate that the system can perform reliably under live conditions without any major disruptions or failures.

- **Outcome:** The system is fully verified and ready for commercial service, having completed the trial period without interruptions or restarts.

7.1.4 Final Commissioning Certificate

- **Description:** The official commissioning certificate that verifies the system has passed all necessary tests, completed the trial operation, and is ready for full commercial service.
- **Purpose:** To formally certify that the system has met all commissioning and performance standards, authorizing its transition to operational use.
- **Outcome:** The final commissioning certificate is issued, marking the completion of the commissioning process and confirming the system's readiness for commercial service.

7.1.5 Final Handover Documentation

- **Description:** A comprehensive documentation package that includes all relevant reports, certificates, and records required for the operational team to take over system management.
- **Purpose:** To provide the operations team with all the necessary documentation, including system operating manuals, performance reports, and safety procedures, ensuring they are equipped to manage the system effectively.
- **Outcome:** The final handover documentation is prepared and delivered to the operations team, for a smooth transition to operational responsibility.