Facilities Systems Completion Planning and Execution

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Introduction

The systems completion process is the sequential activities within a project that verify and prove the construction, installation, integration, testing, and preparation of systems have been completed as designed, and thus, the facility is ready for start-up and operations. The systems completion process is designed to help prepare and manage the transfer of care, custody, and control of facilities under construction through appropriate certification and documentation, such that the details of progress are evident.

The systems completion process identifies two main phases in the project life cycle — planning and execution. The planning phase begins in front-end engineering design (FEED) and comprises evaluation/planning through the beginning of fabrication/construction. The execution phase (field activities) starts with factory acceptance tests (FATs) and ends with stable operations and acceptance of the facility by operations. Systems completion planning and execution activities overlap at detailed engineering and procurement and fabrication/construction.

For many years the petrochemical industry has prepared documents representing the combined knowledge and experience of the industry on various phases of petrochemical industry operations. In continuation of this effort, this recommended practice assembles in one document established processes, practices, and terminology to standardize systems completion planning and execution within the petrochemical industry.

Facilities Systems Completion Planning and Execution

1 Scope

This document applies to a wide variety of projects within the oil and gas industry excluding subsurface. Although intended for oil and gas industry, the process described in this document can be applied to other industries as well. It is intended that the processes and practices established herein can be adapted and applied from a single piece of tagged equipment to a complex petrochemical facility. The process described within is intended to be applied at a system level.

2 Terms, Definitions, and Abbreviations

2.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

2.1.1
"A" check sheet
A recorded verification that the equipment is mechanically complete.

2.1.2
"B" check sheet
A recorded verification that the equipment has been energized and function tested per the engineering design specification.

2.1.3
"C" check sheet
A recorded verification that a system commissioning activity has been completed.

2.1.4
commissioning
Group of energized and dynamic tests that constitute verification that each "system or subsystem" is fabricated, installed, cleaned, and tested in accordance with design and the systems are ready for start-up.

2.1.5
certificate
Documents that the system is complete for each step of the process.

2.1.6
mechanical completion
Milestone point in time when tagged items and equipment within a system is installed in accordance with all drawings, specifications, and documented in accordance with the inspection test plan and is ready for pre-commissioning.

2.1.7
handover
Internal transfer of assets based on either an area/module or systems determination between functional groups within the project organization

2.1.8
inspection and test plan
Document describing activities required to assure quality of manufacturing and installation.

2.1.9
inspection and test record
Record documenting manufacturing and installation of equipment.

2.1.10
function testing
The dynamic testing of a tag or tags, components, or loops to confirm functionality.

2.1.11
pre-commissioning
Group of energized and static tests that constitute verification that the “equipment or component” is fabricated, installed, cleaned, and tested in accordance with the design and ready for commissioning.

NOTE Also referred to as static commissioning.

2.1.12
punch list
A list of outstanding or unacceptable work associated with a component or system.

2.1.13
“A” punch list item
Outstanding or non-conforming work associated with a component or system that is completed before pre-commissioning can begin.

2.1.14
“B” punch list item
Outstanding or non-conforming work associated with a component or system that is completed before commissioning can begin and prior to systems being put into operation.

2.1.15
“C” punch list item
Outstanding or non-conforming work associated with a component or system that is completed prior to final facility acceptance.

2.1.16
ready-for-commissioning
Minor milestone in project when pre-commissioning activities for a discipline (electrical, instrumentation, mechanical, piping, etc.) are essentially complete and ready to commence commissioning.

2.1.17
ready-for-start-up
Signifies that system construction, pre-commissioning, and commissioning work are complete and the required safety verification is ready to commence start-up.

2.1.18
subsystem
Partial section of originally defined system that consists of interconnected items or group of equipment performing a specific utility or operational service or function; will be able to be isolated and separated from the associated system for independent pre-commissioning.

2.1.19
system
Interconnected items or group of equipment performing a specific utility or operational service or function; will be able to be isolated and separated from the overall facility for independent pre-commissioning and commissioning.

2.1.20
systems completion
The process through which the technical integrity and design of a newly built facility is verified and the new facility is turned over from the project to asset owner or from contractor to owner.

2.1.21
systems completion certification process
The process through which a system, subsystem, or piece of equipment has been installed, tested, and certified as ready to be put in service.

2.1.22
systems completion database
Software application that provides the project management team and contractors with the means to organize and manage progress and certification of all systems completion activities.

2.1.23
systems engineering
Engineering input to facility design from a systems completion perspective that encompasses functional systemization, commissioning activities, start-up sequence, and the certification process ensuring the facility design can start-up as designed and planned.

2.1.24
turnover
Transfer of care, custody, and control of a system from a contractor organization to a company organization.

2.1.25
turnover and completion package
The required documentation to define that a system has been built, installed, tested and is ready to be placed into operation.

2.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

FAT	factory acceptance test
FTP	Functional Test Procedure
FEED	front-end engineering design
HAZID	Hazard Identification
IRN	inspection release notice
LOTO	lock out/tag out
MC	mechanical completion
NDT	nondestructive testing
PFD	process flow diagram
PID	piping and instrument diagram
PSSR	pre-start-up safety review
PTW	permit to work
SAT	site acceptance test
SIT	site integration test
SC	systems completion
SCDB	systems completion database
SCP	system commissioning procedure
SIMOPS	simultaneous operations

3 Systems Completion Planning

3.1 General

The systems completion planning phase is composed of system engineering, plan and procedure development, organization and resource identification, interface coordination and development. The planning phase should start in FEED and be complete by the end of detailed engineering (see Table 1).

3.2 Planning and Organization

The potential for failure increases significantly if the project team does not start planning early for systems completion. The project team shall "begin with the end in mind" early in the project life cycle. This means that the project team shall incorporate systems completion into the design of the facilities and develop a systems completion plan that is updated as the project progresses. The key to a safe, smooth, and efficient completions process is obtaining complete alignment with all involved parties in the planning phase and solid communication throughout the execution phase.

Table 1—Systems Completion Planning and Organization Activities

Recommended FEED Planning Activities	Recommended Detailed Engineering Activities
a) Develop systems completion strategy.	a) Systems completion risk assessment.
b) Develop systems completion execution plan.	b) Finalize systems and sub-system definition and inclusion in engineering documents.
c) Define certification process.	c) Procure and implement SCDB.
d) Review asset register and ensure systems completion (SC) database requirements are included.	d) Obtain and track vendor IRN and punch lists in SCDB.
e) Produce system list and minimum system testing requirements and acceptance criteria.	e) Develop permit to work (PTW)/lockout/tag out (LOTO) system.
f) Produce initial start-up sequence with milestones and integrate into schedule.	f) Produce site SC turnover procedure: 1) define certification process; 2) define and prepare turnover completion package; 3) finalize SC milestones and schedule.
g) Identify risks based on start-up sequence.	g) Define and purchase commissioning and start-up spares.
h) Produce SC scope for execution contracts.	h) Witness and track factory acceptance tests.
i) Identify required function tests, tie-ins, commissioning, and/or start-up procedures for each system.	i) Review project redline procedure.
j) Identify and plan regulatory requirements.	j) Produce and finalize the following plans: 1) systems completion execution plan; 2) systems completion database execution plan; 3) equipment preservation plan; 4) vendor support plan; 5) subcontracts plan and SOW; 6) produce systems completion turnover package (one per system), see example in Annex A.
k) Provide and review SC requirements in procurement plans.	k) Finalize systems definition and mark on engineering documents.
l) Define A, B, and C check sheets and preservations responsibilities, requirements, and certificates.	l) Safety instrumented function proof test procedures.
m) Define inspection test plan with project quality process.	
n) Initiate systems definition on PFDs, P&IDs, instrument block diagrams, and one line diagrams.	
o) Gather lessons learned for inclusion into execution plan.	
p) Liaise with engineering to agree an efficient and controlled data exchange with SCDB.	

The best approach is for the project management team to assign a systems completion manager to work with operations to decide how the facility will be started up and operated, and then jointly develop performance testing and acceptance criteria. Establishment of this information early in a project will provide the data required by the project to determine how the facility should be designed, constructed, and commissioned for a safe and smooth start-up.

A systems completion manager should be assigned at the beginning of FEED to lead the systems completion planning activities.

4 Systems Completion Execution

4.1 General

The systems completion execution phase begins with equipment factory acceptance testing and ends with final system handover to the operating asset or entity.

Figure 1 is a high-level overview of the systems completion execution process in the field.

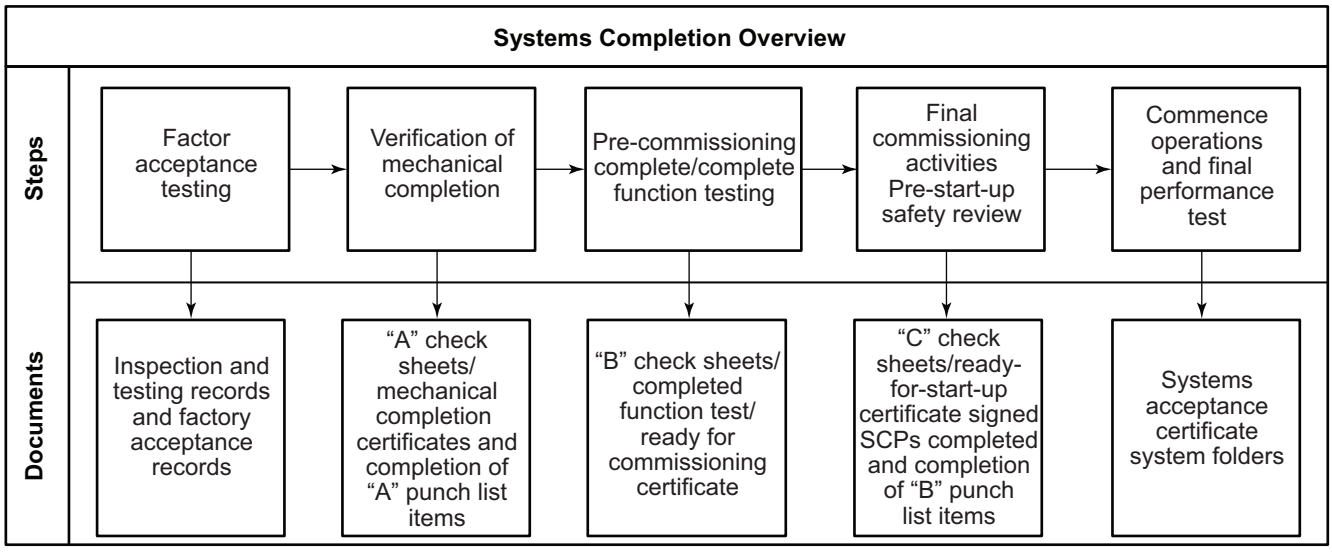

Figure 1—Systems Completion Execution Process

4.2 Factory Acceptance Testing

The systems completion execution process begins with the testing of the individual components or packages by the supplier or manufacturer.

4.3 Verification of Mechanical Completion

Mechanical completion shall be the point where construction is complete and mechanical integrity has been validated. Inspection and testing of workmanship and materials prove, validate, and document the complete and correct execution of all fabrication and installation work in accordance with project specifications, design drawings, and other written requirements of the owner.

Mechanical completion validates the construction and installation of equipment, piping, electrical services, instrumentation/controls, and utilities are physically complete, but not energized, and that designated inspections, integrity testing, and checks are documented on inspection test records.

At the point of mechanical completion the equipment shall be mechanically clean. Cleaning shall include the following:

a) piping flushing;

b) pipeline pigging;

c) clean vessels internally;

d) removal of debris from ditches and culverts;

e) clean debris from fins in air coolers;

f) clean all site glasses, pressure gauges;

g) cleaning inside building and substations;

h) duct cleaning (HVAC, building);

i) removal of scaffolding, removal of construction temporary facilities and temporary bracing, gather and organize surplus materials.

Mechanical completion is validated using “A” check sheets on a single-discipline basis. Upon completion of all “A” check sheets, a mechanical completion certificate will be issued for the system.

4.4 Pre-commissioning

Pre-commissioning activities are activities undertaken immediately following mechanical completion but prior to commencing the dynamic component of system commissioning without the introduction of hydrocarbons. Pre-commissioning activities prove and validate the functioning of components and equipment. These activities are intended to verify that pieces of equipment, and the associated control loops, shutdown systems, utility supplies, etc., are in the required state of readiness for full dynamic testing. These function checks are carried out and documented through discipline-specific check sheets known as “B” check sheets.

When pre-commissioning is complete, a ready-for-commissioning certificate shall be issued for the system on which the mechanical, electrical, instrumentation, and piping leads attest that their pre-commissioning activities are complete.

The following is an overview of the pre-commissioning activities:

a) hazard identification and analysis for systems completion procedures;

b) specialized cleaning passive or chemical flushing, steam blows, airblows, and inspections;

c) flushing of lube/seal oil systems;

d) energizing equipment;

e) motor no-load;

f) final equipment cold alignment;

g) cause-and-effect testing;

h) loop testing;

i) function testing;

j) panel function test;

k) switchgear function test;

l) control system interface testing;

m) complete “B” check sheets;

n) walk systems;

o) prepare punch list.

4.5 Commissioning

Commissioning comprises activities undertaken after pre-commissioning to verify dynamically that the functioning of systems and subsystems is in accordance with specified requirements and to verify, as accurately as possible, that the system is ready for start-up. Typically these function checks are carried out and documented through the turnover and completion package (see Annex A), which contains detailed step-by-step system commissioning procedures (SCPs). Commissioning activities may also include circulation with temporary fluids, leak testing, or testing of complex control functions. A contractual transfer of care, custody, and control from contractor to company usually occurs at the end of commissioning unless contractor has contractual responsibility for start-up and operations.

Upon the completion of commissioning, a ready-for-start-up certificate shall be issued for the system.

The following is an overview of the commissioning activities:

a) walk systems;

b) walk lines;

c) prepare punch list;

d) perform pre-start-up activities;

e) final leak testing;

f) final drying;

g) purging/inerting;

h) cleaning – cleaning that takes place prior to imminent use of the system;

i) first fills;

j) complete “C” check sheets or commissioning procedures;

k) complete “B” punch list items;

l) complete system commissioning procedures;

m) complete system turnover and completion package;

n) pre-start-up safety review (PSSR).

4.6 Start-up

Start-up is the introduction of process fluids (normally hydrocarbons) into systems whereby all equipment and processes are placed into continuous operation after final testing is performed. The process control loops are fine-tuned to provide for smooth, automated operation within tested and confirmed operational limits. During start-up, data associated with motor amperage draw, pump curve performance, interface control, etc., is collected and verified. Additionally, data collection associated with operational parameters such as pipe wall thickness bases readings, noise, vibration, and performance specifications is initiated.

4.7 Performance Testing

Performance testing involves operating the facility and carrying out a series of defined tasks, demonstrations and tests to measure the new plant and equipment against the contract, design, and nameplate parameters.

4.8 Operations Assistance and Project Closeout

Operations assistance and project closeout activities support operations after start-up as defined in the planning phase and in the final acceptance criteria.

Annex A
(informative)

Turnover and Completions Package

The following is an example table of contents for a turnover and completions package.

1) System definition:
    a) systems description;
    b) system boundaries;
    c) systems drawings;
    d) tagged data.
2) Supporting documentation:
    a) as-commissioned PIDs, block diagrams, single line diagrams;
    b) blind list;
    c) preservation records;
    d) LOTO/software bypass log;
    e) start-up spares;
    f) MSDS.
3) Mechanical completion records:
    a) installation ITRs;
    b) certificates;
    c) punch list.
4) Pre-commissioning records:
    a) test procedures;
    b) “B” completed check sheets;
    c) punch list items.
5) Commissioning records:
    a) commissioning procedures;
    b) completed “C” check sheets;
    c) punch list items.

6) Vendors:

    a) site reports and drawings;

    b) spare parts and special tool list;

    c) documentation.

7) Operational, start-up and performance testing:

    a) PSSR;

    b) start-up procedure;

    c) performance test procedure.

8) Management of change (MOC).

9) Regulatory documents.

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