PROJECT OCEAN SPACE CENTRE

STRATEGY FOR SYSTEMATIC COMPLETION OF BUT

01	04.11.2021	Draft issue			TS	OJH	SiB
Version	Date	Text			Prep by	Checked by	Approved by
Project number: **1107305**	**Issued by:** **TS**	**Project name** **Ocean Space Centre**	**Code:** **O**	**Document type:** **Governing document**	**Document code:** **OSC-SB-O-SD-00008**		**Version:** **01**

Strategy for systematic completion of BUT in **the OSC**

Purpose	Ensure that the completion of M3, and M4 user equipment in the OSC project is carried out in a structured and systematic manner so that the project is taken over by builder and end user according to plan. Completion and tests must be documented in order for the owner and the end user to be able to verify the functionality and performance of the deliverables.
Follow-up responsibility	Project Manager Completion
Executed by	Builder, Engineering team, Contractors
Referrals	

Contents

1 Abbreviations and definitions

1.1 Abbreviations

Abbreviation	Description Norwegian	Description English
FAT	Fabrikktest	Factory Acceptance Test
KFD-sertifikat	Klar for Drift, kan starte SAT hvis aktuelt	Ready for operation, can start SAT if applicable
KFO-rapport	Klar for Overtakelse (Protokoll/Levering drift)	Ready for Takeover (Protocol/Delivery Operation)
KFT-sertifikat	Klar for Test (Kan starte SIT hvis relevant)	Ready for Test (Can start SIT if applicable)
MF	Mekanisk Ferdigstilling (Bygg/installasjon)	Mechanical Completion (Building/Installation)
MF-pakke	Mekanisk Ferdigstilling disiplin-pakke (Inndeling pr fag under SF-pakke)	Mechanical Completion Discipline Package (Division per subject under SF package)
MKS	Montasje kontroll/sjekkliste	Assembly control/checklist
ML	Mangelliste Punch-liste	Punch list
RAMS	Reliability, Availability, Maintainability and Safety	Reliability, Availability, Maintainability and Safety
SAT	Site Acceptance Test etter KFD	Site Acceptance Test after KFD
SF	Systematisk Ferdigstilling	Systematic Completion
SF pakke	SF flerfaglig pakke (Overordnet arbeidspakke)	SF Multidisciplinary Package (Parent Work Package)
FT	Funksjonstest før KFD	Function test before KFD
TKS	Test kontroll/sjekkliste	Test control/checklist
VEP	Varsel om energipåsetting	Warning, voltage applied

1.2 Definitions

Systematic Completion
Systematic completion is a collective term for the process described in this document, which includes the activities Mechanical Completion (MF) and Testing (Function/System), as well as the method used for structured control, overview and status in and between the different phases KFT and KFD up to KFO for the takeover protocol.

Completion system
The database tool (PIMS365) is used to manage all relevant processes within Systematic Completion and Preservation.

System
A system is the highest level in a functional hierarchy (processes) that divides the entire project's technical completion into system groups as shown in TFM-Amendment document.

Delsystem (Part System)
Is a division of System into Part System Groups as shown in TFM-Amendment document.

SF Pakke (SF Package)
Is a logical or practical collection of plant parts or equipment that is completed and possibly tested together into a functional unit. An SF package is usually divided into one or more MF packages for discipline/subject overview. All SF packages must go through both a "Ready for Test" certificate (KFT) and a "Ready for Operation" certificate (KFD) even if no dedicated functional testing is performed, and then on to Takeover (KFO).

MF pakke (MF Package)
Is the smallest and most appropriate division (scope of work) for a subject or discipline within an SF package.

Object ID (Equipment Code/Tag)
A unique number that identifies each individual physical component of a plant or installation. All tagging should be in accordance with the regulations specified in NS3457-7.

SF sjekkliste (SF checklist)
SF checklist is a common term for checklists used in the construction phase (MKS) and the test phase (TKS) that are signed to verify the completion of inspections or tests of the various plant parts and objects.

Mangler (Punch items)
Are errors and deficiencies revealed in a check of the work performed related to Systematic Completion. These shall be classified as A or B deficiencies according to severity.

Avgrensingstegning (Boundary drawing)
Is a drawing or sketch with markings showing the scope of work/boundary of one or more SF packages.

Fabrikktest (FAT) (Factory acceptance test, FAT)

Is a technical verification and approval test performed at the Contractor's or Supplier's production facilities prior to shipment of equipment.

Varsel om energipåsetting (VEP) Warning of energized systems (VEP)

A notification to inform all parties involved that plant parts, equipment or systems will be applied energy, (e.g. voltage, pressure). Warnings shall provide an adequate description of the activity, as well as provide information, locking or restrict access to areas or provide other necessary safeguards at the construction site.

Funksjonstest (FT) Function test (FT)

Are documented functional tests with procedures within the System Hierarchy to verify/validate that the dynamic functionality and operation coincide with the design.

Site Acceptance Test (SAT)

The SAT consists of documented tests with procedures within the System Hierarchy to verify/validate the function and the entirety of the complex system integrated with operational, overall control and management systems and other systems. SAT can also contain stability and performance tests.

Klar for Test (KFT) Ready for Test (KFT)

One or more SF packages are mechanically completed and ready for transfer to the test phase. The SF packages that have been built/installed must then be functionally tested (FT) if required. This is documented by issuing a "Ready for Test" certificate.

Klar for Drift (KFD) Ready for Operation (KFD)

One or more SF packages have been fully functionally tested, and thereby ready for the Site Acceptance Test (SAT) to check that functionality and reliability comply with the requirements of the Contract. This is documented by issuing a "Ready for Operation" certificate.

Klar for Overlevering (KFO) Ready for Handover (KFO)

The system has been tested both internally and against other relevant systems. Punch lists have been signed off. The system is ready for handover, and a certificate for KFO is to be issued.

Preservering Preservation

Is the process of preserving all plant parts during the project so that these are protected from potential external or internal degradation and delay decomposition and aging. This includes both first-time preservation from the supplier and subsequent preservation maintenance at the construction site.

RAMS

RAMS is short for Reliability, Availability, Maintainability, and Safety

Reliability: A system's ability to perform a required function over time.

Availability: a system's ability to perform a required function at the time required. Can also be

defined as uptime

Maintainability: a system's ability to be held in, or returned to, a state in which it can perform a required function.

Security: Addresses a systems' risk of harming people, the environment or other systems during the lifetime of the system.

2 Introduction

The purpose of this document is to describe the strategy for Systematic Completion (SF) for M3 and M4 user equipment (BUT) in the Ocean Space Centre (OSC) project.

The document describes:

- Overall and general requirements
- Organization and responsibility
- Computer system for completion (PIMS365)
- Supervision and follow-up
- Design phase and preparatory tasks
- Construction phase (MF) through to certificate "Ready for Test" (KFT)
- Test phase (FT) through to certificate "Ready for Operation" (KFD)
- Test phase (SAT) through to certificate "Ready for Takeover" (KFO), protocol and handover to Statsbygg
- Operational phase and operational test
- Miscellaneous definitions, requirements and activities

The strategy deals with system-based project completion, split between construction/installation, function-based testing and takeover with certificates and integration with SF and PIMS365. The strategy also requires a structured Object-based engineering in accordance with NS-3457-7 as well as the use of a common design database in dRofus for continuous exchange of technical information to all users, e.g. BIM, SF, contractors/suppliers, Statsbygg and to the FDV.

Necessary additions from Statsbygg, which are not covered directly by the SF process, will be included where it falls naturally under verifications/certificates in the run-up to the takeover from the contractors (KFO) and further handover to Statsbygg and further operation by Sintef/NTNU.

The process with SF will also support the requirements for RAMS in the project through the phases of construction and testing (e.g. requirements for verification and validation).

Based on this strategy, a document "Requirements for Systematic Completion" shall be prepared and be included in contracts. For any early contracts entered into (prior to the strategy/requirement document), an option may be included for subsequent implementation of this document. The requirement document in the contracts shall contain a detailed description of the contractor's tasks for carrying out SF in the project, as well as the use of PIMS365 through the various phases of the project.

3 Purpose

In order to achieve the overall objective of project completion, as well as contribute to planned start-up of the plant, both in terms of safety and quality, OSC shall put requirements for Systematic Completion into all contracts.

Follow-up of construction and testing, both at the factory and on site, shall be handled in an organized and systematic manner using checklists and punch lists, so that the correct technical status can be found in the PIMS365 computer tool at all times.

The intention is to ensure the best possible overview and status for all deliveries, from manufacturer/factory to operational phase, as well as to be able to clear all deficiency points as early as possible in the process during construction and testing in an efficient manner.

The goal is to eliminate all deficiency points continuously in the implementation, thereby ensuring the handover of the correct functional requirements and quality of all user equipment in the project that will be completed before handover to Statsbygg and further operation by NTNU/Sintef. In this process, OSC will use the PIMS365 database tool to monitor and assist in completion activities. The PIMS365 tool is used to organize packages, checks/checklists and deficiencies, as well as certificates, technical status and reports. PIMS365 will be made available internally in the project, as well as for all contracts where SF is relevant. Contractors and external users will be given training and support by the OSC in order for all parties to get the most out of the process with SF.

3.1 Success factors

- A common strategy and method for systematic completion of all scopes of work throughout the project.
- Establish an anchoring of the strategy in the management and motivate project employees
- Focus on System-based completion and procedural function testing.
- A common computer system for systematic follow-up and technical status through project phases up to takeover from the contractors.
- Continuous follow-up and control that established objects corresponds to NS-3457-7
- Use of object-based checklists within the different disciplines and work types.
- Continuously documented check-out and status of work performed in the field.
- Systematic overview of errors and deficiencies, as well as continuous actions from the responsible parties.
- Keep track of the status of completed work and technical quality at all times, as well as an overview of remaining unfinished work.
- Clarify interfaces between deliveries and ensure that responsibility for the interfaces is taken care of

4 Overall requirements

4.1 General

Implementation of Systematic Completion in accordance with the requirements shall be a continuous process in the implementation of the project and generally follow the steps below:

- Establish SF process and documentation based on substrates from engineering.
- Update PIMS365 in preparation for building and testing verifications.
- Plan and time the scope of work for SF and align these plans with the planning system.
- Carry out verifications in the field when building and testing as prepared.
- Issue certificates KFT and KFD for technical status during transition between phases.
- Issue report KFO as technical basis for takeover protocol.
- Monitor the technical status and report in PIMS365 as needed.
- Collect, organize and archive relevant SF documentation in PIMS365.

4.2 Organization

In order to follow up the requirements for SF in the project, an SF organization will be established with both the Builder and contractors who will be organized and dimensioned in line with the size and complexity of the systems. An SF team shall always include a position/function that exercises the management of Systematic Completion as well as the associated functions necessary to lead and coordinate SF activities.

Completion of tasks related to PIMS365 and data entry will depend on the type and scope of the contract:

- For total contracts, the contractor shall carry out all system work related to work assignments/scope in PIMS365, i.e. everything required to keep the system up to date at any given time. Alternatively, other solutions can be agreed upon if it is beneficial.

4.2.1 Key personnel

The Contractor shall nominate a Manager for Systematic Completion who will be included in the Contractor's project management and lead all SF activities on the Part of the Entrepreneur.

- The nominated person shall be approved by the Builder and classified as "key personnel" in accordance with the contract.
- The start-up of the completion manager shall be agreed with the Builder (if less than full-time work (100%) is being planned this must be agreed with the OSC).
- The role of senior manager Systematic Completion (PL-SF) shall be held by the OSC/ Builder. The person concerned shall be part of the project management team and align/integrate the various Contractors' work deliveries. Depending on the type of contract and the need, the manager SF shall also have its own internal SF team for facilitation and follow-up of the contracts.
- The SF team shall be assigned assistance from the various technical subjects/disciplines upon verifications and tests to ensure the achievement of technical requirements, specifications and quality.
- The service organisation should also contribute personnel to verifications, particularly for deliveries of mission-critical plant parts.

4.2.2 Computer system (PIMS365)

PIMS365 shall be the main tool for preparing and facilitating the scope of work for SF, as well as where all technical status from verifications is collected and archived. The degree of completion and status must be reported for all BUT contracts as well as for the project as a whole. Contributions to updating PIMS365 shall come from both the Builder's own follow-up team and contractors and be used as a common tool.

PIMS365's work processes shall be the last status check after work performed (100%) and shall verify the contractor's work and quality system. Relevant subject/discipline checklists, as well as certificates must be issued to document this. The contractor has overall responsibility for delivering a scope of work with the right quality and will use its own quality system (KS) to achieve/ensure this along the way. PIMS365 does not replace internal and external KS routines, but is a supplement to ensure that work ends with agreed technical status between the parties. The builder is responsible for ensuring that all overall codification in PIMS365 is made and updated during project execution, and that decomposition in systems follows the code manual in a hierarchical structure that logically distinguishes the different plant parts from each other.

4.2.3 Responsibility

Projecting and executing contractors must deliver and make available early and continuously all technical information that SF teams need to work on the preparation and implementation of SF in all project phases.

The contractor shall assist in the implementation of SF activities in line with the schedule of the SF packages that correspond to the structure of PIMS365.

If the Contractor is only responsible for Construction/Installation and not Test/ Start-up, all SF certificates shall nevertheless be sequentially issued and signed in PIMS365 up to the takeover protocol (and KFO). This is because remaining defects normally will be transferred

to the next phase, as well as to retain similarity in the structure for all types of works.

The builder shall have the right, but is not obliged to, deploy his/her personnel with the Entrepreneur in order to participate in test and start-up activities. This personnel shall be provided free of charge to the Entrepreneur.

Relevant spare parts for test and start-up activities, temporary equipment and consumables, as well as first refills (e.g. oil or glycol) must be delivered from the respective contractors. The entrepreneur is also responsible for the correct storage of his material prior to use.

The Contractor shall prepare and carry out training of operators and maintenance personnel prior to the takeover (KFO) of the respective systems. This will be carried out as classroom teaching, as well as practical courses and programmes at the Contractor and/or at the facility, depending on what is specified in the contract.

The contractor is responsible for all SF activities/ verifications in the field, through approved certificates for carried out construction (KFT), carried out test (KFD) and right up to technical status at takeover protocol (KFO).

5 General requirements

5.1 Punch lists

A list punch list is a list of deficiencies that shall describe all defects, errors and unapproved nonconformities in relation to contract requirements, engineering or regulatory requirements when performing the SF process in the project. Executing contractors/suppliers are responsible for creating deficiency lists in PIMS365. The builder can also register new defects in the system, as well as verify that defects have been cleared/carried out. During construction and testing (incl. FAT), all remaining work, or errors and defects, after completed SF verification with checklists shall be written down and documented as part of the status of work performed in PIMS365. This routine shall apply in all phases of the project, and must be followed up both during construction and testing. Deficiencies shall have deadlines for clearance, and they shall be tagged with type of error in PIMS365.

Defect points must always be signed by the executors, but also by others who participate in the verification, such as any suppliers and the Builder. The receipt and clearance of a deficiency shall be made upon signing, either directly in PIMS365 or on the appropriate deficiency report from PIMS365 documenting this.

5.1.1 Categories

Defect points shall be classified in category A or B depending on the severity:

- **A-points** are significant errors and deficiencies that prevent completion/testing/functionality and that must be cleared/rectified before approval/delivery in the current completion phase. (The principle is: Before delivery after FAT, before transition certificate KFT, KFD and KFO).
- **B-points** are less important deficiencies that do not have the same consequences as at A-points and can therefore be postponed to a later completion phase if accepted by the Builder or recipient of certificates.

In the case of delivery, the Builder generally considers that all outstanding defect lists from the contractor/supplier as A-points (they shall not occur). If a delivery still needs to be sent/delivered with A-points, this must be agreed with the Builder, who will then decide whether the defect can be changed to B and delivered.

The builder can freely, and in accordance with his own understanding, up- or downgrade categories on defects in PIMS365. In cases where there is disagreement about the seriousness, a separate follow-up code must be used to track this in the system.

Furthermore, if the total number of B-points on a list appears unreasonably high, the entire list can be classified as a (severe) A-point, thereby withholding the delivery or approval of certificates until several points are trusted.

5.2 Notification of completion activities

5.2.1 Invitations

Executing contractors shall invite the Builder to participate in test verifications/validations for all relevant plant parts, equipment, units and areas. Planned typical activities with notification deadlines within regular working days are shown below:

Description	Notification deadlines	Comments
FAT, incl. verification Construction (MF)	4 Weeks	Procedures/programmes and other relevant documentation shall be available at the time of notification
Construction control (MF phase)	1 day	PIMS365 must be up to date at the time of notification and relevant documentation must be available
Inspection «Ready for test» KFT	3 days	PIMS365 must be updated at the time of notification.
Function test (FT)	1 week	Procedures and other relevant information shall be available upon notification
Inspection «Ready to operate» (KFD)	3 days	PIMS365 must be updated at the time of notification. KFD = Pre-start technical approval before SAT
System/Integration Test (Test phase SAT)	2 Weeks	Procedures and other relevant documentation shall be available at the time of notification.
Inspection «Ready for takeover» (KFO)	3 days	PIMS365 must be updated at the time of notification. KFO = technical approval before signing takeover protocol

Table 1 Notification deadlines for invitations to Builder/OSC

All relevant SF packages, procedures, drawings and documents, as well as other necessary references shall be listed in the invitation together with a clear description of the scope of work, time and place.

5.3 Work permit system

If the Builder does not already have a system for work permits, the Entrepreneur shall establish and manage such a system to ensure safety during the implementation of Test and Start-up activities carried out in parallel with construction activities.

The system must be sufficiently advanced to provide an overview and manage risks that may arise from parallel activities between construction, testing and operating mode.

Work permit must always be used according to the issued and approved KFD certificate.

5.3.1 Barriers and locking during testing

When the project enters the Test and Start-up phase, a new regime will be introduced for approval of work on equipment that has been applied voltage, or pressurized, while other parts are still in the construction phase.

Marking

In connection with the test activities, the Contractor shall use a marking system to identify all relevant plant parts during testing. Special cordons and marks for this purpose must be approved by the builder and used. This marking shall inform you that the plant is undergoing testing and that a signed work permit is required if work is to be carried out on or near the equipment.

Routines

The following sequence applies:

1. Carry out marking/blocking of areas and equipment.
2. Activate energies in preparation for testing.
3. Temporary works

Temporary work shall follow the same principle and processes for establishing workloads into PIMS365 and verifications in fields after completing work, applicable both for construction and testing. Checklists from PIMS365 (MKS) must be used and any deficiency lists registered.

Temporary work shall be established in its own System in the hierarchical system breakdown in PIMS365 and can use Object ID from the code manual or local fictitious SF Objekt-id or dummy-tags as needed.

5.5 Subcontracts and Factory Test (FAT)

5.5.1 Generally

When following up subcontracts from equipment suppliers, SF falls under the MF phase of Construction and Installation, but will often also have a procedural factory test as part of the delivery (FAT).

Contractors and other parties that have subcontracts into the project shall implement the requirements for Systematic Completion and Preservation in all their contracts.

All equipment that is not classified as off-the-shelf (bulk material), i.e. all specified vendor-built plant parts or assemblies for the project, shall have verified status with signed checklists and any defect lists updated in PIMS365 prior to acceptance shipment to the site.

In order to identify information related to each subcontractor and deliverables, objects must be associated with the purchase order contract number (PO) and part-delivery (call-off) in PIMS365.

Checklists shall be linked to objects in the subcontract in PIMS365 together with other associated and relevant documentation compiled in a purchase dossier that is submitted to the supplier for follow-up, and returned to PIMS365 after completion and possibly executed FAT.

Review of relevant documentation such as checklists, procedures and drawings, as well as preservation status shall be part of the follow-up against subcontractors.

All relevant activities for the subcontractor's SF status, i.e. from procedures, verifications, defect lists, test reports, etc. should be sent to the Builder and updated in PIMS365.

The subcontractor shall complete/close all punch lists before shipping the delivery to the site in accordance with the routine for processing punch lists (Ref. separate section).

5.5.2 Factory test (FAT)

The purpose of carrying out a FAT is to verify the delivery with regard to assembly (MF), as well as function, capacity and performance before it is sent to the site.

The builder shall be invited to observe/verify the implementation of the FAT.

An internal acceptance test (IAT) shall be carried out and documented by the supplier/contractor before the Builder is invited to witness a FAT, this to ensure that the delivery is complete and ready for FAT without significant deficiencies.

Relevant documentation, a detailed FAT test program and testing procedure must be sent to the Builder for review no later than 4 weeks before the planned FAT.

The FAT program and test procedure should include at least the following information:

- Documents/ drawings/ sketches (and revisions) included
- Test equipment to be used
- Description of test rig/ setup
- Detailed testing procedure and expected results
- Checklists and journals

The FAT shall check that the equipment is delivered at least in accordance with the following requirements:

- That the delivery is built in accordance with requirements, design and documentation
- That the functionality, capacity and performance of the delivery are in accordance with the specifications
- Satisfactory operation of the equipment in both regular and irregular modes
- That the equipment meets requirements for maintenance during the operational phase (Usability)

A copy of the signed FAT test report shall be part of the purchase dossier returned to the Builder for review.

The FAT shall be regarded as a combination of MF and functional testing and shall comply with the same requirements and routines as for SF and PIMS365 in general.

5.5.3 Software & Electronics

Software:

FAT on software installed in systems with PLC/ controllers shall be carried out with the use of test drive that allows simulation of all signals for inputs and outputs, where the signals shall be encoded with ID according to requirements for signal coding in the code manual.

Each software test setup should be performed as much as possible equal to a normal operating state, or where one simulates such a condition.

Electronics & Circuit Boards (Hardware):

FAT on the production of electronics and circuit boards shall include tests according to the type of equipment and standard routine tests for that type of electronics.

Electronic equipment produced for installation on the outside of buildings must be "splash-tested" to check/ document that it is waterproof.

6 Parent follow-up

6.1 In the contract progress schedule

The completion process shall structure the order/sequence of SF-related activities to ensure that Statsbygg receives a facility that is delivered on time, with the right quality and functionality, as well as the necessary documentation.

The project shall apply this strategy and system-based work methodology/processes in all project phases. Progress plans must therefore incorporate the possibility of system-based planning and overview coordinated with SF, especially important for test planning.

This process is described in Fig. 2 which shows how the completion activities and various certificates (KFT/KFD), as well as takeover (KFO) are integrated through all phases of the contract.

If the Contractor is to carry out an Operational Test (Test Operation), timelines and programmes for this shall be specified/defined in the contract.

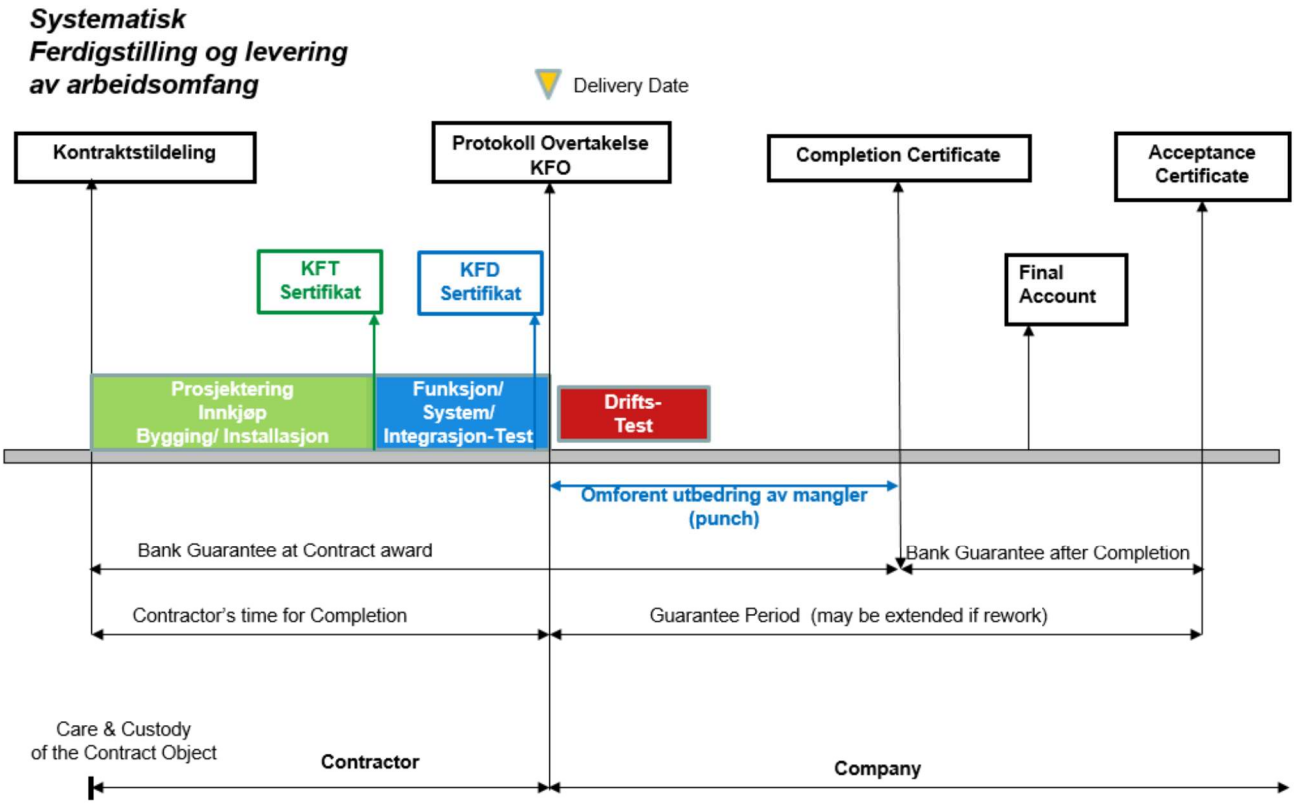


Fig. 2: Typical sequence for Systematic Completion as part of contracts.

6.2 In the project phases

SF activities in the project are carried out in three phases, Engineering, Construction and Installation, as well as Test and Start-up.

Completion will begin early in the Design phase to prepare and plan subsequent Construction and Installation and then Test and Start-up. The strategy is based on (and requires) early planning and systematic preparations for completion.

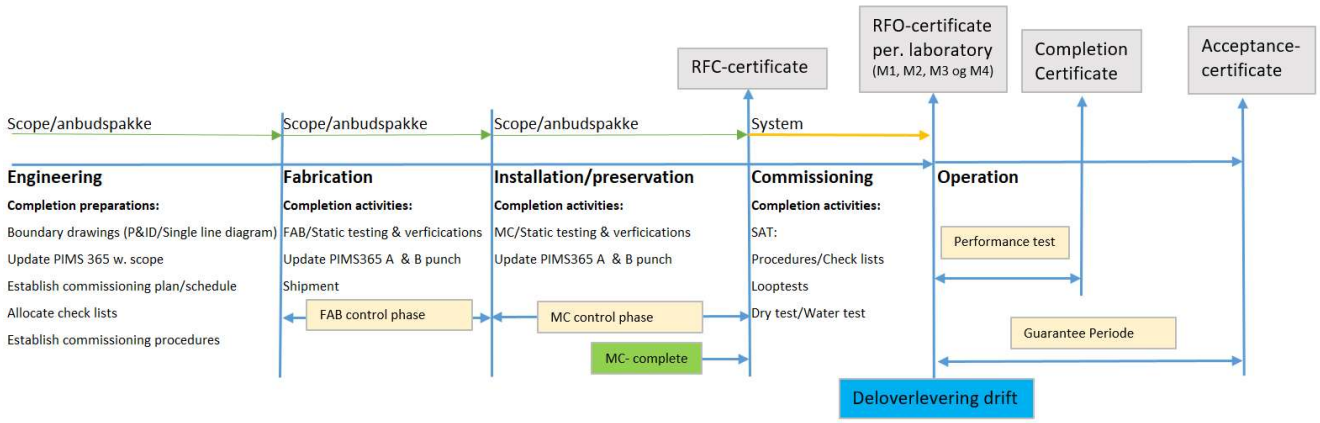
Technical status in PIMS365 will govern and approve the issuance of KFT and KFD certificates for completion rate within each project phase, as well as termination of contracts

at KFO.

Systematic implementation and achievement of the levels will help ensure the start-up of the Ocean Space Centre with expected technical quality at the agreed time.

Figure 3 demonstrates principles, tasks and activities within the various project phases, as well as workflows for transferring technical responsibility and sub-delivery from project to operation for M3 and M4 equipment respectively.

Heavy user equipment:



M3	Specialized lab equipment with control system with a few suppliers. Often acquired upon request to several suppliers.
M4	Custom equipment adapted to buildings. Few suppliers. Procurement takes place to specification and associated requests (typically pools/tanks built on site)

Fig. 3: SF as part of the project's completion phases for M3 and M4 equipment.

All activities must be systematized in Completion Packages (SF Packages) in PIMS365. The various packages will have separate timelines for when they achieve KFT, KFD and KFO, this in accordance with the actual date when the SF and MF packages are finalized in the various contracts.

7 Engineering phase

7.1 Generally

Technical information from engineering, such as BIM, drawings, documents and object information, shall be the basis for defining the scope of work for SF packages, MF packages, controls and checklists into PIMS365 structured according to the code manual for the project.

Engineering shall continuously establish and maintain a common database in dRofus for all code manual/object-based plant parts and associated engineering data (metadata), which will form the basis for the establishment and follow-up of Systematic Completion, as well as for electronic FDV deliveries to the Builder/Operation (including the Construction Data Bank).

The object ID for plant parts shall be established in dRofus continuously as soon as equipment/ construction parts are known and have an affiliation in the design.

Early and continuous access to defined Object ID from engineering is essential for preparing

SF in PIMS365. Regular import routines from dRofus and BIM to PIMS365 shall therefore be set up, or preferably "on-line" electronic information flow between the systems shall be established if possible.

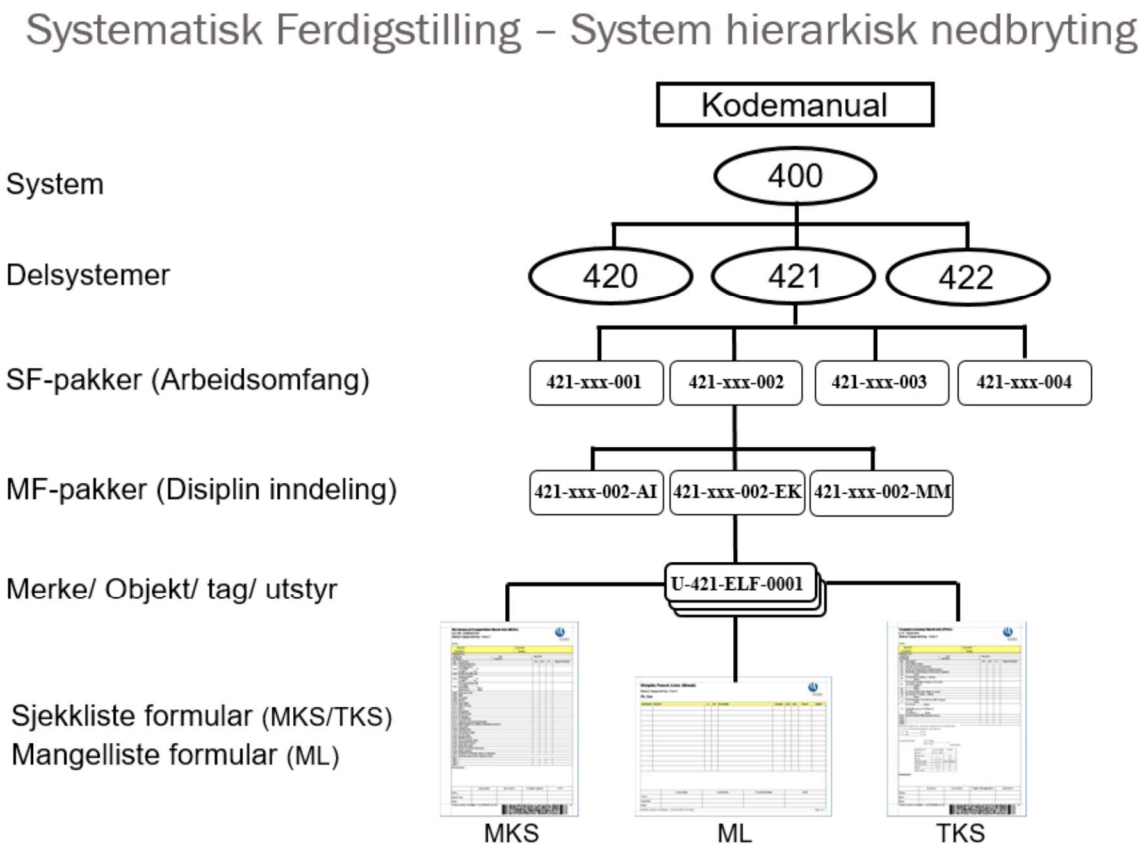
In the early phase of the SF design, division and marking of SF packages shall be made in accordance with the system breakdown, where the focus is on practical/ logical testing and functionality in the implementation of the scope of work (for the SF package) up to takeover.

SF packages and MF packages shall be established in PIMS365PIMS365 and object ID and subject/discipline-based checklists shall be attached to the packages.

Completion packages can be updated with additional information for several grouping and sorting purposes in the follow-up, e.g. Milestones, Areas, Contracts, Plan data, etc., so that SF status can be presented based on different needs for overview.

Systematic completion shall be divided into a hierarchical tree structure, and shall be kept up to date in PIMS365 throughout project execution.

The figure below illustrates how Tag and checklists are organized into packages under the system section of PIMS365.



Figur 4: Typical hierarchical decomposition structure in PIMS365.

7.2 Preparatory tasks

Preparation of the completion process shall commence early in the design phase in order to prepare and plan upcoming activities as well as to update the scope of the SF process in PIMS365.

A critical/decisive success factor is to define Completion Packages (SF packages) in PIMS365 and assign Object ID and checklists for them as early as possible. The main tasks will be to issue checklists for approval/verification of plant parts/equipment and status follow-up from factory/production to completed installation at the construction site/plant.

The status in PIMS365 will control and approve the issuance of KFT and KFD certificates within each phase and help ensure a safe start-up of the plant and installations in accordance with the agreed schedule and expected quality.

Progress overview should be delivered as standard reports generated from PIMS365.

Not all contracts or work types will have a typical Test and Start-up activity, such as performing dynamic function tests.

Ordinary use of planning tools shall be maintained as usual. PIMS365 will be an additional tool for monitoring project status and progress.

7.3 Typical tasks

Preparatory main activities for Systematic Completion shall include at least:

- Establish an SF requirement document for use in the contracts that reflect the requirements of this document and describes the implementation of principles and requirements for the use of Systematic Completion.
- Establish an SF test document (strategy /manual) for use in the contracts that reflect the requirements of this document and that describe methods and principles for the execution of system-based testing programs and integration with Statsbygg's control systems.ual) for use in the contracts reflecting the requirements of this document and describing methods and principles for the execution of system-based testing programs and integration with Statsbygg's control system emer.
- Create boundary drawings that show the extent of completion within each SF package and boundaries between them. Boundaries are marked on relevant surfaces from engineering and shall primarily be available in electronic format.
- Create SF packets and MF packets based on the system breakdown in the code manual and update PIMS365 along with boundary drawings.
- Establish relevant subject/discipline checklists linked to SF/MF packages.
- Update SF packages with contract relationships, milestones, sites, phases, plan, etc. for status and reporting as needed.
- Organize all SF substrate with focus on system completion and final testing.

7.4 Planning

SF activities shall be able to be carried out in accordance with system-based planning that follows the division of systems in accordance with the regulations. NS3457-7, TFM-Amenedement and dRofus. This applies in particular to achieving system-based completion through testing, as well as for managed takeover from contractors and further handover to Statsbygg and on to NTNU/Sintef.

- Plans shall have integration with all completion activities, i.e. systems and SF packages number shall have references into the planning system for coordinating activities between Plan and SF in PIMS365.
- Plans must be submitted no later than 3 months before the first FAT, MF or testing (before the first time of testimony).

8 Building and Installation Phase (MF Phase)

8.1.1 Generally

Mechanical Completion (MF) is part of the SF process where deliveries or facilities are built and installed according to discipline or discipline-wise, and where the status of these in the field is verified/confirmed to be in accordance with contract, drawings, specification and regulatory requirements/regulations.

The term MF phase is also used on the Build and Installation phase due to repeated and ongoing MF activities "owned" by associated SF packages.

MF check means that one does a 100% verification after construction/assembly/installation (possibly under construction if necessary for part-status), as a daily continuous verification activity at the construction site using checklists from PIMS365.

Status from such verification and possible defect lists shall be entered and updated in

PIMS365 continuously.

The same applies to supplier packages in the factory/construction site, i.e. the SF process checks with the supplier that the plant part/equipment has been verified/approved and ready for factory test (FAT).

After completion of construction and installation, the plant is ready for Test and Start-up and function testing (transition test phase).

8.1.2 Mechanical completion (MF)

Upon completion of construction/installation work, i.e. before the test phase (KFT), all equipment and all plant parts/structures shall be inspected and possibly "statically tested" without hazardous operating energy (current, pressure, etc.) being supplied/applied. Only static tests under control are permitted, e.g. pressure test of pipes, electrical test with test equipment/pusher, load test of lifting equipment, termination control/ callout, etc.

The builder shall be invited to participate in field verifications of the MF content in the SF packages, no later than 24 hours in advance. As part of the invitation, the contractor shall present relevant engineering information, MKS, ML and appraisal drawings for the Builder.

All inspections and tests must be carried out and documented in a holistic manner and all relevant documentation shall be available to the Builder.

MF shall be carried out continuously after completing the installation or construction of relevant plant parts following the division of SF packages during the hierarchy structure in PIMS365 and the code manual of Statsbygg.

Status from MF verifications, Deficiency lists and other relevant documentation shall be updated in PIMS365 on an ongoing and no later than the next working day.

MF inspection and testing shall at least include the following:

- All plant parts/structures are in place and type/quantity is correct
- All construction parts/ structures are free of damage
- All plant parts / structures are correctly installed / built
- All electrical equipment is correctly assembled, wired, terminated, measuredand controlled
- All field equipment has been tested as far as possible without adding operating energy (e.g. with the use of relevant test equipment)
- All relevant MSKs have been verified and signed in PIMS365
- Punch lists are registered in PIMS365

8.1.3 MF control/checklist (MKS)

All objects for fieldwork should have their own MF checklist (MKS) or be part of a collect/multi MKS that lists several relevant objects on the same MKS, depending on practical customization for the type of work and plant parts.

Several discipline/subject-related MKS's shall be developed and made available in PIMS365 in cooperation between the construction management and SF, as well as with contractors/ suppliers if the current ones defined are not sufficient or suitable for verification of the specific construction/ installation.

MKS shall be connected to a control in PIMS365 and verifications of work performed shall be updated and signed continuously and electronically on PC or PAD. Any punch points are connected to the checkpoints at MKS continuously for traceability.

Checklists can also be printed on paper or in PDF if this is necessary for verification of the MF work.

All MKS's must be verified, signed and updated continuously into PIMS365 to indicate MF status. All remaining work or errors and omissions shall be entered as category A or B punch points.

8.1.4 Demolition work

Demolition work shall follow the same principle of verification after completion of demolition as after completed construction and installation work. Custom checklists from PIMS365 (MKS) for the demolition job should be used. If demolition work is considered temporary work, they shall be part of the system for such work (temporary).

8.1.5 Electric static loop test (Termination and continuity)

Verification that correctly performed termination and continuity in electric loops is in accordance with drawings and substrates, shall be carried out as part of the construction phase (MF). This should be carried out in a voltageless state, i.e. before connecting normal operating voltage to the equipment.

Loop tests must be documented in PIMS365 using checklists (MKS) for this purpose with associated marked surfaces such as termination drawings, signal lists, etc.

8.1.6 MF dossier and reports

In order to keep track and overview of relevant documentation (substrates) belonging to SF verification and check-out in the field, the executors shall organize an electronic MF-dossier/ file folder that is entered PIMS365 at the designated location. The dossier will be built up in accordance with system structure and SF packages in PIMS365 for traceability between documentation and checklists (MKS), as well as punch lists. In principle, a dossier shall be made for each SF package or, if applicable, a collection of SF packages if this is beneficial/ agreed with the Builder.

The MF dossier shall collect all relevant documentation for check-out in the field, such as:

- Boundary drawings showing corresponding SF packages
- Relevant documents, drawings, overviews
- Red markings (as built)
- Measurement values and results
- Pictures and explanations
- Etc.

8.1.7 "Ready for Test" Certificate (KFT)

Upon completion of construction/installation and mechanical completion (MF), a KFT certificate from PIMS365 shall be issued to confirm that the transfer of the finished building and installed SF package can be approved transferred to the Test and Start-up phase.

The builder issues the KFT certificate at the request of the Supplier/Contractor, but the responsibility for signing lies with the responsible party of the supplier, and must be signed/approved by the test manager and by the Builder.

Certificates will contain lists of relevant SF packages and associated information, e.g. status, punch lists, various documentation, etc.

Only category B defect points are allowed, if accepted by the Builder.

Any SF package shall review the KFT certificate (and the MF phase), either individually or as part of groups that together constitute equipment, plant part, part system, system, possibly within areas.

This principle also applies to plant parts and SF packages without direct requirements for technical functional testing, e.g. buildings, facilities, roads, areas, tunnels, etc., i.e. static plant parts.

KFT certificates are usually an internal transfer at the Contractor that changes its duties from static plant inspections to dynamic/active functional testing where relevant and required.

Selv om det ikke skjer dynamisk verifikasjon og test av utstyr etter KFT-sertifikat, kan det være statisk kontroller eller område gjennomgang på andre typer anleggsdeler som avsluttes under Test-fasen, samt klareringer av eventuelt gjenstående mangellister fra byggefasen (MF-fasen).

9 Test– og Oppstartsfase (Testfase)

9.1 Generelt

Fasen for "Testing og Oppstart" kommer etter fasen for "Bygging og Installasjon", og er fasen når man gjennomfører tester beskrevet i prosedyrer for å verifisere at dynamisk funksjonalitet og brukbarhet samsvarer med design. Anleggsdelene vil etter godkjent funksjonstesting aktiveres i en driftslignende tilstand.

The transition from construction to testing takes place by making an internal transfer of responibility to the contractors, documented by the issuance of the KFT certificate from PIMS365

Testing can only start after completion of construction/ installation when KFT certificate has been issued and approved by responsible persons at the recipient.

Test status shall be based on completed and signed procedures and checklists, as well as any punch lists registered in PIMS365

After testing has been documented, the facility will be ready to go into an operational state when issuing a KFD certificate (Starting Test SAT).

The execution of System and Integration tests and any extended test of stability/capacity/performance can be started according to an approved KFD certificate if this is required and described in the contracts.

After moving to the KFD, the executing contractor (or the Builder/Operations organisation) will have the formal responsibility for general and overall safety, and will coordinate these activities between the parties if necessary. A work permit from the Builder is required for work carried out after KFD.

9.2 Test requirements

All plant parts/equipment must be verified, functionally tested and documented to the builder that the plant is ready to be put in an operational-like condition.

The focus should be on dynamic functions and verifications/validations, but static tests can also be included where relevant. Primarily, static tests will be performed as part of the construction phase (MF), e.g. pressure test, load test, termination and static loop check, etc.

In connection with system integration and overall testing, the contractor shall, if necessary, allow other Contractors and Builders to access their installed equipment, plant parts and systems for joint testing and integration.

Before all supplier-built equipment is packed and sent to the installation site, any customer test (FAT) must have passed, where there should normally be no remaining defect points on delivery.

On a general basis, all functional testing must be completed as far as possible before a KFD certificate is issued, but in many cases and for practical and safety reasons, "System and Integration testing" may be done after obtaining approved technical status at KFD. In the pre-KFD phase, some of the testing may be practically impossible due to lack of access to operationally controlled energies and/or control systems.

Tasks for general testing and the level of this will be defined in the contracts with the contractors.

Due to safety and/or operational responsibility, work and testing in the phase following the KFD Certificate (SAT) shall be governed by work permits to be approved by the Builder.

All testing shall follow the general principles for Systematic Completion in this document and be fully completed before issuance of a KFD certificate, with the exception of any agreed remaining activities described as B-deficiencies in PIMS365

Satisfactory dynamic function and operation of equipment shall be demonstrated within each SF package in PIMS365. Testing should be carried out using safe and effective methods.

Testing shall be witnessed by the Builder and shall verify the requirements have been achieved, such as:

- Dynamic features and operating conditions matching design
- Capacity and performance of equipment are according to specifications
- Satisfactory operation of the equipment in regular and irregular mode
- All interfaces with other equipment work correctly

If a single test, or group of tests, does not meet the criteria, it must be reported, rescheduled and repeated until the requirements have been met.

If the Builder's personnel are required for the completion of the test, this shall be arranged and agreed in accordance with the requirements of the contract.

9.3 Test phases

Schematic representation of test sequences as part of the project's SF process compared to approval levels for function tests (KFT), start System test (KFD) and start Operation test after Takeover/ Handover (KFO).

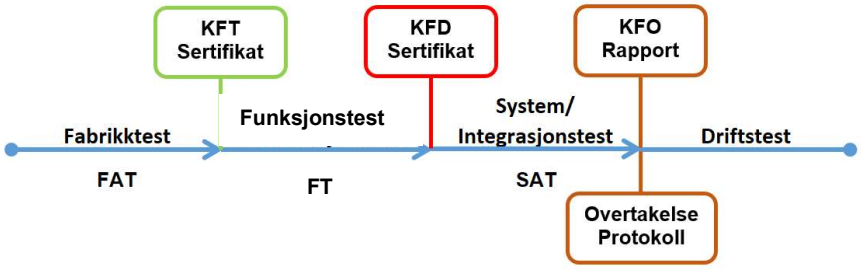


Fig. 5: Test phases in the project's SF process. (Construction (MF) not shown here).

9.4 Test procedure

All testing shall be described in test procedures that define all requirements for its execution and expected results, explained in a step-by-step and logical process. The procedure shall also collect and record all the necessary data and values from the testing and compare them against the requirements.

A test procedure can be made for plant parts, systems or part systems structured according to the division of the code manual. The procedures should always have reference to the SF packages included in the test scope.

Testing procedures should be sent to the Builder for review no later than 6 weeks before the scheduled time for testing.

Procedures for testing plant parts in systems that have interfaces with superior control/monitoring systems, the procedures shall also refer to the SF packages in these.

Test binders and procedures where test results are documented shall be available for verification throughout the test period.

9.5 Test Control/Checklist (TKS)

The test control/checklists from PIMS365 must be linked to the Objekt-id and used as a pre-check or supplement to the test procedures, where this is relevant for the follow-up.

Relevant TKS shall be verified, signed and updated in PIMS365 to indicate the status of SF packages regarding testing. All remaining work or errors should be listed as category A or B punch points depending on the severity.

Before issuing the KFD certificate, there should always be at least one updated TKS in PIMS365 where the technical status of the performed test procedure and documentation is documented (red-marked drawings, procedures, documentation, spare parts, test tools, etc.).

9.6 Electric dynamic loop test (Logical function)

Before switching on electrical supply where PLC and controllers control energy, a logical function test should be performed on all relevant electric loops.

Dynamic loop test should only be performed after verified "Electrical static loop test", which is part of the installation control during the MF phase (before KFT certificate), ref. 8.1.5.

Functional test of electrical control circuits shall be verified on relevant marked

documentation as part of test procedures and checklist (TKS) in PIMS365.

9.7 Test doses and reports

For each test setup, a test dose/folder must be made available that must contain at least the following documentation:

- Test procedure with reference to SF packets
- Descriptive text/ program/ configuration
- Test setup and equipment
- Requirements and acceptance criteria
- Read values and results
- Boundary drawing with reference to marked SF packets
- TKS (Test checklists from PIMS365)
- Substrate documentation and working drawings
- Print of relevant test reports
- As built documentation (red-marked)
- Accepted/approved nonconformities from contract
- Punchlist (Updated in PIMS365)

9.8 Function test (FT)

FT are functional tests that are carried out on equipment/ plant parts in the first part of the test phase after Construction/Installation and approved KFT certificate, where each SF package with its objects will be tested according to criteria described in test procedures.

Test procedures must be signed and status on checklists and any deficiencies updated in PIMS365 before KFD certificate is issued.

If possible, and there is no need to do subsequent System and Integration testing, "FT" shall lead to a complete and final testing when issuing the KFD certificate.

Any remaining tests that must be done according to KFD certificate shall be registered in deficiency lists in PIMS365 and completed by agreement, or in connection with System and Integration testing.

The builder must approve all remaining deficiency points in PIMS365 after test (FT).

Only category B defect points are allowed, if accepted by the Builder.

9.9 "Ready for Operation" Certificate (KFD)

Upon completion of the Functional Test (FT) at the construction site, a PIMS365 KFD certificate shall be issued to confirm that the corresponding and tested SF packages have achieved an acceptable technical status to possibly perform the System and Integration Test (SAT).

The builder issues the KFD certificate at the request of the contractor, but the responsibility for signing the KFD certificate lies with the executing/test-responsible party, but must also be signed/approved by the Builder.

The certificate shall list all related SF packages and contain relevant information about the status of completion/ testing, as well as defied lists and relevant attachments, etc.

Only category B defect points are allowed, if accepted by the Builder.

Any SF package shall undergo KFD certificate, as part of the testing phase, either individually or as part of groups that together constitute equipment, plant part, part system, system, possibly in areas.

The KFD certificate shall confirm the technical status of all plant parts/equipment included, thereby verifying that the plant parts at the time have achieved a completion rate that allows one to start the execution of the System and Integration Test if this is part of the scope of work.

Even if there is no dynamic verification and testing of equipment according to KFD certificate (SAT), there may be areas of review and clearance of any remaining deficiency lists from the precursive test phase (FT).

9.10 Site Acceptance Test (SAT)

The phase immediately after KFD certificate is defined as System and/or Integration Test. The phase is procedurally controlled and requires special focus and preparation with regard to safety and technical content. The purpose of making a SAT is to verify the function and the entirety of the complex system integrated up to operational overall control and management systems before the plant enters a permanent operating state and thereby ready for handover to the operations organization.

Here contributions with personnel and expertise from the Builder/Statsbygg operations organisation to NTNU/Sintef will be required, as well as for training personnel on new equipment in the project.

The following requirements must be complied with in the SAT:

- The performance of work shall only take place after issued and signed KFD certificate.
- A work permit with approval from the Builder, or Operation, is always required.
- Testing activities shall be carried out in cooperation with the Builder, or Operation.
- The SAT will be approved when the Builder signs on the accepted/performed test.
- The builder must approve all remaining punch points in PIMS365 after testing.
- Only category B punch points are allowed, if accepted by the Builder.

9.11 Extended system test (Long-term test)

Sometimes it is necessary to carry out long-term tests (test operation) as part of the SAT and the scope of work of the contractor. In this case, it will be described as a claim in the contract. Examples here can be a water treatment system or similar mission-critical equipment in test over time.

The purpose of extended functional testing is to prove that the system will function satisfactorily in an operating state over a longer period of time. That is, putting equipment with connected systems into long-term operation and performing function, reliability and performance tests.

Extended functional testing should only start after all other precursusal relevant tests have been completed as far as possible with accepted status in PIMS365.

The extended functional test, if required, shall include commissioning of a sufficient system at the same time in such a way that there is equivalent operational operation of the plant parts.

Extended functional testing of plant parts and associated systems shall at least include:

- Functional test – The test must prove that the equipment works satisfactorily under conditions corresponding to normal operational
- Maximum load test – The test should prove that the system's dimensioning and performance under load comply with the requirements
- Reliability test – The test should prove that all equipment works without interruption, intervention or failure for a specified duration
- Degraded mode test – The test should prove that the system in degraded mode works according to the requirements. Recovery time should also be tested

All stops in operation must be coordinated and planned in advance. If an unforeseen stop occurs due to errors in the installation, the test period should be reset and the test should restart. The test will be accepted when the test periods are successfully completed, and the following are met:

- The tests shall be witnessed and accepted by the Builder
- All measurements should be logged during testing and at the end of the test
- All alarms should be analyzed and the root cause to be identified

9.12 "Ready for Takeover" report (KFO)

Upon completion of the System and Integration Test (SAT) at the construction site, or when the work is completed, a KFO report (technical status) from PIMS365 shall be issued to confirm that any remaining points in test procedures and punch lists have been cleared, and that the facility has thereby achieved an acceptable technical status in order to be taken over

from Contractor by the Builder and handed over to Statsbygg.

The report shall list all related KFD certificates with status of completion/testing, checklists, deficiencies (censuses) and any remaining unified deficiency list, as well as other relevant and necessary documentation.

The builder shall approve all defect points in PIMS365 that have not been cleared prior to the takeover and a final operating condition.

Normally there should be no punch lists in the takeover protocol. In exceptional cases, category B deficiency points may be permitted if accepted by the Builder, but will then be included in the final settlement.

The KFO report shall be an appendix to the takeover protocol and issued by the Builder at the request of the Contractor or Contract when the minutes are prepared for signing.

The responsibility for signing the KFO report lies on the contract/executing/test-responsible party, but must also be signed/approved by the Builder.

The takeover of finnished work from Contractor to Builder shall in principle follow the approved plan for handover from Statsbygg to the operations organisation of the end user.

This means that the project will deliver operationally ready facilities to the end user in the order in which the work is completed and taken over from the contractor.

9.13 Project Scope Takeover

9.13.1 Generally

The individual systems or plant parts taken over can either be complete (Full takeover) or partially complete (Sub-takeover) by agreement with the Project/ Builder and Operation.

Requirements for approved KFO with technical status from PIMS365 apply to both full and sub-takeovers. The contractor, The Project and Operations can agree in advance which priority finished systems or plant parts (within the KFO) should be taken over. Close cooperation with the operating organisation is required to carry out final and smooth transfer from the project.

9.13.2 Sub-takeover

In cases where parts of the project is to be put into operation, this shall be resolved through a partial takeover and transfer of scope of work to operators. In this case, PIMS365 shall organize the scope of work so that the KFO report shows only the relevant scope to which the takeover applies.

This type of planned sub-adoption will be grouped and handled in PIMS365 through the organization of SF packages within relevant key fields such as level, milestones, contracts, areas, systems, priority, etc.

10 Operational phase

10.1 Generally

After completing testing and achieving technical status with "Ready for Takeover" (KFO),

systems, part systems or groups of plant parts taken over from the contractors shall usually be delivered successively to the end user. The relevant solution for handover must be clarified with Statsbygg. Any defects in systems arising from KFO and onwards will be classified as a warranty issue against contractors and suppliers.

10.2 Operational test

The phase just before full operation or the first part of ordinary operation is defined as an operational test period and requires special focus and preparation.

An operational test is activities that are required to be carried out when plant parts in systems are to be put into normal operation in commercial use. The activities with the performance of the operational test must be followed up with technical status from PIMS365 in the same way as during the actual project execution.

As a minimum, the operational test of systems and plant parts of shall include:

- Stability – Stable function in all operational situations.
- Performance - Equal performance in repetitive operations.
- Capacity – Enough capacity at maximum load.

10.2.1 Operational test assistance

The operational test shall be led by Statsbygg, but the project with relevant Contractors/Suppliers shall contribute to the overall operational test of the Ocean Space Centre in accordance with the requirements for assistance described in the contracts.

As part of operational test assistance, the builder may require the Entrepreneur to develop proposals for testing procedures and programs where they have the knowledge, which will be integrated into the general test program.

10.2.2 Shadow test

Once all operational tests for plant parts in the project delivery have been completed and approved by project/operation, the Ocean Space Centre will enter a "shadow test" state over a period of 3-6 months. Close follow-up of stable operation will take place during this period.

The "shadow test" shall show function during operation, as well as stability/performance/capacity of plant parts and equipment when the entire plant is in commercial operation over time.

11 Preservation

Maintenance carried out during the project period is often called preservation and involves carrying out necessary protection and routine maintenance on all materials/equipment, plant parts and systems throughout the project's construction and testing phases until the operations organization takes over these tasks.

The executing contractor is responsible for carrying out all routine and periodic maintenance of its scope of work. Preservation shall primarily be based on the supplier's recommendations, as well as separate internal routines that the contractor uses to ensure that the work is carried out correctly.

Requirements for preservation consist of two main groups, "First time" (at the supplier) and "Subsequent" which are done periodically at the site of construction.

The contractor shall prepare a maintenance program with periodic codes (e.g. days, weeks, months) in PIMS365 and use suitable checklists to verify that maintenance is followed up on all materials, whether in stock or placed in the field. In particular, such preservation is important before material is used, or is put an operational state. PIMS365 shall be used for status overview and reports on performed periodic maintenance.

The builder shall prepare a requirement document for "Project maintenance" explaining general requirements for maintenance and principles for carrying these out in an organized

and systematic manner, and logged in PIMS365.