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## ESS PROCEDURE FOR FACTORY ACCEPTANCE TEST (FAT) AND SITE ACCEPTANCE TEST (SAT)

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TABLE OF CONTENT .....		PAGE
1.	SCOPE .....	4
1.1.	Introduction.....	4
1.2.	Purpose .....	4
1.3.	Applicability.....	4
2.	GENERAL PREPARATION BEFORE CONDUCTING A FAT.....	5
2.1.	Documents typically prepared by ESS.....	5
2.2.	Documents typically prepared by Manufacturer.....	6
3.	FAT PERFORMED BY MANUFACTURER.....	7
3.1.	General.....	7
3.2.	FAT test plan .....	8
3.3.	Test procedure .....	8
3.4.	Acceptance Criteria.....	8
3.5.	Documentation .....	9
4.	FAT PERFORMED BY ESS .....	10
4.1.	General.....	10
4.2.	Method.....	10
4.2.1.	Prerequisites.....	10
4.3.	Acceptance Criteria.....	11
4.4.	Documentation .....	11
5.	GENERAL PREPARATION BEFORE CONDUCTING A SAT .....	12
5.1.	Documentation .....	12
6.	SAT PERFORMED BY THE MANUFACTURER.....	13
6.1.	General.....	13
6.2.	SAT test plan .....	13
6.3.	Acceptance Criteria.....	13
6.4.	Documentation .....	14
7.	SAT PERFORMED BY ESS .....	15
7.1.	General.....	15
7.2.	Method.....	15
7.2.1.	Prerequisites.....	15
7.2.2.	Performance.....	15
7.3.	Acceptance Criteria.....	16
7.4.	Documentation .....	16
8.	GLOSSARY .....	17
9.	REFERENCES.....	17
DOCUMENT REVISION HISTORY.....		17

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## LIST OF TABLES

No table of figures entries found.

## LIST OF FIGURES

Figure 1 Verification Workflow.....5

## 1. SCOPE

### 1.1. Introduction

ESS systems need to meet their requirements and specifications (e.g. as listed in a Technical Specification document); meeting requirements and specifications is demonstrated through various verification and validation steps. For this purpose, the Verification and Validation plan template [1] is to be used.

Many systems are supplied to ESS by external contractors or In-Kind contributors/partners. In such cases, ESS engages in a contractual agreement with these Manufacturers, whereby ESS expectations and technical requirements on the deliverables are part of the contract. A Factory Acceptance Test (FAT) and a Site Acceptance Test (SAT) can be used to demonstrate compliance by the Manufacturers with the requirements as delineated in the contract.

In the Verification and Validation report for the system, one can take credit for requirements that have been met through a FAT or SAT. In the case of the SAT, this requires the equipment to be in its final location on site at ESS, connected via the final infrastructure to its installed final interfaces.

### 1.2. Purpose

This document is a procedure defining requirements and expectations on FAT and SAT testing for equipment from external Manufacturers that is to be incorporated into the ESS facility, in particular when the Manufacturer already has its own FAT or SAT template. The Factory Acceptance Test template [3] and Site Acceptance Test template [4] are consistent with these requirements and expectations. These templates can be used when a Manufacturer has no FAT or SAT template or for ESS internal purposes.

This document provides a means for all stakeholders, including ESS and the Manufacturer, to clearly establish and agree on the scope of activities and responsibilities involved in performing tests in order to achieve a timely delivery and acceptance of the ESS system.

### 1.3. Applicability

The FAT and SAT are typically performed by the Manufacturer. The FAT and SAT shall be performed in accordance with applicable standards (e.g. SS-EN 62381:2012 [2]), or any other ESS approved test procedure. The test shall be documented in a protocol, produced by the Manufacturer, that has been approved and accepted by ESS. The FAT and SAT performed by ESS shall be documented using the protocol templates for FAT [3] and SAT [4].

If a FAT has several systems, objects or components as scope, the FAT on the single unit has to be completed with an integrated testing procedure covering the functionalities that are to be performed. This can require several steps depending on the level of complexity, i.e. a whole system containing several objects that are supposed to act together necessitates a more complicated testing regime.

In those cases, it must be stated in the contract that the Manufacturer shall be designated to be responsible for performing the tests for all functionalities that are to be performed.

FAT reports serve as input to the Installation Readiness Review (IRR) and SAT reports to the System Acceptance Review (SAR) (see Figure 1 below).

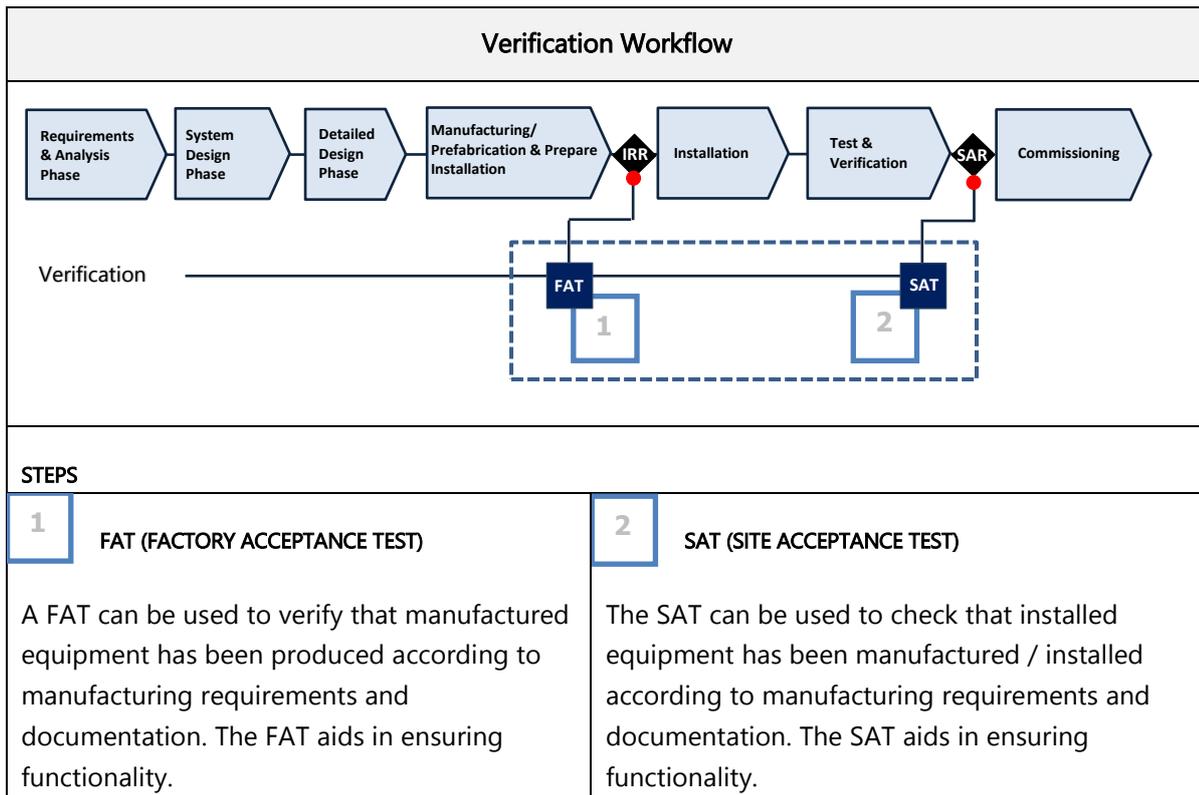


Figure 1 Verification Workflow

## 2. GENERAL PREPARATION BEFORE CONDUCTING A FAT

Prior to commencing the FAT, the Manufacturer and ESS shall agree on a full in-house FAT test plan. The test plan(s) shall be available for review before the FAT tests are commenced.

A list of pre-requisites needs to be prepared and acted upon. Examples of possible pre-requisites are risk assessments of the test and the working area, safety precautions for performing the test, availability check on enabling systems etc.

All relevant documents needed during the FAT shall be prepared prior to it. The following two lists show documents typically used, but these can be adapted to specific project needs.

### 2.1. Documents typically prepared by ESS

For example, the following documents:

- ESS requirement specification
- Preceding agreement(s)
- Function or logic diagrams
- Cause and effect matrix
- Sketches of operator displays and relevant text
- Control loop description
- Loop list
- HMI specification
- Loop sheet
- Trip point list & configuration parameter list

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- Safety manuals
- Test procedures for all safety instrumented functions
- Classification for each safety instrumented function into the levels SIL1, or SIL2, or SIL3, or none

## 2.2. Documents typically prepared by Manufacturer

For example, the following documents:

- Requirement specification
- Manufacturer documents, operating manual, certificates
- Structural diagram DCS/PLC, SIS
- Cabinet layout drawings
- I/O list
- Graphic printouts
- Configuration printouts
- In-house test reports
- Test plan(s)

### 3. FAT PERFORMED BY MANUFACTURER

The ESS FAT template [3] should be used for FAT test procedures & protocols whenever possible. If the Manufacturer uses its own FAT template, ensure to the extent possible that it covers the same points as in the ESS FAT template.

#### 3.1. General

When the FAT is performed by the Manufacturer, ESS shall be given the possibility to witness the test activities. ESS shall be given the possibility to carry out some parts of the FAT themselves, if deemed to be appropriate/necessary.

The FAT shall cover the following areas:

- project-relevant scope of supply
- application-related functions (e.g. functions of the automation system from signal source)
- system-related functions
- adequate infrastructure shall be provided by the manufacturer

The FAT results shall be documented using the FAT test report template. Results could also be documented using another template approved by ESS.

With respect to the requirement specification, any incomplete work or non-conformances detected during the FAT shall be recorded in a punch list.

Punch list issues will be categorized as follows:

- to be cleared on the spot, FAT to continue after rectification
- on-going rectification during FAT
- FAT to be repeated
- modifications to be made after FAT, before the system is shipped to site
- remaining work to be rectified, i.e. at site

The FAT shall be considered complete when the Manufacturer has successfully proven all necessary functions according to the FAT procedures and requirement specifications, with the exception of the mutually agreed remaining items of the punch-list.

Upon successful completion of the FAT, authorized representatives of ESS and the Manufacturer shall sign the FAT protocol.

### 3.2. FAT test plan

A test plan (activities and time-schedule) shall be mutually agreed upon between ESS and the Manufacturer. The schedule should include, but is not limited to, the following activities:

Item	Description
1	Start-up meeting (document review, schedule, etc.)
2	Manufacturer documentation (including in-house test reports) check
3	HW and SW inventory check
4	Mechanical inspection
5	Wiring and termination inspection
6	Start-up test
7	General systems function including hardware redundancy and diagnostic check
8	Visualization/operation
9	Test of functionality against all documents mentioned in the test procedure
10	Complex functionality and operation modes (for example, batch, sequence control, shutdown/trips handling)
11	Subsystem interface test
12	FAT rework, punch list for onsite (SAT) work
13	FAT close-out meeting



### 3.3. Test procedure

A test procedure shall be developed by the Manufacturer and/or ESS and be approved by ESS before any tests are conducted. Test procedures shall be compliant with requirements from applicable standards (e.g. SS-EN 62381:2012 [1]) and with functional requirements given by ESS. They shall be based on clearly defined test cases with clear pass/fail criteria.

### 3.4. Acceptance Criteria

Non-conformities with respect to the current requirements meant for FAT shall be documented in a non-conformity report and registered in the Enterprise Asset Management (EAM) system at ESS. ESS shall perform an evaluation for every non-conformity report and come to a decision whether the test should be aborted or continue. It must be described in the report if the non-conformity shall be corrected before delivery can take place.

Verify that:

- FAT for the equipment was carried out successfully
- Non-conformities have been documented and mitigating measures have been taken care of by the Manufacturer and that the result is accepted by ESS
- The result from the performed FAT has been documented

### 3.5. Documentation

The Manufacturer shall create a report of the performed FAT. The report shall as a minimum include the following:

- Inspected item (system, software etc.)

Product, designation or other identification shall be stated. It is good practice to also state the ESS order number.

- Examination procedure

Reference to test programs with checklists if any. Tools and measuring instruments used shall be identified, including the last calibration date of the latter.

- Result

It shall be evident that the item has met the requirements laid down.

- Open items and non-conformities

Open items shall be identified and listed. It shall be described, how, when and by whom the open items shall be closed in a non-conformity report in EAM.

- The Manufacturer and ESS Representatives

Date and signatures by the examination team of the performed FAT.

- Approval

The document shall have been examined and approved according to the Manufacturer internal QA/QC – instructions and by the Manufacturer's department responsible for quality. The report shall be signed by the Manufacturer and by ESS if the FAT was carried out successfully.

## 4. FAT PERFORMED BY ESS

When ESS performs the equivalent of a FAT, this self-performed work is an in-house verification. The V&V plan and report template [1] is the master document to be used for this case. One can, in addition, use the ESS FAT template [3] when the FAT is performed by ESS, whereby one can take credit for the test in the V&V report.

### 4.1. General

Based on the test plan contained in or referred to from the FAT report the test shall verify:

- the equipment's performance
- function and design to be sure that the components and equipment meet specified requirements
- user documentation

### 4.2. Method

#### 4.2.1. Prerequisites

Test and Verification Coordinator that is designated according to ESS Engineering Handbook Management [5] is responsible for creating an agenda. The Work Unit Leader may take on the role of Test and Verification Coordinator for the FAT.

Test and Verification Coordinator is responsible for creating test procedures and communicate them to concerned parties for approval.

Test and Verification Coordinator is responsible for premises, test equipment and test documentation.

Before the FAT, the equipment shall be set up and a complete inspection with respect to function and performance according to stated configurations shall have been performed. The test shall be documented by the Test and Verification Coordinator.

When the documentation has been approved, it shall be locked and shall not be changed without the process being backed up to the stage when development of the documentation had still not been completed.

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### 4.3. Acceptance Criteria

Non-conformities with respect to the current requirements meant for the FAT shall be documented in a non-conformity report and registered in EAM. The Test and Verification Coordinator shall perform a judgment for every non-conformity and come to a decision if the test should abort or continue. It must be described in the report if the non-conformity shall be corrected before installation can take place.

Check that:

- FAT for the equipment was carried out successfully
- Non-conformities have been documented and taken care of by the Test and Verification Coordinator and has been accepted by concerned parties
- The result from the performed FAT has been documented

### 4.4. Documentation

The Test and Verification Coordinator shall document the performed FAT in a report based on the FAT template. The report shall as a minimum include the following:

- Inspected item (system, software etc.)

Product, designation and/or other identification shall be stated, as well ESS order number.

- Examination procedure

Reference to test programs with checklists if any. Tools and measuring instruments to be used shall be identified, including the last calibration date of the latter.

- Result

It shall be evident that the item has met the requirements laid down.

- Open items and non-conformities

Open items shall be identified and listed in FAT PUNCH LIST. It shall be described, how, when and by whom the open items shall be closed in a non-conformity report in EAM.

- Test and Verification Coordinator and Representatives

Date and signatures by the examination team of the performed FAT.

- Approval

The document shall have been examined and approved according to ESS internal QA/QC – instructions and by the department responsible for quality. The report shall be signed by the Test Leader (e.g. Project Lead Engineer) if the FAT was carried out successfully.

Other requirements according to documentation are specified in the Technical Specification.

## 5. GENERAL PREPARATION BEFORE CONDUCTING A SAT

The SAT shall be performed after the delivery and installation of the system in its final location at the ESS site and can serve as validation if connected via the final infrastructure to its final interfaces, unless otherwise stated via contractual agreement in advance of verification and validation for the system.

The SAT is performed to prove the functionality of the system after delivery and installation in its final location, before the integrated testing can start.

A list of pre-requisites needs to be prepared and acted upon. Examples of possible pre-requisites are risk assessments of the test and the working area, safety precautions for performing the test, availability check on enabling systems etc.

Furthermore, once the relevant HW/SW components or systems have been delivered to the ESS site, they shall be properly inspected and installed according to applicable rules as needed (e.g. ESS Rules for Verification of Installed Electrical Equipment [6]). As an example, the following actions shall be completed during the installation of a DCS/PLC before its SAT can be carried out:

- HW installation (controllers, I/O cards, marshalling racks, operating/engineering stations)
- Power supply installed for the relevant HW being tested
- Grounding system installed for the relevant HW being tested
- Network communications installed (for example, hubs, switches, fibre optic, Ethernet)
- Verification of installed Electrical Equipment according to [6]

### 5.1. Documentation

The Manufacturer and ESS shall create a report of the performed SAT as per section 6.4 or 7.4.

## 6. SAT PERFORMED BY THE MANUFACTURER

The ESS SAT template [4] should be used for SAT test procedures & protocols whenever possible. If the Manufacturer uses its own SAT template, ensure to the extent possible that it covers the same points as in the ESS SAT template.

A SAT performed by the Manufacturer shall comply with applicable standards (e.g. SS-EN 62381:2012 [1]), or with any other ESS approved test procedure agreed with the Manufacturer.

### 6.1. General

The SAT shall verify that the delivered component or equipment fulfils specified requirements for its intended use.

### 6.2. SAT test plan

A test plan (activities and time-schedule) shall be mutually agreed upon between ESS and the Manufacturer. The schedule shall include, but is not limited to, the following activities:

1. Start-up meeting (document review, schedule, etc.)
2. Manufacturer documentation check
3. HW and, where applicable, SW inventory check
4. Mechanical, electrical inspection as applicable (e.g. grounding system, power supply, network connections, etc.)
5. Start-up/diagnostic check (where applicable; e.g. turn on power supply, initialize/commission controllers, perform diagnostic check)
6. Download SW

### 6.3. Acceptance Criteria

Check that:

- SAT for the equipment was carried out successfully according to the approved test procedures
- Non-conformities have been documented and taken care of, or have been accepted
- The result from the performed SAT has been documented

#### 6.4. Documentation

The Manufacturer shall create a report of the performed SAT. The report shall as a minimum include the following:

- Order number  
Reference to ESS order number.
- Inspected items  
Product, designation etc.
- Prerequisites  
Reference to test procedures, acceptance criteria, measuring equipment and tools etc.
- The Manufacturer and ESS representatives  
Date and signature for performed SAT.
- Result  
It shall be evident that the object has met current requirements and acceptance criteria for the intended use.
- Open items and non-conformities  
Open items shall be identified and listed in SAT PUNCH LIST. It shall be described how and when the open items shall be closed including in a non-conformity report.
- Approval

The document shall have been examined and approved according to the manufacture internal QA/QC – instructions. The report shall be signed by the Manufacture and by ESS if SAT carried out successfully.

## 7. SAT PERFORMED BY ESS

When ESS performs the equivalent of a SAT, this self-performed work is an in-house verification and can serve as validation if connected via the final infrastructure to its final interfaces. The V&V plan and report template [1] is the master document to be used for this case. One can, in addition, use the ESS SAT template [4] when the SAT is performed by ESS, whereby one can take credit for the test in the V&V report.

### 7.1. General

The SAT shall verify that the delivered component or equipment fulfils the specified requirements for its intended use.

### 7.2. Method

#### 7.2.1. Prerequisites

Following requirements shall be fulfilled:

- FAT has been performed and approved
- Open items from the FAT shall have been addressed
- The Test and Verification Coordinator is responsible for creating test procedures and communicate them for approval at least 2 weeks before the SAT
- All used test instruments and tools shall be calibrated and their calibration date listed
- It shall have been verified that the component or equipment has not been affected by transport, storage or installation

#### 7.2.2. Performance

The verification shall be performed according to the approved SAT procedure.

The verification shall demonstrate and assure correct functionality according to the ESS requirements and technical specification.

All information related to the SAT as controlling documentation, responsible persons, test equipment used etc. shall be specified in the test procedures.

Non-conformities with respect to the current requirements meant for the SAT shall be documented in a non-conformity report and reported in EAM. The test leader shall perform a judgment for every non-conformity and come to a decision if the test has to abort or can continue.

When a non-conformity has been resolved (e.g. related actions have been implemented), the SAT can be restarted. If applicable the test leader may decide that only specific parts of the SAT need to be repeated.

All decisions shall be documented and added to the non-conformity report.

### 7.3. Acceptance Criteria

Check that:

- The SAT for the equipment was carried out successfully according to the approved test procedures
- Non-conformities have been documented and taken care of, or have been accepted
- The result from the performed SAT has been documented

### 7.4. Documentation

The Test and Verification Coordinator shall create a report of the performed SAT based on the ESS SAT template [4]. The report shall as a minimum include the following:

- Order number  
Reference to ESS order number.
- Inspected items  
Product, designation etc.
- Prerequisites  
Reference to test procedures, acceptance criteria, measuring equipment and tools etc.
- Test and Verification Coordinator and Representatives  
Date and signature for performed SAT.
- Result  
It shall be evident that the object has met current requirements and acceptance criteria for the intended use.
- Open items and non-conformities  
Open items shall be identified and listed in SAT PUNCH LIST. It shall be described how and when the open items shall be closed including in a non-conformity report.
- Approval  
The document shall have been examined and approved according to ESS internal QA/QC – instructions. The report shall be signed by the Test Leader (e.g. Project Lead Engineer) if the SAT was carried out successfully.

## 8. GLOSSARY

Term	Definition
DCS	Distributed Control System
EAM	Enterprise Asset Management system
ESS	European Spallation Source
FAT	Factory Acceptance Test
HMI	Human Machine Interface
HW	Hardware
I/O	Input / Output
PLC	Programmable Logic Controller
QA	Quality Assurance
QC	Quality Control
SAT	Site Acceptance Test
SIS	Safety Instrumented System
SIL	Safety Integrity Level
SW	Software

## 9. REFERENCES

- [1] Verification or Validation Plan template (ESS-0004794)
- [2] SS-EN 62381:2012 – Automation system in the process industry – Factory acceptance test (FAT), site acceptance test (SAT), and site integration test (SIT)
- [3] Factory Acceptance Test template (ESS-0113710)
- [4] Site Acceptance Test template (ESS-0113711)
- [5] ESS Handbook for Engineering Management (ESS-0092276)
- [6] ESS Rules for Verification of Installed Electrical Equipment (ESS-0145259)

## DOCUMENT REVISION HISTORY

Revision	Reason for and description of change	Author	Date
3	Changed from guideline to procedure. Updated to expand the scope from FAT and SAT for electrical systems to one for any system.	Eugene Tanke	2020-06-24
2	Added inspected according to ESS-0145259 to chapter 5.1	Stefan Arvidsson	2019-02-14
1	First issue	Stefan Arvidsson	2018-01-10