

Engineering Procedure

SAEP-1634

28 February 2005

Factory Acceptance Test

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1 Scope

The Factory Acceptance Test (FAT) Plan covered by this procedure shall be considered as one of the Non-Material Requirements (NMR) called for by [SAEP-16](#). The main purpose of the FAT is to test the customization aspects of the equipment, both software, hardware and special application packages. Standards, commercial-off-the-shelf (COTS) software and hardware shall be excluded.

- 1.1 This Saudi Aramco Engineering Procedure (SAEP) provides instructions for the development and approval of the process automation system (PAS) project Factory Acceptance Test (FAT) Plan. The FAT Plan shall contain the information specified in this SAEP. However, it is not required to follow the format provided.
- 1.2 The FAT Plan will be used by the Contractor to guide and control the performance of the FAT. The FAT Plan will be used by the Company as the basis for monitoring performance of the FAT and for determining satisfactory completion of the FAT.
- 1.3 The purpose of the FAT is to demonstrate, to the fullest extent possible at the Contractor's facility, that the System meets all requirements of the Job Specification, particularly the Functional Specification Document.

2 Conflicts and Deviations

- 2.1 Any conflicts between this Procedure and other applicable Saudi Aramco Engineering Procedures (SAEPs), Saudi Aramco Engineering Standards (SAESs), Saudi Aramco Materials System Specifications (SAMSSs), Saudi Aramco Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this Procedure in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.

3 Applicable Documents

All referenced Procedures, Standards, Specifications, Codes, Forms, Drawings, and similar material or equipment supplied shall be considered part of this Procedure to the extent specified herein and shall be of the latest issue (including all revisions, addenda, and supplements), unless stated otherwise.

Saudi Aramco Engineering Procedures

[SAEP-16](#)

*Project Execution Guide for Process Automation
Systems*

[SAEP-302](#)

*Instructions for Obtaining a Waiver of a
Mandatory Saudi Aramco Engineering
Requirement*

[SAEP-1638](#)

Site Acceptance Test Plan

4 Responsibilities

The PMT has overall responsibility for the development of the FAT Plan per [SAEP-16](#). The FAT Plan is to be delivered with 601 NMRs and 602 NMRs, which require approval by both PMT and the Operating Organization (OO).

The Manager, Process & Control Systems Department may be requested to review the FAT Plan as a consultant to either PMT or the OO on an as-required basis.

5 Instructions

5.1 Depending on the job specification for the particular job, the FAT may be comprised of two or three types of tests:

- Structured tests (performed by the Contractor, using step-by-step procedures from the FAT Plan).
- Unstructured tests (performed by the Company to further ensure that the System meets all requirements).
- Reliability test (continuous operation of the System over a period of several days, with no failure allowed, to give an indication of the System's ability to meet the availability requirements), if required by the job specification.

The purpose of the FAT Plan is to provide a complete definition of the FAT, including detailed, step-by-step procedures.

5.2 Appendix 1 is a suggested outline for the FAT Plan. The Plan shall contain, as a minimum, the information specified. The Plan need not follow the particular format of the outline.

5.3 Use Appendix 2 as a guide to the required level of detail for the structured test procedures.

6 Definitions

The following is a list of definitions of terms whose meanings may not be obvious from their usage in this document. Terms that have special meanings when capitalized are shown in that form.

Company: refers to a Saudi Arabian Oil Company (Saudi Aramco) organization.

Contract: refers to a specific contract.

Contractor: is an organization under contract to Company.

Factory Acceptance Test (FAT): demonstrates compliance of the System with all requirements, to the extent possible in the Contractor's factory environment.

FAT Plan: is a document which specifies and describes the conditions, requirements, plans, procedures, success criteria, and responsibilities for performance of the FAT. The FAT Plan shall contain sufficient content and detail such that successful completion of the FAT, according to the FAT Plan, will demonstrate and document that the System satisfies all requirements of the Job Specification.

Functional Specification Document (FSD): provides the technical requirements for the System.

Job Specification: The scope of the work to be performed pursuant to a contract; it describes or references the applicable drawings, standards, specifications, as well as the administrative, procedural, and technical requirements that the contractor shall satisfy or adhere to in accomplishing the work.

Non-Material Requirements (NMRs): The complete set of documentation required from the vendor and/or the contractor during the design and development phase of the project. There are three categories of NMRs:

- 601 NMRs** Preliminary drawings for review and approval
- 602 NMRs** Certified drawings, literature, photographs, and parts data/requirements
- 603 NMRs** Operations, maintenance manuals, installation instructions, test certificates, etc.

Pre-FAT: A comprehensive test, completed prior to FAT, which ensures that the System can be tested according to FAT procedures without unanticipated delays.

Process automation system: A network of computer-based or microprocessor-based modules whose primary purpose is process automation. The functions of a PAS may include process control, safety, data acquisition, advanced control and optimization, historical archiving, and decision support. Examples of process automation systems are DCS, SCADA, MIS, ESD, PC and PLC-based systems.

Project Management Team (PMT): The team of Company individuals who are assigned the responsibility of managing the project.

Site Acceptance Test (SAT): The acceptance test, performed on the installed System, that demonstrates compliance with all requirements, except availability.

System: is the process automation system that is procured under the Contract.

System Design Document: A document prepared by the vendor and/or the design contractor that contains the design narratives and the key design issues of the system.

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SAEP-1634

Factory Acceptance Test

28 February 2005	Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with no other changes.
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Appendix 1 – Required Fat Plan Contents

1. Introduction

1.1 Scope

This section shall introduce the FAT Plan, describing the content and how it is to be used.

1.2 Applicable Documents

All documents referenced in the FAT Plan shall be listed.

1.3 Terms and Abbreviations

Definitions of all acronyms, mnemonics, and special terms used in the Plan shall be provided.

2. Overview

A concise summary of the test scenario and plan shall be presented in this section.

3. Prerequisites

All conditions and requirements that must be met or completed before initiation of the FAT shall be listed and described.

3.1 System Equipment

All items that are a part of the System to be tested during the FAT shall be enumerated and verified to be present. Specific items include system equipment (hardware, firmware, and software), including part numbers and revisions numbers as necessary for identification and verification.

3.2 Documentation

Documentation which is part of System and / or is needed during FAT shall be listed and described. Specific items typically include User's Manuals, Maintenance Manuals, configuration drawings, connection drawings, database listings, logic drawings, instrumentation loop drawings, P&IDs.

3.3 Inspections and Pre-Testing

All inspections and pre-testing that must be completed before the FAT initiation shall be specified. Methods to document completion of inspections and pre-testing shall be specified. Specific items to be addressed include:

- a) Saudi Aramco Inspection per appropriate SA-175 form.

- b) System configuration, documentation and validation.
- c) The Vendor is to conduct pre-FAT testing. Pre-FAT is basically a trial run of all FAT procedures (as approved by Company) without the presence of Company representatives, performed so as to identify and correct any deficiencies that would cause delays during FAT. The purpose of the pre-FAT is to insure that all hardware, software, and application program deficiencies have been identified and corrected before the official FAT (for example: incorrect wiring from the test panel to the I/O points, incorrect wiring inside the equipment, bad I/O modules). A formal, signed pre-FAT report shall be submitted to Saudi Aramco one week before the start of the FAT.
- d) Reports showing results of other tests, such as loop tests. It is common to include a certain percentage of loops in the loop tests performed during FAT. A more extensive loop test, perhaps even 100%, is sometimes required in a pre-test. In such cases, a formal certification of test results is required.

3.4 Test Equipment

All test equipment needed for all aspects of FAT shall be identified. Test panels with switches and lights to simulate field inputs and outputs may be needed, depending on the specific needs of the project.

3.5 Other Prerequisites

All other items not directly related to the System that must be prepared or completed before the FAT initiation shall be given. Specific items may include test cases, data bases, or interfaces via modem linkup.

4. Personnel Requirements

All personnel required during the FAT shall be specified. Specific items to be addressed include:

- a) Contractor personnel requirements and responsibilities. A QA representative is required to participate in the FAT.
- b) Company personnel requirements and responsibilities
- c) Special personnel qualifications (electrician, instrument technician, etc.).

5. Configuration

5.1 Management / Control

This section shall state the configuration management method to be followed during the FAT.

The System configuration shall be controlled from the beginning of the FAT to ensure that the correct items are tested; that the configuration, including any modifications, may be ascertained for subsequent problem identification and resolution; and that the exact System configuration will be documented and properly tracked through any subsequent revisions or modifications.

5.2 System Configuration

This section shall provide a reference to or description of the System configuration. Specific items to be included are:

- a) System configuration summary
- b) Brief descriptions of major System components and operational environment.

5.3 Test Configuration

Deviations from the System configuration are allowed for only those items that cannot be tested without a system modification.

If this configuration is changed for the FAT, the modified System configuration shall be described in sufficient detail such that the effects on the System's functional requirements may be determined. Specific items to include are:

- a) Hardware/software configuration deviations (System component replacements, additions, and deletions)
- b) Operational and performance deviations
- c) Reason for each deviation and requirement(s) affected.

5.4 Simulation

All items that must be simulated for the FAT shall be described, including hardware, software, and firmware. This description shall be of sufficient detail to determine the simulation's effect on the System's requirements. For each item simulated, the following information shall be included:

- a) Item simulated
- b) Requirement(s) affected
- c) Reason for simulation
- d) Simulation method
- e) Simulation hardware and software description
- f) Simulation quality (equivalence, fidelity, etc.)

- g) Additional manual operations involved
- h) Verification of simulation
- i) Additional system resources required for simulation (memory, mass storage, CPU time, etc.)
- j) Effects of simulation on system performance (if applicable).

5.5 Factory Untestable Items

All items that are impossible to test or simulate in the factory configuration or environment shall be described in this section. Provisions for testing these items during the Site Acceptance Test shall be stated, and a reference to such tests given. Specific items addressed include:

- a) Requirements not tested during the FAT
- b) Reason item is factory untestable
- c) Effects of untested item on other tests performed
- d) Effects of untested item on system performance
- e) SAT plan reference for completion of testing.

5.6 Test Data Base

Any deviations to the System data base required for the FAT shall be described in detail. These deviations shall not prevent testing the data base requirements. If a modification is required due to a configuration change or simulation process, these modifications shall be described in sufficient detail to determine the effects on the System's requirements. Specific items to be addressed include:

- a) Deviations to the System data base (replacements, additions, and deletions)
- b) Requirements affected
- c) Reason for change.

6. Testing

All testing to be performed during the FAT shall be described in detail.

6.1 Structured Testing

An overview of the structured testing portion of the FAT shall be provided.

6.1.1 Test Plan

The structured tests shall demonstrate and document the satisfaction of all requirements of the System as stated in the Job Specification. The philosophy, and method of structured testing shall be described in detail in this section.

6.1.2 Activity Network

The structured testing activity network shall provide a diagram showing the interdependencies between the structured tests. The tests shall be referenced by name and number as they appear in the description of the structured test procedures. The activity network shall be of sufficient detail to show:

- a) Test sequence requirements
- b) Test failure impact on other tests.

6.1.3 Testing Schedule

The structured testing schedule shall provide a day-by-day schedule of the chronological structured tests. This schedule shall reflect the following:

- a) Time required for each test
- b) Day-by-day planned structured tests.

6.1.4 Mandatory Tests

The following are mandatory tests (unless the requirement has been formally waived). Test procedures shall specify whether all modules shall be tested or only representative samples of each module type shall be tested.

- a) Redundancy or fault tolerance: fail one item (e.g., by power down or disconnection), verify proper response by backup unit or other fault tolerant operation.
- b) Replacement of redundant or fault tolerant modules: replace redundant or fault tolerant modules per Vendor instructions to verify ability to perform replacements on-line.
- c) Upgrade of system operating software: perform upgrade of system operating software on each type of redundant or fault tolerant module per Vendor instructions to verify the ability to meet requirements while performing software upgrades on-line.
- d) Analog output upon failure test: test that analog outputs maintain configured safe status (e.g., maintain last good

value, fail to 0%, or fail to 100%) upon controller input failure.

- e) Invalid value propagation test: verify that invalid value of input is properly propagated through control schemes.
- f) Loop test: verify that the basic functionality associated with the System I/O works properly as evidenced on standard and custom displays. This will include checks that the I/O are wired properly, configured properly, displayed properly, and documented properly. Per [SAEP-16](#), a minimum of 10% of wired I/O integrated and staged for FAT must be tested, although more complete testing is frequently required in the Job Specification.
- g) Performance test: verify that all performance requirements are met under system peak load conditions.
- h) Spare capacity and expansion test: verify that required spare capacity and expansion are met.

6.2 Unstructured Testing

During this phase, which follows satisfactory completion of structured testing, Company representatives may repeat any tests and conduct other tests to further validate the robust operation and response of the system under a variety of potential scenarios. Documentation shall include:

6.2.1 Contractor Test Support and Constraints

This section shall contain a description of the support to be provided by the Contractor and the constraints under which the Company will conduct the test.

6.2.2 Schedule

The time available to Company representatives for unstructured testing shall be defined. Items to be addressed include:

- a) Total time span available for unstructured testing
- b) Adjustments to time span available in event a valid System failure or deficiency is discovered
- c) Daily hours that the System will be available for unstructured testing.

6.3 Reliability Test

A test shall be performed to demonstrate that the System can satisfy the reliability test requirements without discrepancy or System errors under

simulated operational loads. (**Note:** applicable only if required in the Job Specification.)

6.3.1 Test Plan and Procedures

All plans and procedures for conducting the reliability test shall be defined in this section. Any discrepancy occurring during the test shall be resolved in a manner similar to that used for structured test, except that after the correction is implemented the testing shall begin again from the start.

6.3.2 Test Period and Reliability Requirement

The reliability continuous time period and the normal and peak operational load requirements shall be as stated in the Job Specification. Detailed information shall be provided in this section to describe how these loads will be simulated.

6.4 Retest Method

This section of the FAT Plan shall describe the retest method to be followed to ensure that the discrepancy was corrected and that no other related areas of the System were affected. Any retest of an item as a result of a discrepancy correction shall also retest all related System areas. Specific procedures to be addressed shall include the following:

- a) Method of determining related areas of the System for a retest item
- b) Method of identifying structured test procedures to repeat for both the retest item and the related system areas
- c) Consequence of retest results - describe actions to take if the test passes, fails, or new problems are identified.

7. Requirement / Test Cross Reference

A cross-reference of the System requirements stated in the Job Specification to the corresponding structured test(s) shall be provided. This cross-reference shall be organized by requirement, preferably in the order presented in the Job Specification and its attachments, and shall contain the following information for each requirement:

- a) Brief statement of the requirement
- b) Paragraph number and name of the document containing the requirement
- c) Name of test(s) which demonstrates the requirements
- d) A description of how the test(s) will demonstrate that the requirement is satisfied.

8. Test Documentation

The documentation to be generated during the FAT shall be described. The FAT results shall be documented sufficiently such that retests may be compared and testing performed during the Site Acceptance Test may be compared to the FAT results.

8.1 Test Log

A procedure for maintaining a chronological test activity log during the FAT shall be described.

8.2 Test Results

The test result documentation to be produced during FAT shall be described. Specific items include:

- a) System generated hard copy reports and logs
- b) Manually completed forms.

8.3 Test Discrepancies / Corrections

The procedure for documenting and reporting discrepancies and corrections during structured, unstructured, and reliability FAT testing shall be described. Specific items include:

- a) Discrepancy/correction report format
- b) Discrepancy/correction reporting procedure.

9. Problem Resolution

The actions to be taken during the FAT in the event discrepancies are detected shall be defined.

9.1 Resolution during FAT

Actions to be taken by the Contractor during the FAT to resolve minor problems shall be defined. Items to be addressed include:

- a) Maximum time allowable for problem resolution during the FAT
- b) Scheduling of problem resolution time
- c) Reference to the configuration management methods as described in Section 5.1 for the procedure to follow for documenting and controlling corrections
- d) Retest method to validate corrections as described in section 6.4.

9.2 FAT Suspension / Resumption / Restart

This section shall contain the procedures to be followed in the event a discrepancy is encountered which cannot be resolved during the time allowed for resolution during the FAT. The following notices shall be

defined to process these discrepancies with a description of the procedures to be followed for each:

- a) Notice of FAT suspension [testing is terminated until problem(s) are resolved]
- b) Notice of FAT resumption [resume testing after problem(s) have been resolved and all necessary retesting has been completed]
- c) Notice of FAT restart [(begin testing again from the start of the structured tests or reliability tests; testing cannot be resumed due to the number or nature of problem(s)).

10. Factory Acceptance Test Report

The Factory Acceptance Test report shall be written such that, when approved by Company, it may be used as the certification that the FAT has been successfully completed and as the documentation of all activities and results of the FAT. The report shall meet the following minimum specific requirements:

- a) Identify System and Contractor
- b) Include certification statement
- c) FAT location, start date, completion date
- d) Configuration identification at the FAT completion
- e) Contractor representative signature
- f) Company representative signature
- g) An official copy of the FAT Plan
- h) All test documentation defined in Section 8.

Appendix 2 – Structured Test Procedures Documentation

The structured tests shall be described completely in this section. Each test shall be detailed in a single procedure. When a version of the FAT Plan without step-by-step procedures is required as stated in the Job Specification, items A) through G) of each test procedure shall be completed, with the remaining items completed to the extent practical (consistent with the level of detail provided in the preliminary design of the system).

The initial tests shall consist of generation of all system software from configuration controlled source media, data base generation from source media, and data base validation. Each structured test procedure of a FAT Plan shall include the following items:

- a) Test identification number, name, and test sequence number
- b) Description of the test and purpose
- c) Estimated time required for the test
- d) Reference to specific Job Specification requirement(s) addressed by the test
- e) Special equipment requirements for the test
- f) Special software requirements for the test
- g) Special personnel requirements for the test
- h) Step-by-step details of any special setup required for the test
- i) Step-by-step test sequence, including for each step:
 - 1) Operator action required
 - 2) Exact input sequences required
 - 3) Exact manual hardware operations required
 - 4) Expected response or results (including any tolerances)
 - 5) Space for recording actual response or results
- j) Pass/fail criteria for the test
- k) Space for Company representative's verification of test execution and test results.