Project Management Institute.
Kingdom of Saudi Arabia

Digital Insights:

Plant Pre-commissioning

Loop Checks Versus Functional Testing

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INTRODUCTION

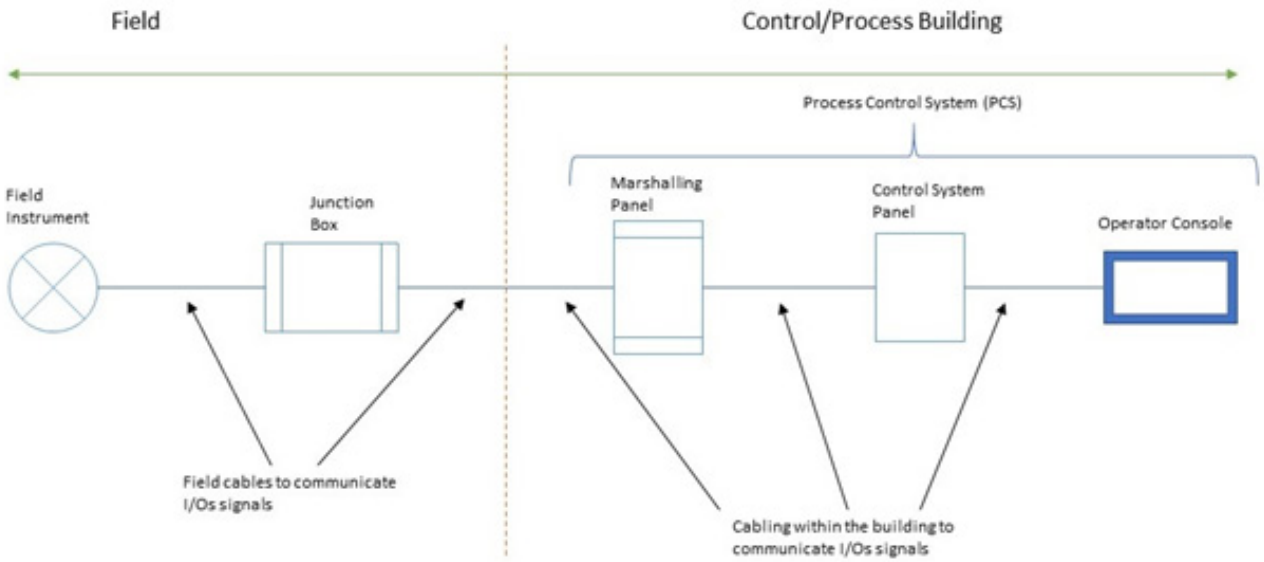
Once constructing a new Plant for Oil or Gas productions and as project construction phase completes, Pre-commissioning phase begins with many activities. These Pre-commissioning activities involve hydrotesting, chemical cleaning, drying and purging, flushing and blowing, electrical testing, instrumentation checks and general equipment alignment and lubrications. The purpose of having these Pre-commissioning activities after construction phase is completed, is to ensure plant readiness in terms safety, integrity, functionality, cleanliness and preservations for Commissioning and Start-up phases. Two Pre-commissioning activities known as loop checks and functional tests are very essential activities for plant automation utilizing control systems and field (outdoor) or building (indoor) instrumentations.

Before constructing any new plant and during the design phase of Oil and Gas Plants, field processes are designed to be automated through Process Control Systems (PCS) and instrumentations devices are distributed around the plant field as the plant processes require. This article explores the latter mentioned very essential activities, instrumentation loop checks and control systems functional tests and how these activities are usually performed with Saudi Aramco projects.

WHAT IS LOOP CHECK AND HOW TO PERFORM?

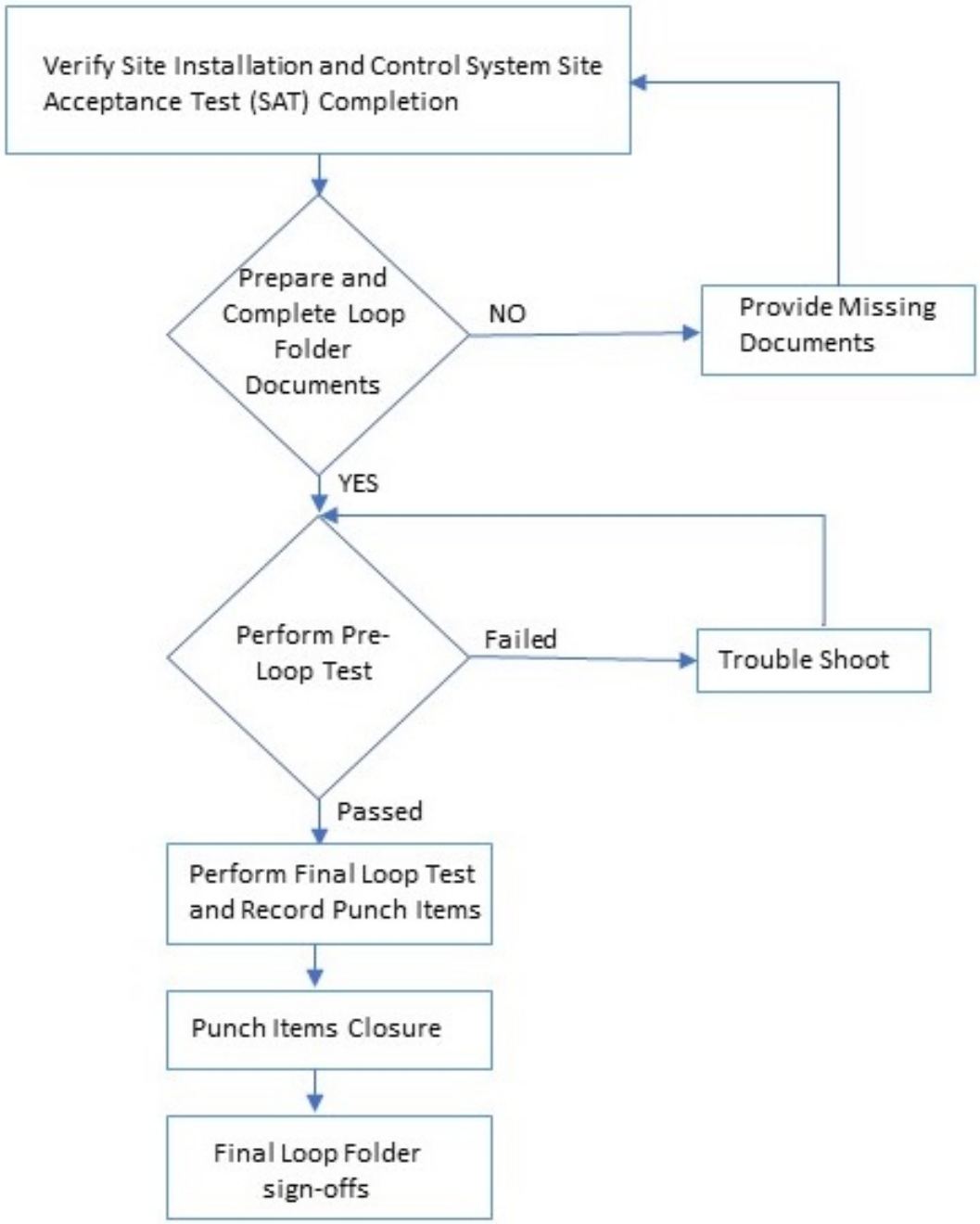
Loop check testing is one of the Pre-commissioning activities which will verify the integrity and installation of the following while ensuring that Inputs and Outputs (I/Os) signals are communicating between the field instrument and the respective (PCS) Operator Console. Figure.1 Shows a Loop Sample:

- Filed instrument (Pressure, Level, Flow and Temperature Transmitters, Control Valves, switches and etc.).
- Cabling and Wiring.
- Junction Box.
- Marshalling panel.
- System panel.
- Operator Console.



Loop Checks can only commence when the respective PCS site Acceptance Test (SAT) is completed, Loop folder is prepared and Pre-loop test is completed. Consequently, each loop folder may have multiple signals (I/Os) for instruments depending on the required process action required of the loop or for ease of testing and tracking. The loop folder shall be prepared before preforming the loop check test including the following documentations as minimum and through the flow chart shown in Figure.2:

- Loop Test Description "Cover Sheet" (Area, number, service, instrument tags and etc..). This is signed by contractor and Saudi Aramco team once loop check test is completed and related punches are closed.
- Related Piping and Instrumentation Diagrams (P&IDs)
- Related Instrumentation Loop Diagrams (ILDs).
- Related Instrument calibration certificate.
- Instrument Specification and Calculation Sheet (ISS).
- Cabling continuity test records.
- Installation inspection records including (Instrument, tubing, impulse piping, hook ups, pulling, terminations and etc...)
- Pre-Loop Test Sheet (Test is performed and signed by contractor Quality Control and Assurance team).
- Loop Test Sheet (Test is performed and led by contractor team and signed by contractor and Saudi Aramco team).
- Punch log.


Verify Site Installation and Control System Site Acceptance Test (SAT) Completion
Prepare and Complete Loop Folder Documents
NO
Provide Missing Documents
YES
Perform Pre-Loop Test
Failed
Trouble Shoot
Passed
Perform Final Loop Test and Record Punch Items
Punch Items Closure
Final Loop Folder sign-offs

WHAT IS FUNCTIONAL TESTING?

The Functional Testing another Pre-commissioning activity that is conducted after loop check completes to verify the integrity and functionality of the respective (PCS) programmed logic in terms of Process Automation and display on operator console through designed Human Machine Interface graphics (HMI). This test is conducted to ensure the respective PCS is operating, controlling and monitoring safely the related equipment and instrument.

Generally, Control loops and logic associates to relevant subsystem or grouped in accordance to main equipment or package. Therefore, one functional test folder might be two or more loop folders which depends on the subsystem that is planned to be tested. Functional test folder and test can be prepared and tested as shown in Figure.3 in the following page and shall have the following documentation as minimum:

- Functional Test Description "Cover Sheet" (Area, number, service, instrument tags, subsystem or package name and etc..). This is signed by contractor and Saudi Aramco team once functional test is completed and related punches are closed.
- Related Loop Check Tests Signed-Off Folders.
- Control Narrative and logic descriptions.
- Alarm and Trip Set-points Register.
- Cause and Effect matrixes.
- Equipment Typical such as valves.
- Inputs and Outputs (I/Os) list with alarm definition.
- Force/overrides Register.
- Pre-Test Sheet (Test is performed and signed by contractor Quality Control and Assurance team with vendor support as required).
- Functional Test Sheet (Test is performed and led by contractor/vendor team as required and signed by contractor and Saudi Aramco team).
- Punch Log.

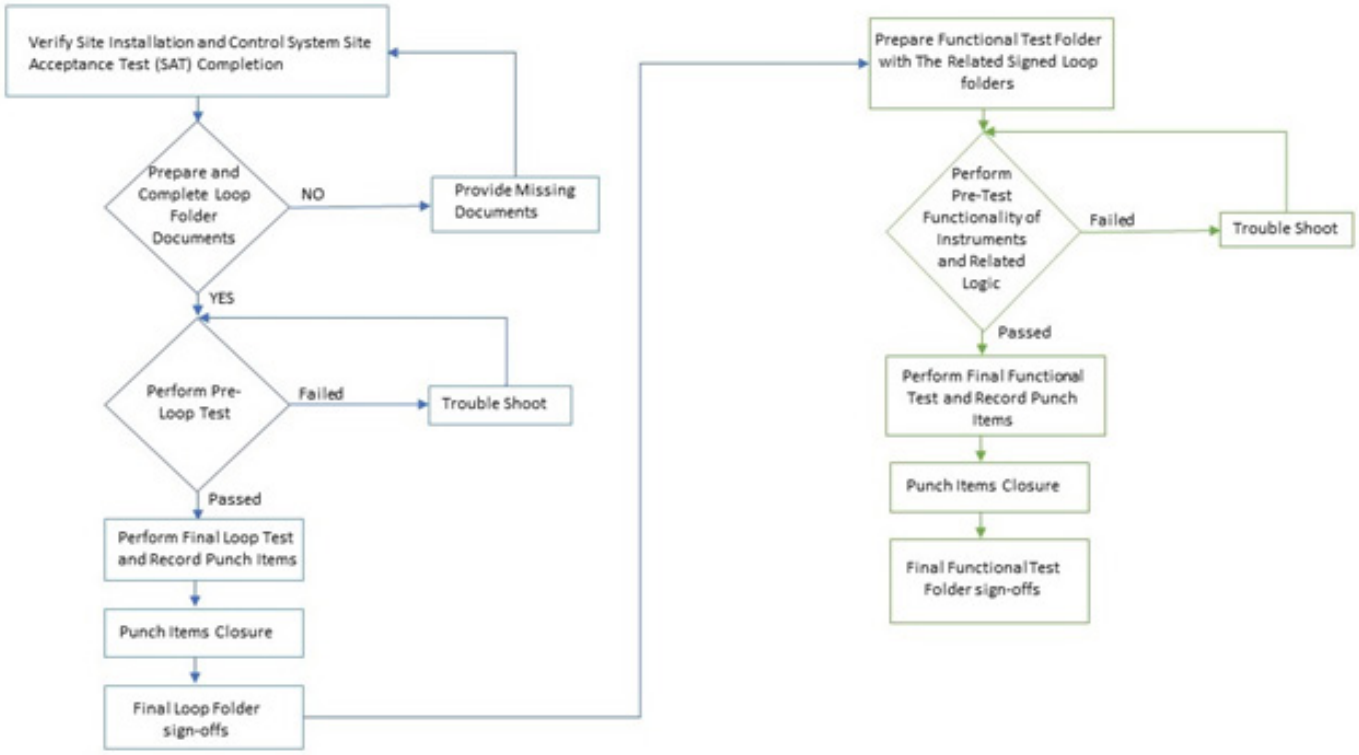


Figure.3 Functional Test Folder Preparation and Test Flow Chart

WAYS TO IMPROVE COMPLETING LOOP CHECKS AND FUNCTIONAL TESTING?

In terms of Project progress enhancement, we practice the following as minimum practices to improve the project schedule for Loop Checks and Functional Testing activities:

PCS READINESS:

Before starting these Pre-commissioning activities, we ensure PCS Factory Acceptance Test (FAT) is completed without any major issues and panels for the following main control systems as minimum are delivered to site:

- Distributed Control System (DCS).
- Emergency Shutdown System (ESD).
- Machinery Protection System (MPS).
- Compressor Control System (CCS).

ENSURE SITE READINESS:

Ensuring site readiness is the most crucial way to improve the project schedule and this involves completeness of the following site activities which shall be parallelized to avoid project delays:

- Readiness of Control or Process buildings for accepting PCS panels and Consoles.
- Completeness of all internal cabling for PCS within Control or Process buildings.
- Completeness of Site Acceptance Test (SAT) of PCS.
- Delivery and Installation of all field instruments.
- Installation of all cabling from the field instrument to the Control or Process buildings.

LOOP AND FUNCTIONAL TESTING FOLDERS READINESS:

In parallel of completing the above site activities, Loop checks and Functional Testing folders shall be prepared with all required and related documentations as mentioned previously in this article.

INCREASING TESTING TEAMS AND SHIFTS:

One way to progress on completing these Pre-commissioning activities that we practice within Saudi Aramco project, is increasing the number of teams and shifts for preforming the Loop checks and functional testing activities. Teams are not only increased from Saudi Aramco side but also from contractor and vendors. Usually a team can complete from 20 to 30 loop check tests per shift depending on how complex the loop is and as additional teams and shifts are introduced the completion rates of loops increases as shown in Table.1. Similarly, functional testing is planned; however, the rate of completion for a team, is usually 4 to 6 functional tests per shift.

Activity	1 Team 1 Shift	1 team 2 Shifts	2 Teams 1 Shift	2 Teams 2 Shifts	3 Teams 1 Shift	3 Teams 2 Shifts
Loop Tests completed per shift	30	60	60	120	90	180
Functional Tests completed per shift	6	12	12	24	18	36

Table.1 shows the maximum Completion Rates compared to teams and shifts

TOOLS FOR TESTING:

Having the testing tools available at site before testing, will definitely support enhance the testing of these Pre-commissioning activities. Therefore, we in Saudi Aramco plan and ensure that the testing teams are equipped with the below listed tools as minimum:

- Signal simulator/ (Highway Addressable Remote Transducer) HART communicator.
- Multimeter.
- Pressure Temperature Calibrators.
- Process Calibrator.

In addition to the above tools, we plan to equip the testing with chemicals or gases such as Nitrogen and calibration gases, instrument air and water. These fluids and chemicals are used to pressurize, force, simulate, purge and or leak test the instrument

CONCLUSION:

In conclusion of this article, instrumentation loop checks tests and control systems functional tests are two critical Pre-commissioning activities are always planned within Saudi Aramco projects to ensure plants integrity, functionality and readiness for commissioning phase. These activities will also ensure that installation, cabling, connectivity and functionality with control systems completed within construction phase are accurate, validated end-to end and documented for starting commissioning phase. Performing such Pre-commissioning activities will also minimize any unexpected risks during plants commissioning and ensure reliable and safe plant start-up.