

CONVERSATORIO :



Junio 3, 10, 17, 24

Sistemas HVDC

SESIÓN 1 :

Aspectos claves del diseño y especificación de sistemas HVDC

HVDC Transmission Project: Specification, Testing and Training

Proyectos de transmisión en HVDC: especificación, prueba y entrenamiento



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Un evento:





SUMMARY OF TOPICS



SPECIFICATION



DESIGN REVIEW



TESTING



FACTORY TESTS



COMMISSIONING



STAFF TRAINING



SPECIFICATION



**DATA REQUIRED
FOR SPECIFICATION**



**WHAT TO INCLUDE
IN SPECIFICATION**



PREPARATION TIME





DATA FOR SPECIFICATION



**INFORMATION ON THE AC SYSTEMS
CONNECTED TO HVDC SYSTEM**



**COMPLETION OF SYSTEM STUDIES FOR
DEFINING THE HVDC SYSTEM REQUIREMENTS**



**RESULTS OF ACTUAL HARMONIC IMPEDANCE
MEASUREMENTS OF BOTH AC SYSTEMS**



**INFORMATION ON THE CONVERTER SITE AND
RELATED INFORMATION FOR CONSTRUCTION**





WHAT TO INCLUDE IN SPECIFICATION



SYSTEM RATING



PERFORMANCE REQUIREMENTS



RIGHT TO REVIEW OF ALL STUDIES AND FACTORY TESTS



LOSS EVALUATION CRITERIA



LIST OF FACTORY AND COMMISSIONING TESTS



PARTICIPATION IN FACTORY TESTING



PARTICIPATION IN COMMISSIONING TESTS





WHAT TO INCLUDE IN SPECIFICATION



SPARE PARTS



WARRANTY PERIOD



TRAINING OF OPERATING AND MAINTENANCE STAFF



PSCAD, PSSE AND RTDS MODELS OF HVDC SYSTEM FOR STUDIES



RTDS REPLICA FOR THE OPERATING STAFF



RIGHT TO VIDEO RECORD THE TRAINING SESSIONS FOR OPERATING AND MAINTENANCE STAFF





DESIGN REVIEW



CONTACTOR SUBMITS DESIGNS FOR ALL COMPONENTS



DESIGNS ARE REVIEWED



ANY CONCERNS ARE DISCUSSED



IF NECESSARY, THE DESIGN IS MODIFIED



DESIGNS ARE APPROVED





TESTING





TESTING



FACTORY TESTING



SITE TESTING



ALL TEST PLANS MUST BE APPROVED BEFORE TESTING STARTS



ALL TESTING SHOULD BE WITNESSED



List of Tests



Off line tests



Energization tests



Open Circuit & Open Line tests



Block/Deblock



Protection Operation tests





List of Tests



Step response tests



Control mode transfers



Commutation failure tests



Power/Current ramp tests



AC and DC faults





List of Tests



Auxiliary systems



Reactive power control



Generator/Last AC line tripping



Dynamic Tests of Auxiliary controls



Verification of replica





FACTORY TEST OBJECTIVES



**VERIFICATION OF
CONTROLS AND
PROTECTION**



**VERIFICATION OF
PSCAD STUDY
RESULTS**



**VERIFICATION OF
RTDS REPLICA**



**TRAINING OF
ENGINEERING
PERSONNEL**



**TRAINING OF
OPERATING
PERSONNEL**





FPT – FUNCTIONAL PERFORMANCE TESTS



- The objective of the functional performance tests is to check proper operation of individual cubicles and correct interaction, functionality and interfacing of all components and subsystems.





Parallel Factory System Tests (PFT)



Converter transformer protection and cooling system



Converter valves and Cooling system control and protection



DC switchgear operation



AC and DC filter protections



Auxiliary supplies





Test List Review



The vendor should provide a proposed list of tests to be performed at least 6 months before the start of tests.



The list is first reviewed by the owner



Any concerns are discussed with the vendor



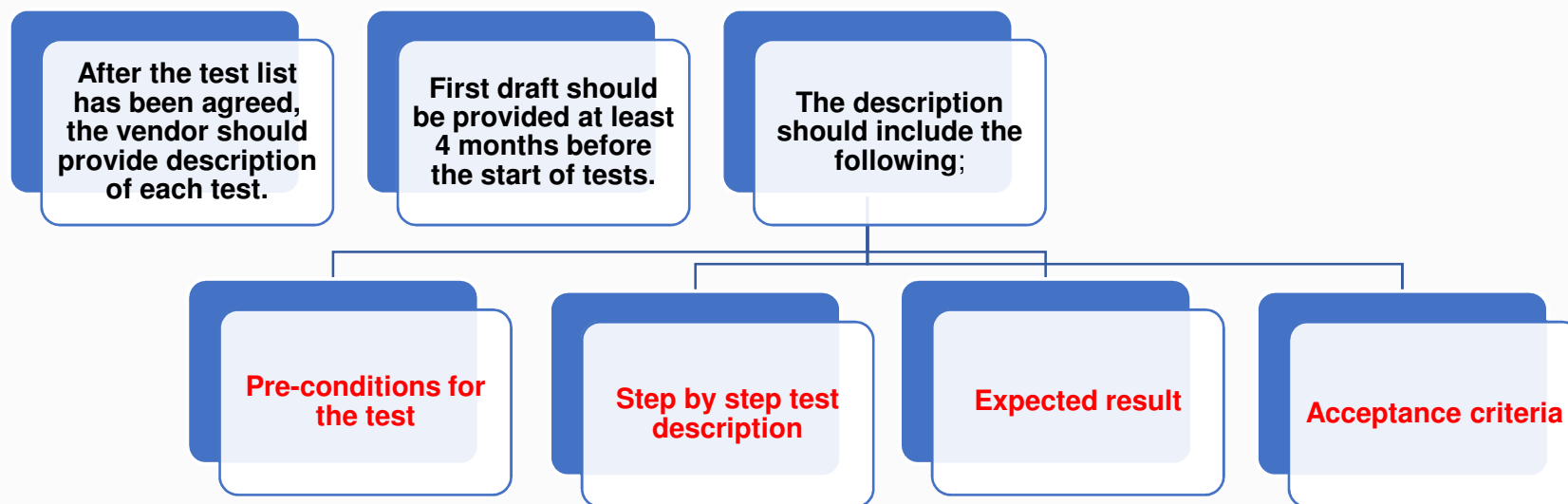
List of tests is then finalized.



The tests that shall be repeated during site commissioning should be agreed upon at this time as well



Test Descriptions





Review of Test Descriptions



Details of each test should be reviewed



Any concerns should be discussed with vendor



The descriptions should then be changed to reflect the agreed changes.



The list of tests that customer will witness is agreed at this stage.



Testing Method



The tests can be performed using any of the following methods

Using actual hardware and AC equivalents

Using replica and AC equivalents

Using PSCAD and AC equivalents



Some tests must be repeated by more than one method to verify the models.





Time Schedule



It usually takes 3-4 months for the vendor to be ready for the actual FPT/DPT tests



During this time the vendor sets up the cubicles and performs the tests without customer presence.



At the end, the software is finalized.



The customer is then invited to witness the tests (3-6 months)





CUSTOMER PARTICIPATION



The customer participation should be as following:

**System studies engineers
Maintenance engineers
Station and Control Center operators**



The system studies engineers should be the one who were involved in system studies.



The maintenance engineers and operators should be the individuals who are assigned to actually maintain and operate the DC system.



The objective is to ensure that tests meet the requirements and to train the operators.





Test Approval Process



- The process should include the following:
 - **The documentation to be provided to customer**
 - **Time for review and comments**
 - **Process for discussion of failed tests**
 - **Process for repetition of failed tests**
 - **Discussion of any control/protection changes.**
 - **Documentation of control/protection changes**





FPT STEPS



**PRE-COMMISSIONING
SETUP**



SUB SYSTEM TESTS



SYSTEM TESTS





PER-COMMISSIONING SETUP



Setup each cubicle



Check Power Supplies



Verify the all the hardware is included



Verify all the settings are correct



Power up the cubicle



EQUIPMENT MODELS



AC sources (Infinite source)



Converter and AC filter breakers



DC switchgear, Electrode lines, DC line/cable



Converter valves, Converter transformers, Smoothing reactors



AC & DC filters



Sub System Tests



Check each cubicle for its functions



Check all signal outputs to other cubicles



Check all incoming signals from other cubicles



Factory System Tests



Check operation of control and protection



Operator controls



Monitoring Systems



The control and protection systems are connected to a simulator model



Type of System Tests



Switching sequences



Reactive Power Control



Trip tests



System redundancy changeover



Operator Controls



Closed Loop Controls



Dynamic Performance Tests



- The purpose of Dynamic Performance Tests is to test the interaction between AC and DC systems as well as to verify the proper Pole control and DC protection behaviour under transient, dynamic and steady state conditions.





Dynamic Performance Tests Setup



Using RTDS

Actual control hardware is used
DC system is modelled in RTDS
AC system equivalent is modelled in RTDS



Using PSCAD

HVDC Control and protection is modelled in PSCAD
DC system & AC System equivalents are modelled in PSCAD



Initially some tests are repeated both in RTDS and PSCAD to validate the PSCAD models.



This method allows the tests to be carried out simultaneously and reduces the number of tests on RTDS



FPT DPT RECORDS



All TFR, SER and HMI information is recorded during FPT/DPT tests so they could be used as reference during actual system tests.



The test configurations are chosen such that they can be repeated on the actual system.



The actual system configuration may vary slightly from FPT/DPT



Final Documentation



- The final documentation should include the following:
 - Test Description
 - TFR recordings
 - SER alarm listings
 - HMI screen shots
 - Plots of important system variables for PSCAD cases.
 - Explanation of any abnormal alarms.
- The FAT tests results are then used as benchmark for site commissioning tests that are repeated at site.



COMMISSIONING TESTS



DURING PREPARATION OF LIST OF FACTORY TESTS, THE TESTS TO BE REPEATED DURING COMMISSIONING SHOULD BE IDENTIFIED AND AGREED UPON



IT IS NOT NECESSARY TO REPEAT EVERY FACTORY TEST DURING COMMISSIONING



THE RESULTS OF THE FACTORY TESTS DESIGNATED TO BE REPEATED DURING COMMISSIONING SHOULD BE USED FOR VERIFICATION OF COMMISSIONING RESULTS.



THE OPERATING STAFF SHOULD PERFORM THE SWITCHING OPERATIONS AS MUCH AS POSSIBLE



COMMISSIONING TESTS SHOULD INCLUDE VERIFICATION OF ISOLATION AND RESTORATION OF EQUIPMENT FOR MAINTENANCE



ADDITIONAL TESTS FOR VSC



Energization of the VSC converter and charging of valve capacitors.

Special VSC protections (e.g. PIR overload)

Reactive Power Control mode

AC Bus Voltage Control mode

Power Factor Control mode.

Transfer between various control modes

STATCOM mode

Black start test

Energization and discharge of cable

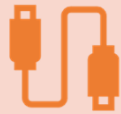




TRAINING



STAFF TRAINING



HVDC STATIONS GENERALLY TRANSMIT LARGE AMOUNT OF POWER



THE STAFF MUST BE PROPERLY TRAINED TO MINIMIZE THE OUTAGE TIME



TRAINING MUST BE TAILERED TO THE STAFF FUNCTION





TRAINING PROCESS



- **AT THE BEGINNING OF THE PROJECT IDENTIFY THE ENGINEERING, OPERATIONS AND MAINTENANCE STAFF THAT WILL BE RESPONSIBLE FOR THE HVDC SYSTEM**
- **ENGINEERING STAFF SHOULD PARTICIPATE IN ALL FACTORY TESTS AND THE SYSTEM TESTS DURING COMMISSIONING**
- **OPERATING STAFF SHOULD PARTICIPATE IN FACTORY TESTS AND COMMISSIONING OF THE EQUIPMENT ON SITE.**
- **A COMPREHENSIVE CLASSROOM TRAINING SHOULD BE PROVIDED BY THE SUPPLIER'S SPECIALISTS BEFORE THE COMMISSIONING STARTS.**





TRAINING PROCESS



- **ALL HANDS-ON DEMONSTRATIONS AND LECTURES SHOULD BE VIDEO RECORDED.**
- **A TRAINING SIMULATOR (REPLICA) SHOULD BE PROVIDED FOR THE OPERATORS.**
- **SIMULATOR SHOULD BE ABLE TO DUPLICATE NORMAL AND FAULT CONDITIONS.**
- **A REAL TIME DIGITAL SIMULATOR (RTDS) REPLICA OF THE HVDC CONTROLS SHOULD BE PROVIDED FOR THE ENGINEERING STAFF**





OPERATING STAFF



At least two operators from each station should participate in the FACTORY testing

The operators will perform switching operations

Familiarize with TFR and SER recordings

Familiarize with HMI screens

Familiarize with reactive power control

Familiarize with protection operations and reset process

Familiarize with active power control

Familiarize with current control mode

Familiarize with clearance procedure for maintenance





ENGINEERING STAFF



Engineers from System studies, Maintenance and Operating departments should participate

Engineers will learn everything the operators will learn

Details of control and protection systems

How to analyze Transient fault recordings

How to use SER recordings for fault analysis

How to identify faulty equipment

How to restore HVDC system after converter tripping

How make control and protection setting changes





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Gracias

