

## Section 2, Chapter 7

### TESTING & DOCUMENTATION

#### 7.0 General

This section describes the specific requirements for testing and documentation of the SCADA/DMS system. The general requirements of testing and documentation are covered in **Section 7**.

#### 7.1 Type testing –

Equipments wherever mentioned in the specification for type testing shall conform to the type tests listed in the relevant chapters. Type test reports of tests conducted in NABL accredited Labs or internationally accredited labs with in last 5 years from the date of bid opening may be submitted. In case, the submitted reports are not as per specification, the type tests shall be conducted without any cost implication to employer.

#### 7.2 Factory Acceptance Tests (FAT)

The SCADA/DMS system including DR centre ( (DR is part of the project area) shall be tested at the Contractor's facility. All hardware and software associated with the SCADA/DMS system and atleast two RTUs alongwith , LDMS & 10 FRTUs & all Remote VDUs, shall be staged for the factory testing and all remaining RTUs /FRTUs/FPIs shall be simulated for the complete point counts ( ultimate size). The requirements for exchanging data with other computer systems like DR ( if DR is not a part of the project area) , IT system under R-APDRP, SLDC shall also be simulated.

Each of the factory tests described below (i.e. the hardware integration test, the functional performance test, integrated system test and unstructured tests) shall be carried out under factory test for the SCADA/DMS system. The factory tests, requiring site environment, shall be carried out during the Field Tests after mutual agreement for the same from owner.

##### 7.2.1 Hardware Integration Test

The hardware integration test shall be performed to ensure that the offered computer hardware, conforms to this Specification requirements and the Contractor-supplied hardware documentation. All the SCADA/DMS system hardware shall be integrated and staged for testing. Applicable hardware diagnostics shall be used to verify the hardware configuration of each equipment. The complete hardware & software bill of quantity including software licenses & deliverables on electronic media shall also be verified.

##### 7.2.2 System Build test

After completion of hardware integration test, the SCADA/DMS system shall be built from the backup software on electronic media (CDs/Magnetic Tapes) to check the completeness of backup media for restoration of system in case of it's crashing/failure. The software deliverables shall include one copy of backup software on electronic media.

### 7.2.3 **Functional Performance Test**

The functional performance test shall verify all features of the SCADA/DMS hardware and software. As a minimum, the following tests shall be included in the functional performance test:

- (a) Testing of the proper functioning of all SCADA/DMS & other software application softwares in line with the requirements of various sections of technical specification.
- (b) Simulation of field inputs (through RTU/FRTU/FPI) from test panels that allow sample inputs to be varied over the entire input range
- (c) Simulation of field input error and failure conditions
- (d) Simulation of all type of sample control outputs
- (e) Verification of RTU /FRTU/FPI communication Protocol IEC60870-5-104 /101 etc
- (f) Verification of MFT communication Protocol MODBUS etc
- (g) Verification of compliance of supporting interfaces such as IEC61850, IEC60870-5-103 etc.
- (h) Verification of CIM compliance
- (i) Verification of Security & Encryption using SSL for all FRTU/FPI connectivity
- (j) Verification of Data Integration from SCADA/DMS system other systems viz IT Systems etc over Open Standards over CIM/XML, IEC 61968 Series Standards, OPC, ICCP etc.,
- (k) Verification of Integration between GIS / SCADA/DMS System over OAG, CIM/XML or tight Native Integration, that enables updates within GIS to percolate over ESB / SOA to IT Systems
- (l) Verification of data exchange with other systems

- (m) Verification of interoperability profile of all profiles of all protocols being used.
- (g) Verification of RTU /FRTU/FPI communication interfaces
- (h) Verification of LAN and WAN interfaces with other computer systems
- (i) Testing of all user interface functions, including random tests to verify correct database linkages
- (j) Simulation of hardware failures and input power failures to verify the reaction of the system to processor and device failure
- (k) Demonstration of all features of the database, display, and report generation and all other software maintenance features on both the primary and backup servers. Online database editing shall also be tested on primary server.
- (l) Demonstration of the software utilities, libraries, and development tools.
- (n) (m) Verification that the SCADA/DMS computer system meets or exceeds employer's performance requirements (as per table for peak & normal loading in section 8 Verification of Design parameters as mentioned in section 8 & wherever defined in the specification.
- (o) Verification that ultimate expansion requirements are met.
- (p) Verification of DTS (if it is in the project area)
- (q) Verification of Development system
- (r) Verification of data transfer of main to back up SCADA/DMS system.
- (s) Functions of DR system , if it is in the project area.
- (s) Unstructured testing of the SCADA/DMS system by employer. The unstructured tests shall include the test, which are not in the approved test procedures and may be required to verify the compliance to the specification . (Max 20% of total testing)

#### 7.2.4 Continuous operation Test (48 hours)

This test shall verify the stability of the SCADA/DMS hardware and software after the functional performance test has been successfully completed. During the test, all SCADA/DMS functions shall run concurrently and all Contractor supplied equipment shall operate for a continuous 48 (forty eight) hour period with simulated exchange with other interconnected system viz. R-APDRP IT system etc. The test procedure shall include periodic repetitions of the normal and peak loading scenarios defined. These activities to be tested may include, but shall not be limited to, database, display, and report modifications, configuration changes (including user-commanded processor and device failover), switching off of a primary server and the execution of any function described in this Specification. During the tests, uncommanded functional restarts or server/device failovers are not allowed; in case the problems are observed , the Contractor shall rectify the problem and repeat the test.

### **7.3 Field Tests (Site Acceptance tests -SAT)**

The SCADA/DMS system shall be tested at the site. All hardware and software associated with the SCADA/DMS system along with all RTUs/FRTUs/FPIs along with all field devices including MFTs connected shall be tested under the field tests.

#### **7.3.1 Field Installation Tests**

The equipment which has undergone the factory testing shall be installed at site and integrated with the RTUs /FRTU/FPI and other computer systems through the communication medium.

The field installation test shall include the following:

- (a) Proper installation of all delivered hardware as per approved layout.
- (b) Interconnection of all hardware
- (c) Interconnection with communication equipments
- (d) Interconnection with power supply
- (e) Diagnostic tests to verify the operation of all hardware
- (f) Random checking of SCADA/DMS software basic functions

The Contractor shall be responsible for performing the field installation tests and Employer may witness these tests

#### **7.3.2 End-to-End Test**

After the field installation tests, the Contractor shall carry out end-to-end test to verify:

- (a) the communication of RTUs/FRTUS/FPIs/MFTs with SCADA/DMS system
- (b) the RTU /FRTU/FPI communication channel monitoring in the SCADA/DMS system
- (c) the mapping of SCADA database with RTU /FRTU/FPI database for all RTU /FRTU/FPI points
- (d) the mapping of SCADA database with displays and reports

The Contractor shall provide the details of all the variances observed and corrections carried out during end to end test.

#### **7.3.3 Field Performance Test**

The field performance test shall concentrate on areas of SCADA/DMS operations that were simulated or only partially tested in the factory (e.g., system timing and loading while communicating with a full complement of RTUs/FRTU/FPI and data links and system reaction to actual field measurements and field conditions). Further

the validity of factory test results determined by calculation or extrapolation shall be examined.

After the end to end test, the Contractor shall conduct the field performance test to verify the functional performance of the system in line with the technical specification which includes the following:

- (a) the communication of other system i.e R-APDRP IT , SLDC, DR system with SCADA/DMS system
- (b) Mapping of SCADA/ISR database with other system database viz R-APDRP IT , SLDC, DR system.
- (c) Verify that all the variances observed during the Factory test are fixed and implemented.
- (d) Conduction of the Factory tests deferred (tests requiring site environment)
- (e) Functional tests of SCADA/DMS system
- (f) Verify the execution rates of all SCADA/DMS application
- (g) Verify update rate & time for data update & control command execution as per specification requirements
- (h) Verify the response time of all SCADA/DMS applications.
- (i) Verify the response time for User interface requirements
- (j) Testing of all features of the database, display, and report generation and all other software maintenance features on both the primary and backup servers. Online database editing shall also be tested on primary server.
- (k) Conduction of unstructured tests as decided by the Employer

#### **7.4 System Availability Test (360 hours)**

Contractor shall provide & approve theoretical and practical figures used for this calculation at the time of detailed engineering. The calculation shall entail reliability of each individual unit of the System in terms of Mean Time Between Failures (MTBF and a Mean time to Repair (MTTR) as stated by OEM. Reliability figures of existing equipment shall be supported by evidence from operational experience at similar types of installation / figure given by OEM.

From those data, the unavailability of each sub-system shall be calculated taking in account each item redundancy. The global availability shall then be calculated from those different unavailability data. This calculation shall lead to the failure probability and equivalent global MTBF data for the control center system.

The overall assessment of System availability shall be provided in the form of an overall System block diagram with each main item shown, complete with its reliability data. The calculation of overall availability shall be provided with this diagram.

System availability tests shall be conducted after completion of the field tests. The system availability test shall apply to the SCADA/DMS system (hardware and software) integrated with its RTUs/FRTU/FPIs and R-APDRP IT SYSTEM . However, the non-availability of RTUs/Data Concentrators/ FRTU/FPI , R-APDRP

–IT system etc & Communication System shall not be considered for calculating system availability. However , RTU/FRTU, communication equipments , Auxiliary power supply shall be tested as per the provisions given in their chapters.

The SCADA/DMS system (hardware and software systems) shall be available for 99.5% of the time during the 360hours (15 days) test period. However, there shall not be any outage /down time during last 85 Hours of the test duration. In case the system availability falls short of 99.5%, the contractor shall be allowed to repeat the system availability test after fixing the problem, failing which the system shall be upgraded by the contractor to meet the availability criteria without any additional cost implication to the owner.

Availability tests of RTUs/FRTUs shall be conducted along with System availability test for 360 hours. Each RTU/FRTUs shall exhibit minimum availability of 98%. In case the RTU/FRTU availability falls short of 98%, the contractor shall be allowed to repeat the RTU/FRTU availability test (for failed RTU/FRTU only) after fixing the problem, failing which the equipment shall be upgraded by the contractor to meet the availability criteria without any additional cost implication to the owner.

In the event of unsuccessful reruns of the availability test, employer may invoke the default provisions described in the General Conditions of Contract.

The system availability tests will be performed by the owner by using the SCADA/DMS system and RTUs/FRTU/FPI for operation, control and monitoring of distribution system and using Contractor supplied documentation. The owner will also be required to generate daily, weekly and monthly reports. The supplied system shall be operated round the clock.

The SCADA/DMS system shall be considered as available if

- a) one of the redundant hardware is available so that all the SCADA/DMS applications are functional to ensure the design & performance requirement as envisaged in the specification
- b) atleast one of the operator console is available
- c) atleast one of the printers is available (off-lining of printers for change of ribbon, cartridge, loading of paper, paper jam shall not be considered as downtime)
- d) All SCADA applications are available
- e) All DMS applications are available
- f) All SCADA/DMS functions described in the specification are executed at periodicities specified in the specification. without degradation in the response times
- g) Requests from available Operator Consoles & VPS are processed
- h) Information Storage and Retrieval applications are available
- i) Data exchange with other system is available

However each device, including servers, shall individually exhibit a minimum availability of 98%.

The non-availability of following Non-Critical functions shall not be considered for calculations of system availability; however these functions should be available for 98% of the time.

- (a) Database modification and generation
- (b) Display modification and generation
- (c) Report modification and creation
- (d) DTS

During the availability test period, employer reserves the right to modify the databases, displays, reports, and application software. Such modifications will be described to the Contractor at least 48 hours in advance of implementation to allow their impact on the availability test to be assessed, except where such changes are necessary to maintain control of the power system.

The successful completion of system availability test at site shall be considered as “**operational acceptance**” of the system.

#### **7.4.1 Downtime**

Downtime occurs whenever the criteria for successful operation are not satisfied. During the test period, owner shall inform the Contractor for any failure observed. For attending the problem the contractor shall be given a reasonable travel time of 8 hours. This service response time shall be treated as hold time and the test duration shall be extended by such hold time. The downtime shall be measured from the instant, the contractor starts the investigation into the system and shall continue till the problem is fixed. In the event of multiple failures, the total elapsed time for repair of all problems (regardless of the number of maintenance personnel available) shall be counted as downtime. Contractor shall be allowed to use mandatory spares (on replenishment basis) during commissioning & availability test period. However it is the contractor's responsibility to maintain any additional spares as may be required to maintain the required system availability individual device/ equipment availability. All outage time will first be counted but if it is proven to be caused by hardware or software not of Contractor's scope, it will then be deducted.

#### **7.4.2 Holdtime**

During the availability test, certain contingencies may occur that are beyond the control of either employer or the Contractor. These contingencies may prevent successful operation of the system, but are not necessarily valid for the purpose of measuring SCADA/DMS availability. Such periods of unsuccessful operation may be declared "holdtime" by mutual agreement of employer and the Contractor. Specific instances of holdtime contingencies could be Scheduled shutdown of an equipment, Power failure to the equipment, Communication link failure.

#### **7.5 Documentation**

The complete documentation of the systems shall be provided by the contractor. Each revision of a document shall highlight all changes made since the previous revision. Employer's intent is to ensure that the Contractor supplied documentation thoroughly and accurately describes the system hardware and software.

The contractor shall submit the paper copy of all necessary standard and customised documents for SCADA/DMS in 2 sets for review/approval by the Employer for necessary reference which includes the following:

- a) System overview document
- b) Cross Reference Document
- c) Functional design document
- d) Standard design documents
- e) Design document for customisation
- f) System Administration documents- software utilities, diagnostic programs etc.
- g) Software description documents
- h) Bill of Quantity & List of software and hardware deliverable
- i) protocol implementation documents
- j) point address document
- k) IP addressing plan document
- l) Software User document for dispatchers
- m) Software Maintenance document
- n) Training documents
- o) Real time & RDBMS documents
- p) Database settings, Displays and Reports to be implemented in the system
- q) Test procedures
- r) Test reports
- s) Hardware description documents
- t) Hardware User documents
- u) Hardware Maintenance documents
- v) Data Requirement Sheet (DRS) of all Hardware
- w) Site specific Layout, Installation, GA, BOQ, schematics and cabling details drawings/documents
- x) SCADA & IT Integration Plan Document using CIM/XML Adapters & Messaging Interfaces.
- y) Cyber Security Plan & Mitigation document for the system if Public Networks are used.
- z) Interoperability profiles/ Tables

After approval two sets of all the above documents as final documents shall be delivered to site by the Contractor. In case some modifications/corrections are carried out at site, the contractor shall again submit as built site specific drawings in three sets after incorporating all such corrections as noticed during commissioning. Any software modifications/updates made at site shall also be documented and submitted in three sets to site and one set to Employer.

In addition to paper copies, two sets of final documentation shall be supplied on Electronic media to employer. The contractor shall also submit two sets of



the standard documentation of Operating system and Databases in electronic media. Paper copies of these may be submitted, if the same are available from the OEM as a standard part of delivery. One copy of the software packages used for accessing & editing the final documentation in electronic media shall also be provided.

After successful completion of System availability test, the contractor shall take the software backup of complete SCADA/DMS system on electronic media and two copies of these backup software shall be submitted to the owner.

**End of Section 2, Chapter 7**

