

REPORT OF THE COMMITTEE FOR UPDATING THE BEST PRACTICES IN TRANSMISSION SYSTEM IN THE COUNTRY

1. Preamble

1.1 The Government of India, Ministry of Power vide their Office letter No. 11/5/2001-PG dated 9.11.2001 (Annexure - 'A') constituted a Committee under the chairmanship of Dr. S. Mukhopadhyay, Chief Engineer (System Engineering and Technology Development Division), Central Electricity Authority for updating the best practices in Transmission System in the country. The composition of the Committee is given below:

- i) Dr. S. Mukhopadhyay, Chief Engineer, SETD, CEA - Chairman
- ii) Shri V.K. Prashar, ED, POWERGRID (LD&C, HVDC) - Member

1.2 The Committee was authorized to co-opt representatives from the state entities.

1.3 The terms of reference of the Committee are as under:-

- i. To consolidate and update the best practices in Transmission and Distribution in
- ii. the Central and State sector.
- iii. To make recommendations regarding bridging the gap between best practices
 - level and average industry practices in both Govt. and private sectors.

1.4 The Committee was to submit its report within 30 days i.e. by December 8, 2001. First meeting of the Committee was held on November 26, 2001 in the office of Dr. S. Mukhopadhyay at New Delhi wherein it was decided to co-opt members from state entities also. In the first meeting, the scope of Committee was discussed in detail and it was decided that as a separate Committee was being set up for the Distribution system, the scope of this Committee should be restricted to Transmission system only. Further, it was felt that, it might not be feasible to submit the report within the stipulated time and as such suitable extension for submission of the report would also be sought from the Ministry of Power. Accordingly a letter was sent to Ministry of Power on both the issues. Ministry of Power vide their letter No. 11/5/2001 dated January 02, 2002 conveyed the acceptance of the proposal of the Committee for confining the scope of the Committee to best practices in Transmission System only and granted extension of time for submission of the Report up to January 31, 2002 (Annexure - 'B').

1.5 After co-opting the members from state entities, the composition of the Committee became as under:

- i) Dr. S. Mukhopadhyay, Chief Engineer, SETD - Chairman
- ii) Shri V.K. Prashar, ED, POWERGRID (LD&C, HVDC) - Member
- iii) Shri Vishnu Sharma, GM(TW), UPPCL, Meerut - Member(co-opted)
- iv) Shri N.N. Pendharkar, SE (Trans. Plg.), MSEB, Mumbai - Member(co-opted)

2. Scope of Work

The Committee identified the issues of Planning, Design and Engineering, Project Construction and Monitoring, Operation and Maintenance, Training and Store Management concerning EHV Transmission Lines and Substations to be covered in the Report.

3. Deliberations of the Committee

The Committee met 4 times during the period from November 26, 2001 to January 15, 2002 and finalized its Report. It consists of the following topics

1. Planning and System Engineering
2. Feasibility Report Preparation
3. Design, Engineering & Specification Finalization
4. Procurement Practices
5. Project Management & Monitoring
6. Quality Assurance
7. Construction Practices

8. Operation & Maintenance
9. Safety
10. ISO-9000 Certification
11. Training

4. **Acknowledgement**

The Committee gratefully acknowledges the valuable contribution and the cooperation extended by the members of the Committee and their Organisations for furnishing the necessary material covered in the Report.

Annexure – 'A'

No. 11/5/2001-PG

Government of India

Ministry of Power

New Delhi, the 9th November, 2001.

ORDER

- - SUB: **Setting up of the Committee for updating the best practices in transmission and distribution in the country.**

For consolidating and laying down the best practices in transmission and distribution, it has been decided to set up a committee under the Chairmanship of Dr. S. Mukhopadhyay, Chief Engineer (System Engineering & Technology Development Division), CEA. Shri V. K. Parashar, Executive Director, POWERGRID will be a member of the Committee.

2. The Committee may co-opt representatives from the state entities.
3. Terms of reference of the Committee are:
 - i. To consolidate and update the best practices in transmission and distribution in Central and State sectors;
 - ii. To make recommendations regarding bridging the gap between the best practice levels and average industry practices in both Government and private sectors.
2. CEA will meet all the administrative expenses including rendering secretarial assistance to the Committee.
3. The Committee shall submit its report within 30 days.

Sd/-

(P. K. Tripathi)

Director

1. Chairman, Central Electricity Authority, New Delhi.
2. CMD, POWERGRID, New Delhi.
3. Dr. S. Mukhopadhyay, Chief Engineer, (SE&T), CEA, New Delhi.
4. Shri V. K. Prashar, Executive Director, POWERGRID, New Delhi.

- - Copy to : PS to Minister of Power/ PS to MOS(P)/PPS to Secretary (Power) / Sr. PPS to Spl. Secretary (Power) / JS (T&D).

Annexure – 'B'

No. 11/5/2001-PG

Government of India

Ministry of Power

New Delhi, the 2nd January, 2002.

To

Dr. S. Mukhopadhyay,

Chief Engineer, (SE&T)

Central Electricity Authority

Sewa Bhawan, R. K. Puram

New Delhi

SUB: Setting up of the Committee for updating the best practices in transmission and distribution in the country.

Sir,

Please refer your note. No. SETD/204-D/2001/2552 dated 24.12.2001 on the above subject. The proposal to confine the scope of the Committee to best practices in **Transmission System only** and to grant extension of time for the Committee to complete the work has been accepted. The Committee may submit its report by **31st January, 2002**.

Yours sincerely,

Sd/-

(P. K. Tripathi)

Director

BEST PRACTICES IN TRANSMISSION SYSTEM IN THE CONUTRY

1.0 Introduction

- - The report Covers all the stages of Power transmission system from Concept to construction to Operation and Maintenance. The report has been divided in sections covering Planning & System Engineering, Project Engineering, Procurement, Quality Assurance & Inspection, Operation & Maintenance, and Safety. Inputs have been taken from various organizations such as CEA, POWERGRID, UPPCL, etc. regarding practices followed by them and also from various publications of CBIP. It is to be noted that these organizations have developed these practices in line with their own organizational structure.

2.0 Transmission System Planning & System Engineering

2.1 Purpose:

- - - - Transmission Planning Studies are carried out for evacuation of power from a Power Station, which is either newly constructed or where a new generation capacity is added, for grid strengthening, for intra-regional exchange of Power, for inter regional connection for exchange of power. These studies are carried out keeping in view the long-

term power plans of the country framed by CEA. Load flow, short-circuit, stability and Over voltage studies are the ones need for this purpose.

2.

2. Practices:

•

○

■

- From the Point of view of power system planning and system engineering following are needed:

i.

i.

- i. The data and time schedules for carrying out Planning Studies are to be collected from various Organizations, such as CEA, Planning Commission, Respective Electricity Boards (SEB)/Electricity Departments (ED), Regional Electricity Boards (REB), Regional Load Despatch Centres (RLDC), Power Utility's own system and operational data etc. These are corresponding to different time frames including present scenario and comprises of:

•

○

■

- Generation Details
- Load (both Active and Reactive)
- Details of Transmission Network at different voltage levels
- Transformer Capacity
- Details of Reactive Compensation

•

○

■

- ii) Long term transmission plans are to be evolved considering the long term power transfer requirement from generation resources to Load Centres.

iii) Data are to be compiled in a format suitable for simulation software.

iv) Different Transmission alternatives are to be evolved. While developing an alternative following issues are to be considered:

•

○

■

- Minimization of Transmission Cost and Loss
- Right- of - way (ROW) Considerations
- Optimal utilization of energy resources
- Adoption of new technologies like, FACTS (Flexible AC Transmission System) at suitable locations.

i.

i.

- i. Most optimal system is to be evolved by carrying out computer studies based on the input available from above.
- ii. System Engineering studies are carried out to decide various equipment rating and parameters, charging instructions.

•

○

■

- vii) The outputs of these studies are forwarded to various groups for carrying out system design.

While choosing any transmission alternative, flexibility of development and provision of adequate control features should be kept in view to take care of grid operation under normal and contingent conditions. Power System Planning Criteria issued by CEA in 1985 and modified from time to time may be referred to in this context for further details.

3.0 Feasibility Report Preparation

- - Once a transmission system is finalized, Project Feasibility Report is prepared for the investment approval from the competent authority. The Feasibility Report consists of details of transmission system, justification, scope of the project, technical parameters, Estimated cost of the project, details pertaining to project management, environmental impact, project completion schedule, tariff, etc. For the preparation of the report:
- - The necessary statutory obligations for the system that emerged, like issue of notifications as per electricity act, forest clearance, PTCC (Power Telecom Coordination Committee) clearances, etc. are completed.
 - Based on the studies the system that emerged and the various cost data, feasibility report of the project is prepared and submitted to the approving authority.
- - The feasibility report is a base document used in execution of the project.

4.0 Design, Engineering & Specification finalization

- - The feasibility report, output from system studies, recommendations of various standardization committees of CEA, CBIP, relevant statutory regulations, operational feedback and past experience become the inputs for detailed Design, Engineering & Specification finalization.

4.1 Transmission Line Design

- i.
 - i.
 - i. The design for each type of tower is to be either developed in house or sought from Contractors.
 - ii. The full-scale proto of each type of tower is tested at the test station to validate the design.
 - iii. Based on the experience the soil categorization has to be done and the guidelines incorporated in the specification for foundation classification for transmission line tower foundation
 - iv. Foundation design for each type of soil category and each type of tower is to be developed.
 - v. River Crossing towers and their foundation designs (Pile/Well) are to also developed in house.
 - vi. The line material parameters are to be finalized based on standardization committee report, various Indian and International Standards, etc.
 - vii. The equipment are to be type tested to conform to the specification requirement.
 - viii. Optimization / Techno – economic studies are carried out for the selection of parameters for the new system.
 - ix. Some power utilities including POWERGRID have standardized some of the towers and foundation designs. To save the time and cost and to expedite the erection of transmission lines, the same may be referred to.
 - x. Use of multi-circuit and narrow based tower should be attempted wherever

- - - - - - ROW constraint exist.

4.2 Substation Design

- - The practices followed in respect of various aspects of substation design are as given below.

i) Switching Scheme of a substation:

- - For 400 kV switchyard One & Half breaker scheme or Double Main and Transfer bus bar scheme, for 220 kV switchyard Double Main & Transfer scheme or Double Main with breaker by pass scheme and for 132 kV switchyard Main & Transfer scheme may be adopted. CBIP manual (Publication No. TR-3) on substation layout may be referred to for further details in this regard. Deviation from the standard scheme may be done under exceptional cases.

ii) Site Selection & General Arrangement Development:

- - Following factors often govern selection of an optimal site for construction of a substation

- - - - - Technical: The technical factors includes Area Required, Line Corridors, restriction (if any) from aviation authority, forest stretches limitation (if any) for line routing, Location, Pollution, etc.
 - Physical: The Physical factors include Topography of the land, geological consideration, geographical location etc.
 - Infrastructural factors: The Infrastructural factors include Accessibility, Amenities available, availability of water and power, etc.
 - Social and Environmental Factors: The Social and Environmental Factors include Habitation/Displacement, ownership of the land (Private or Govt.), Forest Encroachment, Landscaping
 - Commercial: Cost of the land, development cost, increase/decrease in line length/cost, etc.
 - A committee comprising of members from site and Engineering Dept. carry out survey based on various parameters as above and finalize the land for substation

iii) Layout Development:

- - The switchyard layout is finalized with due consideration to the statutory safety requirement, ease of erection, maintenance, etc. The basic layout arrangement may be standardized for 400 & 220 kV Switchyards and used for development of final layout according to scope and switching scheme. IEC –865 may be referred to for short circuit calculations. Direct stroke lightning protection is to be provided with the use of Lightning Masts or shielding wire or by both.

iv) Equipment Parameters:

- - The references are drawn from the various Indian and International standards, standardization committee reports, and engineering studies carried out.

Only SF₆ Circuit Breakers may be used at EHV levels. At 400 kV level the circuit breakers are to be provided with closing resistors, if used for switching the line longer than 200 km.

The Instrument transformers may be live or dead tank oil insulated type. In future novel sensors may also be used.

The isolators may be generally Horizontal center break type, however double break isolators may also be used depending on layout requirement. The Isolators are to be provided with motor operated operating mechanism.

The surge arresters to be used are only of metal oxide gapless type.

Shunt reactors to be used are of oil insulated, iron or air core type with ONAN cooling.

Inter-connecting transformers should be provided with On Load Tap Changer and with ONAN/ONAF/OFAP cooling. The transformer may be single phase or three phase depending upon the considerations of transportation constraints or size of the transformers. In case of single phase transformer arrangement, one single phase transformer should also be procured as spare and kept connected to the system. The switching arrangement of this transformer should be so designed that it can be connected to any of the phases, whenever required.

All equipment are to conform to the type test and routine tested as per relevant standards.

v) Protection and Control:

■

■ Control Room:

Presently protection and control panels are housed in a common control room that also houses other indoor equipment like PLC Panels, batteries, charger, LVAC & DC distribution boards, and other facilities. The control room layout should be standardized one and to be used for all substations (as done by POWERGRID). The Control Room should be of extensible type and can be extended if need arises.

Control Concept:

All EHV Circuit Breakers are controlled and synchronized from switchyard Control Room. All Isolators have remote operation control from Control Room as well as local operation control. The Earth Switches can be operated locally only. Isolators and associated earth switches are provided with electrical as well as constructional mechanical interlocks. These practices may continue to be followed.

Protection System:

Protection system is provided for lines, transformers, reactors, busbars, for fault clearance to minimize damage to the equipment and the system. CBIP recommendations may be continued to be followed by Power Utilities.

Transmission Lines:

400 kV and 220 kV lines are provided with double main protections based on independent principles.

132 kV lines are provided with one distance protection and other directional O/C and E/F protection.

Two Stage over voltage protection is also provided on 400 kV lines.

These may continue to be followed.

Power Transformers:

Following protections are provided for Power Transformers:

•

○

■

■

■

- Differential protection
- Restricted Earth Fault Protection
- Directional Back up O/C and E/F Protection on HV & MV sides
- Over fluxing Protection
- Over Load Alarm
- Buchholz, Pressure Relief Device (PRD)
- Alarm & Tripping due to Oil and Winding temperatures

•

○

- These may continue to be followed.

Reactor:

Following protections are provided for Reactors:

- Differential protection
- Restricted Earth Fault Protection
- Back up Impedance
- Buchholz, PRD
- Alarm & Tripping due to Oil and Winding temperatures

These may continue to be followed.

Bus Bars:

400 kV bus bars are provided with two bus bar protections and 220 kV bus bars are provided with one bus bar protection.

These may continued to be followed.

Local Breaker Backup Protection:

The protection is provided to take care of following contingencies:

- Failure of local end breaker
- Fault between CT &CB

- In addition to above Disturbance recorders and fault locators on each line and Event Logger for each station is provided to provide information about the fault.

Each Substation is also provided with Global Positioning System (GPS) based time synchronizing equipment and all recorders in the substation are time synchronized. In addition time of all substations are also synchronized through GPS.

Use of new generation relays working on numerical principles that offer benefits like economy, self supervision, support for network based substation control, faster repair swap, reduced spare inventories, etc. may also be considered for further installation, and so also substation automation because of technological innovation in the field. (POWERGRID is already using Numerical relays for its system.)

vi) Metering for Energy:

- - Availability Based Tariff has been implemented in the country as per the orders of CERC, which already has produced results in term of better compliance to IEGC(Indian Electricity Grid Code) and for maintenance of grid discipline. The pre-requisite for implementation of ABT (Availability based tariff) was installation of Special Energy Meters(SEM) at least at all the metering points. All utilities may endeavor to encourage installation of SEM even at their sub transmission levels and may also attempt to adopt a tariff structure that can be in tune to ABT that has been implemented at primary transmission level.

vii) Substation Structure:

- - Lattice steel structures are to be used for Bus Support gantries, and C.T. support. For other equipment pipe support structures are to be used. All support structures are to be hot dipped galvanized for protection against corrosion. Short circuit forces on the structures may be calculated as per IEC- 865 and other design loads considered as per IS-875. Fabrication is to be done as per IS-802 and IS-800.

All structures are to be designed for worst combination of dead loads, live loads, wind loads, seismic forces, loads due to conductor deviation, unbalance tension in the conductor, erection loads, loads encountered during maintenance, and short circuit forces, etc.

Factor of Safety (FOS) of 2.0 under normal condition and 1.5 under short circuit conditions are to be considered on all external loads.

Lightning Mast is to be designed for diagonal wind conditions.

Designs of Substation structures may be standardized for 400 kV and 220 kV switchyards (as already done by POWERGRID).

viii) Electrical Auxiliaries:

- - **AC System:**

To achieve desired availability AC system is to be duplicated. HT connections from two independent sources are to be obtained, one from respective SEB that is stepped down by LT Transformer and other from auxiliary power transformer, which is connected to the tertiary of the ICT. In case ICT is not available the second connection is also to be obtained from SEB from another source.

In addition to above one DG set of suitable rating is also to be provided at each substation.

DC System:

Each substation is to be provided with two Nos. 220 V DC batteries, Chargers and DC Boards to cater the DC loads of the station

Two Nos. 50 V DC batteries, Chargers and DC Boards are to be provided to cater the PLCC System Loads.

Cabling System:

PVC Insulated armoured fire resistant low smoke (FRLS) power and control cables are to be used. For the feeders requiring high current carrying capacity, XLPE cables may be used such as DG set, LT Auxiliary transformer, Fire fighting pump, etc. Cables are to be normally laid in the trenches. Road crossing is to be carried out by either providing culvert or through Hume Pipes. GI Pipes or Hume pipes may be used to lay cables if number of cable is small. Armour of the cable also serves the purpose of screening. Sometimes, if needed, the cables are also to be buried for which suitable protection and route markers are to be provided as per relevant standards.

ix) Mechanical Auxiliaries:

- **Air Conditioning System:**

Control Room, PLCC room, and Relay testing Room/Electronic laboratory are to be provided with air conditioning for temperature and humidity control in that area. Air Conditioning system using packaged air-cooled chillers with centralized air supply system of suitable rating is to be provided for this purpose.

Fire Protection System:

The following fire protection systems are to be provided in the substation.

- - - Fire Detection and alarm system for control room building for 400 kV substations.
 - Hydrant System for buildings, transformers/reactors and stores.
 - High velocity water (HVW) spray system/Emulsifier System for 400 kV transformer and reactors.
 - Fire wall between transformers/reactors, if the free space between them is less than specified to protect each other from the effect of another in case of fire, i.e., for transformers/reactors with oil quantity of 30 kl or more, if the space between them is less than 15 m a fire wall is to be provided. The rating of the fire wall is to be for 3 hours.

- **x) PLCC System:**

- PLCC Systems are to be provided on all lines. The PLCC System is used for

- - - Speech & FAX Communication
 - Communication required for Protection system
 - Telemetry
 - SCADA

- - CVTs provided on the lines are to be used for PLCC purposes

Nos. of Channels and type of coupling to be used are:

	Sp+Data each	Sp+Prot. each	Type of Coupling
400 kV S/C Lines 1	2		F –F Coupling
400 kV D/C Lines 1		4	-Do-
220 kV S/C Lines -	2		-Do-
220 kV D/C Lines 1		2	Inter-circuit Coupling

132 kV S/C Lines 1	2	F –F Coupling
132 kV D/C Lines -	2	Inter-circuit Coupling

xi) Substation Grounding System:

- Substation grounding is to be designed as per IEEE-80 (Green Book) recommendations. In calculation of design presently single as well as two layer soil strata is being used or simplicity of design, calculation and construction.

The ground mat is constructed with mild steel rounds of suitable size that is calculated based on various factors such as fault currents, time, corrosion margins, etc.

Shielding wire of the line and switchyard is also connected to the ground mat.

The connection to the ground mat to the equipment and structure is done by risers. The riser above ground is of galvanized steel flat of suitable size.

Grounding of lightning arresters, CVT, and Neutral of the transformer/reactors is done with electrodes, which in turn are connected to the ground mat.

All the buildings are provided with shielding arrangement by laying earth strip at the terrace, which is also connected to the earth mat.

These may continue to be followed.

4.3 IT in Drawing Approval and Documentation disbursal

- Information technology and computerization are used in drawing and document approvals and their disbursal to the executing agency. The drawings and documents are archived in the computer format to reduce the space for documentation storage. Powergrid has also started on line submission and approval of design documents and drawings for one of its projects. This substantially reduces the time required for finalization of engineering. Because of benefits achievable, this practice may be extended further.

4.

4. Benefits of Standardization

- Wherever possible as mentioned earlier too, standardization may be carried out and followed for future uses. The benefits derived are:

a) Transmission Line:

i.

- i. Standardization of Tower Design, eliminates repeated type testing of towers, Permits usage of tower of one line for other line, reduces spare requirement.
- ii. The standardization of tower design makes the data readily available for foundation design.
- iii. The procurement of steel by the manufacturer/ fabricator of the tower can be done immediately without waiting for design finalization and successful type testing.
- iv. Foundation design can be done without waiting for design finalization and successful type testing of Tower.
- v. Standardized design also helps construction staff for ease in construction activities.
- vi. The standardization of Towers and foundations reduces engineering time, project gestation period / line construction period considerably.

- **b) Substation:**

- The standardization reduces engineering time, project gestation / construction period considerably.

5.0 Procurement Practices

- A detailed document, covering procurement policy should be available with the officers dealing with the procurement of equipment and materials. POWERGRID has developed a detailed work and procurement policy document, which details out all policies and procedures to be followed for procurement of goods and awarding works. This document may be referred by the executives of the power utilities for uniform approach.

i) Package list for Procurement:

- Package list for Procurement is prepared based on cost of the package, availability of materials, completion schedule etc. Substations may be packaged for turnkey execution except that transformer/reactors may be procured separately and erected by turn key contractor under supervision of the manufacturer, with due consideration that the design philosophy is maintained. The turnkey concept of substation execution merely ensures single point responsibility for procurement, co-ordination and project management.

Following packaging may be adopted for construction of transmission lines:

- Tower Package with line accessories – Supply & Erection
- Insulator and Conductor – Supply to be delivered to main contractor carrying out erection of transmission lines.

ii) Cost Estimate:

- Cost Estimate of each package is to be prepared based on the cost data available. The cost data are to be regularly updated.

iii) Qualifying Requirements:

- Qualifying Requirement is an important part of the procurement document. Qualifying requirement for each package is to be prepared based on the technical requirement of the equipment/system to be procured, estimated cost of the package, Completion schedule and the source of finance. The stipulation of Qualifying Requirement helps in selecting the competent supplier/contractor for supply /execution of the project on schedule with best quality.

In this context, POWERGRID has prepared a well-documented manual covering works and procurement policy and procedures that is followed for all contracts activities related to works and procurement across the organization. These may be referred to for necessary guidance.

6.0 Project Management & Monitoring

- Project management and monitoring is one of the most important aspects of project execution on schedule with control on cost over run. The project management starts from the beginning of the project concept itself. A detailed Master Network is to be prepared for each project for completion of the project on schedule. The network should incorporate all the activities involved and the time for completion of each activity. The contractor is also required to prepare a network schedule of activities for completion of work within time frame as per the contract awarded on him. Both the schedules are properly coordinated. Project monitoring is to be regularly carried out by a dedicated group through review meetings and status report is to be put up to the management. The monitoring parameters includes financial as well as physical progress parameters. In the review meetings various hold points/ needs to be discussed and resolved.

7.0 Quality Assurance

- The Quality Management System to be followed by Power Utilities should be built around a philosophy of "prevention" rather "detection and cure". The quality Management system is time tested and may have an ISO-9001 certification for an utility like POWERGRID has from EAQA, UK through NQA, India, and it is the first utility in the Power Sector to have ISO – 9001 Certification.) The Various Steps involved in the Quality System Management are given below:

- - Inclusion of Quality Requirement in the Contract.
 - Selection of good quality vendors/sub vendors.
 - Approval of unambiguous Manufacturing Quality Plan (MQP)
 - Finalization of Field Quality Plan (FQP)
 - Ensuring regular, timely and consistent inspection at various stages, viz. Raw material, during in- process stage and final inspection and testing prior to dispatch.
 - Analyze the equipment failures in association with Engineering and Operation services departments and use feedback for improvement of systems.
 - Implementation of Quality Systems and Procedures as per ISO – 9001.

1.

1. System Of Vendor And Sub Vendor Approvals

2. The list of approved sub vendors is maintained for all the sub vendors irrespective of the fact whether the Technical Qualifying Requirements are specified in the contract or not. The contractors can choose any sub vendor from the list possessing a large number of sub vendors to choose from, with full transparency. The list is continuously revised based on the feed back obtained from the inspection reports, surveillance audits and failure reports, etc.

3. Manufacturing Quality Plan

4. A standard format (such as developed by POWERGRID) is to be developed for the approval of Manufacturing Quality Plan (MQP) which includes the quality requirements at the raw material stage, In process testing and final inspection and testing requirements as per Technical specifications of the contract, National and International Standards and Manufacturer’s internal plant standards and well known good engineering practices of the industry. This document has to be self-sufficient and it should include sample size, acceptance norms, place of testing, requirements of test reports and hold point beyond which the work can progress only after clearance from the utility. By standardizing the various testing requirements and procedures it is to be ensured that it is not biased towards any particular manufacturer. These MQP(s) may be approved for a period of three years instead of approval on contract-to-contract basis; this alone could reduce the project execution time substantially by eliminating the requirements of submission of MQP, discussions and approval for each contract.

5. Field Quality Plan

6. Field Quality Plans (FQP) should be followed for various construction activities such as Transmission Line, Civil Construction, Buildings, Fire Fighting System, etc. The FQP(s) describe the various stages for checks and testing requirements at each stage. The FQP defines the requirement with regard to proper unloading/receipt of equipment and material at site, storage, testing requirements of erection material, sampling and acceptance norms, test report requirements, pre commissioning checks. The responsibility of implementation FQPs is with the site organizations, which are ensuring its implementation through Project Managers responsible for construction. In order to supplement the efforts of project manager, regional quality set- ups should be created to have more surveillance over construction activities. Executives from the Corporate Center may also be deputed for surveillance and inspection.

7. Inspection

- Customer Inspection Points (CIP) are identified in MQPs to be carried out at various stages such as raw material stage, in-process stage and final stage. A certificate known as CIP is to be issued at each stage, if the material/product/Sub System meets the various requirements specified in the specification, Standards, Approved data sheets/Drawings etc. In other words issuance of CIP certifies the various routine checks and technical features. However it does not certify the various contractual obligations, which are necessary for release of payment. Material Inspection and Clearance Certificate (MICC) is to be issued for all billable items as per contract after all the CIP stages, type tests, Bill of Quantities and other requirement are checked by the inspection engineer. Issuance of MICC does not require any inspection of the equipment but it requires checking of other contractual documents. It is a responsible job as it enables dispatch and payment to the contractor. Inspection is most critical and important activity in the quality system.

8.0 Construction Practices

- Utility has to prepare manuals covering all areas of site construction activities to ensure that uniform approach in various site activities are followed by site staff and the contractors. These manuals should be well coordinated with the provisions of specification and field quality plans. In this context manuals prepared by POWERGRID may be referred to.

9.0 Operation & Maintenance

- Regular and Periodic maintenance of transmission system is of utmost importance for its un interrupted operation. All the Power Utilities have their own set procedure. POWERGRID is following the State- of- the- Art Operation and Maintenance Practices that includes state of art condition monitoring techniques, Live Line monitoring and maintenance, Disaster Management System etc. The best practices to be followed in this regard are given below.

1.

1. Condition Monitoring of Transmission System

○ i) Switchyard Equipment:

- A comprehensive preventive maintenance schedule is to be prepared for all the equipment provided in the switchyard. It has to be duly approved by a competent authority. As per this schedule various condition monitoring tests are to be carried out for each equipment annually / once in three year to assess the condition of the equipment and carryout maintenance as required.

ii) Transmission Line:

- A detailed schedule of patrolling is to be chalked out for each line by various levels (From work man to Executive). The person carrying out patrolling has to check various items as per the standard check list and indicate the same in the format. These checks, the next level person verifies, when he goes for patrolling.

In addition to Patrolling following techniques are also to be utilized for line Maintenance, wherever possible/feasible:

- - - Hot Line Maintenance
 - Hot Line Washing
 - Hot line Puncture Detection of Insulators
 - Preventive Maintenance by using portable earthing hot line tools
 - Vibration Measurement of the line
 - Thermo-scanning
 - Pollution Measurement of the equipment

○ iii) Residual Life Assessment:

- Equipment health assessment is necessary to ascertain whether the equipment is aging normally or there is abnormal degradation, which may lead to sudden pre-mature failure. POWERGRID is adopting Reliability Centered Maintenance (RCM) with an ultimate aim of reducing the O&M Cost and carry out maintenance only when necessary to avoid unnecessary system outage on account of periodic maintenance. Some of the new tests introduced by POWERGRID are

- - - Dissolved Gas Analysis

- Frequency Response Analysis of the transformers
- Tan d and capacitance measurements
- Breaker timing measurements
- Dynamic Contact Resistance measurements of the breakers
- 3rd Harmonic resistive current measurements of surge arresters
- Recovery Voltage Measurements of the Transformers
- Vibration measurements of the reactors
- Thermo Scanning of equipment and connectors etc.
- Dynamic testing of Protective Relays.

○

■

- Utilities may start adopting these gradually.

iv) Specialized Testing Laboratory and Transformer Oil Labs:

■

- POWERGRID has established world class Oil Testing Laboratories catering the needs of POWERGRID as well as other organizations. Use of these practices and facilities are advocated.

9.2 Disaster Management

- Disaster Management System should be set up by all power utilities for immediate restoration of the transmission system in the event of major failures. POWERGRID has formed a Central Disaster Management Center (CDMC) at Corporate Office and Disaster Site Task Force (DSTF) at regional level to manage any disaster condition that may include major failure of equipment and transmission line. The disaster management is carried out by deploying **Emergency Restoration System (ERS)**, DG Sets, Skilled and specialized manpower.

In case of natural disaster POWERGRID also extend these facilities to other sister organizations. Advantage of this may be availed by the power utilities.

3.

3. Live Line Monitoring & Maintenance

4. POWERGRID employs live line testing and maintenance techniques for transmission lines and substation in order to avoid system outage. For some transformers and reactors POWERGRID has used on line gas measuring device (Hydran). These practices may be followed by the power utilities taking advantage of existing Hot Line Trainings Centre of CEA at Bangalore.

5. Inventory Control & Spare Part Management

6. POWERGRID has developed its own unique spare and component level codification system. Components that are interchangeable or are from same manufacturer and identical are given a unique number. The required data of the spares is computerized and the information is accessible to all in the POWERGRID through its own intranet. This helps not only in reducing the spares inventory but also make the spares available to the needy group expeditiously.

POWERGRID has, on the basis of experience and consumption rate of the spares have developed the norms for procurement and storage of spares. The spares are procured and stored on the basis of line/substation level and regional level. Power Utilities may adopt the procedure for better management of the store within their organizational set-ups.

7. Failure Analysis System

8. A committee, whose formation depends upon the gravity of the failure and importance of the equipment, investigates and analyzes each failure. Sometimes the manufacturer is also requested to participate in the investigation and carry out analysis of the failure. The Failure report is then submitted to the competent authority as per the system developed and the recommendation of the report are circulated for implementation to all concerned department. The compliance is then verified through various internal and external audits. This practice may be continued to be followed.

9. Feedback System (SIR & ISO Audit)

i.

- i. **System Implementation Review (SIR):**

ii. POWERGRID carries out system implementation review of each group. A team comprising of two to three experts who are not the part of the group under review carries out review audit of each group to ensure that all the construction, operation and maintenance systems and administrative systems are implemented in the manner as stipulated as per various manuals and procedures. The deviations are duly recorded and conformance report is then furnished to the Corporate Operation Services, who is the monitoring agency, through regional head. This is a very effective system and helps in high quality of workmanship and high level of availability and reliability.

iii. **ISO Audit**

- - - - POWERGRID has obtained ISO 9000 certification for its systems and procedures. To ensure compliance to ISO requirements and the system and procedures POWERGRID annually carries out internal audit of all departments at corporate office and site, which is followed, by audit by external auditor for reconfirmation of ISO certification. This audit system is a very effective feedback system for any correction or improvement

iii) Regular O&M and safety conferences are conducted, that works as a good feedback system.

- - - - Power utilities may try to adopt these means for their systems.

10. **Safety**

10.1 Each Power Utility should recognize and accept its responsibility for establishing and maintaining a safe working environment for all its employees. This responsibility arises from: -

- a.
 - a. Providing the best practicable conditions of work from the point of view of health and safety.
 - b. Obligation to consult with its staff and their representatives to implement policies and procedure developed as a result of discussion.
 - c. Fulfilling statutory requirement in respect of health, safety and welfare of employees emanating from relevant legislation such as the Factories Act, The Indian Electricity Act, etc.

10.2 POWER UTILITY'S RESPONSIBILITY

- - The Power Utility shall take all such steps which are reasonably practicable to ensure best possible conditions of work, and with this end in view the Company shall do the following: -
 - i) To allocate sufficient resources to provide and maintain safe and healthy conditions of work.
 - ii) To take steps to ensure that all known safety factors are taken into account in the design, construction, operation and maintenance of machinery and equipment of substation and transmission lines.
- i.
 - i. To ensure that adequate safety instructions are given to all employees.
 - ii. To provide wherever necessary, protective equipment, safety appliances and clothing and ensure their proper use.
 - iii. To inform employees about material, equipment or processes used in their work, which are known to be potentially hazardous to health or safety.
 - iv. To keep all operation and methods of work under regular review for making necessary changes from the point of view of safety in the light of experience and up-to-date knowledge.
 - v. To provide appropriate facilities for first aid and prompt treatment of injuries and illness at work.
 - vi. To provide appropriate instruction, training, retraining and supervision in health and safety and first aid and ensure that adequate publicity is given to these matters.
 - vii. To ensure proper implementation of fire prevention and appropriate fire fighting services, together with training facilities for personnel involved in this service.
 - viii. To ensure that professional advice is made available wherever potentially hazardous situations exist or might arise.

- ix. To organize collection, analysis and presentation of data on accident, sickness and incidents involving personal injury or injury to health with a view to taking corrective, remedial and preventive action.
- x. To promote through the established machinery, joint consultation in health and safety matters to ensure effective participation by all employees.
- xi. To publish/notify regulations, instructions and notices in the common language of employees.
- xii. To prepare separate safety rules for each type of occupation/process involved in a project.
- xiii. To ensure regular safety inspection by a competent person at suitable intervals of all substation equipment, workplaces and operations.
- xiv. To co-ordinate the activities of the Company and of its contractors working on the Company's premises for the implementation and maintenance of safety systems of work, to comply with their legal obligations with regard to the health, safety and welfare of their employees.

3.

3. RESPONSIBILITY OF THE EMPLOYEE

- 4. The establishment and maintenance of best possible condition of work is, no doubt, the responsibility of Management, it is also necessary that each employee follows prescribed safe methods of work. He should take reasonable care for the health and safety of himself, of his fellow employees and of other persons who may be affected by his action at work. With this in mind, employees should be healthy and safety conscious and:

- REPORT potential hazards

- OBSERVE Safety Rules, procedures and code of practice

- USE with all reasonable care the tools, equipment, safety equipment and protective clothing provided by the Company; these items should be kept in good condition

- PARTICIPATE in safety training courses when called upon to do

- MAKE USE of Safety Suggestion Schemes.

- TAKE an active and personal interest in promoting health and safety at work.

10.4 Responsibility for Implementation

- i. The ultimate responsibility for ensuring the implementation of the policy on health and safety at work rests on the Management, the Corporate Personnel Division at the corporate level and the concerned Heads at the Regional level. The officers in-charge of safety will be functionally responsible to the Corporate headquarter for ensuring that the policy is promulgated, interpreted and carried out in the manner expected.
- ii. Immediate responsibility for safety at work is that of the managers/executives of each department/section who are primarily responsible to prevent accidents involving members of their staff and other persons. It is their responsibility to issue clear and explicit working instructions compliance with which will ensure safe working and to require the effective use of approved equipment.
- iii. Accepted rules, procedures and codes of practice, which are formulated with proper regard to health and safety consideration, must be strictly observed by all concerned contracting agencies executing works. They should be made responsible, through various measures including appropriate provisions in the contract, for discharging their safety obligations.
- iv. In designated areas of particular hazard the appropriate executives are required to authorize, in writing the commencement of any work and, before doing so, personally to ensure themselves that all necessary safety precautions have been carried out. Such executives must themselves be authorized, in writing as competent persons to perform these duties.
- v. Safety Officers are appointed to advice Management on question of safety at work including advice on the application in particular local situations of the system of work. Company Safety Rules and relevant code of practice in consultation with area Engineers. They will be consulted as and when system, rules and codes are being formulated and shall advise Management in the investigation and analysis of accidents and the circulation of appropriate statistics.

10.5 Major Site Incidents

- i. The Officer – in- Charge in each region is required to ensure that plans are devised for action in the event of fire, major site

incident and necessary evacuation procedure. These plans must be communicated to all staff and rehearsed from time to time.

- ii. Fire-fighting training and the formation of fire fighting team on a voluntary basis will be encouraged by the Station Management.
- iii. All accidents and dangerous occurrences will be reported immediately to the Officer-in-Charge, who will implement an established procedure to ensure that an investigation takes place and recommendations are made to prevent recurrence

11.0 ISO – 9000 Certification

In order to carry out activities involved effectively, it is highly desirable that power utilities obtained ISO-9000 certification. As for instance, POWERGRID has obtained ISO-9000 certification from M/S BVQI the accrediting agency for all its system manuals and procedures. Most of the departments and activities are covered under ISO ambit. The head of each department is responsible for implementation of ISO procedures and head of the organization is responsible for ensuring adherence to ISO systems in the organization. Regular internal audit of all departments is carried out and surveillance audit by external auditors is carried out as per the periodicity stipulated in the ISO-9000 standards. POWERGRID has secured ISO-9000 certification since 1994 and continuance of the same has been consistently confirmed by the accrediting agency as per the recommendation of their surveillance auditors who carry out audit on their behalf.

12.0 Training

Each power utility should devise different modules of training for their workers, Junior, Senior, and Administrative Executives to update their knowledge, based on the latest development in the respective fields. Power Utility should have well defined HRD systems and policy. An annual calendar covering various training programme for employees of all levels may be prepared, which is based on the feedback from previous programme, inputs from various departments, as well as requirement of individual employee obtained from them every year. A separate HRD department may maintain the records of each employee for deputing them for the relevant training.

In the contract document provision should be kept for deputing Power Utility's technicians and engineers to the manufacturers' works for specialized training about the equipment and systems supplied by that manufacturer and accordingly Power utilities should send its employees to the manufacturers' works.

In addition to above Power utilities should also conduct technical workshops and training programme where experts from manufacturers are to be invited to impart the training and explain the O&M procedures of their equipment. During these programme the site engineers are encouraged to get their doubts clarified and voiced the difficulties faced by them during O&M of the respective equipment.

13.0 Conclusion

The report has been prepared to provide guidelines to the Power Utilities in the country for developing their own system on procedures in order to achieve improved effectiveness in their practices for Planning, construction, Operation & Maintenance, Safety, HRD etc. This may help them in improving their overall performance, achieve higher level of system availability and help them in improving the moral and dedication of their work force.

The Documents listed at Annexure-I are prepared by various organizations v.i.z. POWERGRID, UPPCL, MSEB, BBMB and CBIP. The documents published by CBIP are the priced document and if required can be procured by Power Utilities from them. It is to be noted that other organizations have developed these practices in line with their own existing practices and organizational structure, and may not be applied as it is for other utilities as each organization has its own existing system and structure. Each power Utility may have to develop their own document, which should not contradict their existing systems, however, they can refer the documents mentioned at Annexure-I in preparation of their own system and procedures. The documents prepared by other organization are meant for their internal consumption and if Power Utilities need to refer these for development of their own system & procedures, they may contact these organizations. The addresses of the contact persons of these organizations are given at Annexure- II.

In order to appreciate the content of the report and to receive the information about the practices of the various other utilities and their feedback on the report a two day work shop of interactive nature may be organized through CBIP, where the utilities and other organizations may participate.

ANNEXURE-I

List of Reference

Manuals Available with POWERGRID

1. Master list of O & M Documents

S.N	DOC. REF. NO.	DOCUMENTS NAME
1	D-3-13-XX-01-01	Standard Formats for Substation Operation
2	D-5-10-30-01-00	Standard List of Testing Instruments for Substation and Regional Testing Labs
4	D-2-01-03-01-01	Pre- commissioning Procedures and Formats for Substation Bay Equipment
3	D-5-10-XX-01-02 D-5-10-XX-01-03	a. Inventory Levels for Transmission Systems. b. Inventory Levels for Transmission Systems (for Substation Equipment only) (<i>Revision-3</i>)
5	D-2-01-70-01-00	Pre-commissioning procedures and formats for Transmission Line
6	D-2-03-20-01-00	Testing procedures for Transmission System Protection Schemes (Vol.-I).
7	OS/PG/AC&V/01	Standard PG test procedure for AC & Ventilation system
8	OS/PG/FPS/01	Standard PG test procedure for Fire Fighting
9	D-2-03-50-01-00	Procedure for testing of Insulating oil
10	D-4-02-XX-01-03	Preventive Maintenance Schedules for Sub-Station Equipment
11	D-2-02-52-01-00	Overhauling Procedures of ABCBs
12	D-1-10-XX-01-01	Preservation Procedure and Condition Monitoring of Spares
13	D-6-02-52-01-00	P-Manual for M/s CGL make 400kV, SF6 CBs.
14	D-6-02-52-02-00	P-Manual for M/s BHEL make 400kV, SF6 CBs.
15	D-6-02-52-02-00	P-Manual for 400kV, ABB make SF6, CBs
16	D-7-02-70-01-00	Hand Book on Transmission Line Maintenance Procedure
17	D-2-02-61-01-00	Maintenance Procedure for Battery and Battery Charger
18	D-3-01-09-01-00	Pre-commissioning Formats for Gas Insulated Sub-Station (GIS)
19	D-3-02-XX-01-02	Formats for Preventive Maintenance Checks for Substation Equipment
20	D-5-02-XX-01-00	Acceptable/Permissible limits for Maintenance test results of Substation Equipment
21	D-2-12-XX-01-00	POWERGRID Safety Rule Hand Book Incorporating Safety Policy, Safety Rules and Safety instructions
22	D-2-03-50-02-00	Oil sampling procedure for Transformers and Reactors
23	D-5-02-70-01-01	Schedule of Patrolling and Maintenance & norms for Patrolling and Maintenance for Transmission Lines

24	D-2-03-XX-01-00	Maintenance Procedures for Switchyard Equipment Vol. I: EHV Transformers/Reactors
25	D-2-02-70-03-00	Procedure & Guidelines for Hotline Maintenance work on 400kV Transmission line Part-II
26	D-2-02-70-05-00	Procedure & Guidelines for Hotline Maintenance work on 220kV Transmission Line Part-III
27	D-6-02-02-01-00	P Manual for WSI Make CVT
28	D-6-02-01-01-00	P Manual for WSI Make Current Transformer
29	D-5-03-70-01-00	Norms and Technical Specifications of testing/ measuring instruments for Transmission Lines
30	D-2-02-70-02-00	Erection manual of ERS (Disaster Management)
31	D-6-02-02-02-00	P-manual for ABB make 400kV CVT
32	D-6-02-01-02-00	P-manual for ABB make 400kV CT

2. Construction Management Manuals

S.N	DOCUMENT NAME
1	LINE SURVEY (Hindi version of manual also issued)
2	TOWER ERECTION (Hindi version of manual also issued)
3	STRINGING
4	ENVIRONMENT MANAGEMENT
5	SUBSTATION AUXILIARIES(ELECT.)
6	SUBSTATION AUXILIARIES(MECH.)
7	TRANSFORMERS AND REACTORS
8	SWITCHYARD ERECTION
9	CONTRACT MANAGEMENT
10	MEASUREMENT BOOK
11	CHECK FORMATS FOR TRANSMISSION LINE CONSTRUCTION
12	SOIL INVESTIGATION AND FOUNDATION
13	PILE AND WELL FOUNDATION
14	LAND & INFRASTRUCTURE
15	CIVIL CONSTRUCTION
16	LABOUR REGULATION
17	SAFETY DURING CONSTRUCTION

18	SYSTEM CONTROL & CO-ORDINATION
19	HISTORY BOOK OF SUBSTATION
20	FIELD VISIT INSPECTION REPORT OF GM/ED
21	MATERIALS RECONCILIATION
22	HISTORY BOOK OF TRANSMISSION LINE
23	INSURANCE OF OWNER SUPPLIED MATERIALS

3. Material Management Manuals

S.No.	DOC. REF. NO.	DOCUMENT NAME
1	C/MM/SYS/SMSM/Vol-I/RO	Stores Management System Manual: Vol-I Store's Standardized Procedures & Formats
2	C/MM/SYS/SMSM/Vol-II/RO	Stores Management System Manual: Vol-II Custody of Materials;
3	C/MM/SYS/TM/RO	Transport Management System Manual
4	C/MM/SYS/INS/RO	Insurance Manual
5	C/MM/SYS/PM/RO	Purchase Manual
6	C/MM/IC/UMCS/R1	Unified Materials Codification System
7	C/MM/IM/UMCD/Vol-I to VII	Unified Materials Codification Directory
All the manuals have been circulated in Hindi also.		

4. Contract Manual

S.N	DOC. REF. NO.	DOCUMENT NAME
1	DC-7000	Works and Procurement Policy and Procedure Vol –I

Manuals on Transmission System Available with UPPCL, Lucknow

- a. Guidelines for construction of transmission line & practice in UPSEB.
- b. Guidelines for construction of EHV substation in UPSEB.

Operation and Maintenance Manuals Available with Bhakra Beas Management Board

S.No.	DOC. REF. NO.	DOCUMENT NAME
1.	Publication No. 4,	Operation and Maintenance Manual for 220 kV Double Circuit

	1983	Line.
2.	Publication No.19	Operation and Maintenance Manual for 220 kV Single Circuit Line.
3.	Publication No.7, 1984	Construction, Operation and Maintenance Manual for 400 kV Single Circuit Line.

List of Publication Prepared by Panel of Experts and Published by CBIP

S.No.	Publication Title	Publication No.
1.	Transmission Line Manual(1998)	268
2.	Manual on Transformers, October 1999	275
3.	Manual on Sub-station-Chapter on Design of Earthing Mat for High Voltage Sub-station (1992)	P-223
4.	Manual on Layout of Sub-station (1974) (Revised Edition 1989)(Reprinted in 1990& 1995)(Re-Revised 1996)	TR- 3
5.	Manual on Sub-station Chapter 1- on Specification for Sub-station Battery Charging Equipment and D.C. Switchgear(1991)(Revised September 1996)	79

ANNEXURE – II

Addresses of Contact Persons for Availability of Manuals

- GENERAL MANAGER
BUSINESS DEVELOPMENT DEPARTMENT
POWERGRID CORPORATION OF INDIA LTD.
HEMKUNT CHAMBERS, 89, NEHRU PLACE
NEW DELHI –110019
- GENERAL MANAGER (TW)
UP POWER CORPORATION LTD.,
H-2, SHASTRI NAGAR,
MEERUT – 250004

3. SUPERINTENDING ENGINEER (TRANS. PLG)
MAHARASTRA STATE ELECTRICITY BOARD
PLOT NO.-G-9, PRAKAONGAD
STATION ROAD, BANDRA
MUMBAI – 400051
4. SUPERINTENDING ENGINEER (O&M) CIRCLE
BBMB, PANIPAT
5. SECRETARY, CENTRAL BOARD OF IRRIGATION & POWER
MALCHA MARG,
CHANAKAYA PURI,
NEW DELHI-110021.

ADDENDA

(to the report for updating the best practices in transmission system in the country)

In the main report updating the best practices has been talked about in the following aspects:

1. Planning and System Engineering
2. Design and Engineering
3. Construction
4. Operation Maintenance
5. Others

Following the best practices though qualitatively improvement in all the above mentioned aspects may be achieved in all the areas individually, however, fixing of certain benchmarks may not be feasible due to one or more constraints. To the extent feasible within the practical limitations they are being described one after another.

Planning and System Engineering

Power system planning criteria in vogue in the country are based on the deterministic considerations. With the availability of data vis-à-vis experience in operating the EHV system (particularly in 400 kV level over two decades), it is high time to configure the system based on stochastic approach as adopted in some of the developed countries. Even there is requirement of much stringent condition regarding setting limit of steady operating voltage with proper reactive power management through adequate availability of flexible / dynamic sources. The issue of frequency however has got bearing with generation as well as load and hence transmission has got limited role to play. On the other hand with more and more development of network and addition of generation while strength of the system increases, in an ac system there exists also a requirement to meet the enhanced short circuit level by the equipment already installed. While inclusion of HVDC system may be an alternative to contain this level, other means like application of dynamic series reactor may have to be thought of for usage.

Design and Engineering

With CEA taking the lead, along with other power utilities in the country standardization of 400 kV parameter is to be relooked into. Similarly there is need to firm up the same for 800 kV class of equipment that were made more than a decade ago in anticipation of the system to come in future. Based on the experience, for the structure of transmission tower, reliability based design with ultimate strength has been adopted. However, going by the trend or as experienced in the developed countries loading conditions need to be assessed for the optimum design. Permitting high temperature upto 95 °C be a good option for optimum utilization of transmission corridor, if relevant combination of sag and tension is taken care of in the design of

tower and electrical clearance. Similarly for the protection, metering and control of the power system, use of Intelligent Electronic Devices (IES) with multi-functional capability has to be resorted to.

Construction

No doubt POWERGRID as a leading transmission utility in the country fix up every year through Memorandum Of Understanding with the Ministry of Power target of construction of EHV transmission, substation and other facilities, other utilities may find problem in fixing such target, primarily for want of financial resources. Still for the purpose of benchmarking the ones adopted by POWERGRID may be referred to.

Operation and Maintenance

With transmission network being basically of passive nature, unlike generators with moving components, wear and tear is comparatively less. However, with more and more application of power electronics, having lesser life of relevant components, there is necessity of timely replacement of the same for making the system available. To keep the system in operating condition with full capacity available, practice has been in general to have periodic maintenance of all the equipment concerned; exception being sudden failure leading to emergency repair to being the system component in order. With number of condition assessing devices available, now-a-days it is possible to go for even condition-based maintenance or in other words with online monitoring of the condition, based on the trend when needed, detailed maintenance may be carried out. For some equipment even predictive corrective method may be adopted online to avoid or defer detailed maintenance upto certain period of time.

Others

Under this, the issues like, safety, training, etc. come for due consideration. While safety is of concern both for operating personnel and equipment installed, the practice should evolve round as nearly as possible 'no' major accident leading to loss of life vis-à-vis assets. Development of human resources through well-drawn training program in every aspect, be it planning or design or construction or operation or maintenance, should lead to nearly hundred percent perfection in the relevant sphere of activities.

Conclusion

Finally entire effort, right from conceiving the idea of a transmission system and through to its end of life, availability vis-à-vis reliability index would show its performance vis-à-vis service to transfer power and energy from source to load. With the availability of 400 kV and 220 kV system over two and three decades respectively data compiled so far shows not only lines owned by POWERGRID, but also quite a good number of lines owned by state utilities have achieved availability level near to 99%, as against the stipulated value of 98.5% set by CERC. Reports from developed countries show achieved level of even 99.7% against the target of 99.95%. with more and more expansion of network taking place and to meet the challenge of electricity for all by the year 2012, it is recommended that benchmark on availability of transmission system as a whole should be 98.75% and 99.0% by the end of 10th and 11th Five Year Plan respectively.