Technical Requirements for Connecting Transmission and End-User Facilities to the El Paso Electric Company (EPE) Transmission System.

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1.0 Introduction

1.1 *Scope*

This document specifies the general technical requirements for connecting a new (or previously isolated) Transmission or End-User Facility (Facility) to the El Paso Electric Company (EPE) Transmission System. These requirements apply to all Facilities which will be directly connected to the EPE Transmission System.

This document includes only the technical requirements specific to interconnection of Facilities. Any contractual, tariff, power pool, auxiliary services, operating agreements or other requirements to complete the interconnection are not in the scope of this document.

In the EPE system, an End-User is defined as a customer taking retail service. As such, most End-User Facilities are at the distribution level, 24 kV or below. The requirements for those Facilities are contained in EPE's Distribution Standards. However, in some instances, an End-User may own facilities connecting to the EPE transmission system at a transmission voltage, such as a 115/13.8 kV power transformer. In this instance, the End-User Facility requirements are the same as the requirements given in this document for a similar Transmission Facility. Please note that the requirements in this document only apply to those End-User Facilities at the 69 kV or above.

This document may not cover all details in specific cases. When information on the location and size of a proposed Facility has been received, EPE will provide more specific requirements and guidelines. Additional requirements may be necessary as a result of the findings of system studies and depend upon the loading and location of the proposed Facility. Other agreements may preclude these requirements and be more restrictive. The requirements presented in this document should be considered minimal requirements.

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1.2 *Guiding Principles*

The requirements specified in this document are consistent with the requirements for Facility Connections specified by applicable NERC and WECC Planning Standards and EPE documents.

1.3 *The Interconnection Process*

The Facility Owner shall contact System Planning to request interconnection. The Facility Owner should become informed of the requirements in this document and prepare the specified information to expedite the interconnection process.

2.0 Description of the Proposed Transmission (or End-User) Facility

System Planning requires different levels of detailed information throughout the various stages of the proposed project. Five discrete project stages are considered in this document:

1. Preliminary Information;
2. System Access Application;
3. Construction;
4. Commissioning; and
5. Commercial Operation.

Please Note: Not all information in this document may be relevant or necessary for every Facility. System Planning will work with prospective Facility Owner to identify the specific information requirements for proposed facilities. Please contact System Planning to discuss further.

2.1 *Preliminary Information.*

A prospective Facility Owner who wishes to have System Planning assess possible Transmission or End-User Facility interconnections on a preliminary basis should provide System Planning with following information:

- Desired point(s) of interconnection to the transmission system;
- Type(s) of facilities;
- Facility voltage(s);
- Bus configuration(s);
- Transformer size(s);
- Conductor size(s);
- Reactor/capacitor sizes;
- Estimated load or power flow (MW and MVAR) on Facility (if possible).

2.2 *System Access Application Stage*

At the System Access Application Stage, prospective Facility Owner applying for access to the EPE system should provide actual (where known), or best estimate, facility data as listed in Appendix A to this document.

If a Facility Owner expects to interconnect any generating facilities to EPE, the Facility Owner should refer to the EPE Open Access Transmission Tariff, Attachment M (Large Generator Interconnection Procedures) located on the EPE website (www.epelectric.com).

2.3 *Construction Stage*

At the Construction Stage, the prospective Facility Owner should upgrade the information provided in Section 2.2 to reflect the improved level of accuracy based upon more complete design and actual equipment ordered. Facility data requirements are specified in Appendix A. In particular, at this stage the prospective Facility Owner should provide to System Planning the following:

- Actual transformer, regulator, and breaker nameplate data;
- Finalization of protection requirements; and
- Planned date to interconnect to the grid.

2.4 *Commissioning Stage*

At the Commissioning Stage, the prospective Facility Owner shall perform on-line tests to verify the estimated parameters provided earlier, and should provide the verified information to EPE System Planning to enable final acceptance. In addition, the prospective Facility Owner should provide System Planning with any changes in the project's scope resulting from actual construction.

- Adequate visibility to the System Controller;
- Actual dates to perform required testing and commissioning of major equipment; and,
- Preliminary test results from commissioning tests.

2.5 *Commercial Operations – Approved System Access Stage*

After completing the commissioning tests, the Facility Owner shall provide System Planning and EPE System Operations with final testing, performance and validation reports. Assuming that the results are acceptable to System Operations, System Operations will approve access to the EPE system and the facility will be able to enter Commercial Operation. After entering Commercial Operation the Facility Owner should notify System Planning and System Operations of any changes in the technical information pertaining to the facilities. The Facility Owner should not unilaterally modify any control equipment parameters (e.g., protection settings) without EPE approval.

3.0 Interconnection Requirements

To be eligible for interconnection to the EPE transmission system, a proposed Transmission or End-User Facility must comply with the technical requirements outlined below. Please note, however, that some of these requirements may be waivered for End-User Facilities, depending on the applicability of these requirements to those Facilities.

3.1 *Determination of the Interconnection point*

System Planning, in consultation with the proposed Facility Owner and with other relevant parties, shall determine the point of interconnection. In broad terms there are three possibilities, each of which entails different requirements for adequately coordinating interconnection:

1) The Proposed Facility Owner owns the existing terminal facilities to which the new facility will be connected;
2) The new facility will connect to existing terminal facilities owned by another party; and,
3) A new terminal facility must be constructed to connect the new transmission facility to the EPE transmission system.

3.2 *Line Design Criteria*

New transmission lines should meet EPE transmission line design standards – see Appendix B.

3.3 *Power Quality*

The Facility shall comply with the following power quality requirements:

3.3.1 Harmonics and Flicker

Certain electrical equipment located at a connecting party facility (arc furnaces, cycloconverters, etc.) may generate flicker and harmonics which will negatively impact the utility power system. The connected facility shall comply with harmonic voltage and current limits specified in the most recent revision of IEEE Standard 519, *"IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems"*. Flicker generated by the connected facility shall not exceed the General Electric (GE) *'Border Line of Irritation'* curve contained in IEEE 519.

3.3.2 Sensitive Electrical Equipment

Certain electrical equipment may be sensitive to normally occurring electric interference from nearby connected loads in the connecting party's facility or from other customers connected to the power system. If sensitive electrical equipment is to be supplied directly from the electric power system, it is recommended that the equipment grounding requirements and power supply requirements be examined by the connecting party or its consultant prior to installation. Attention should be given to equipment tolerance to various forms of electric interference, including voltage sags and surges, momentary outages, transients, harmonics, or other electrical noise. When electrical disturbances to sensitive electrical equipment such as computer, electronics, controls, and communication equipment cannot be tolerated, the connecting party shall furnish additional equipment as may be necessary to prevent equipment malfunctions. The supplier of such sensitive electrical equipment should be consulted regarding the power supply requirements or the remedial measures to be taken to alleviate potential misoperation of the equipment. A power quality consultant can also perform a site survey of the electric power supply environment and furnish recommendations to provide the acceptable level of reliability.

3.3.3 Voltage Levels

The connecting party's facility will be connected to the EPE transmission system, which is designed to operate between 95% and 105% of nominal voltage under normal conditions. If the connecting party's supply voltage requirements are more restrictive than the 95-105% range, EPE recommends that the connecting party consider the addition of voltage regulation equipment in its facility. Nominal transmission system phase-to-phase voltages currently are 345 kV, 115 kV and 69 kV.

If required and determined through system studies, a Transmission Facility shall have line reactors on one or both ends of the Facility to maintain voltage during switching.

Under certain emergency conditions, the transmission system may operate for a period of time outside of this range. The connecting party is responsible for providing any voltage sensing relaying required to protect its facility during abnormal voltage operation.

3.3.4 Power Factor Requirements

The WECC/NERC Planning Standards guide states that "Distribution entities and customers connected directly to the transmission systems should plan and design their systems to operate at *close to unity power factor* to minimize the reactive power burden on the transmission systems." The EPE interpretation of 'close to unity power factor' is that the power factor of the connected load should be controlled to be within the range of 0.96 lagging to 0.99 leading.

Capacitors provide an effective means of controlling the power factor of a connecting party's facility. However, there are several areas that should be addressed in applying capacitors to avoid potential problems. These problems can include, but are not limited to, transient voltages due to capacitor switching and voltage amplification due to resonance conditions. The services of a qualified consultant should be obtained to review the specific application and provide recommendations in regard to control of these phenomena.

3.3.5 Frequency Range

The EPE transmission system typically operates at a nominal 60 Hz with a variation of + or – 0.05 Hz. Under certain emergency conditions, the transmission system may operate for a period of time outside of this range. The connecting party is responsible for providing any frequency sensing relaying required to protect its Facility during abnormal frequency operation.

3.3.6 Voltage Unbalance

Any three-phase AC Facility shall not increase the phase-to-phase voltage unbalance of the system, as measured with no load and with balanced three-phase loading, by more than 2.0% at the point of interconnection. Voltage unbalance will be calculated using:

Unbalance (%)= 100 x (deviation from average) / (average)

3.3.7 Reactive Power

Third Party interconnections on the EPE transmission system cannot either deliver or take reactive power from the EPE system without the concurrence of EPE. As such, Facility Owner must install sufficient reactive compensation for their projects such that inadvertent reactive power flows between the Facility and the EPE transmission system.

3.4 *Clearances and Access*

The minimum vertical clearance of the conductors above ground and the vertical and horizontal clearance of conductors passing by but not attached to a building or wall shall be in accordance with the National Electrical Safety Code or applicable state and local codes.

3.5 *Transformer Connections*

The interface transformer connection(s) shall be designed to provide an effectively grounded transmission system at all times.

3.6 *Transformer Surge Protection (Lightning Arresters)*

Metal oxide arresters are preferred for transformer protection. Arresters protecting transformers are generally mounted on the transformer. When the arresters will not be mounted next to the terminals of the equipment to be protected, the voltage at the protected insulation will usually be higher than at the arrester terminals. MOV arrester application guide, ANSI C62.22, should be consulted to determine the maximum acceptable separation distance between the arresters and the protected equipment.

Consult manufacturer's catalog for details concerning arrester protective characteristics, ratings, and application.

All switches are to be manufactured and tested in accordance with the latest revision of ANSI C37.30, ANSI C37.32, and ANSI C37.34.

3.7 *Substation Fence Safety Clearances*

The fence safety clearances in the connecting party's substation shall comply with Section 11 of ANSI C2-1997, "National Electrical Safety Code."

3.8 *Ground System Resistance*

The resistance of the ground system should be one ohm or less. The grounding system shall be designed in accordance with IEEE Standard 80 - latest revision, *"IEEE Guide for Safety in AC Substation Grounding."* The minimum vertical clearance of the conductors above ground and the vertical and horizontal clearance of conductors passing by, but not attached to, a building or wall shall be in accordance with the National Electrical Safety Code or applicable state and local codes.

3.9 *Breaker Duty*

Fault studies will be performed to determine appropriate circuit breaker continuous and interrupting ratings for the Facility.

3.10 *System Protection and Control*

3.10.1 Protection Selection Process

Protection of transmission systems is a function of many variables. It depends on the role the transmission element is playing, the reliability the transmission system is required to meet, and so on. Generally the higher voltage transmission facilities are equipped with faster operating and redundant protection as a reflection of the role they play in the stability of the power and the number of customers that the loss of such an element affects. It is recognized that protection has two key functions: to uphold the reliability of the power system and to avoid or minimize damage to the protected equipment. It is also recognized that the technology of the equipment used to implement protection systems is constantly changing. Given all of these considerations, it is not possible to pre-define the protection philosophy and equipment type that is required in each case. However, it is possible to define a process that should be followed to determine what protection philosophy and what specific equipment is required for each particular application. Certain criteria are valid when choosing protection schemes. These are as follows:

- Chose a scheme that will adequately protect the subject equipment;
- Chose a scheme that will not degrade the reliability of the power system to which it is applied; and
- Chose a scheme that will upgrade the reliability of the power system, if that is one of the objectives of the transmission facility being added.

A proposed Facility Owner shall follow the process described below when selecting a protection philosophy and scheme for the new Facility. The actual choice of relays for the implementation of the protection is the responsibility of the proposed Facility Owner with the concurrence of the EPE Substation and Relay Department. The proposed Facility Owner must demonstrate that it has followed the process and that the selected protection scheme and equipment meet the established requirements. The participants in this process include the proposed Facility Owner, the owner of the existing transmission facilities (if different) and EPE's Substation and Relay Department.

3.10.2 Fault Protection

The Proposed Facility Owner must provide suitable fault protection to detect and cause proper isolation of all fault current contributions necessary to meet the safety and reliability requirements of the interconnection. A proposed Facility Owner must ensure that a single protection system component failure does not jeopardize an interconnected transmission facility's responsibility to meeting the NERC and WECC Reliability Criteria. As such, suitable redundancy shall be provided in the transmission protection schemes.

High speed relays, high speed circuit breakers and communication aided protection schemes should be used where studies indicate that their application will enhance system stability margins. The protection schemes must be coordinated with the neighboring interconnected systems.

3.10.3 Remedial Action (RAS) or Special Protection Schemes (SPS)

Remedial Action Schemes (RAS), also referred to as Special Protection Schemes (SPS), are control systems that make automatic adjustments or corrections to the power system without System Operator intervention. These schemes are usually implemented to alleviate facility overloads or other potential system problems in response to certain operating conditions within a specific time frame. Examples of RAS schemes are underfrequency or undervoltage and load tripping schemes. Proposed RAS schemes shall be coordinated with other protection and control schemes identified by EPE System Operations or other Facility Owners. EPE normally only utilizes and will only authorize underfrequency and/or undervoltage RAS. The dependability, security, selectivity and soundness of the RAS schemes should be consistent with other fault type protection schemes. The testing, monitoring and maintenance of these schemes should likewise be similar.

3.10.4 Automatic Control

Automatic transmission line reclosing should be applied where studies indicate that system requires this feature. Single pole tripping and reclosing may be appropriate in certain cases to deliver the needed system stability.

Automatic reclosing during out-of-step swing conditions should be avoided. The need for synchronism check or synchronizing control of circuit breakers will be determined on a case by case basis. The above parameters are all determined as part of the overall protection scheme selection process.

3.10.5 Synchronizing of Facilities

If required and determined by EPE, Facilities will have synchronizing relays such that the Facility can be closed into the EPE transmission system without a power angle impact to the system generators. System studies will be performed to determine the limits of closing angles for the Facility.

3.10.6 Transmission Control Devices

Certain transmission devices that provide dynamic control are usually employed as solutions to specific system performance problems or shortcomings. Such devices include phase shifting transformers, HVDC links, unified power flow controllers (UPFCs), static VAr compensators (SVCs), or thyristor controlled series capacitors (TCSCs). EPE System Planning will identify the need for such devices.

3.11 *Insulation and Insulation Coordination*

As required, the propose Facility insulation will be as per Good Utility Standards and all applicable standards and regulations. The Facility insulation ratings will be coordinated with the EPE system as required.

3.12 *Interchange Metering*

The need for interchange metering will be determined by EPE System Planning and EPE System Operations in conformity with the EPE Tariff and Good Utility Practice. Included in the metering equipment are the instrument transformers (voltage transformers, current transformers), secondary wiring, test switches, meters and communication interface. Unless otherwise agreed to by EPE, the Facility Owner shall dedicate separate instrument transformers to metering purposes only. The instrument transformers must meet EPE's accuracy standards.

3.13 *Supervisory Control and Data Acquisition*

EPE System Operations will specify the data control and indication requirements of a proposed Facility. These requirements will be determined by a Facility's location, its function, and the extent to which the Facility Owner wishes the EPE System Controller to control the transmission equipment. A Facility Owner interconnecting to the EPE transmission system must equip its facility with telecommunications for supervisory indication. System Operations requires supervisory indication capability to satisfy requirements outlined in WECC and NERC operating policies and to maintain a proper level of system visibility for overall network security. The Facility Owner shall provide, as a minimum, a Remote Terminal Unit (RTU), capable of exchanging the following supervisory control and data acquisition (SCADA) information with the System Controller:

- Breaker(s) status;
- Status of isolation device(s);
- Line MW and MVAr flows including direction;
- Transformer MW and MVAr flows including direction;
- Bus Voltages;
- Status of rotating and static reactive sources;
- Operational status of protective relay and remedial action schemes;
- The tap position of any on load tap changing (LTC) transformer in service connected to the transmission voltage bus.

Facilities offering other support services require additional SCADA capability.

3.14 *Metering and Telemetry*

The Facility Owner shall use metering of a suitable range, accuracy and sampling rate (if applicable) to ensure accurate and timely monitoring of operating conditions under normal and emergency conditions.

3.15 *Disturbance Recording*

To aid in post-disturbance analysis, the Facility Owner may be required to provide automatic disturbance oscillographs and event recorders installed at key locations on the new facilities and synchronized to Mountain Standard (MST) time. EPE's Substation and Relay Department shall determine the requirement and, if necessary, the key locations.

3.16 *Communications*

The Facility Owner shall provide dependable communication channels to handle voice, telemetry, protection, and control requirements. Furthermore, the Facility Owner shall provide backup channels for critical circuits. The Facility owner shall also provide automated channel monitoring and failure alarms for those protective system communications that, if faulty, could cause loss of generation, loss of load or cascading outages.

3.17 *Inspection* of Facilities

During the construction of and upon completion of a Facility, EPE will, as required, inspect the Facility as required to ensure all applicable standards are met.

4.0 Technical Issues Requiring Commercial Arrangements

Facility Owners capable of, and interested in, providing or receiving services beyond the minimum requirements in the previous contact EPE's Marketing Department.

In addition, if the Facility Owner desires that EPE perform Maintenance for the Facility, a separate agreement will be required. The Facility Owner should contact EPE's Transmission Engineering Department or Substation and Relaying Department as required. If the Facility Owner performs its own maintenance, coordination of such maintenance with EPE System Operations shall be required as needed.

5.0 System Planning Studies

System Planning studies may be required by EPE to determine system impacts and required additional facilities for the proposed Facility. These transmission studies will be performed in accordance with NERC and WECC planning and reliability standards and Good Utility Practice. At the sole option of EPE System Planning, these studies may be performed by third parties (contractors) at the sole cost of the prospective Facility Owner.

System Planning will notify all applicable parties on the interconnected transmission system of new or modified Facilities on the EPE transmission system.

6.0 Responsibility of El Paso Electric

EPE System Planning is responsible for overall planning of the EPE transmission system. EPE's technical departments maintain a technical database for all EPE facilities. EPE System Planning will provide to the proposed Facility Owner any other specific information as required and appropriate to enable interconnection of the proposed facilities.

6.1 *Contacts*

EPE System Planning shall provide the name and telephone number of contact persons at any of EPE's technical departments as required.

6.2 *Technical Information*

EPE System Planning conducts the planning studies required to assess the security of the EPE system and to plan for future additions of equipment and services in light of EPE's security requirements. System Planning may choose to make the results of the studies available to the Facility Owner to help establish interconnection parameters, such as voltage level selection, voltage regulation requirements, short circuit capacity impacts, stabilizer parameter determination, participation in special RAS's, and so on. As they occur, System Planning shall provide the Facility Owner with information relative to any changes in system operating standards and procedures that may affect the operation of the Facility Owner's facilities.

6.3 *Acceptance of the Interconnection*

EPE System Operations shall review and may, at its sole discretion, choose to accept the interconnection of Facilities that meet its requirements. System

Operations, or such other EPE technical departments as needed, shall witness any interconnection commissioning test that System Operations deems necessary and shall keep copies of all interconnection commissioning test results.

6.4 *Agreements*

EPE System Planning shall implement the relevant interconnection tariffs, and shall support the Facility Owner in obtaining any operating agreements required to permit interconnection.

7.0 Responsibility of Existing and Proposed Facility Owners

The interconnection of new Facilities may require modification of systems and equipment owned by other Facility Owners. It is the responsibility of the Facility Owners to contact those parties to determine the extent and costs of such modifications. EPE will assist, where requested by the Facility owners, in this process. If required, EPE will assist the Facility Owner in any joint studies with other owners of the interconnected system

7.1 *Technical Information*

The proposed Facility Owner will be responsible for determining the rating (current, real and reactive power, fault throughput, etc.) of all equipment included in the proposed Facility. The proposed Facility Owner shall provide EPE System Planning with Facility ratings applicable for both normal and emergency operation as required both for real-time system operation and for the modeling of the facilities in transmission studies. The proposed Facility Owner shall define the standards, practices and assumptions used to establish the proposed equipment ratings. Thermal, short and long term loading and voltage limits should be identified along with seasonal (temperature) characteristics, as applicable.

7.2 *Operating Authority*

Overall responsibility for ensuring the security and reliability of the EPE transmission system rests with EPE System Operations pre-real time and with the System Controller in real-time. The System Controller will issue dispatch instructions to the Facility Owners based upon real-time requirements in accordance with EPE System Operations' Operating Policies and Plans during normal and emergency operating conditions.

In the interest of personnel and equipment safety, each Facility Owner has final operating authority over their own facilities, unless otherwise agreed to by EPE and the Facility Owner in writing. The Facility Owner shall follow the System Controller's dispatch instructions except where such instructions pose a threat to the safety of personnel, the public or equipment. For common control or isolation points the affected Facility Owner shall jointly agree on an appropriate operating procedure and shall provide this procedure to EPE System Operations. The proposed Facility Owner shall designate a contact person and provide EPE System Operations, the System Controller and the owner of any interconnected transmission facilities the contact person's name and telephone number, for the purposes of operational communication. This contact person, or a designated alternative, shall be available on a 24 hour basis.

8.0 Approvals

Date	Name	Title
	Dennis Malone	Director, System Planning
5/24/11	[signature]	

9.0 Revision History

Effective Date	Version	Revised By	Revision History
	0.1	Dennis Malone	New Document
11/2007	1.1	Dennis Malone	Update for system changes
06/2009	2.1	Dennis Malone	Added "End-user" term with explanation – Section 2.0
05/31/2011	2.2	Rhonda Bryant	Added formal version history

10.0 Distribution

Date	Name	Department
6/7/2011	Joe Nevarez	Systems Operations
6/7/2011	Dennis Malone	System Planning
6/7/2011	Rhonda Bryant	NERC Reliability Compliance
6/7/2011	Western Electricity Coordinating Council	
6/7/2011	Public Service Company of New Mexico	
6/7/2011	Tri State Generation and Transmission Association, Inc.	
6/7/2011	Tucson Electric Power Company	

Appendix A:

Transmission Facility Data

The proposed Transmission Facility Owner shall submit to EPE System Planning the following information, as applicable, at a level of accuracy appropriate to the project stage:

I. Contact names, mailing addresses, phone and fax numbers, e-mail addresses for:

   A. Commercial terms;
   B. Engineering design; and
   C. Operating terms.

II. Siting Information:

   A. Detailed map showing the proposed location of the new facilities;
   B. Single line (one line) diagrams of each substation;
   C. Site plan(s) showing the arrangement of the major equipment at each substation; and,
   D. Diagram showing the voltage and current rating of each major component.

III. Functional Specification:

   A. Description of the intended function of the proposed facilities, to an appropriate level of detail for the project stage;
   B. Site plan(s) showing the arrangement of the major equipment at each terminal; and,
   C. Diagram showing the voltage and current rating of each major component.

IV. Interconnection Protection:

   A. Complete and accurate protection diagrams;
   B. A description of the proposed protection schemes; and
   C. Maintenance plans for the interconnection protective devices and interconnection interrupting devices.

V. Transformers:

   A. MVA base rating;
   B. Fan rating and cooling type;
   C. High voltage - nominal voltage, connection;
   D. Low voltage - nominal voltage, connection;

E. Tapchanger - on-load or off-load, tap chart; and
F. Ratio and accuracy class of instrument transformers. If multi-ratio, state the available ratios and the proposed ratio.

VI. Voltage Regulators:

A. MVA base rating;
B. Voltage rating;
C. Voltage setting range;
D. Voltage setting tolerance; and
E. Control information.

VII. Reactive Power Devices: shunt and series capacitors, reactors, synchronous condensers and static compensation systems:

A. Control information, include control block diagrams;
B. Nominal MVAr range;
C. Impedance (60 Hz base);
D. Percent compensation (for series devices);
E. Voltage ratings and ranges;
F. Switching step size, if non-continuous;
G. Switching equipment;
H. Electromagnetic transient control schemes (zero crossing breakers, pre-insertion reactors, etc.).

VIII. AC Transmission Lines:

A. Nominal voltage;
B. Line length;
C. Arrangement (underground /overhead, single / multiple circuit);
D. Structure type (lattice, tubular steel, wood, single or double pole);
E. Conductor configuration and size/type (vertical, horizontal, delta, bundling, dimensions, composition);
F. Meteorological and construction mechanical loading design parameters;
G. Self and mutual impedance's;
H. Surge impedance;
I. Line charging;
J. Nominal and emergency ratings.

IX. DC (Direct Current) Transmission Lines:

A. Nominal voltage;
B. Line length;
C. Structure type;
D. Conductor configuration and size/type (vertical, horizontal, delta, bundling, dimensions, composition);
E. Meteorological and construction mechanical loading design parameters;

F. Nominal and emergency ratings.

X. HVDC Links:

A. Nominal voltage;
B. Nominal and emergency power ratings;
C. Control information, include control block diagrams; and
D. Harmonic filter specifications.

End-User Facility Data

The proposed End-User Facility Owner shall submit to EPE System Planning the following information, as applicable, at a level of accuracy appropriate to the project stage:

I. Contact names, mailing addresses, phone and fax numbers, e-mail addresses for:

A. Commercial terms;
B. Engineering design; and
C. Operating terms.

II. Siting Information:

A. Detailed map showing the proposed location of the new facilities;
B. Single line (one line) diagrams of each facility;
C. Site plan(s) showing the arrangement of the major equipment at each facility; and,
D. Diagram showing the voltage and current rating of each major component.

III. Functional Specification:

A. Description of the intended function of the proposed facilities, to an appropriate level of detail for the project stage;
B. Diagram showing the voltage and current rating of each major component.

IV. Interconnection Protection:

A. Complete and accurate protection diagrams;
B. A description of the proposed protection schemes; and
C. Maintenance plans for the interconnection protective devices and interconnection interrupting devices.

V. Transformers:

A. MVA base rating;
B. Fan rating and cooling type;
C. High voltage - nominal voltage, connection;
D. Low voltage - nominal voltage, connection;
E. Tap changer - on-load or off-load, tap chart; and
F. Ratio and accuracy class of instrument transformers. If multi-ratio, state the available ratios and the proposed ratio.

VI. Voltage Regulators:

A. MVA base rating;
B. Voltage rating;
C. Voltage setting range;
D. Voltage setting tolerance; and
E. Control information.

VII. Reactive Power Devices: shunt and series capacitors, reactors, synchronous condensers and static compensation systems:

A. Control information, include control block diagrams;
B. Nominal MVAr range;
C. Impedance (60 Hz base);
D. Percent compensation (for series devices);
E. Voltage ratings and ranges;
F. Switching step size, if non-continuous;
G. Switching equipment;
H. Electromagnetic transient control schemes (zero crossing breakers, pre-insertion reactors, etc.).

Appendix B: Transmission Line Design Criteria

The design criteria set out in this document use a reliability-based approach which recognizes the statistical variations of both loading and strength and provides a consistent and logical way of relating loads and strengths. The approach set out here also recognizes that a transmission line is a system of interconnected components. Hence, the overall performance and reliability depends not only on the strength of a given component, but on the relative strength of key components in the system. The concept of sequence of failure is very important and is addressed in this document. This design criteria may be changed from time to time by the EPE Transmission Engineering Department.

The reliability based approach provides a way of designing lines for consistent levels of reliability even though the lines may be of different design and be located in different parts of the province. Also, it is relatively easy to increase or decrease the relative reliability of a given line by increasing or decreasing the return period of the design weather loadings.

The design approach set out here recognizes that transmission lines must be designed to withstand loadings other than those associated with weather. These are failure containment, or security loadings and construction and maintenance loadings. These loadings are deterministic in nature and the requirements for them are set out in this document.

The basic load and strength equation, which applies to any of the loadings in this document, is:

$$\zeta \times \text{effect of loads } Q \leq \Phi \times \text{strength } R_c$$

where :

ζ = load factor (taken as 1.0, except for construction and maintenance loads)
Q = loads (dead loads, weather loads, failure containment loads,
construction loads, etc.)
Φ= strength factor, as set out in this document
R_c = characteristic strength of the component.

This is the value guaranteed in standards, also called the minimum strength or nominal strength. It is a value that has a high probability of being met. It is not the average strength.

The equation given above is the basis of numerous design standards and practices for steel and wood structures. In recent years, several international standards groups have set out proposals for transmission line design based on this methodology. The implementation set out here is simpler than those proposed elsewhere, but retains the key features and advantages of the approach.

Loadings

Transmission lines shall be designed to withstand loadings of the following four types:

- dead loads;
- live loads;
- failure containment (or security) loads; and,
- safety (construction and maintenance) loads.

Dead Loads

Dead loads are the weight of bare wires, hardware, insulators and supporting structures. Since the magnitude of dead loads can be determined with reasonable certainty, dead loads are treated as deterministic in nature, i.e. they are given a single constant value, for a given structure and configuration. The load factor for dead loads shall be taken as 1.0.

Live Loads, or Weather Loadings

Live loads are random loads caused by ice and wind, acting separately or in combination. These loads are to be treated in a statistical manner. When data are available for annual extreme values of wind and/or ice, it is generally accepted that Gumbel extreme value analysis should be used to obtain the loading value corresponding to a given return period. Line reliability is changed by using different return periods for design weather loadings. Using loadings with higher return periods will result in higher reliability, although there is no clear analytical relationship between return period and reliability. The load factor for live loads shall be taken as 1.0.

A 50 year return period shall be used for wind loadings, unless approval is obtained for use of a different value. This wind loading shall be assumed to occur at the mean annual temperature for the general area where the line is being constructed. Appropriate corrections shall be made to adjust the basic wind velocity for the height of the average height of conductors and structures above ground. Wind loading on structures shall take into account the shape of the structural elements (round, flat, etc.). The formulae and methods used for calculation of wind loading shall be obtained from industry recognized sources and shall apply specifically to the design of power transmission lines.

Statistical data for ice loadings may not be readily available. Appropriate design values can be obtained by use of ice modeling computer programs or based on the long term operating experience of the utility.

Failure Containment Loadings (Security Loadings)

The purpose of failure containment loadings is to ensure that a failure initiated by a single component or structure does not progress far beyond the location of the initial failure. In general, this type of failure takes the form of a longitudinal cascade, where structures fail like dominoes until the failure reaches a dead-end tower or other "strong point" in the line. Failure containment loadings are deterministic in nature. The load factor (ζ) for failure containment loadings shall be _____.

Transmission lines shall be designed with failure containment capability utilizing one of the following two methods:

1) Each structure shall be designed to withstand a torsional load equal to the residual static load (RSL) caused by the release of tension of a whole phase or overhead ground wire in an adjacent span. The loading conditions shall be taken as 0°C, without any ice or wind. The RSL for suspension structures should be calculated for average spans, taking into account the reduction of load resulting from insulator swing, structure deflection and interaction with other phases or wires.
2) Use of anti-cascading structures. This is achieved by the insertion at a given interval (typically every 5 km to 10 km) of strong structures called anti-cascading structures. Each structure is typically designed to withstand loads due to the tension release of all conductors under ice or wind conditions. The wind condition would be the 50 yr return wind and the ice condition would be the 50 yr return ice loading, as described previously. Conventional heavy angle or dead-end structures often meet these requirements.

Construction and Maintenance Loadings (Safety Loadings)

These loadings are intended to ensure the safety of personnel during construction and maintenance operations. The magnitude of these loads, and the applied overload factors, are set so as to provide a reasonable safety margin relative to failure. The loads are considered constant and are treated in a deterministic manner. There is no requirement to apply ice or wind to the safety loadings, since it is reasonable to assume that the operations included here are not normally conducted during storm conditions. Provision shall be made for the following construction and maintenance activities, with loadings and overload factors as indicated:

Structure erection – the strength of all lifting points and related components shall withstand at least twice the static loads produced by the proposed erection method, i.e. load factor (ζ) = 2.0. Where the erection operations are under the direct supervision of an engineer, the load factor may be reduced to 1.5. Conductor stringing and sagging – structures shall be designed to withstand wire tensions equal to 1.5 times the sagging tension or 2.0 times the stringing (pulling) tension. Tensions shall be calculated at the minimum temperatures likely to be encountered during the stringing and sagging operations for the line. Care shall also be taken to ensure that the tension increase due to conductor overpull for deadending, particularly in short spans between dead-end structures, is taken into account. Conductor tie down locations shall be located sufficiently far from tangent structures so as to maintain a load factor (ζ) of at least 2.0 for vertical loading.

Maintenance – all wire attachment points shall be able to support at least twice the bare vertical weight of wire on the structure at sagging tensions. Any temporary lifting or deadending points located near permanent wire attachment points shall be able to resist at least twice the bare wire loads at sagging tensions. All structural members that may be required to support a worker shall be designed for a load of 1500 N applied vertically at the center of the member, in addition to the stresses imposed by external bare wire loadings.

Strength

Two items need to be considered in determining the strength of transmission line components. The first is the actual strength of a given component, and its statistical variation. The second is the coordination of strength between the various components within the transmission line system, so as to achieve (as far as reasonably possible) a desired sequence of failure

Coordination of Strength of Components (Sequence of Failure)

Transmission lines shall be designed with a given sequence of failure in order to minimize, or contain, the damage due to failure of a single component or structure. The following criteria are recommended for establishing a failure sequence:

1) The first component to fail should introduce the least secondary load effect (dynamic or static) on other components, in order to minimize cascading failure.
2) Repair time and costs following a failure should be kept to a minimum.
3) A low cost component in series with a high cost component should be at least as strong and reliable as the high cost component, in particular when the consequences of failure are high.

Application of the above criteria leads to the following preferred failure sequence:

1) Tangent towers

2) Tangent tower foundations and hardware
3) Angle and dead-end towers
4) Angle and dead-end tower foundations
5) Conductor

Strength of components is coordinated, or adjusted by means of strength factors, so as to achieve the desired failure sequence as indicated in the following paragraphs.

Determination of Characteristic Strength (R_c)

The value of R_c for insulators, hardware and conductors can be obtained from standards or manufacturers' published data. For lattice and tubular steel structures, R_c can be taken as the value obtained from the design formulae. For other components, where the given strength data is the average value or where the statistical strength variation information is provided, the characteristic strength can be determined using the following equations:

$COV = {}_sR / R_m$

$R_c = R_m (1 - k \times COV)$

Where:

COV = coefficient of variation of component strength
${}_sR$ = standard deviation of the strength
R_m = mean strength
R_c = characteristic strength
k = statistical factor (=1.28 for normal distributions)

Strength Factor (f)

The strength factor is applied to the characteristic strength to achieve the desired sequence of failure (f_s), or to account for the situation where a significant number of the same component, e.g. structures, are subjected to the maximum load intensity (f_n). One or both of these strength factors may be applied, as required. The value of f_s for the first component to fail shall be 1.0. The value of f_s for the second component to fail (assuming it is an angle structure) is 0.9 and for the third component to fail $f_s = 0.8$.

A values of $f_n = 1.0$ shall be used for transmission line structures, for the three weather loading cases (high wind, ice alone, and combined ice and wind). This takes into account the fact that structures are generally not loaded to the maximum design values. This fact is assumed to offset the situation where several structures see the maximum value of load at the same time.

Strength factors shall not be applied to the characteristic strength for failure containment loads or for construction and maintenance loads.

Design of Line Components

The basic design equation for reliability based design is:

ζ x effect of loads Q $\leq \Phi$ x strength R_c

The following equations show how this basic design equation is applied to specific line components.

Structures:

$R_c \geq$ Structure design loads
f_s, f_n:

For typical tangent structures (wood or steel), $f_s = 1$, and for angle and dead-end structures, $f_s = 0.9$.

For all structures, $f_n = 1.0$. For single pole wood structures, the effect of deflection (P-delta) shall be taken into account.

Foundations:

$R_c \geq$ Foundation design loads
f_s, f_n:

For foundations designed with the accepted factors of safety for soil parameters, $f_s = 0.9$ for tangent structures and $f_s = 0.8$ for angle and dead-end structures.

The value of f_n can be taken as 0.9, for all foundations.

Conductors and ground wires:

$f_s = f_n = 1.0$ and maximum conductor tension shall not exceed R_c.

Insulators and hardware:

The design equation is the same as for structures. $f_s = 0.9$ for all hardware and 1.0 for insulators. Use a value of $f_n = 1.0$.

Electrical Clearances

Transmission lines shall be designed with electrical clearances in accordance with the requirements of EPE Transmission Engineering Department.

In addition to meeting these requirements, the following criteria for clearance between structures and energized conductors shall be met:

1) For the high wind design loading, the minimum distance between the energized swung conductors and any part of a structure shall be the 60 Hz air gap required for a voltage equal to the nominal line to ground voltage of the line. Conductor shall be assumed to be at final sag, with no ice and at a temperature of 40° C.
2) For a one year return period wind, the minimum clearance between the energized swung conductors and the structure shall be the air gap required for the switching surge voltage of the line. Conductor shall be assumed to be at final sag, with no ice and at a temperature of 40° C.

Radio Interference

Transmission lines shall be designed to meet the requirements for radio noise as set out in ____________.