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

Table of Contents

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.

For information contact System Interconnections at El Paso Electric Company:

Manager System Interconnections
e-mail: Roberto.Favela@epelectric.com

EPE System Interconnections Group
e-mail: interconnections@epelectric.com

1.2 Guiding Principle

The requirements specified in this document are consistent with the requirements for Facility Connections specified by applicable North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) Interconnection Standards and EPE documents.

Applicable Codes, Standards, Criteria and Regulations

To the extent that the codes, standards, criteria and regulations are applicable, the new or modified facilities shall be in compliance with all applicable standards, codes, criteria and regulations.

1.3 The Interconnection Process

The Facility Owner shall contact the System Interconnections Group 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.

This document is not intended as a design specification or an instruction manual. The information presented is expected to change periodically based on industry events and evolving standards. Technical requirements stated herein are consistent with EPE's internal practices for system additions and modifications. These requirements are generally consistent with principles and practices of the North American Electric Reliability Corporation (NERC), and Western Electric Coordinating Council (WECC).

Contractual matters, such as costs, ownership, scheduling, and billing are not the focus of this document. Official requests for Interconnections or Transmission Service are not addressed by this document. EPE's Open Access Transmission Tariff governs the interconnections and transmission service process.

1.4 Safety, Protection, and Reliability

EPE will make the final determination as to whether the EPE facilities are properly protected and operationally correct before an interconnection is energized. The Requester or interconnecting utility is responsible for proper protection of their own equipment and for correcting such problems before facilities are energized or interconnected operation begins. EPE may determine equivalent measures to maintain the safe operation and reliability of EPE's Grid. In situations where there is direct interconnection with another utility's system, the requirements of that utility also apply.

1.5 Responsibilities of the Parties

EPE, the Requester and if applicable, the interconnecting utility, are each responsible for the planning, design, construction, compliance with applicable statutes, reliability, protection, and safe operation and maintenance of their own facilities unless otherwise identified in the construction, operation and/or maintenance agreements.

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

The System Interconnection Group 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. The System Interconnections Group will work with prospective Facility Owner to identify the specific information requirements for proposed facilities. Please contact System Interconnections to discuss further.

2.1 Preliminary Information

A prospective Facility Owner who wishes to have EPE's System Interconnections group assess possible Transmission or End-User Facility interconnections on a preliminary basis should provide System Interconnections group with the following information:

- Desired point(s) of interconnection (POI) 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).
- Facility layout
- Single line diagram
- KMZ file with facility coordinates
- EPE acceptable PSLF steady state and dynamic models
- Appropriate study deposit
- Equipment data files
- Enforceable site control (when required)

2.2 Required Information for Interconnection Requests

2.2.1 Introduction

Requests for energy storage or generation interconnection to EPE's Transmission grid are made via the Large Generation Interconnection Procedure (LGIP) for generating facilities equal or greater than 20 MW, or by the Small Generation Interconnection Procedure (SGIP) for generating facilities smaller than 20 MW. Requesters must refer to EPE's OATT for application forms or download the applications from EPE's System Interconnection website. Requester can also email Interconnection's group at:

EPE System Interconnections Group
e-mail: interconnections@epelectric.com

2.2.2 Connection Location

EPE requires the Requester to submit location information with the interconnection request in order to adequately study the impacts.

- Locations of new substations, generators or new line taps on existing lines must include the state, county, township, range, elevation, or latitude and longitude.
- Identify the substation or Transmission Line if connecting to an existing EPE Facility.
- Evidence of Site Control

2.2.3 Electrical Data

- Electrical One-Line Diagram
- Generator or Storage Facility Data
- Steady State Models and Technical data
- Dynamic Models and Technical Data
- Load information Data (if applicable)

2.3 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 in compliance with NERC requirements and guidelines.
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 EPE'sOASIS site and submit an interconnection request to the System Interconnections Group (interconnections@epelectric.com). Generating Facility Owner shall comply with all NERC, WECC and FERC requirements and guidelines.

2.4 Construction Stage

At the Construction Stage, the prospective Facility Owner should upgrade the information provided in Section 2.2 within 30 days of notice to proceed or E&P agreements to reflect the improved level of accuracy based upon more complete design and actual equipment ordered. Customer shall first execute an NDA with EPE and coordinate the exchange of technical and design information. Facility data requirements are specified in Appendix A. In particular, at this stage the prospective Facility Owner should provide to System Interconnections Group the following:

- Transformer specifications, reactive devices specifications, and circuit breaker data;
- Updates on facilities protection settings;
- Testing and scheduling updates.
- Updated Single Line Diagram including line and equipment impedances.
- Transmission line design configuration.

2.5 Commissioning Stage

If the customer is a Generating/Storage Facility, customer shall adhere to EPE's commissioning requirements and comply with all applicable IEEE standards approved by EPE. The Generating/Storage Facility shall comply with all NERC standards and recommendations. 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 Interconnections to enable final acceptance. In addition, the prospective Facility Owner should provide System Interconnections Group within 30 days 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 tests of major equipment
- Preliminary and final test results from commissioning tests of major equipment
- Meter testing
- Testing Protection schemes at the POI
- Verify All Protective System Inputs
- Verify Protection System Settings
- Protection System Drawings and Wiring
- Perform Trip or Other Operational Tests
- In Service, Load and Directional Tests (voltage)
- Voltage and Frequency Control Performance Commissioning Tests

2.6 Commercial Operations – Approved System Access Stage

After completing the commissioning tests, the Facility Owner shall provide System Interconnections group and EPE System Operations with final testing, performance, and validation reports. Assuming that the results are acceptable to EPE, 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 EPE's System Interconnections group 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.

All transmission arrangements for power schedules within, across, into or out of EPE Balancing Authority Area (BAA) require metering and telemetering. Some generators or loads that are in another BAA, referred to as a 'host' BAA, also require metering and telemetering to EPE BAA. Transmission arrangements with loads, generators, or new transmission facilities may include voltage control, and automatic generation control (AGC).

3.0 Interconnection Requirements

3.1 Requirements for Generator Interconnections

3.1.1 Reactive Power Requirements

All generator installations are required to provide reactive power for voltage support of the transmission system. All generation interconnected to EPE's system shall be required to provide reactive power compensation as specified in the interconnection studies. Both dynamic and static reactive power may be required for stability purposes and are defined as follows:

- ***Dynamic reactive power*** is provided by fast-acting continuously controllable reactive power devices to provide automatic voltage response to system voltage changes, including generation output changes, grid disturbances to stabilize the power system; and to smooth shunt reactive switching steps. Continuously controllable, fast-acting reactive power devices include synchronous generator excitation systems, generation with electronically controlled output, such as inverter-based resources, and electronically controlled reactive power devices. The typical dynamic reactive power response time frame is from several cycles (after fault interruption) to a second, similar to synchronous generators with modern excitation systems. Common dynamic reactive devices include static VAR compensators (SVCs), static synchronous compensators (STATCOMs), and the inherent dynamic reactive power capability of inverters.
- ***Static reactive power*** is slower acting to maintain a voltage schedule during normal system operation, to aid system recovery after a disturbance, and to maximize the availability of the generator's dynamic reactive power. The typical static reactive power response time frame is several seconds to a minute. Secondary reactive power elements often include mechanically-switched shunt capacitors and reactors and are implemented in a programmable logic controller as part of the generation installation's control system. Common static reactive power devices include switched capacitors and switched reactors.

NERC's Reliability Guideline for BPS-Connected Inverter-Based Resource (IBR) Performance defines a generator's Point of Measurement (POM) as the high side of the generator step-up transformer. EPE will require the POM at the POI (Point of Interconnection) for those facilities design the high side of the generator step-up transformer at a distance longer than 5 miles from the POI.

EPE requires all generation plants (synchronous and non-synchronous) be capable of providing the Minimum Plant Reactive Capability for all MW output levels. Minimum Plant Reactive Capability is defined as +/-33% of the plant's nameplate MW in dynamic MVARs at the POM (except as notes above). Plants with inverter technology unable to meet this performance when actual power output levels are 10% or less of nameplate MW (e.g. doubly-fed induction generators) may request a study to determine if reduced dynamic MVAR capability is permissible.

According to NERC's Guideline for IBR Performance, IBRs should utilize the dynamic reactive capability from the inverters to the greatest possible extent within the specified power factor requirements (Figure 1). Inverters should not have artificial settings imposed to limit reactive power output.

EPEA Transmission Operations publishes voltage schedules in terms of the POI. Requestors are responsible for ensuring POM voltages support the POI voltage schedule while meeting the dynamic reactive support requirements at the POM. Additional Voltage control requirements are covered in Section 6.3.1.1.

Figure 1 illustrates the required Minimum Plant Reactive Capability for any generation plant at the POM, when the POI voltage is at the nominal voltage schedule. This requirement includes inverter-based generation and inverter-based energy storage facilities. This rectangular characteristic is more stringent than FERC's "triangular" minimum requirement for 0.95 lead/lag power factor when operating at plant nameplate MW.

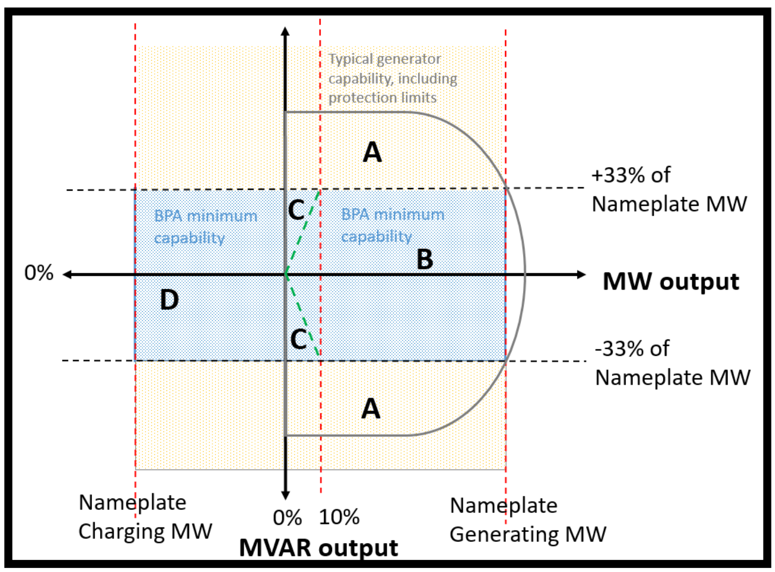

Figure 1: Required Reactive Power Capability at POM (for nominal voltages 0.95 pu-1.05 pu)

Note A: Exceeds Minimum Plant Reactive Capability region, comprised of dynamic devices and any static devices if applicable. A plant is permitted and encouraged to be capable of operating in this region.
Note B: Minimum Plant Reactive Capability region, comprised of dynamic reactive power devices. Required for any MW output level.
Note C: Plants shall not have artificial settings imposed to limit reactive power output in this region.
Note D: Energy storage components must provide dynamic reactive support equal to 33% of Nameplate for any charging levels (negative MW), as most storage components are expected to be synchronous or otherwise interconnected via capable inverter technology.

Automatically switched shunt reactive devices may be allowed as part of the plant's overall control system to meet the Minimum Reactive Capability requirements if specifically allowed by EPE's Interconnection group. Additional shunt reactive devices may also be required as part of the interconnection to compensate for the effects of:

lower voltage (collector) system reactive losses, reactive charging, step-up transformer reactance, transmission line reactive losses, transformer taps/turns ratios, bus-fed auxiliary loads, and collector system impacts during low power output levels.

All shunt reactive devices shall be coordinated with a power plant voltage controller or similar coordinated controller, such that reactive device switching is optimized for dynamic reactive reserves needed at the POI during transmission system disturbances. The voltage controller shall coordinate mechanically switched shunts and dynamic reactive resources to provide smooth shunt reactive switching steps. The power plant voltage controller shall be capable of receiving EPE voltage reference signals for the POI scheduled voltage, and account for any line drop compensation looking forward through the substation step-up transformer impedance to the POI. When the voltage at the control point is above the scheduled voltage, the plant is expected to consume reactive power (inductive operation) from its POM. When the voltage at the control point is below the scheduled voltage, the plant is expected to supply reactive power (capacitive operation) from its POM. This includes coordination of but not limited to: shunt device status, shunt device output, POI reference voltage and collector system voltage. All generator installations will be required to provide data on reactive capability.

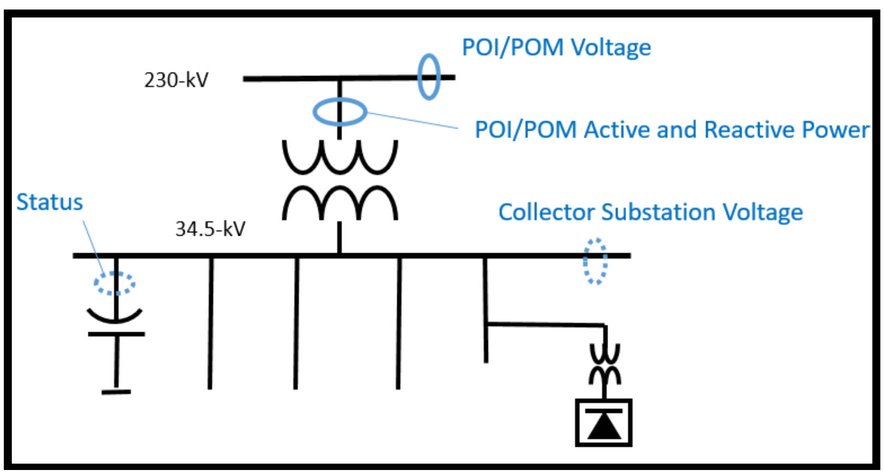

Figure 2: Example Of Important Reference Quantities Required For Acceptable POM Voltage Control

Generation must be able to maintain their Minimum Reactive Capability and voltage schedule at the POM at all times including when transitioning between control modes (e.g., NightVAR mode, WindFree mode, day mode, etc.) and shall not violate POI voltage swing requirements as listed in section 3.2 or as otherwise indicated by the interconnection study. These requirements must also be met during times of no and low real power output, such as times of low solar irradiance or low wind.

3.2 Voltage Control

All generators interconnected to EPE's transmission system are expected to control voltage control at the respective POI. EPE expects the POI scheduled voltage to be used as a primary reference or input to the plant's overall control scheme. Additional or alternative voltage control requirements will be identified in the Facilities Operational Instructions developed by EPE and the facility owner. Automatic Voltage Regulation (AVR) is required for all generators regardless of size, unless EPE grants an exception. The interconnection customer shall equip each generator with AVR and shall operate AVR in voltage control mode at all times when the generator is synchronized to the transmission system. Voltage control shall include line drop compensation or reactive current compensation, to provide fast response for major system events while desensitizing for small changes in voltage. Intentional dead band or additional time delays in the voltage control are not permitted without concurrence by EPE. "Power factor control" or equivalent operating mode is also not permitted for AVR control designs.

AVRs should be of continuously acting solid-state analog or digital design. Generator voltage regulators to the extent practical should be tuned for fast response to step changes in terminal voltage or voltage reference. Terminal voltage overshoot should generally not exceed 10% for an open circuit step change in voltage test. Tuning results should be included in commissioning test reports provided to EPE.

For applications where no external dynamic devices are required, the AVR control system shall be sufficiently fast to react to the maximum change in generation anticipated without invoking the operation of transmission-level (high side of POI) voltage control devices such as shunt capacitors and tap changers unless specifically instructed otherwise by EPE. The control system shall be coordinated to minimize operation of customer load regulation equipment including voltage regulators and tap changers. For switched reactive equipment supporting generation reactive power requirements, voltages at the POI shall not vary more than 0.5% per switching operation; and POI voltage shall not deviate more than 1% due to rapid fluctuations in generation output. When the need is identified by EPE studies, the requester will be required to provide dynamic controllable compensation, such as an SVC.

Voltage regulator controls and limit functions (such as over and under excitation and volts/hertz limiters) shall coordinate with the generator's short duration capabilities and protective relays.

3.3 Determination of the Interconnection Point

System Interconnections Group, 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.

Location information required will vary depending upon the proposal. The proposed Facility Owner shall provide the location information coordinates for an interconnection request.

3.4 Line Design Criteria

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

3.5 Power Quality

The Facility shall comply with the following power quality requirements:

3.5.1 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.

Under certain circumstances, the power output fluctuations may cause excessive voltage change for transmission customers in the area due to fluctuations in transmission line power flows. The generator voltage control system shall be coordinated to minimize operation of customer load regulation equipment including voltage regulators and tap changers when applicable.

Perceptible flicker may also result from the change in voltage at the terminal of the generation project for changes in generation output and / or as the power output changes the line loading voltage. As the power plant output fluctuates, so does the customer POI voltage, even if the voltage at plant POI is held constant.

When the need is identified by studies or from operational experience, the project will be required to provide dynamic controllable reactive compensation such as SVC.

3.5.2 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 mis-operation 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.

3.5.3 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 static and/or dynamic voltage regulation equipment in its facility. Nominal transmission system phase-to-phase voltages currently are 345 kV, 115 kV and 69 kV.

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.

The Generating Facility shall have low voltage ride-through (LVRT) capability. The Facility should remain online during voltage disturbances up to the time periods and associated voltage levels set forth in the NERC standards.

The Generating Facility shall provide sufficient dynamic voltage support in accordance with the NERC recommended Interconnection guidelines or inverter-based resources which shall be met at the POI. When the need is identified by EPE studies, the Generating Facility interconnecting will be required to provide dynamic controllable compensation, such as an static VAR compensator (SVC), static synchronous compensator (STATCOM), or line reactors on one or both ends of the Facility to maintain voltage during switching.

3.5.4 Power Factor Requirements

Generator Low Voltage Ride-Through Capability

All generator installations shall meet NERC and WECC requirements for low voltage ride through (LVRT). The generator(s) shall be capable of staying on-line for nearby faults, except for faults on the line or bus the generator is connected to. This includes all energy producing facilities including gas, thermal, wind, solar PV, solar thermal, and Energy Storage facilities, etc.

Inverter-based resources **shall not use momentary cessation** within the voltage and frequency ride through curves specified in NERC PRC-024. Use of momentary cessation is not considered “ride through” within the “No Trip” zone of the curves defined in PRC-024. These facilities must consult the NERC Reliability Guideline on Recommended Performance of Inverter-Based Resources for recommended performance characteristics. Inverter-based resources must continue to inject active and reactive current to support the BPS during and immediately after fault conditions. The settings of active current (frequency controls) and reactive current (voltage controls) injection during ride-through conditions will be provided to EPE during the interconnection study process, during the construction of the facility and after commissioning of the generating facility in order to properly model the behavior.

In addition to the NERC and WECC LVRT requirements, all generators must meet EPE under/over voltage and under/over frequency requirements for operation, unless EPE has determined otherwise.

3.5.5 Frequency Range

According to FERC Order No. 842, all new interconnecting generating facilities (large and small, synchronous, and asynchronous) shall install and enable primary frequency response capability as a condition of interconnection.

To comply with NERC BAL-003-1 Reliability Standard, EPE may need to acquire frequency response from generators within its Balancing Authority. Therefore, EPE requires that all generators have capabilities to provide frequency response, specifically:

- Prime mover control (governors and inverters) shall operate with appropriate speed/load characteristics to regulate frequency
- Prime mover control (governors and inverters) should operate freely to regulate frequency. Governor droop should be set between 3% and 5% with a total governor dead band (intentional plus unintentional) not to exceed +/-0.06% of 60HZ (+/-36 mHZ). These characteristics should in most cases ensure a coordinated and balanced response to grid frequency disturbances. Prime movers operated with valves or gates wide open should control for overspeed or over frequency.

EPE realizes that some generating facilities will operate at maximum turbine output unless providing frequency control and spinning reserve ancillary services. EPE requires governor controls to be set for 'droop control mode'.

3.5.6 Blackstart Capability & Blackstart Resources

If EPE determines that a generating source needs to be blackstart capable, this will be addressed in a separate study as part of the planning review process after such facility has been identified as a Blackstart Resource in EPE's Restoration Plan. Generating facilities seeking interconnection are not required to be blackstart capable as part of the interconnection process.

3.5.7 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)

Unbalanced phase voltages and currents can affect coordination of protective relaying, create higher flows of current in neutral conductors, and cause thermal overloading of transformers and motors. The measurement of voltage unbalance, Negative Sequence Unbalance Factor (NSUF), is the ratio of the negative sequence voltage divided by the positive sequence voltage expressed as a percentage. The NSUF limits listed herein applies to normal system operations (no significant transmission outages). For connections at 115 kV and above, the voltage unbalance should not exceed 1%. For connections below 115 kV, the contribution at the POI from a single interconnection should not be allowed to cause a voltage unbalance greater than 1.3%. The voltage unbalance limit is 2% at Points of Common Coupling for the aggregate effect of multiple loads.

System problems such as a blown transformer fuse or open conductor on a transmission system can result in extended periods of phase unbalance. It is the Requester's responsibility to protect all of its connected equipment from damage that could result from such an unbalanced condition.

3.6 Clearances and Access

The minimum vertical clearance of the conductors above ground and thevertical 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.

In addition, refer to EPE Substation and Transmission engineering’s latest Design Criteria and Construction Standards for specific clearances and voltages.

Execution of a non-disclosure agreement (NDA) with EPE will be required for

Interconnection customers seeking clearance and right-of-way information on EPE’s Transmission System. An NDA would also be required upon execution of an interconnection agreement with EPE and to obtain construction specifications.

3.7 Transformer Connections

The interconnector’s transformer connection shall be either Wye-grounded high-voltage/delta low-voltage or Wye-grounded high-voltage/wye-grounded low-voltage. EPE’s Interconnection Department must approve the transformer connection.

3.8 Substation Transformer Surge Protection (Lightning Arresters)

Metal oxide arresters are preferred for transformer protection. Arresters protecting transformers are generally mounted on the transformer.
All switches are to be manufactured and tested in accordance with thelatest revision of ANSI C37.30, ANSI C37.32, and ANSI C37.34. For additional information, consult manufacturer for details concerning arrester protective characteristics, ratings, and application.

3.9 Substation Fence Safety Clearances

The fence safety clearances in the connecting party's substation shallcomply with Section 11 of IEEE C2-2017, "National Electrical Safety Code."

3.10 Ground System Resistance

The resistance of the ground system should be less than one ohm. The grounding system shall be designed in accordance with the latest version of IEEE Standard 80 *"IEEE Guide for Safety in AC Substation Grounding."*

In addition, refer to EPE Substation engineering’s latest Design Criteria and Construction Standards for more details on ground system design and construction practices.

3.11 Breaker Duty

A short circuit analysis will be performed within the required “Interconnection Analysis Study”. This portion of the study will determine appropriate short circuit breaker interrupting ratings for the Facility given system impedance changes as well as system X/R ratios.

3.12 System Protection and Control

3.12.1 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 powersystem 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 facilitybeing added.

EPE's Protection & Control Engineering Department will be responsible for the design of the high voltage protection schemes located the Transmission Provider's Interconnection Facilities. The protection schemes located at the Interconnection Customers Interconnection Facilities must be reviewed by EPE's Protection & Control Engineering Department to ensure proper coordination between transmission and interconnection facilities.

3.12.2 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 must be used where studies indicate that their application will enhance system stability margins. The protection schemes must be coordinated with the neighboring interconnected systems.

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

EPE does not approve of any Remedial Action Schemes (RAS) for any system mitigations.

3.12.4 Automatic Control

Automatic transmission line reclosing should be applied on all 115kV or 69kV lines. Automatic reclosing on 345kV lines is not allowed. Single pole tripping and reclosing is also not allowed on any transmission lines.

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.

3.12.5 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. Synchronizing and requirements can vary depending on the specific circumstances. The prospective Facility Owner is responsible for coordinating any synch-check relay settings with EPE's Protection & Control Department.

At the POI, the customer is not allowed to energize a de-energized line connected to the EPE grid without approval of the EPE System Operations. Breaker reclose supervision (automatic and manual including SCADA) may be required at the connecting substation and/or electrically adjacent stations. This may include hot-bus and dead-line checking, synchronization checking, etc.

3.12.6 Transmission Control Devices

Changes to or the addition of new Transmission (or End-User) Facilities can impact the Transmission System. To maintain system reliability, transmission devices may be required for voltage regulation, reactive support, or power transfer capability.

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 Interconnections Group will identify the need for such devices.

3.13 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 shall be coordinated and reviewed by EPE transmission and substation groups. Any facility owned or to be owned by EPE shall comply to EPE standards.

3.14 Interchange Metering

The need for interchange metering will be determined by EPE System Interconnections Group 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.

3.15 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.
- The tap position of any on load tap changing (LTC) transformer inservice connected to the transmission voltage bus.
- Generator unit status and output
- Real time instantaneous data as required by System Operations
- Real time accumulated data for 5 min, 15 min, 1hr intervals and/or as requested by System Operations
- Other data as requested by System Operations prior to the construction of the facility

Facilities offering other support services require additional SCADA capability.

3.16 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.

All interconnections and transmission arrangements requiring energy transactions within, across, into or out of the EPE BAA require metering and telemetry. Revenue billing, system dispatching, operation, control, transmission scheduling and power scheduling each have slightly different needs and requirements concerning metering, telemetering, data acquisition, and control. The specific data requirements for each project will be determined as part of the interconnection agreements. If EPE observes a severe discrepancy between the Facility Requesters provided data and monitored results, the projects generation output may be curtailed and/or the Facility Owner shall be required to perform parametric testing of the generation equipment.

3.17 Disturbance Recording

EPE monitors the response to system events by generation projects connected to the EPE grid by measuring bus voltage and frequency, and generation current and power. Performance monitoring and disturbance data collection of the generation project is required to fully validate performance and verify the models provided by the Facility Owner.

To aid in post-disturbance analysis, the Facility Owner may be required to provide disturbance oscillographs and event recorders. In addition, the facility owner may require the installation of digital fault recorders and phasor measurement units (PMU’s) installed at key locations on the new facilities. All oscillography and event reports must be time synchronized via a satellite-synchronized clock. EPE's Protection & Control Department shall determine the requirement and, if necessary, the key locations. If EPE observes a severe discrepancy between the Facility Requesters provided data and monitored results, the projects generation output may be curtailed and/or the Facility Owner shall be required to perform parametric testing of the generation equipment.

3.18 Communications

The Facility Owner shall provide a highly reliable, scalable, secure, and robust network between the substation and the control center. These communication channels will 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. Refer to Doc. No: DC-015 for additional communication requirements.

Communications for SCADA, revenue metering system and telemetering must function at the full performance level before and after any transmission system fault condition. Maintenance personnel must restore service continuity immediately after the transmission fault without the need for intervention by EPE personnel.

3.19 Control Building

The Facility Owner shall construct a stand-alone, fire resistant and low maintenance control building to provide:

- protective enclosure for controls, relays, station batteries, and other essential components
- a lighted and protected workspace for personnel
- space for tools, spare parts, and drawings associated with the substations
- a communication hub for all equipment withing the substation
- physical security and protection from vandals

Refer to Doc. No: DC-017 for additional Control Building requirements

3.20 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.

The Facility Owner is responsible for pre-energization and testing of their equipment. The Facility Owner must provide System Operations written prior notice of pre-energization and testing and in accordance with their agreement with EPE. The Facility Owner shall also provide System Operations the testing schedule and test reports.

4.0 Technical Issues Requiring Commercial Arrangements

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 Interconnection Studies

System Interconnection studies are required by EPE to determine system impacts and required additional facilities for the proposed Facility. These studies are conducted based on the type of Interconnections Customers Request. EPE will determine whether other types of studies are required such as electro-magnetic transient (EMT) or control interaction studies. All System Interconnection studies conducted are at the prospective Facility Owner’s expense. These transmission studies will be performed in accordance with the most current NERC and WECC planning and reliability standards, EPE’s Transmission System Performance Criteria, and Good Utility Practice. At the sole option of the EPE System Interconnections Group, these studies may be performed by third parties (contractors) at the sole cost of the prospective Facility Owner.

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

Before any modifications can be made to a prospective Facility or existing Facility, a study or studies of the Facility will be required to evaluate any impacts on the 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 Interconnections Group will provide to the proposed Facility Owner any other specific information as required and appropriate to enable interconnection of the proposed facilities.

6.1 Contracts

EPE System Interconnections Group shall provide the name and telephone number of contact for any of EPE's technical departments as required.

6.2 Technical Reliability Information Updates

EPE System Interconnections Group conducts the required interconnection studies required to assess the reliability of the EPE system. The results of the studies will be made 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, , and so on. EPE 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 Interconnections Group and 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, at its sole discretion, witness any interconnection commissioning test that deems necessary and such Facility Owner shall provide copies of all interconnection commissioning test results.

6.4 Agreements

EPE System Interconnections Group 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 EPE System Interconnections Group 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 Inspection of Facilities

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 Interconnections Group 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.

If the prospective or existing Facility requires modification, the Facility Owner shall also provide the System Interconnections group with the following information:

- 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).
- Facility layout
- Single line diagram
- KMZ file with facility coordinates
- EPE acceptable PSLF steady state and dynamic models
- PSCAD models or other electromagnetic transient (EMT) models
- Equipment data files

The existing or prospective Facility Owner is responsible for providing the most accurate technical information for their Facility. If any of the information provided is different from the actual Facility, then additional studies will need to be conducted at the Facility Owners expense. The existing or prospective Facility Owner will be responsible for meeting the performance specifications as given in the technical information provided.

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, e-mail address 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 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
07/12/2023	3.0	System Interconnections Group	Reviewed and updated by departments.

Appendix A: Transmission Facility Data

Appendix A.1: Prospective Generation Transmission Facility Data

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

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

A. Proposed type(s) of facility
B. Desired point(s) of interconnection (POI) to the transmission system
C. Legally Enforceable Site Control
D. Generating Facility PSLF Models and EMT (PSCAD/EMTP) Models
    i. Must reflect one-line diagram
E. Engineering design
    i. Single line diagram of Generating Facility (must be signed and stamped by a licensed Professional Engineer)
    ii. Line ratings and impedances
    iii. Equipment ratings
F. Proposed operating description
    i. If storage facility is included, describe configuration to the grid

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
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
C. Diagram showing the voltage and current rating of each major component

IV. 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
F. Ratio and accuracy class of instrument transformers.
   - If multi-ratio, state the available ratios and the proposed ratio

V. Voltage Regulators:

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

VI. Reactive Power Devices: shunt and series capacitors, reactors, synchronouscondensers 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 A.2: Existing Generation Transmission Facility Data

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

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

   A. Material Modification request or increase capacity of an existing Generating Facility shall be submitted by email request to the System Interconnections Group
      i. Describe Configuration
   B. Engineering design
      i. Single line diagram of Generating Facility (must be signed and stamped by a licensed Professional Engineer)
      ii. Line ratings and impedances
      iii. Equipment ratings
   C. Updated Generating Facility PSLF and EMT (PSCAD/EMTP) Models
      i. Must reflect one-line diagram
   D. Proposed Operating description
      i. If storage facility is included, describe configuration to the grid

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
   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
   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
   C. Maintenance plans for the interconnection protective devices and interconnection interrupting devices

V. Transformers:

A. MVA base rating
B. Impedance values
C. Fan rating and cooling type
D. High voltage - nominal voltage, connection
E. Low voltage - nominal voltage, connection
F. Tapchanger - on-load or off-load, tap chart
G. 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
E. Control information

VII. Reactive Power Devices: shunt and series capacitors, reactors, synchronouscondensers 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
D. Harmonic filter specifications

Appendix A.3: End-User Facility Data

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

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

   A. Commercial terms or expected load
   B. Proposed type(s) of facility
   C. Desired point(s) of interconnection (POI) to the transmission system
   D. Engineering design
      i. Single line diagram of Generating Facility (must be signed and stamped by a licensed Professional Engineer)
   E. Proposed operating description
      i. If storage facility is included, describe configuration to the grid

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:

x effect of loads Q <l> x strength Re

where:

=load factor (taken as 1.0, except for construction and maintenance loads)
Q = loads (dead loads, weather loads, failure containment loads, construction loads, etc.)
<l>= strength factor, as set out in this document
Re= 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 theapproach.

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 determined by EPE's transmission design department.

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 equalto 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 wiretensions 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 dead ending, 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 dead ending 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 thevarious 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 Re for insulators, hardware and conductors can be obtained from standards or manufacturers' published data. For lattice and tubular steel structures, Re 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/ Rm

Rc = Rm(1-k x COV)

Where:

COV = coefficient of variation of component strengths
sR = standard deviation of the strength
Rm= mean strength
Rc= 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 (fs), or to account for the situation where a significant number of the same component, e.g. structures, are subjected to the maximum load intensity (fn). One or both of these strength factors may be applied, as required. The value offs for the first component to fail shall be 1.0. The value offs for the second component to fail (assuming it is an angle structure) is 0.9 and for the third component to fail fs= 0.8.

A values of fn = 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 failurecontainment 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 $\leq$ Φ x strength Rc

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

Structures:

Rc ≥ Structure design loads
fs, fn:

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

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

Foundations:

Rc ≥ Foundation design loads
fs, fn:

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

The value off fn can be taken as 0.9, for all foundations.

Conductors and ground wires:

fs = fn = 1.0 and maximum conductor tension shall not exceed Rc.

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 fn= 1.0.

Electrical Clearances

Transmission lines shall be designed with electrical clearances in accordancewith 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 asset out in _________________.