Business Practice

FACILITY CONNECTION REQUIREMENTS (FCR)

Effective Date: 7/24/2018
Version 9

This document is published at http://www.oasis.osti.com/SRP/index.html
## TABLE OF CONTENTS

1.0 INTRODUCTION........................................................................................................ 1  
2.0 STUDY PROCEDURES, COORDINATION AND NOTIFICATION................................. 2  
3.0 VOLTAGE LEVEL AND MW AND MVAR CAPACITY/DEMAND............................... 8  
4.0 SYSTEM PROTECTION/BREAKER DUTY .............................................................. 12  
5.0 METERING AND TELECOMMUNICATIONS ............................................................ 17  
6.0 GROUNDING AND SAFETY ISSUES....................................................................... 20  
7.0 INSULATION AND INSULATION COORDINATION ................................................ 21  
8.0 VOLTAGE, REACTIVE POWER, AND POWER FACTOR CONTROL..................... 21  
9.0 POWER QUALITY IMPACTS .................................................................................... 24  
10.0 EQUIPMENT RATINGS ........................................................................................ 25  
11.0 SYNCHRONIZING OF FACILITIES ................................................................... 27  
12.0 MAINTENANCE COORDINATION ...................................................................... 27  
13.0 OPERATIONAL ISSUES....................................................................................... 28  
14.0 INSPECTION REQUIREMENTS ......................................................................... 30  
15.0 NORMAL AND EMERGENCY OPERATING CONDITIONS ............................... 31  
16.0 MISCELLANEOUS REQUIREMENTS .................................................................... 32  
17.0 INDEMNIFICATION.............................................................................................. 34
1.0 INTRODUCTION

Salt River Project (SRP) has prepared this document which outlines the minimum requirements for all generation facilities, transmission facilities, and end-user facilities connecting to the SRP Transmission System (connecting entity or connecting entities), connecting to an existing SRP generation facility which is connected to the SRP Transmission System, connecting to a transmission system operated by SRP, or connecting to an existing generating facility which is connected to a transmission system operated by SRP. These requirements, as well as the planning procedures and criteria described in SRP document, Guidelines for Electric System Planning, are consistent in content and application to those requirements used by SRP when connecting its own new or modified generation, transmission, or end-user facilities. In addition to the specifics in this document, all connecting entities shall comply with applicable codes, standards (including NERC and WECC), federal and state regulations, environmental regulations, citing requirements, contracts, operating agreements, and NERC/WECC reporting requirements. Additional details can be found in the following SRP documents:

- SALT RIVER PROJECT STANDARD LARGE GENERATOR INTERCONNECTION PROCEDURES (LGIP)
- SALT RIVER PROJECT STANDARD LARGE GENERATOR INTERCONNECTION AGREEMENT (LGIA)
- SMALL GENERATOR INTERCONNECTION PROCEDURES (SGIP)
- GUIDELINES FOR ELECTRIC SYSTEM PLANNING

These document and all referenced SRP documents are available upon request (within 5 business days) and are available on the SRP OASIS. All three interconnection types (generation, transmission, and end-user facilities) use the same application form which is Appendix 1 of the LGIP.

Background

In the present electric utility environment characterized by deregulation, open access to the transmission network, wholesale and retail competition, etc., there is wide recognition that electric system reliability, safety and quality of service are to be maintained. Maintaining reliability, safety and quality of service in this changing environment places additional challenges in the planning and operation of electric systems. Each request to connect to the SRP Transmission System will be reviewed to identify the facility impacts and necessary system improvements on the system. These reviews ensure that comparable treatment is given to all users, and that reliability, safety, and quality of service is maintained.

Scope

This document informs entities seeking facility connections to the SRP Transmission System or to an SRP generation facility connected to the SRP Transmission System of the connection requirements. The scope of this document is limited to the technical requirements for connected facility design and operation. These requirements do not
preclude the need for specific Interconnection Agreements between SRP and entities connecting to the Transmission System.

The scope of this document satisfies the NERC Planning Standards by identifying requirements for connections to the Bulk Power System at voltages generally 69 kV and above. Requirements applicable for all types of facilities, regardless of voltage level and capacity, are covered. The minimum requirements pertaining to connected facilities are contained herein.

The requirements for initial facility connection apply equally to continued operation of existing connected facilities. Therefore, any upgrades, additions, enhancements, or changes of any kind to an existing connected facility are subject to SRP’s review to ensure continued compliance with these requirements.

The scope of these documents is limited to the technical requirements for connected facility design and operation. Customers interested in the terms of transmission service should refer to the SRP Open Access Transmission Tariff.

The information contained in this document is supplementary to and does not intentionally conflict with or supersede the National Electric Safety Code (NESC) as approved by the American National Standards Institute (ANSI) or such federal, state and municipal laws, ordinances, rules or regulations as may be in force within the cities, towns or communities in which SRP furnishes electric service. It is the responsibility of the entity connecting with SRP to conform to all applicable national, state and local laws, ordinances, rules, regulations, codes, etc.

Objectives

SRP, in its role as a transmission provider, has prepared this document based on the following objectives:

a) Maintain system reliability, personnel and equipment safety, and quality of service as new facilities are added to the transmission network and existing facilities are modified to meet customer load demands.

b) Ensure comparability in the requirements imposed upon the various entities seeking to connect facilities to the transmission network.

c) Satisfy compliance with NERC Planning Standard FAC-001-2 pertaining to documentation of facility connection requirements by those entities responsible for system reliability.

d) Inform those entities that seek facility connections to the SRP Transmission System of the various requirements for system reliability, safety of personnel and equipment, and quality of service.
e) Facilitate uniform and compatible equipment specification, design, engineering, and installation practices to promote safety and uniformity of service.

2.0 Study Procedures, Coordination and Notification

When evaluating connection requests, near-term and long-term studies are necessary to ensure required system performance is achieved throughout the planning horizon. Required studies generally include: short-Circuit (fault duty), stability, power flow, and transfer capability. A detailed discussion of each type of study can be found in the SRP document titled: Guidelines for Electric System Planning. The criteria and guidelines described in SRP’s OASIS, Attachment K and in this document are intended to ensure required system performance is achieved and all applicable standards (including all Transmission Planning standards) are met. The criteria and guidelines are applied for all studies relating to both internal and external requests for connection and studies performed as part of the normal planning process. A general description of each type of study follows:

Power Flow Studies

Power flow analyses are conducted to examine the impact of the proposed facility on transmission lines and transformers, and voltage profiles. Contingencies consisting of single or multiple outages of lines and/or transformers are considered in these analyses. Where the analyses indicate that transmission upgrades are necessary, alternative plans may be devised and evaluated to accommodate the proposed facility. Equipment voltage limits, both transmission provider and customer are analyzed both steady state and single contingency conditions as described in Section 2.1 and 2.2 of the Guidelines for Electric System Planning.

Short Circuit Analyses

Short circuit analyses (fault current or fault duty studies) are conducted to examine the impact of the proposed facility on equipment fault duties. These analyses will be used to determine the impact of the connection (often relating to a generator connection) on the fault duty (i.e., interrupting capability or rating) of previously installed equipment such as circuit breakers or switches. Increased fault duties may require the need to upgrade existing equipment. The study results can also be used to help select the size or ratings of the proposed facilities to be connected.

The incremental short circuit impact that an interconnector creates at Palo Verde and Hassayampa 500kV buses will also be studied and monitored.

Transient Stability Analyses

A transient stability analysis may be performed to determine the transmission systems’ response to a sudden change in the state of the system due to faults and unit outages. Specifically, the analysis will evaluate the transmission system in the area of the added generation as well as the generator’s response following system faults. Stability studies may
also be required to evaluate transmission or end-user connection requests. Transient voltage dips, post-transient voltage and transient frequency dips are analyzed as described in Section 3 of the Guidelines for Electric System Planning.

Transfer Capability Studies

Transfer capability studies are often necessary to evaluate all types of connection requests. In general, the impact of the proposed facility on the ability to import and export power is evaluated through power flow studies. Single contingencies are normally evaluated.

Additional Analyses

Other analyses may be required based on power flow analyses and depending on the nature of the proposed connected facility and its location within the transmission network. This could include power quality analyses for End-User load that could potentially cause harmonic current or voltage and/or telephone interference, post-transient voltage stability studies, and voltage deviation studies. When adverse sub synchronous torsional interaction is possible (for End-User’s equipment such as arc-furnaces and/or cycloconverters to be located in close electrical proximity to existing generation) additional analyses may be required.

Specific Generation Connection Study Procedures & Communication

The SRP document titled: Large Generator Interconnection Procedure describes the various studies and procedures required to evaluate a generation connection request. A detailed interconnection study will generally require the creation of an ad-hoc study group consisting of SRP and potentially impacted neighboring systems. Additional details regarding coordinated study efforts, communication, and notification can be found in the SRP documents titled: Guidelines for Electric System Planning and Attachment K posted to the SRP OASIS.

Specific Transmission & End-User Study Procedures & Communication

A plan of service is developed to provide for the physical connection between the transmission system and a proposed connected facility. The electrical configuration of the connection equipment are determined which include transformers, switchgear and other station equipment, and required transmission line sections. The physical layout of equipment and right-of-way needs are determined in the plan of service as well. A multi-step approach may be considered in the plan of service to accommodate a multi-step increase in load for the connected facility. Normally, the expense of developing a plan of service is the responsibility of the Transmission End-User.

In order to assess the impact of a proposed facility connection on system reliability, system impact studies need to be conducted. These system impact studies, as a minimum, examine the transmission line and transformer loading, voltage profiles and schedules, and power quality impacts of the proposed facility for a range of expected seasonal loading and power transfer conditions. The effect of the proposed facility on short circuit duties is examined for
all proposed transmission connections. A multi-step approach to the proposed facility may be considered where the impact of each step is assessed separately.

The SRP planning department will also interface with the regional and sub-regional entities. In addition, SRP coordinates planning studies through WECC.

For interconnection on its transmission systems with voltage levels that meet WECC Criteria, SRP coordinates with affected systems through WECC processes. These include the Regional Planning Project Review, Project Rating Review, and Progress Reports. The Regional Planning Project Review is intended to inform others entities of the opportunity to participate in or review a project and solicit participation. The Project Rating Review is intended to ensure that new projects are integrated into the existing system while recognizing protected ratings of other facilities. The Progress Reports allow SRP to report potential significant additions and changes to the interconnected system; WECC members can review and comment on the additions or changes. The objectives of these WECC processes are to:

1. adequately communicate project plans, performance and limitations to all affected parties during the period from project inception to commercial operation.
2. provide the opportunity for owners of existing or future facilities that may be affected by the project to participate in review of the project studies.
3. integrate projects into the existing system in a manner that will preserve interconnected system reliability and operating efficiency.

Joint studies are included, and these WECC processes apply to the interconnection of generation, transmission, and load.

The Western Arizona Transmission System (WATS) Task Force consists of various utilities and acts as the planning and operating technical study group for Mead-Phoenix, Arizona Nuclear Power Projects (ANPP) and Navajo System Projects. The task force reviews all study work and provides technical feedback for any proposed interconnection to the transmission systems within WATS. The task force is to maintain all projects’ capability while allowing all interconnections that do not adversely impact capability. SRP is involved in the WATS Task Force as it operates and owns some of the transmission systems within WATS. Through this task force, SRP implements joint studies to ensure that any new interconnections of generation, transmission or load do not negatively impact reliability.

If joint studies for interconnection do not fall within the realm of the aforementioned WECC processes and WATS Task Force, SRP will coordinate with affected systems in a review that is similar to the WECC.

The system impact studies will be coordinated with neighboring transmission system owners/operators as appropriate. As a minimum, all interconnected neighbors and other impacted parties will be notified of significant transmission system additions or modifications upon execution of an Interconnection and Operating Agreement (or other contract or legal document that indicates the intent to proceed with the system addition or modification). In
addition, significant additions and modifications will be reflected in the power flow models as submitted by SRP to the regional reliability organization. These additions and modifications will also be identified in the regional transmission system assessments as appropriate. More details concerning coordination, study procedures, and criteria used to determine acceptable performance can be found in SRP document Guidelines for Electric System Planning.

The scope of all the above system impact studies will be determined by SRP based on the type, location, and power level of the proposed facility. Normally, SRP will perform the system impact studies. The cost of these studies will be chargeable to the Interconnection or End-User in accordance with SRP Open Access Transmission Tariff. Report(s) documenting the assumptions, results, and conclusions of the system impact studies are made available to the Interconnection or End-User.

SRP must be notified of new facilities, upgrades, or additions such as an increase in load or generating capability to existing facilities connected to the transmission system within the SRP Balancing Area. System impact studies are to be conducted to determine the need for any upgrades of transmission equipment or transmission system addition to accommodate the changes in the connected facility.

Information Required for Transmission or End-User

As soon as available, the entity wishing to connect to SRP shall provide the following information for review and comment by both the Transmission Planning and the Transmission and Generation Operations groups at SRP.

   a) Connecting entity Information – company name, mailing address, contact representative and phone number

   b) Project Design/Engineering Information – company name, mailing address, contact representative and phone number

   c) Requested in-service date for the transmission connection, and a date for temporary service to test facilities prior to formal in-service.

   d) Plot plan or description showing exact location and orientation of the proposed facilities and point of electric service delivery

   e) One-line, schematic diagrams, plan and elevation drawings of the proposed facilities showing dimensions, clearances, and grounding layout

   f) Information on characteristics of load, including initial load build-up, 5 and 10 year load projections, and power factor of such loads

   g) Information concerning the power factor correction equipment. This information should include size and amount of fixed or switched capacitors, or other power factor correction equipment and methods used for operation.

Revision 9
Effective Date: Jul 24, 2018
At least three months before starting electrical construction of the proposed facility, the following additional information must be sent to SRP’s Manager of System Operations. Failure to provide this information in a timely manner may delay the facility in-service date.

h) Data on equipment to be installed

i. High side interrupting and sectionalizing devices – Manufacturer, type, voltage rating, and current ratings

ii. High side relaying equipment – Complete manufacturer’s data

iii. Power transformer – Complete nameplate and test report data, including manufacturer, serial number, high and low side voltage taps, kVA ratings, high and low side connections, low side grounding (if used), load loss watts and positive-and zero-sequence impedances between the high-low, high-tertiary, and low-tertiary transformer windings (as applicable) at each tap.

i) Data on low voltage protection equipment, including fuses, breakers, relays, and relay settings

The information in subsections h and i is required to perform coordination selectivity studies in a timely manner. Any disagreement in this regard must be resolved prior to energization.

Depending upon the nature of the connecting entity equipment to be installed, the following data may be required to complete the portion of the system impact studies addressing power quality and/or subsynchronous torsion interactions.

j) Data on the harmonic and sub-harmonic current/voltage spectra of the equipment to be installed under three phase balanced and unbalanced conditions.

k) Maximum magnitudes (MW and MVAR) of sudden load swings at the point of connection and the number of such fluctuations per second, minute or hour.

l) Data on SVC equipment and harmonic filters if applicable.

m) Maximum expected MW and MVAR demand at the point of connection.

**Initiating a Transmission or End-User Facility Connection or Facility Change**

The following table outlines the SRP personnel to be contacted with regard to any request for a new facility connection or significant change to an existing connected facility.

<table>
<thead>
<tr>
<th>Type of Customer To be Connected</th>
<th>Service or Activity Required From SRP</th>
<th>SRP Contact</th>
</tr>
</thead>
</table>

7

Revision 9
Effective Date: Jul 24, 2018
Following the initial contact regarding a proposed Interconnection or End-User facility connection, when the proposed location and power level are established, a plan of service is prepared and system impact studies are undertaken by SRP. The information needed to develop a plan of service and to conduct the system impact studies is identified in this document and should be provided to SRP at this point. The system impact studies may, as noted above, identify additional requirements for reliability beyond the minimum requirements covered by this document.

SRP approval of a proposed facility or facility change is contingent upon a design review of the proposed connected facility. Operation of a connected facility is also subject to continuing compliance with all applicable construction, maintenance, testing, protection, monitoring, and documentation requirements described herein, as well as the applicable NERC Standards and WECC Documents noted herein.

Interconnection and End-Users may be responsible for the costs associated with connecting to the SRP Transmission System.

The information contained herein is subject to change and may be revised at any time.

3.0 Voltage Level and MW and Capacity/Demand

Load Following/Remote Control Functions/Automatic Generation Control (AGC)

Specific provisions for load following and/or remote control functions will be considered on a case-by-case basis. When related to a transmission service request, the SRP OATT will apply. If any generator is to provide load following services to SRP, the output must be remotely controllable under direction of the SRP automatic generation control (AGC) in response to system needs. The generator owner must provide an interface compatible with SRP’s AGC control mechanism. Provisions for AGC should be included in an Interconnection Agreement between the connecting entity and SRP. SCADA telemetry will be required to support AGC.

Reactive Power Output and Power Factor

In order to maintain transmission voltages on SRP’s transmission facilities within acceptable limits, generating facilities and non-generation resources capable of providing reactive power that are under the control of the balancing area operator must be operated to produce (or absorb) reactive power as required by SRP’s transmission facilities. All transmission customers taking service from SRP under the OATT must obtain reactive supply and voltage control from generation or other sources service from SRP for each transaction on SRP’s
transmission facilities. The amount of reactive supply and voltage control from generation or other sources service that must be supplied with respect to the transmission customer’s transaction will be determined based on the reactive power support necessary to maintain transmission voltages within limits that are generally accepted in the region and consistently adhered to by SRP. In general, generating facilities power factor design limitation minimum requirement shall be a reactive power capability sufficient to maintain a composite power delivery at the Points of Interconnection at a power factor between 0.95 leading and 0.95 lagging.

Capacitor additions at the generator switchyard may be necessary to meet the reactive requirements. The use of capacitors will require specific studies and be evaluated on a case-by-case basis.

In addition, individual generators in the generation facility must make available the full steady-state over- and under-excited reactive capability given by the manufacturer’s generator capability curve at any MW dispatch level. This requirement should be considered in all internal generator designs (including transformer ratings/taps/impedances, cooling systems, generator/exciter rating). In general, the generation facility must be capable of continuous non-interrupted operation within a steady-state voltage range during system normal and single facility outage conditions. This range is from 91.7% to 105.8% range.

All reasonable measures should be taken to avoid tripping of the generation facility due to high or low voltage. Specification of the generator voltage schedule will be determined under the direction of the SRP Control Center. A steady-state deviation from this schedule between +0.5% to –0.5% of the nominal voltage will be permissible.

Transmission interconnected equipment shall have the tap ranges and self-regulation necessary to accommodate the transmission system’s reactive power flow requirements.

Minimum Operating Capability

The minimum operating capability required will be determined based on limits that are generally accepted in the region and consistently adhered to by SRP.

Black Start Capability

The provision of black start capability may be required or desirable. A black start capable generation facility is one that can be started without the aid of off-site power supplied from the Transmission System.

Automatic Underfrequency Load Shedding

SRP may require automatic under frequency load shedding relaying on connected loads to comply with NERC and/or WECC requirements or other system stability considerations. SRP, as a WECC member, is obligated to have an automatic under frequency load shedding plan in effect that meets WECC requirements. Connecting parties without an automatic under frequency load shedding plan meeting WECC requirements may need to
install under frequency relaying at the request of SRP. The amount of load to be shed and the frequency set-points will be specified by SRP as required meeting WECC under frequency load shedding compliance.

**Manual Load Shedding**

End-User’s facilities may be subject to SRP’s Emergency Operating Plan that can require interruption of load to deal with generation deficiencies and/or transmission system emergencies. It is noted that interrupting of load will only be done in extreme conditions that would result in a more serious degradation of system performance than if the load were not shed.

**Other Load Shedding**

Other load shedding such as over-voltage is not required at this time. However, other automatic load-shedding system may be required in the future.

**Power System Stabilizer**

Studies may identify the need for the use of power system stabilizers, depending on the plant size, excitation system type and settings, facility location, area transmission system configuration and other factors.

**Excitation Control**

All generation control system settings should be coordinated with, and approved by, SRP. It may be necessary to coordinate generator settings to ensure proper operation of the SRP under frequency load shedding program. In addition to the normal excitation system and automatic voltage regulation equipment, the following controls are also required for each synchronous generator.

Overcurrent Limiter: The excitation system is to be provided with a current limiting device which will supersede or act in conjunction with the AVR to automatically reduce excitation so that generator field current is maintained at the allowable limit in the event of sustained under-voltages on the transmission system. This device must not prevent the exciter from going to and remaining at the positive ceiling for 0.1 seconds following the inception of a fault on the power system.

Underexcitation Limiter: A limiter to prevent instability resulting from generator underexcitation is required.

Speed Governing: All synchronous generators shall be equipped with speed governing capability. This governing capability shall be unhindered in its operation consistent with overall economic operation of the generation facility. Overspeed protection in the event of load rejection is the responsibility of the connecting entity.
Sub-Synchronous Torsional Interactions or Resonances: The provision of high speed reclosing following transmission line faults may result in excessive torsional duties. The connecting entity must provide SRP with immunity from damaging torsional oscillations resulting from all SRP Transmission System operations, and insure the turbine generator is not excited into resonance by normal system operations.

**Mode of Frequency/Voltage Control**

The connecting entity’s generating facility shall operate with its speed governor and voltage regulators in automatic operation. If the connecting entity’s speed governor and voltage regulators are not capable of such operation, the connecting entity shall immediately notify SRP.

**Speed Droop Setting**

The droop setting of any generator connecting to the SRP system will be considered on a case-by-case basis and shall be coordinated with SRP.

**Generator Step-Up Transformers**

SRP has the right to require tap changes be made to step-up and auxiliary transformers to ensure voltage schedules and reactive requirements can be met.

**Coordination with Appropriate Operating Entity**

Any entity connecting to the SRP transmission system must coordinate appropriate data, processes, operating procedures, and any other information as necessary to reliably operate the system and to comply with applicable codes, standards (including NERC and WECC), federal and state regulations, environmental regulations, citing requirements, contracts, operating agreements, and NERC/WECC reporting requirements.

**Generator Frequency Range**

The connecting entity’s generating facility will provide a balanced, symmetrical, three phase interchange of electrical power with the SRP Transmission System at a nominal frequency of 60 Hz. The generation facility must be capable of continuous, non-interrupted operation in the frequency range of 59.5 to 60.5 Hz. Limited time, non-interrupted operation is also expected outside this frequency range in accordance with the generator manufacturer’s recommendation.

**Transmission System Frequency Range**

The SRP transmission system typically operates at a nominal 60 Hz with a variation of +0.05 Hz to −0.05 Hz. Under certain emergency conditions, the transmission system may operate for a period of time outside of this range. The Requester is responsible for providing any frequency sensing equipment required to protect their facility during abnormal frequency operation.
Transmission Impacts

All proposed connections shall consider the impact on adjacent areas voltage and reactive power flow requirements. These impacts should be identified in the study process and discussed or coordinated with the potentially impacted system(s). Any additional upgrades required to mitigate these impacts will be the responsibility of the connecting entity.

4.0 System Protection/Breaker Duty

Breaker Duty and Surge Protection

SRP will be responsible for supplying the ultimate fault duty for appropriate sizing of Power System Breakers. The fault duty that is given by SRP will be the maximum fault duty foreseen by the end of the 6 year system plan or study. The responsibility for future upgrades that may increase this fault duty and thus require either upgrading or replacing the existing breakers will be the responsibility of the party requesting the system upgrade.

SRP has specific standards for surge protection. The connecting entity will be required to meet these standards. See Appendix 1 for SRP’s Apparatus Design Requirements for Surge Arrestors (Extracted from SRP Substation Design and Construction Standards - Chapter 20, Standard 20-1.20).

System Protection and Coordination

SRP has established protection standards established in the System Protection Relay Design Standards. These standards include redundant and backup protection systems. SRP’s standards require 3 independent Line Relaying Protection Systems for 500 KV Lines with a minimum of two independent communication paths. It also requires dual primary redundant systems for 230 KV Lines, 230/69 KV Transformers, 500/230 KV Transformers and all Generators over 20 MVA. These standards should provide guidance for requirements that any project would have to meet in order to interconnect with SRP’s grid. SRP has used several relay manufacturers but our standard is GE or SEL relays. SRP requires that the relays have equivalent functionality to these relays such as a nonproprietary communication interface for both local and remote communications. However, every project will need to be evaluated prior to design start to verify that there are not unusual configurations that would require special protection systems such as Remedial Action Schemes or special transfer schemes.

Protective Relay settings must be provided and coordinated with SRP prior to commissioning. These settings should be provided in electronic format and documented by SRP for achieving compliance with PRC-001-1 Req. 3.1 and 3.2. SRP will provide any necessary resources to review and provide technical assistance for establishing proper coordination of these settings. SRP will not allow a project to start the commissioning process without complete agreement on these issues. SRP reserves the right to deny energization of the project if it feels that the protective relay settings and systems do not meet the minimum standards and would place our system and or customers at risk.
SRP will provide functional specifications and relay settings for all protective relays at the Requester’s facility that have a potential impact on the reliability of the SRP Transmission System. The criteria for these functional specifications and settings will be based on existing SRP protection practices. SRP reserves the right to specify the type and manufacturer for these protective relays. The specific recommendations and requirements for protection will be made by SRP based on the individual substation location, voltage and configuration. While SRP will endeavor, where possible, to anticipate system changes which may affect system protection needs and requirements, SRP does not assume responsibility or liability with respects to such protective devices nor guarantee their continuing adequacy against increased interrupting capacity requirements resulting from system changes. Any equipment replacements or upgrades to maintain adequacy of the protection system will be at the requestor’s expense.

The resulting system protection system must provide the highest level of public safety possible and prevent or minimize equipment damage. The protection system should be designed to minimize equipment outage time, to minimize the outage area, and to minimize system voltage disturbances.

All protection system requirements, including maintenance and testing, apply to equipment used for protecting the system during normal and abnormal conditions.

To ensure the proper design of the protection system, system studies and other analyses will be necessary prior to placing any new facilities in service. These studies may include grounding, short circuit, stability, power quality, and coordination of protective devices. These studies will be performed by SRP or under the direction of SRP. The cost will typically be the responsibility of the requestor. Specific communication and RTU information can be found in Section 5.0.

System Protection

The connecting entity is responsible for providing adequate protection to SRP facilities for conditions arising from the operation of the connecting entity’s facilities under all SRP transmission system operating conditions. The requester is also responsible for providing adequate protection to their facility under any SRP transmission system operating condition whether or not their generation is in operation. Conditions may include but are not limited to:

1. single phasing of supply,
2. transmission system faults,
3. equipment failures,
4. abnormal failures,
5. lightning and switching surges,
6. excessive harmonic voltages,
7. excessive negative sequence voltages,
8. separation from supply,
9. synchronizing generation,
10. re-synchronizing the Owner’s generation after electric restoration of the supply.

**Interrupting Device – Generation**

A three-phase circuit breaker with SRP approved relaying systems shall be installed to isolate the generation facilities from the SRP supply for all faults, loss of SRP supply, or abnormal operating conditions regardless of whether or not the connecting entity’s generation is in operation. This device shall be capable of interrupting the maximum existing and future available fault current at that location. The three-phase device shall interrupt all three phases simultaneously. The tripping control of the circuit interrupting device shall be powered independently of the utility AC source in order to permit operation upon loss of the SRP transmission system connection.

The specific reclosing times for the connecting entity’s circuit interrupting device will be provided by SRP. It is the connecting entity’s responsibility to design and maintain their interrupting device(s) to properly isolate generation upon loss of the SRP connection until the appropriate SRP facilities are returned to service. Synchronizing of generation to the SRP Transmission System may be, at SRP’s discretion, performed under the direction of the SRP Control Center. All manual or automatic synchronization must be supervised by a generator sync check relay. In addition, sync scopes are required at all transmission substations and generation switchyard to allow reconnection of islanded areas.

**Disconnecting Devices – Transmission or End-User**

A three phase air break switch or a three-pole single-throw disconnect switch shall be installed on each transmission line supply entrance to the connecting entity’s facility and be accessible at all times. This device shall be capable of withstanding momentary fault current. The disconnecting device shall be mechanically lockable in the open position with an SRP padlock in order to provide for a visible electric isolation of the connecting entity’s facility and shall be identified with an SRP designated equipment number.

**Parallel Generation Facility**

The following utility-grade relays shall be provided by the connecting entity for protection of the SRP system. All relays specified for the protection of the SRP system, including time delay and auxiliary relays, shall be approved by SRP. Relay operation for any of the listed functions shall initiate immediate separation of the connecting entity’s generation from the SRP Transmission System.

<table>
<thead>
<tr>
<th>Relay</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>To detect under frequency and over frequency operation.</td>
</tr>
<tr>
<td>Overvoltage</td>
<td>To detect overvoltage operation.</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Undervoltage</td>
<td>To detect undervoltage operation.</td>
</tr>
<tr>
<td>Ground Detector</td>
<td>To detect a circuit ground on the SRP system (applicable to three phase circuits only).</td>
</tr>
<tr>
<td>Directional Overcurrent</td>
<td>To detect the directional flow of current in excess of a desired limit.</td>
</tr>
<tr>
<td>Transfer Trip Receiver</td>
<td>To provide tripping logic to the generation for isolation of the generation upon opening of the SRP supply circuits.</td>
</tr>
<tr>
<td>Directional Power</td>
<td>To detect under all system conditions, a loss of SRP primary source. The relay shall be sensitive enough to detect transformer magnetizing current supplied by the generation.</td>
</tr>
</tbody>
</table>

The purpose of these relays is to detect the connecting entity’s energization of an SRP circuit that has been disconnected from the SRP system, to detect the generation operating at an abnormal voltage or frequency, or to detect a fault or abnormal condition on the SRP system for which the connecting entity shall separate their generation.

Output contacts of these relays shall directly energize the trip coil(s) of the generator breaker or an intermediate auxiliary tripping relay which directly energizes the breaker trip coil(s). The relaying system shall have a source of power independent from the AC system or immune to AC system loss or disturbances (e.g., DC battery and charger) to assure proper operation of the protection scheme. Loss of this source shall cause removal of the generation from the SRP system.

The protective relays required by SRP and any auxiliary tripping relay associated with those relays shall be utility-grade devices.

Utility grade relays are defined as follows:

2. Have relay test facilities to allow testing without unwiring or disassembling the relay.
3. Have appropriate test plugs/switches for testing the operation of the relay.
4. Have targets to indicate relay operation.
SRP will specify settings for the SRP-required relays to assure coordination between the generation protective equipment and the SRP system relays. It is the connecting entity’s responsibility to determine that their internal protective equipment coordinates with the required SRP protective equipment and is adequate to meet all applicable standards to which the generation is subject. SRP further reserves the right to modify relay settings when deemed necessary to avoid safety hazards to utility personnel or the public and to prevent any disturbance, impairment, or interference with SRP’s ability to serve other connecting entities.

**SRP Facilities**

If at any time it is determined that the use of the above relay systems cannot provide adequate protection to the SRP system, the connecting entity shall furnish and install upon the request of SRP, a transfer trip receiver(s) at its facility to receive tripping signals originating from an SRP location(s). This additional protection would also necessitate the purchase and installation of transfer trip equipment at the SRP location(s) and a communication channel between the SRP location(s) and the generation facility.

**Other Protection Requirements**

The following items should be coordinated with each other.

- Volts/Hz and overexcitation protection-limiting.
- Loss-of-excitation and underexcitation limiting.

Any required remote trip schemes must be closely coordinated and approved by SRP. In addition, underfrequency load shedding schemes, undervoltage load shedding schemes, and/or special protection schemes may be required to meet NERC, WECC, or other regulatory requirements. Any such protection scheme will require close coordination with SRP as well as SRP approval prior to placing any such facilities in service.

**Short Circuit Data & Interrupting Device Ratings**

The following estimated short circuit levels will be provided by SRP at the point of delivery.

- Estimated Initial Short Circuit Levels (Year)
  
  3 Phase Fault = ____ MVA ANSI X/R Ratio = ______
  
  Phase-to-Ground Fault* = ____ MVA ANSI X/R Ratio = ______

- Estimated Future Short Circuit Levels (Year)
  
  3 Phase Fault = ____ MVA ANSI X/R Ratio = ______
  
  Phase-to-Ground Fault* = ____ MVA ANSI X/R Ratio = ______
*Note: Phase-to-ground fault values are calculated assuming the Requester’s transformers have either an ungrounded-wye or delta connected high side. For wye grounded transformers, the transformer contribution to the total fault current will have to be taken into account and the fault values recalculated.

Interconnection and End-Users equipment should have adequate interrupting and momentary ratings for the existing and future short circuit conditions listed above.

While SRP will endeavor, where possible, to anticipate system changes which may affect these values, it does not assume responsibility or liability with respects to such protective devices, nor guarantee their continuing adequacy against increased interrupting capacity requirements resulting from system changes. Interconnection and End-Users who use this information should periodically review existing and future fault conditions and equipment ratings for adequacy. Any equipment replacements or upgrades to maintain adequacy of the interconnection or end-users’ facilities will be at the interconnection or end-users’ expense.

All gas insulated protective devices within the Requester’s facility having a direct connection to an SRP transmission line shall be equipped with a low gas pressure alarming/tripping/lockout scheme as appropriate for the particular device.

**Transformer Surge Protection (Lightning Arresters)**

Lightning arresters protecting transformers are station class and may be either polymer or porcelain design and mounted on the transformer, except for 525 kV arresters which are pedestal mounted. However, since lightning arresters can adequately protect equipment some distance from the arresters, the overall number of lightning arresters required in each design can be reduced. Lightning arrester allowable separation distance from the equipment being protected is based on Table 4 of IEEE Std. C62.22. Consult manufacturer’s catalog for details concerning arrester protective characteristics, ratings, and application.

**5.0 METERING AND TELECOMMUNICATIONS**

**Voice Communication Circuit – Generator**

The connecting entity will be required to establish a dedicated voice communication circuit to the SRP Control Center to permit coordination of the synchronization and operation of the generation.

**Voice Communications – General**

Normal – At SRP’s request, the connecting entity shall provide a dedicated voice communication circuit to the SRP Control Center. Such a dedicated voice communication circuit would originate from the connecting entity’s office staffed 24 hours a day and would be typically required for generation facility synchronization and operation within SRP’s Balancing area.
All other normal voice communication concerning facility operations shall be conducted through the public telephone network to the Control Center phone number(s) issued by SRP.

Emergency – Voice communication in the event of a transmission system or energy emergency shall use the dedicated voice circuits, or public telephone network and phone number(s) designated for emergency use.

In the event of a transmission system or energy emergency, the connecting entity may be notified by the SRP Control Center. Specific instructions may also be given regarding the operation of the connecting entity’s unit(s) depending on the nature of the emergency. These instructions may consist of voltage schedule changes, real and/or reactive dispatch changes, or instructions to shut down or start-up the Owner’s unit(s). It is the Owner’s responsibility to ensure that the unit operators follow all instructions given by the SRP Control Center during system emergencies.

At the discretion of SRP, generation control facilities and supervisory control and data acquisition of specific electrical devices from the SRP Control Center may be necessary to integrate the generation into SRP's balancing area. Such additional facilities, including required communication channels, shall, if required, be furnished and installed by the connecting entity.

The requirement for data acquisition and control will depend on the generation capacity or load size, system location, and voltage of connection, and the net generation input into SRP System. In all cases, the equipment shall allow SRP to meet all industry standards that apply to SRP as a balancing authority, planning authority, transmission owner and operator and any other applicable classification. Data acquisition and control information will typically include, but not be limited to:

1. desired generation MW set point,
2. automatic generation control status (on, off),
3. generator availability,
4. generation MW, Mvar output,
5. generator minimum and base MW capability,
6. generator MW AGC high limit and low limit,
7. connection facilities’ breaker status/control/alarms,
8. connection facilities’ MW and Mvar line values and bus voltage, and generator and substation metering (MWh) data.
9. voltage
Revenue Metering

SRP approved revenue class metering equipment shall be installed to meter the aggregated load of the connected facility consisting of instantaneous bi-directional real and reactive power and integrated hourly real and reactive energy metering.

The metering equipment will include exclusive-SRP use, revenue grade, potential and current transformers, meters and test switches. The metering equipment will be tested periodically as defined in the service agreement and the test results will be available to all involved parties. The meters, test switches and wiring termination equipment will be sealed and the seal may be broken only when the meters are to be tested, adjusted or repaired. Proper authorities from both parties will be notified when seals are broken.

Three metering elements will be used to measure all real and reactive power crossing the metering point. Bi-directional energy flows including watt-hour and var-hour will be separately measured on an hourly basis. Appropriate demand quantities will be metered in terms of kilowatts, kilovars, or kilovolt-amperes.

The instrument transformers used for revenue metering shall be installed on the transmission provider’s side of the Requester’s transformer. Under special circumstances and with written approval granted by SRP, revenue metering may be performed on the customer side of the transformer.

Written approval shall only be given if the Requester can provide accurate transformer loss compensation data from the manufacturer to be programmed into the revenue metering when instrument transformers are installed on the customer side of the transformer.

Telemetry

Suitable telemetry equipment will be installed at the metering point to provide real-time telemetry data to SRP and to all other participating parties.

Telemetry equipment will include transducers, remote terminal units, modems, telecommunication lines, and any other equipment of the same or better function. The remote terminal unit, or equivalent device, must have multiple communication ports to allow simultaneous communications with all participants. That device will accommodate data communication requirements specified by each host system, including communication protocol, rate and mode (either synchronous or asynchronous). All metered values provided to the telemetry equipment will originate from common metering equipment. All transducers used for telemetry will have at least 0.2 percent accuracy. As part of real-time data to be provided, SRP has the right to require the status and remote control of switching devices at the Receipt and/or Delivery Points.

A continuous, accumulating record of megawatt-hours and megavar-hours will be provided by means of the registers on the meter. Freezing accumulation data transmission will be
taken every clock hour. The freezing signals must be provided by only one agreed-upon party.

If the freeze signal is not received within a predefined time window, the remote terminal unit, or equivalent device, will be capable of freezing data with its own internal clock.

The metering and telemetry equipment will be powered from a reliable power source, such as a station control battery, in order to allow the equipment to be continuously operational under any abnormal power supply situations. Proper surge protection will be provided for each communication link to protect communication hardware from ground-potential-rise due to any fault conditions. When realtime telemetry is required, a back-up data link must be provided in case of the outage of the primary telemetry line. The back-up link can be a data communication link between involved control centers; the party requesting service is responsible for furnishing the back-up link.

**Additional Metering and SCADA Information**

Requirements for data protocol, the mode of data transmission (e.g. fiber optic, microwave, etc.), control functionality, and maintaining continuity (dual DC sources, dual port RTU, etc) pertaining to metering and SCADA will be determined on a case-by-case basis by SRP. Any requirements imposed by SRP will not exceed those imposed for internal SRP projects unless special reliability or regulatory requirements necessitate more stringent requirements. Additional meter information and requirements for generator connecting to the SRP transmission system is contained in the SRP Large Generator Interconnection Agreement.

### 6.0 GROUNDING AND SAFETY ISSUES

**General**

All work performed by an entity connecting to the SRP transmission system that may reasonably be expected to affect SRP shall be performed in accordance with Good Utility Practice and all applicable laws, regulations, and other requirements pertaining to the safety of persons or property. A Party performing work within the boundaries of the other Party’s facilities must abide by the safety rules applicable to the site.

**System Grounding**

The specific grounding of the connecting entity’s system at the transmission voltage level will be considered on a case-by-case basis. Grounding studies will be necessary and shall be provided to SRP. This is intended to ensure compatibility with the SRP system and connection of the grounding systems. In general, the grounding system should be designed in accordance with IEEE Standard 80 – latest revision, “IEEE Guide for Safety in AC Substation Grounding.” In evaluating the step and touch potential the target body weight value should be set to 50 kg.
As a minimum, a protective grounding loop shall be provided for switches. Under certain conditions, a detailed engineering assessment study may be necessary. This will be determined on a case-by-case basis.

Specifics regarding maintenance/testing, construction techniques and inspections, transmission shielding, cathodic protection, and other items will be considered on a case-by-case basis.

Temporary Protective Grounding

Temporary protective grounding as appropriate for construction, repairs, or maintenance in substations and switchyards shall be performed utilizing procedures which comply with OSHA 1910.269.

Facility Fence Safety Clearances

The fence safety clearances in the Requester’s facility shall comply with Section 11 of IEEE C2, “National Electrical Safety Code.”

Switching

All personnel who are using the operating handles on disconnect switches on energized lines and equipment shall use the appropriate personal protection equipment as required by all applicable regulatory bodies and safety procedures. Before operating, the switch and ground arrangement shall be visually checked.

Electrical safety clearances

Clearance from live parts in the substation or switchyard shall comply with NESC (IEEE C2), Rules 110, 124, 232, 233, and 234. Safe approach distances shall be maintained by persons in the substation or switchyard according to the provisions of OSHA 1910.269.

If the incoming high voltage lines will cross road ways or railroad tracks, such as a siding or main line, to reach the Requester’s facility, it may be necessary to increase the tensions or provide additional height on the structure to meet appropriate crossing requirements. Structural strength and clearance requirements are identified in the NESC and in the SRP Electrical Clearance Standards.

The point of attachment of the line entrance conductors shall be of sufficient height to meet all applicable clearance requirements for the proposed line configuration, including crossings over public streets, alleys, or roads in urban or rural districts, as outlined in the NESC.
In addition, the minimum vertical clearance of the conductors above ground and the vertical and horizontal clearance of conductors passing by but not attached to a structure (building, wall, pole, sign, grain bin, etc) shall be in accordance with the NESC, applicable state and local codes, and SRP Electrical Clearance Standards.

**Fire Mitigation**

All substations and switchyards shall incorporate appropriate fire mitigation measures per the guidelines of IEEE 979. Work in the substation and switchyard areas shall meet the cleanliness standards of IEEE 979 in order to mitigate any fire hazards as much as possible.

**Environmental Hazards**

The connecting entity shall notify SRP, first orally and then in writing, of the release of any Hazardous Substances, any asbestos or lead abatement activities, or any type of remediation activities, each of which may reasonably be expected to affect SRP, as soon as possible but not later than twenty-four (24) hours after the entity becomes aware of the occurrence, and shall promptly furnish to SRP copies of any reports filed with any governmental agencies addressing such events.

All substations and switchyards shall incorporate appropriate mitigation of environmental hazards, in particular:

- Oil containment and control of oil spills shall be incorporated per IEEE 980.
- SF6 gas control and handling shall be implemented per EPA SF6 Emission Reduction Partnership Guidelines documents found at <http://www.epa.gov/electricpower-sf6/resources/index.html#nine>

**Operating Clearances and Hold Tags**

All work on equipment shall be performed using appropriate operating clearance and hold tag (lockout-tagout) procedures in compliance with OSHA 1910.269.

**Non-Qualified Personnel**

All Non-qualified personnel shall be escorted and supervised by qualified persons at all times in substations, switchyards, and control buildings per the requirements of OSHA 1910.269

**Enclosed Spaces**

All entries into enclosed spaces in substations and switchyards shall be performed by qualified persons and in conformance with the provisions of OSHA 1910.269.

7.0 INSULATION AND INSULATION COORDINATION

Power system equipment is designed to withstand voltage stresses associated with
expected operation. Adding or connecting new facilities may change equipment duty, and may require that equipment be replaced or switchgear, telecommunications, shielding, grounding, or surge protection added to control voltage stress to acceptable levels. Voltage stresses, such as lightning or switching surges, and temporary over-voltages may affect equipment duty. Remedies will depend upon the equipment capability and the type and magnitude of the stress. Interconnection Customer shall make available to SRP all drawings, specifications, test plans, application documents, and equipment settings.

8.0 VOLTAGE, REACTIVE POWER, AND POWER FACTOR CONTROL

Voltage Range – Generator

In general, the generation facility must be capable of continuous non-interrupted operation within a steady-state voltage range during system normal and single facility outage conditions. This range is from 91.7% to 105.8% range. All reasonable measures should be taken to avoid tripping of the generation facility due to high or low voltage. Specification of the generator voltage schedule will be determined under the direction of the SRP Control Center. A steady-state deviation from this schedule between +0.5% to –0.5% of the nominal voltage will be permissible.

Voltage Range – Transmission and End-User

All connected facilities on SRP Transmission System should expect voltage levels which generally range between 91.7% and 105.8% of nominal under system normal conditions and single transmission element outage conditions. If the Requester’s supply voltage requirements are more restrictive than the 91.7% to 105.8% range, SRP recommends that the Requester consider the addition of voltage regulation equipment in their facility. Nominal transmission system voltages presently on the SRP system are: 500kV, 230kV, and 115kV. For nominal 500kV, the factors should be multiplied times the normal operating voltage of 525kV.

Under certain emergency conditions, the SRP Transmission System may operate for a period of time outside of the 92% to 105% range. The Requester is responsible for providing any voltage sensing equipment required to protect their equipment during abnormal voltage operation.

Transmission interconnected equipment shall have the tap ranges and self-regulation necessary to accommodate the transmission system’s reactive power flow requirements.

Net Demonstrated Real and Reactive Capabilities

The Net Demonstrated real capability must be provided to SRP annually in accordance with NERC standards and WECC supplements or guidelines. SRP reserves the right to witness these tests.
In addition, individual generators in the generation facility must make available the full steady-state over- and under-excited reactive capability given by the manufacturer’s generator capability curve at any MW dispatch level. This requirement should be considered in all internal generator designs (including transformers, tap settings, motor and other loads, generator/exciter, voltage regulator). Tests which demonstrate this capability must be conducted in a manner and frequency that is in accordance with NERC standards and WECC supplements or guidelines. Such documentation shall be provided to SRP. SRP reserves the right to witness these tests.

**Reactive Compensation**

A circuit should be provided in the automatic voltage regulator (AVR) to permit the control of voltage beyond the generator terminals. This is known as reactive line drop compensation. The point of control is to be adjustable over a range covering 0 to 15% reactance (on the generator base) beyond the generator terminals. The specific requirements for reactive compensation, voltage regulator droop compensation for generators whose terminals are directly connected, and voltage regulators will be considered on a case-by-case basis. In general, any reactive compensation devices will be evaluated to ensure proper coordination with the SRP system.

**Power Factor**

The NERC Planning Standards state 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 SRP interpretation of “close to unity power factor” is that the power factor of the connected load should be within the range of approximately 0.90 lagging to 0.90 leading. The generating facility power factor design limitation minimum requirement shall be a reactive power capability sufficient to maintain a composite power delivery at the Points of Interconnection at a power factor between 0.95 leading and 0.95 lagging.

An End-User will be assessed a penalty for power factors below 90% (leading or lagging) at the time of the end-user peak demand.

Capacitors generally provide an effective means of controlling the power factor of a Requester’s facility. However, there are several factors that should be addressed in applying capacitors. These factors 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.

**Mode of Frequency/Voltage Control**

The connecting entity’s generating facility shall operate with its speed governor and voltage regulators in automatic operation. If the connecting entity’s speed governor and voltage regulators are not capable of such operation, the connecting entity shall immediately notify SRP.
9.0 POWER QUALITY IMPACTS

In general, the connection of a generator, transmission facility, or end-user shall not unacceptably compromise or degrade the power quality of an existing customer. The installation of power quality monitoring equipment by SRP at the requestor’s expense may be necessary to verify compliance with power quality performance requirements. Prior to connection of any facilities, SRP may require, at the requestor’s expense, a power quality study. A power quality study may include studies/evaluations of: voltage unbalance, voltage flicker, voltage fluctuation, harmonic distortion, transient overvoltage, temporary overvoltage, temporary undervoltage, insulation coordination, operating frequency, power factor range, and interruption/outage frequency. The studies may identify the need for additional equipment necessary to meet power quality standards. Additional specifics follow:

Harmonics/Voltage Flicker

Generators: The connecting entity shall take responsibility for limiting harmonic voltage and current distortion caused by their generation equipment. Limits for harmonic distortion (including inductive telephone influence factors) are consistent with those published in the latest issues of ANSI/IEEE 519, “Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.” SRP may require the installation of a monitoring system to permit ongoing assessment of compliance with these criteria.

The generator’s facilities and equipment shall not cause excessive voltage deviations nor introduce excessive distortion to the sinusoidal voltage waves as defined by IEC 61000-2-2 and EN 50160, or any applicable superseding electric industry standard. Voltage flicker levels are unacceptable if 85% of the long term flicker (Plt) exceeds a value of 1.0 in a one week measurement.

End-Users: Certain electrical equipment located at the End-User’s facility (arc furnaces, cycloconverters, etc.) will generate voltage flicker and harmonic distortion which can negatively impact other End-Users. Should this be the case, the End User shall take responsibility, initially or in the future, for limiting interfering levels of harmonic voltage and current distortion and/or voltage flicker. Limits for harmonic distortion (including inductive telephone influence factors) are as published in the latest issues of ANSI/IEEE 519, “Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.” Limits for voltage flicker are defined by IEC 61000-2-2 as a short term flicker (Pst) level of 1.0 and a long term flicker (Plt) level of 0.8.

SRP may, initially or in the future, require the installation of a monitoring system to permit ongoing assessment of compliance with these criteria. The monitoring system, if required, will be installed at the End-User’s expense.

Subsynchronous Torsional Interaction

Certain equipment installations may present a condition that could result in a subsynchronous resonance (SSR) situation that could damage other generation equipment
on the electric system. These situations will be analyzed by SRP, or an SRP consultant, and any appropriate corrective or preventive measures will be identified. Corrective and preventive measures may consist of torsional current monitoring at a defined point of compliance, special protective relaying on the turbine-generator shafts(s), or constrained operation of the End-User equipment under certain system configurations. Costs of studies and the design and installation of protective and/or monitoring equipment shall be the responsibility of the Requester.

Situations where high harmonic voltages and/or currents originate from the transmission system are to be addressed in the Connection Agreement.

Sensitive Electrical Equipment

Certain electrical equipment in the Requester’s facility may be sensitive to normally occurring electric interference from nearby connected loads in the Requester’s facility, from other End-Users connected to the power system, from natural causes, and system switching, etc. 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 Requester or the Requester’s consultant prior to installation. Attention should be given to the equipment’s tolerance to various forms of electric interference, including voltage sags and surges, momentary outages, transients, current and voltage harmonic distortion, or other electrical and electromechanical noise.

When electrical disturbances to sensitive electrical equipment such as computers, electronics, controls and communication equipment cannot be tolerated, the End-User shall install additional equipment as may be necessary to prevent equipment malfunctions and protect against equipment failure. The End-User should consult the supplier of such sensitive electrical equipment regarding the power supply requirements or the remedial measures to be taken to alleviate potential miss operation or failure of the equipment. The End-User may need to hire a power quality consultant to also perform a site survey of the electric power supply environment and furnish recommendations to provide the acceptable levels of reliability and quality of service.

10.0 EQUIPMENT RATINGS

As with all design elements that have the potential to impact the transmission system, SRP has the right to review the facility design and specifications prior to the connection to the SRP transmission system.

In most cases, the cost of any changes to the existing transmission system that are necessary due to the requestor’s project will be the responsibility of the requestor.

Size and Take-Off Tension of Line Conductors and Overhead Ground Wires

The Requester’s structure shall be designed in accordance with Rule 250 of the National Electric Safety Code (NESC).
The line terminal connectors furnished by the Requester should be aluminum conductor with a bolted connector compatible with SRP’s terminal pad. The overhead ground wire shall be connected to the Line Dead End Structure and the Line Dead End Structure shall be grounded using copper conductor connected to the ground grid.

Ratings of Current Carrying Equipment

For tap and looped connections, the Requester’s high voltage bus and associated equipment, such as switches, connectors, and other conductors shall have a minimum continuous current and momentary asymmetrical current ratings which: (1) do not limit the SRP Transmission system network capability and (2) have adequate capability for the initial and future system conditions identified by SRP.

Transformer Surge Protection (Lightning Arresters)

Lightning arresters protecting transformers are station class and may be either polymer or porcelain design and mounted on the transformer, except for 525 kV arresters which are pedestal mounted. However, since lightning arresters can adequately protect equipment some distance from the arresters, the overall number of lightning arresters required in each design can be reduced. Lightning arrester allowable separation distance from the equipment being protected is based on the most recent approved revision of IEEE Std. C62.22.

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

Disconnect Switch(es)

A group operated switch shall be installed on each transmission line supply entrance to the Requester’s facility and accessible to SRP’S personnel at all times. The switch shall be mechanically lockable in the open position with an SRP padlock in order to provide for a visible electric isolation of the Requester’s facility and shall be identified with an SRP designated equipment number.

Disconnect switches shall be three pole, single throw, group operated. Characteristics for all disconnect switches including voltage and BIL ratings, clearances and pole spacing shall meet the applicable requirements. There shall be no braids in the current carrying parts of the switch. Group operated switches shall be complete with a horizontal, rotating-type operating handle. A gear operated or motor operator may be installed instead of a horizontal operating handle. A grounding device is to be furnished for the operating shaft and shall consist of a tin coated, flexible copper braid, located as close as possible to the operating handle. The braid shall have a cross-sectional area equivalent to 4/0 copper cable, or greater. The braid shall be secured to the shaft by means a galvanized steel U-bolt clamp and associated cradle-type galvanized steel hardware. The opposite end of the braid shall have one (1) 9/16 inch hole. Both ends of the braid shall be stiffened and protected by a ferrule or additional tinning. For multi-revolution operating pipe a suitable braidless grounding device shall be supplied.
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.

Other Considerations

Special considerations for specific atmospheric, geological, seismic, or environmental conditions will be evaluated on a case-by-case basis.

11.0 SYNCHRONIZING OF FACILITIES

Synchronization

The connecting entity shall assume all responsibility for properly synchronizing their generation for operation with the SRP Transmission System. Upon loss of the SRP supply, the connecting entity shall immediately and positively cause the generation to be separated from the SRP system. Synchronizing of generation to the SRP Transmission System may be, at SRP’S discretion, performed under the direction of the SRP Control Center though normal voice communication consistent with procedures described in Section 15. All manual or automatic synchronization must be supervised by a generator sync check relay. In addition, sync scopes are required at all transmission substations and generation switchyard to allow reconnection of islanded areas.

Automatic transmission line reclosing must be coordinated with, and approved by, SRP. Specific prohibitions for reclosing will be determined on a case-by-case basis. Test plans must be consistent with NERC and other regulatory standards and provided to SRP for review and approval.

12.0 MAINTENANCE COORDINATION

All Requester owned equipment up to and including the first protective fault interrupting device is to be maintained and calibrated to NERC and SRP standards. The maintenance practices of all entities connected to the SRP transmission system should be performed at a level that ensures the reliability and continuity of service to the interconnected transmission system. Relevant maintenance records must be maintained. This may include transmission facilities, generation equipment, transformers, circuit breakers, circuit switchers, power fuses, instrument transformers, switches, surge arresters, bushings, metering, communication equipment, trip circuits, interrupters, grounding systems, relays, and associated equipment (including battery and battery charger). Details of SRP maintenance procedures will be provided on request.

The Requester shall have an organization approved by SRP test and maintain all devices and control schemes provided by the Requester for the protection of the SRP system. Included in the testing and maintenance will be any initial set up, calibration, and check out of the required protective devices, periodic routine testing and maintenance, and testing and maintenance caused by a Requester or SRP change to the protective devices.
If the Requester’s testing and maintenance program is not performed in accordance with SRP’S Standards, SRP reserves the right to inspect, test, or maintain the protective devices required for the protection of its system.

All costs associated with the testing and maintenance of devices provided by the Requester for the protection of the SRP system, including costs incurred by SRP in performing any necessary tests or inspections, shall be the responsibility of the Requester.

SRP reserves the right to approve the testing and maintenance practices of a Requester when the End-User’s system is operated as a network with the SRP Transmission System.

Necessary outages for transmission or generation equipment maintenance must be approved by SRP and should consider unit commitment obligations, other maintenance schedules, and the overall reliability of the transmission system. It may be necessary to coordinate the requested outage with the Reliability Coordinator or neighboring utilities. The connected entity is responsible to ensure all approvals and clearances are obtained and that proper notifications are made in the appropriate time-frame.

13.0 OPERATIONAL ISSUES

Frequency Variations

Frequency protection must include both an underfrequency function and an overfrequency function. Protection settings must in no instance interfere with the means implemented by SRP to restore system frequency following a disturbance. Frequency protection settings in power plants connected to the transmission system must comply with the steady state frequency range provided by SRP. Specific acceptable ranges will be determined on a case-by-case basis using accepted industry standards intended to maintain the reliability of the bulk transmission system. However, in general the following ranges apply:

Generator Frequency Range: The connecting entity’s generating facility will provide a balanced, symmetrical, three phase interchange of electrical power with the SRP Transmission System at a nominal frequency of 60 Hz. The generation facility must be capable of continuous, non-interrupted operation in the frequency range of 59.5 to 60.5 Hz. Limited time, non-interrupted operation is also expected outside this frequency range in accordance with the generator manufacturer’s recommendation.

Transmission System Frequency Range: The SRP transmission system typically operates at a nominal 60 Hz with a variation of +0.05 Hz to –0.05 Hz. Under certain emergency conditions, the transmission system may operate for a period of time outside of this range. The Requester is responsible for providing any frequency sensing equipment required to protect their facility during abnormal frequency operation.

Unbalanced Electric Conditions – Transmission/End-User
Voltage unbalance attributable to the connected facilities shall not exceed 1.0% measured at the point-of-service. Voltage unbalance is defined as the maximum phase deviation from average as specified in ANSI C84.1, “American National Standard for Electric Power Systems and Equipment – Voltage Ratings, 60 Hertz.” This voltage standard shall be considered during the facility design (prior to connection).

Phase current unbalance attributable to the connected facilities combined generation and load shall not exceed 5% measured at the point-of-interconnection.

Situations where high unbalance in voltage and/or current originate from the transmission system are to be addressed in the Connection Agreement.

Voltage Variations – Generator Connections

Acceptable voltage ranges for use in the design and operation of all facilities connected to the SRP transmission systems are provided in Section 8.0 of this report.

Load Shedding – Operational and Implementation Considerations

Load shedding considerations for the design and operation of all facilities connected to the SRP transmission systems are provided in Section 3.0 of this report.

Relay Coordination to Maintain Stability

Proper relay coordination is necessary to ensure stability. Relay coordination should be considered in both the design and operation of all transmission connected facilities. Specific protection system requirements can be found in Section 4.0.

Generator Connected Through a Tapped Transmission Line

A tapped transmission line is not allowed unless SRP identifies a reliability issue that would require this type of installation. For circumstances where a tapped transmission line is allowed by SRP, the tapped transmission line shall be designed so it can be upgradable to a looped transmission line. The switchyard bus configuration will be determined by SRP but will be at a minimum, a single bus-single breaker bus configuration. Additional equipment to ensure the overall stability and reliability of the transmission system will be required for a tapped transmission line.

Other Applicable Operating Requirements

In order to assure the continued reliability of the SRP Transmission System, the connecting entity may be requested to adhere to other operating requirements and/or encouraged to adopt common operating practices. These include the coordination of maintenance scheduling, performance not to exceed a specified forced outage rate, operations procedures during system emergencies, participation in balancing area operating reserves, provisions for backup fuel supply or storage, and provisions for emergency availability identified by the North American Electric Reliability Council. SRP, as the Transmission
Provider, may require the connecting entity to provide generation based ancillary services per the SRP Open Access Transmission Tariff.

Conformance with applicable requirements in NERC Standards and WECC Supplements or guidelines is required. All data reportable to WECC and/or NERC shall also be made available to SRP.

14.0 INSPECTION REQUIREMENTS

Before a connecting entity owned facility can be energized, it must pass a final inspection by SRP personnel. SRP will inspect all substation equipment from the point of interconnection to the first protective fault interrupting device and the ground system. This may include circuit breakers, circuit switchers, power fuses, instrument transformers, switches, surge arresters, bushings, and relays and associated equipment (including battery and battery chargers). The inspection will consist of a visual inspection of all major equipment as well as review of required test results. In addition, SRP maintains the right to inspect all generator plant facilities prior to synchronizing. The inspections will focus on ensuring all technical, regulatory, and safety requirements have been met. Access to the facility must be provided to SRP to allow the described inspections. The facility owner may be required to modify operations to reasonably comply with the necessary training. However, SRP will coordinate such tests in a manner that minimizes the impact on actual operations.

The connecting entity is responsible for operating its facilities with full regard for the safe practices of, and with full cooperation under the supervision of the SRP Control Center. Under no circumstances shall a connecting entity energize SRP transmission facilities which have been de-energized. Circuits which are electrically disconnected from the SRP transmission system and are energized by a connecting entity constitute a potential safety hazard for both SRP transmission personnel and the general public. Also, the energizing of such circuits at abnormal voltage or frequency could cause damage to electrical equipment of both the SRP Transmission System and the generation.

Specific minimum requirements for operation of generation on the SRP transmission system follow:

The ground system must be checked by using the resistance measurement procedures in accordance with IEEE Standard 81 “Recommended Guide for Measuring Ground Resistance and Potential Gradients in the Earth.”

Prior to the commencement of parallel operation, connecting entity shall obtain the written approval of SRP regarding all protective relay equipment and direct transfer trip equipment it proposes to install for the protection of the SRP transmission system. Prior to granting or denying such approval, SRP or the connecting entity shall inspect and calibrate the system protection facilities in accordance with the relay setting data issued by SRP. Inspection and calibration must either be performed or witnessed by SRP personnel at connecting entity’s expense. Connecting entity shall record the actual settings and inspection data on the relay setting document furnished by SRP, and return such document for approval, which approval shall not be unreasonably denied if it meets applicable standards. After commencement of
parallel operation, SRP shall have the right, but shall have no obligation or responsibility to: i) observe connecting entity's tests and/or inspection of any of connecting entity's system protection facilities; ii) review the settings of connecting entity's system protection facilities; and iii) review connecting entity's maintenance records relative to the facility and/or connecting entity's system protection facilities. The foregoing, rights may be exercised by SRP from time to time as deemed necessary upon reasonable notice to connecting entity. However, the exercise or non-exercise by SRP of any of the foregoing rights of observation, review, or inspection shall be construed neither as an endorsement or confirmation of any aspect, feature, element, or condition of the facility or connecting entity's system protection facilities or the operation thereof, nor as a warranty as to the fitness, safety, desirability, or reliability of same.

15.0 NORMAL AND EMERGENCY OPERATING CONDITIONS

The operators of all facilities (generation, transmission, and end-users) connected to the SRP transmission system shall provide a contact person for communications. This contact must have the authority to operate the facilities according to the instructions of the appropriate operating entity (typically SRP).

**Voice Communications**

Normal – At SRP'S request, the connecting entity shall provide a dedicated voice communication circuit to the SRP Control Center.

Such a dedicated voice communication circuit would originate from the connecting entity’s office staffed 24 hours a day and would be typically required for generation facility synchronization and operation within SRP'S Balancing area.

All other normal voice communication concerning facility operations shall be conducted through the public telephone network to the Control Center phone number(s) issued by SRP.

Emergency – Voice communication in the event of a transmission system or energy emergency shall use the dedicated voice circuits, or public telephone network and phone number(s) designated for emergency use.

In the event of a transmission system emergency, energy emergency, or transmission facility restoration effort, the connecting entity may be notified by the SRP control center. Specific instructions may also be given regarding the operation of the connecting entity’s unit(s) depending on the nature of the emergency. These instructions may consist of switching changes, voltage schedule changes, real and/or reactive dispatch changes or other VAR support issues, instructions to shut down or start-up the connecting entity’s generating unit(s), and the need to implement emergency communication procedures. It is the connecting entity’s responsibility to ensure that the unit operators follow all instructions given by the SRP control center during system emergencies. Connected facilities may be subject to SRP’S emergency operating plan that can require interruption of load to deal with generation deficiencies and/or transmission system emergencies. It is noted that interrupting
of load will only be done in extreme conditions that would result in a more serious
degradation of system performance than if the load were not shed.

It is the connecting entity’s responsibility to take prudent steps when an area or system wide
capacity emergency is declared. Load reductions shall be implemented by reducing
nonessential loads. This type of reduction is usually conveyed through the local media. The
End-User is responsible for providing SRP control center a “customer contact list.”

These End-Users shall be provided an unlisted phone number to be used for emergency or
routine operations to SRP control center. Operational emergencies (equipment) warrant a
direct call either way.

**Disturbance Monitoring**

The connecting entity’s facility must have disturbance monitoring equipment per applicable
NERC standards and WECC supplements or guidelines.

16.0 **MISCELLANEOUS REQUIREMENTS**

**Tapped-Service Connection Definition and Requirements**

Any connection to the SRP transmission system that requires only the End-User load to
pass through the connecting facilities under any condition is considered a tapped-service
connection. In general, installing, operating and maintaining in-line facilities will be at the
End-User’s expense even though these facilities are owned by SRP.

The cost to add or modify facilities at remote locations to integrate the End-User’s
transmission connection will also be at the End-User’s expense to the extent allowed by
SRP Open Access Transmission Tariff.

For tapped-service connections, either a delta or ungrounded-wye high side transformer
winding configuration is preferred. The installation of a grounded-wye high side transformer
could require additional protection facilities and costs to be borne by the End-User.

The installation of a grounded-wye high side transformer winding configuration may be
acceptable but could require additional protection facilities and costs to be borne by the
End-User.

**Looped-Service Connection Definition and Requirements**

Any connection to the SRP Transmission System that provides two line extensions to supply
the End-User is considered a looped-service connection. In general, the two line extensions
are installed to End-Users Facilities obtaining looped service, not to enable SRP to provide
adequate electrical service to any location other than the End-User.
Since some looped-service connections have the potential to significantly affect the reliability and load carrying ability of the SRP Transmission System, specific design and operational requirements are imposed which may not be required for a tapped-service connection.

Network Connection Definition and Requirements

Any connection to the SRP Transmission System that allows bi-directional energy and/or fault current flow between otherwise independent transmission systems is an interconnection. This is considered a special circumstance, which requires a detailed system impact study to determine the acceptability of the proposed transmission interconnection and the specific interconnection requirements. Transmission interconnection requests on the SRP System will be considered on a case-by-case basis. The Interconnection Requester will be responsible for reimbursement of the cost for these studies. In addition, the cost of facilities to establish and reliably integrate the new network connection will be at the expense of the Interconnection Requester to the extent allowed by SRP’S Open Access Transmission Tariff.

Remote Relay Access

For tapped-service, looped-service or network connected facilities, all digital relays which have the capability of recording system disturbance information and are used for protection of SRP transmission facilities shall be provided with the equipment necessary to allow SRP to remotely retrieve this data via Requester supplied access to the public phone system.

17.0 INDEMNIFICATION

The use and reliance upon the information contained in this document shall in no way relieve the Generator, Interconnection, or End-User from the responsibility to meet NEC and NESC requirements governing their design, construction, operation, and materials.

The Requester, for itself, its successors, assigns and subcontractors agrees to pay, indemnify and save SRP, its successors and assigns, harmless from and against any and all court cost and litigation expenses, including legal fees, incurred or related to the defense of any action asserted by any person or persons for bodily injuries, death or property damage arising or in any manner growing out of the use and reliance upon the information provided by SRP. Reliance upon this information shall not relieve the Generator, Interconnection or End-User from responsibility for the protection and safety of the general public.

Version History
<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Action</th>
<th>Change Tracking</th>
<th>Revised By</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>03/1/10</td>
<td>Created</td>
<td>N/A</td>
<td>Luke O’Dwyer</td>
</tr>
<tr>
<td>2</td>
<td>10/31/11</td>
<td>Updated</td>
<td>New version</td>
<td>Luke O’Dwyer</td>
</tr>
<tr>
<td>3</td>
<td>11/09/12</td>
<td>Updated</td>
<td>New version</td>
<td>David Crowell</td>
</tr>
<tr>
<td>4</td>
<td>12/17/12</td>
<td>Updated</td>
<td>New version</td>
<td>David Crowell</td>
</tr>
<tr>
<td>5</td>
<td>11/20/13</td>
<td>Updated</td>
<td>New version</td>
<td>David Crowell</td>
</tr>
<tr>
<td>6</td>
<td>12/18/14</td>
<td>Updated</td>
<td>New version</td>
<td>David Crowell</td>
</tr>
<tr>
<td>7</td>
<td>09/08/15</td>
<td>Updated</td>
<td>New version</td>
<td>David Crowell</td>
</tr>
<tr>
<td>8</td>
<td>08/25/16</td>
<td>Updated</td>
<td>New version</td>
<td>David Crowell, Nicco Magnotto</td>
</tr>
<tr>
<td>9</td>
<td>7/24/18</td>
<td>Reviewed</td>
<td>Same as Previous</td>
<td>Angel Sandoval</td>
</tr>
</tbody>
</table>
Appendix 1 - SRP’s Apparatus Design Requirements for Surge Arrestors
(begins on next page)
PURPOSE

This standard outlines the basic requirements for surge arresters used in SRP Substations. These requirements are the key parameters used for most installations and will cover the majority of design points needed to begin a station design. These requirements may be used for general design purposes, but designers should refer to the exact specifications and as-shipped apparatus documentation to ensure that the equipment and the final design are compatible.

This is only an extraction of the full equipment specification. Equipment should not be purchased based on this document. Refer to the full, current equipment specification authorized by SRP Apparatus Engineering for purchase requirements.

REFERENCES

This standard shall be used in conjunction with the following publications. If these publications have been superseded by an approved revision, the revision shall apply.

IEEE C62.11 - 2012 Standard for Metal-Oxide Surge Arresters for AC Power Circuits (> 1kV)
IEEE C62.82 – 2010 Insulation Coordination – Definitions, Principles and Rules
ANSI C92.2 – 1987 AC Electrical Systems and Equipment Operating at Voltages above 230kV Nominal – Preferred Voltage Ratings

DEFINITIONS

Basic lightning Impulse insulation Level (BIL): (A) The electrical strength of insulation expressed in terms of the crest value of a standard lightning impulse under standard atmospheric conditions. BIL may be expressed as either statistical or conventional (see IEEE C62.82.1). (B) A specific insulation level expressed as the crest value of a standard lightning impulse (see IEEE C62.22).

BIL (conventional): Applicable specifically to non-self-restoring insulations. The crest value of a standard lightning impulse for which the insulation does not exhibit disruptive discharge when subjected to a specific number of applications of this impulse under specified conditions (see IEEE C62.2).

BIL (statistical): Applicable specifically to self-restoring insulations. The crest value of a standard lightning impulse for which the insulation exhibits a 90% probability of withstand (or a 10% probability of failure) under specified conditions (see IEEE C62.2).
Basic Switching impulse insulation Level (BSL): (A) The electrical strength of insulation expressed in terms of the crest value of a standard switching impulse. BSL may be expressed as either statistical or conventional (see ANSI C92.2 and IEEE C62.2). (B) A specific insulation level expressed as the crest value of a standard switching impulse (see IEEE C62.22 and C62.82.1).

BSL (conventional): Applicable specifically to non-self-restoring insulations. The crest value of a standard switching impulse for which the insulation does not exhibit disruptive discharge when subjected to a specific number of impulses under specified conditions (see IEEE C62.2).

BSL (statistical): Applicable specifically to self-restoring insulations. The crest value of a standard switching impulse for which the insulation exhibits a 90% probability of withstand (or a 10% probability of failure) under specified conditions (see IEEE C62.2).

Maximum Continuous Operating Voltage (MCOV): The maximum designated root-mean-square (RMS) value of power-frequency voltage that may be applied continuously between the terminals of the arrester.

Radio-Influence Voltage (RIV): A high-frequency voltage, generated by all sources of ionization current that appears at the terminals of electric-power apparatus or on power circuits.

Crest-voltage: Crest voltage is defined as the voltage times the square root of two. The voltage can be either line to line or line to ground depending on the application for the crest voltage.

Switching impulse Protection Level (SPL): Also called Switching Surge Overvoltage Factor (SSOF) or Switching Surge Protective Level (SSPL). The switching impulse protective level is defined as the ratio of the maximum anticipated switching surge voltage to the nominal line to ground crest voltage.

GENERAL REQUIREMENTS

1. Arrester classification is determined by the prescribed test requirements of this standard. These classifications are: station, intermediate, distribution heavy duty, distribution normal duty, and distribution light duty.

2. Arresters used in SRP Substations shall be station class, with external porcelain or polymer housings.

3. Arresters mounted externally shall incorporate outdoor weather shed design.
4. All arresters shall be connected to the station ground loop using a continuous loop of 4/0 AWG copper conductor, connected to the grid at two points.

5. A ¾” x 10’ copperweld ground rod shall be connected to the ground grid at each point where the arrester ground loop connects to the station ground grid.

6. SRP standard arrester sizes are shown in the following table:

7. Surge arresters shall be located at the high voltage side bushings of all substation transformers and shunt reactors, and at exposed low voltage side bushings of substation transformers (to be purchased separately from the transformers).

8. Where specific system studies show that risk of lightning damage is high and that arresters will reduce the likelihood of lightning damage, then surge arresters shall be installed on transmission line terminations and/or terminations to power circuit breakers. Properly sized intermediate class or station class arresters may be used for this purpose.

9. Where specific system studies show the risk of lightning damage is high and that arresters will reduce the likelihood of damage, then surge arresters shall be installed on transmission buses.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>See Note 9</td>
<td>18kV</td>
<td>15.3kV</td>
<td>B</td>
<td>4.5</td>
<td>_</td>
</tr>
<tr>
<td>12.5 kV</td>
<td>10 kV</td>
<td>8.4 kV</td>
<td>B</td>
<td>4.5</td>
<td>_</td>
<td>5022393</td>
</tr>
<tr>
<td>22kV</td>
<td>21kV</td>
<td>17kV</td>
<td>B</td>
<td>4.5</td>
<td>_</td>
<td>5022404</td>
</tr>
<tr>
<td>34.5kV</td>
<td>27kV</td>
<td>22kV</td>
<td>B</td>
<td>4.5</td>
<td>_</td>
<td>5022397</td>
</tr>
<tr>
<td>69 kV</td>
<td>60 kV</td>
<td>48 kV</td>
<td>B</td>
<td>4.5</td>
<td>2.1</td>
<td>5022408</td>
</tr>
<tr>
<td>115 kV</td>
<td>96 kV</td>
<td>76 kV</td>
<td>C</td>
<td>6.0</td>
<td>1.9</td>
<td>5022519</td>
</tr>
<tr>
<td>230 kV</td>
<td>180 kV</td>
<td>144 kV</td>
<td>F</td>
<td>11.0</td>
<td>1.9</td>
<td>5022523</td>
</tr>
<tr>
<td>345 kV</td>
<td>276 kV</td>
<td>220 kV</td>
<td>F</td>
<td>11.0</td>
<td>1.9</td>
<td>n/a</td>
</tr>
<tr>
<td>500 kV</td>
<td>420 kV</td>
<td>335 kV</td>
<td>G</td>
<td>13.0</td>
<td>1.9</td>
<td>5022524</td>
</tr>
</tbody>
</table>
10. A neutral arrester shall be supplied as part of any transformer that is intended to operate with the neutral not effectively grounded.

11. 15 kV or higher class arresters should not be installed in metal enclosures or inside metal enclosed or metal-clad switchgear.