RTO-WEST

Interconnection Standard

(DRAFT #001; 2000-DEC-01)

Contents

A. INTRODUCTION

This document specifies the minimum requirements for safe and effective operation of Requestor facilities connected to the RTO-West Integrated Electric System (IES). Except where noted, this document applies to all new generation, lines and loads connecting anywhere on the RTO-West IES regardless of size, location or connection voltage level. This document also applies to all existing equipment whenever upgrading or replacement of components affords an opportunity to meet the requirements contained herein. For example, if the exciter of a generator is being replaced, the replacement exciter must meet these requirements.

Interconnection requirements as outlined in this document are for those installations that will be connected to the RTO-West IES. These new installations will need to comply with all applicable Federal Energy Regulatory Commission (FERC), Western Systems Coordinating Council (WSCC), Northwest Power Pool (NWPP), Regional Transmission Organization (RTO) and North American Electric Reliability Council (NERC) requirements.

The Customer desiring to attach their facilities to the RTO-West IES will be referred to as the Requestor. Each facility will be reviewed on an individual basis. Requestors and RTO-West personnel shall use this document when planning the installation of a Requestor-owned facility. Note that these requirements may not cover all details in specific cases. The Requestor should discuss project plans with RTO-West before designing the facility or purchasing or installing equipment.

The minimum required protective relaying and/or safety devices or requirements specified in this document, as may be revised from time to time, are for the purpose of protecting (only) RTO-West facilities from damage or disruptions caused by a Fault, malfunction or improper operation of the Requestor's facility. Minimum protective relaying and interconnection requirements shall not be construed to include additional relaying, protective or safety devices as may be required by industry and government codes and standards or equipment manufacturers or as necessary to protect the Requestor's facility. The requirements and prudent engineering design and practices to fully protect the Requestor's facility or facilities shall be the sole responsibility of the Requestor.

Contractual matters, such as costs, ownership, scheduling, and billing are not the focus of this document. The Requestor assumes the cost of all facilities needed to satisfy the technical requirements for the new or modified connection.

Physical laws that govern the behavior of electric systems do not recognize boundaries of electric facility ownership. Therefore the electric Power Systems must be studied, without regard to ownership, to develop a properly designed connection. The Requestor usually assumes the cost of the *System Impact Study*. Before the *System Impact Study* is started, RTO-West reviews the Requestors proposal with the affected parties, considering issues such as short-circuit duties, transient voltages, Reactive Power requirements, stability requirements, harmonics, safety, operations, maintenance and Prudent Electric Utility Practices.

B. DEFINITIONS

For industry standard definitions of electric industry terminology, please refer to: The New IEEE Standard Dictionary of Electrical and Electronic Terms, IEEE STD 100-1992

Important terms used in this document may be capitalized and are defined in Section AA (Appendix B).

C. SCOPE

The technical requirements contained herein generally apply to all new or modified connections regardless of type, size or connection voltage level. The location of the facility, type of connection, and impacts on the RTO-West IES or another utility's system determine the specific requirements. The connection must not degrade the safe operation, integrity and reliability of the RTO-West IES. The requirements in this document are intended to protect RTO-West facilities, but cannot be relied upon to protect the Requestor's facilities.

Although a physical connection may not exist, this document also addresses technical requirements for Dynamic Signals.

D. APPLICABLE CODES, STANDARDS, CRITERIA AND REGULATIONS

To the extent that the codes, standards, criteria and regulations are applicable, the facilities shall be in compliance with those codes, standards, criteria and regulations. Examples of these codes, standards, criteria and regulations are listed in Section Y of this document.

E. SAFETY, PROTECTION, AND RELIABILITY

RTO-West, in cooperation with affected parties, makes the final determination as to whether the RTO-West IES is properly protected before an interconnection is closed. RTO-West will have operational control of the Point of Connection. The OSHA regulation 29CFR 1910.269 is followed for operational procedures. In British Columbia, the Workers' Compensation Board's Occupational Health and Safety Regulation and its applicable supplementary instructions must be followed (See http://www.worksafebc.com/).

If any problems are encountered during the start up, the Requestor is responsible for correcting these before the facilities are energized or interconnected operation begins. However, RTO-West may determine equivalent measures to maintain the safe operation and reliability of the RTO-West Transmission System. In situations where there is direct connection with another utility's system, the requirements of that utility also apply. RTO-West will also comply with applicable state or Provincial regulations.

F. REQUESTOR RESPONSIBILITIES

The Requestor is responsible for the planning, design, construction, and the operation of its facilities. The Requestor's facilities must be reliable, compatible with the RTO-West system and safe at all times for all operating personnel and the general public. The Requestor will operate and maintain its facilities to a high standard of quality and reliability generally recognized by Prudent Electric Utility Practices.

The Requestor must provide RTO-West with an annual report on plans for upgrading or replacing existing equipment. The report must provide sufficient detail to demonstrate that all equipment upgrades and replacements will meet the requirements of this document and all other applicable requirements. This report must be provided to RTO-West by the last day of August of each year and cover all plans for the 16-month period ending on the last day of December of the following year.

G. SPECIAL DISTURBANCE STUDIES

Series and shunt capacitors, high-speed reclosing, single-pole switching and high-speed reactive switching are used at various locations in the RTO-West IES. These devices and operating modes, as well as other disturbances and imbalances, may affect the connected facilities.

The Requestor is responsible for any studies necessary to evaluate possible effects of system disturbances on the proposed facilities and for taking mitigating measures.

H. CONNECTION STUDIES AND REQUESTOR-SUPPLIED INFORMATION

The connection and its operation will comply with regional practices regarding transmission service. RTO-West must be contacted as early in the planning process as possible for any potential transmission line or load connections to the RTO-West IES and/or where the connection is in RTO-West's Load Control Area. Changes within certain areas of RTO-West IES may be costly due to extensive reinforcements. That is, RTO-West may have to add or modify its transmission system substantially before allowing a new transmission line or load or generation to begin connected operation at the cost of the Requestor. A study must be made to determine the required facilities and modifications to accommodate the new connection. This study may also address the transmission system capability, transient stability, voltage stability, losses, voltage regulation, harmonics, voltage flicker, electromagnetic transients, machine dynamics, Ferroresonance, metering requirements, protective relaying, substation grounding, and Fault duties.

If a System Impact Study is required, RTO-West will notify the Requestor. RTO-West and the Requestor must enter into an agreement before performing the study and as early as practical in the process. The Requestor shall complete and submit the attached TRANSMISSION LINE CONNECTION INFORMATION Form which provides RTO-West with specific information required for performing the study.

I. STUDY RESULTS

The System Impact Study results may include, but is not limited to, the following:

1. A preliminary Project Requirements Diagram;
2. Any modifications and/or additions needed to the RTO-West IES to accommodate the connection;
3. The major connection equipment that the Requestor would provide;
4. The requirements for voltage regulation, harmonics, and Power Factor control;
5. Revenue Metering and interchange telemetering requirements;
6. Protective relaying, grounding, remedial action and control requirements;
7. Telecommunication requirements;
8. Operational control of facilities and maintenance requirements;

9. Approximate schedule and lead times for RTO-West to perform its design, material procurement, construction and energization;
10. An estimate of costs for additions and modifications to be performed by RTO-West;
11. The alternate locations where the new facility(s) may be connected to the RTO-West Transmission System.

J. SAFETY AND ISOLATING DEVICES

At each Point of Connection to the RTO-West IES an isolating device shall be provided that physically and visibly isolates the RTO-West IES from the connected facilities. Safety and operating procedures for the isolating device need to be indicated. All switchgear that could energize equipment shall be visibly identified (tagged), so that all maintenance crews can be made aware of the potential hazards. The isolating device may be placed in a location other than the Point of Interconnection, by agreement of RTO-West and affected parties. In any case the device:

1. Must simultaneously open all phases (gang operated) to the connected facilities;
2. Must be accessible and under ultimate RTO-West transmission operator jurisdiction;
3. Must be lockable in the open position;
4. Would not be operated without advance notice to either party, unless an emergency condition requires that the device be opened to isolate the connected facilities:
5. Must be suitable for safe operation under the conditions of use.

All work practices, involving RTO-West facilities must be done in accordance with the applicable safety practices. RTO-West personnel may direct locking the device in the open position and install safety grounds:

1. If it is necessary for the protection of maintenance personnel when working on deenergized circuits;
2. If the connected facilities or RTO-West equipment presents a hazardous condition;
3. If the connected facilities jeopardizes the operation of the RTO-West Transmission System.

K. POINT OF CONNECTION

1. General Constraints

Connected facilities shall not restrain RTO-West from taking a transmission line or line section or other equipment out of service for operation and maintenance purposes. The line and all components must be designed and installed to be maintainable within RTO-West's right to maintain.

2. General Configurations

Connection of new facilities into the transmission system usually falls into one of three categories:

a) Connection into an existing substation, with (depending on the bus configuration) the existing transmission and new connecting lines each terminated into bays containing one or more breakers;

b) Connection by directly tapping an existing transmission line: A multi-terminal line is created when the new connection becomes an additional source of

Fault current beyond the existing sources at the line terminals. A line with three terminals affects RTO-West's ability to protect, operate, dispatch, and maintain the transmission line. The increased complexity of the control and protection schemes affects system stability and reliability. The additional terminal may also decrease the overall performance and availability of the existing line. RTO-West determines the feasibility of multi-terminal line connections on a case-by-case basis.

c) Connection by looping an existing transmission line into a new substation within an existing transmission path. RTO-West must maintain full operational control of the transmission path. This may include, but not be limited to, SCADA control and monitoring (digital and analog) of circuit breakers, disconnects and other equipment in the new substation. Additionally, RTO-West will retain contractual path rights. Any new equipment shall not degrade the operational capability of the line.

These three categories can include the situation where a non-RTO member utility owns the transmission line or equipment that directly connects to the RTO-West IES.

K.1 TRANSFORMERS

RTO-West will advise the Requestor of the required transformer voltage and winding connection configuration (eg, delta/wye, etc). Normally generator step-up transformers will require off-load taps on the secondary (HV) winding with a minimum range of 2 x 2 1/2 percent above and 2 x 2 1/2 percent below the Nominal Interconnection Voltage. For distribution and other step-down transformers, RTO-West will normally recommend that the transformer be equipped with an Under-Load Tap-Changer (ULTC) providing a range of adjustment of at least+/-10% of the Nominal Interconnection Voltage and in addition provide for regulation through the transformer. The adjustment range necessary for each installation shall be determined in consultation with the RTO-West.

For installations tapped into a transmission line, transformer winding arrangements which result in zero sequence current contributions from the transformer to faults on the RTO-West IES are generally not acceptable for protection reasons. For these installations, a delta connected HV winding is generally recommended. For installations at 230 kV and above, wye-connected HV windings are recommended together with appropriate ground fault protection for the connecting transmission line.

Transformers must be rated to withstand the expected voltage and frequency excursions associated with possible load rejection and system separation events.

L. SPECIAL CONFIGURATIONS

Some new connections to the RTO-West IES require that one or more RTO-West lines (a transmission path) be looped through the Requestor's facilities, or sectionalized with the addition of switches. The design and ratings of these facilities and/or switches shall not restrict the capability of the line(s) and RTO-West's contractual transmission path rights.

The following system considerations may substantially affect the costs of a particular connection plan, sometimes making an alternate connection to the RTO-West IES more desirable:

L.1 EXISTING EQUIPMENT

Existing electrical equipment, such as transformers, power circuit breakers, disconnect switches, arresters, and line conductors were purchased based on the duties expected in response to system additions identified in long-range plans. However, the new connection may cause existing equipment to be underrated, requiring replacement at the Requestor's expense.

L.2 SYSTEM STABILITY AND RELIABILITY

The RTO-West IES has been developed with careful consideration for system stability and reliability during disturbances. The type of connection, size of the load, breaker configurations, load characteristics, and the ability to set protective relays will affect where and how the RTO-West IES develops. The Requestor may also be required to participate in special protection schemes, called Remedial Action Schemes (RAS) such as generator dropping, load reduction, or load tripping. The portion of the transmission path capacity that the Requestor uses determines the pro rata share of RAS. If RAS participation is required, the Requestor and RTO-West will jointly plan and coordinate the RAS implementation.

L.3 CONTROL AND PROTECTION

RTO-West coordinates its protective relays and control schemes to provide for personnel safety and equipment protection and to minimize disruption of services during disturbances. New Connection Points usually require the addition or modification of protective relays and/or control schemes. The new protection must be compatible with existing protective relay schemes. Sometimes the addition of voltage transformers, current transformers, or pilot scheme (transfer trip) also are necessary. RTO-West uses single-pole protective relaying on many 500 kV lines and pilot tripping on most 230 kV and above lines. Conventional directional zone protection is usually used on 161 kV and lower voltage transmission lines.

L.4 DISPATCHING AND MAINTENANCE

RTO-West operates and coordinates the maintenance of its system to provide reliable customer service while meeting the seasonal and daily peak loads even during equipment outages and disturbances. New connections must not restrict timely outage coordination, automatic switching or equipment maintenance scheduling. Preserving reliable service to all RTO-West's customers is essential and may require additional switchgear, equipment redundancy, or bypass capabilities at the Connection Point for acceptable operation of the system.

L.5 ATMOSPHERIC AND SEISMIC

The effects of wind storms, floods, lightning, elevation, temperature extremes, icing, contamination and earthquakes must be considered in the design and operation of the connected facilities. The Requestor is responsible for determining that the appropriate standards, codes, criteria, recommended practices, guides and Prudent Utility Practices are met for equipment that they are installing.

M. TRANSMISSION LINE CONNECTION LOOP

Transmission line designs shall meet the requirements of WSCC/NERC Reliability Criteria along with:

a) The requirements of the NESC C2 and OSHA shall be met. In British Columbia, the Workers' Compensation Board's Occupational Health and

Safety Regulation and its applicable supplementary instructions must be followed (See http://www.worksafebc.com/).

b) The minimum approach distances shall be designed in accordance with NESC Codes and applicable local regulations.

c) The line shall be sagged to NESC C2 at a high assurance level and any applicable local regulations.

d) All new transmission lines shall meet local transmission owner practices.

e) Access to all structures under RTO-West jurisdiction shall be provided.

f) Underbuilds to existing RTO-West transmission line facilities will generally not be allowed. If an underbuild is requested, a special 'pole contract agreement' will have to be negotiated.

N. SUBSTATION CONNECTIONS

Requestor built substations that interrupt an existing RTO-West transmission path or Requestor built facilities in a RTO-West substation must meet the requirements of the WSCC Reliability Criteria. A summary of these requirements follows:

a) The facility must be designed to applicable requirements of the NESC C2, NEC, ANSI and IEEE Standards and applicable local regulations.

b) The site selection must consider environmental aspects, oil containment, and fire suppression.

c) Grounding must be in accordance with IEEE Guide 80.

d) Two sources of station service may be required.

e) Electrical equipment in the substation must be sized to carry the full current rating of the interrupted transmission path. This includes circuit breakers, disconnect switches, current transformers and all other ancillary equipment which will serve as the continuation of the path during any switching configuration.

O. GENERATING STATION CONNECTIONS

O.1 GENERAL

The generators, step-up and auxiliary transformers need to comply with the NERC document titled "Planning Standards", such as Sections IIB, IIIC and others that may apply. The NERC "Planning Standards" are available at http://www.nerc.com.

All new generators must be tested to confirm their capabilities and performance in accordance with Section Z. Any time any components are replaced, upgraded or issued new settings, the relevant generator testing and modeling must be redone and the results provided to the RTO-West within 4 weeks of the date that the unit returned to service.

O.2 REACTIVE POWER REQUIREMENTS

The Requestor shall specify the Maximum Power Output (MPO) of each generator. Each generator will not be permitted to operate above its specified MPO without the approval of RTO-West

When operating at rated terminal voltage and at the generating unit's MPO, each synchronous generator shall be able to operate continuously at an over-excited power factor of 90% or less and at an under-excited power factor of 95% or less.

This means, for example, that a generator with an MPO of 90.00 MW, must be able to operate continuously at rated terminal voltage while producing 90.00 MW and +43.59 Mvar (100.00 MV.A at 90% power factor over-excited). That same 90.00 MW generator must be able to operate continuously under-excited at rated terminal voltage and produce 90.00 MW while absorbing 29.58 Mvar (94.74 MV.A at 95% power factor under-excited).

For test purposes, the generator and its auxiliary equipment must be capable of isolated operation at rated speed for periods of at least 30 seconds at any generator terminal voltage level between 0.30 pu and 1.20 pu.

Under all ambient conditions, each generator must be able to operate continuously:

1. at its MPO and at Rated Field Current (See definition in Section B) and at any terminal voltage level within plus 5% and minus 10% of rated terminal voltage.
2. at all possible combinations of real and reactive output levels within its capability curve

The RTO-West will specify the desired generator voltage setting or desired Mvar output level. The generator may be required to change its Mvar output or voltage reference set point from time to time depending on system conditions and the location of the generator. In most cases, especially for generators larger than 10 MV.A, if the RTO-West does not have direct control over the generator's voltage regulator via supervisory control, the Requestor's operator must be able to respond and implement the new Mvar output or voltage reference set point within 5 minutes.

If the generating unit main (step-up) transformer is equipped with an Under-Load Tap-Changer (ULTC), the ULTC must be operated in manual mode whenever the generator is on line unless the generator’s automatic voltage regulator is sensing the voltage on the HV side of the generator step-up transformer. This is to ensure that, immediately following a major system disturbance resulting in abnormal system voltage levels, the generator participates to the fullest extent to restore normal system voltage levels.

The generator must be provided with limiters that are properly coordinated with protective relays while permitting the full voltage control capability of the generator to be utilized without exceeding any generator or auxiliary equipment ratings. Specifically the limiters must provide the following capabilities:

1. With the generator initially operating at any point within its capability curve and at any terminal voltage level within +5% and -10% of nameplate, and without operator intervention, the generator must be able to withstand, for at least 30 minutes, a system disturbance that results in the generator terminal voltage dropping to 90% of the generator's rated terminal voltage.

2. With the generator initially operating at any point within its capability curve and at any terminal voltage level within +5% and -10% of nameplate, and without operator intervention, the generator must be able to withstand, for at least 30 minutes, a

system disturbance that results in the generator terminal voltage rising to 105% of the generator's rated terminal voltage.

A generator will not be permitted to operate above its MPO without the prior approval of the RTO-West. This is to ensure that the full reactive capability of the generator is available to help control system voltages during extreme or abnormal system conditions. Permission to operate above the generator's MPO will normally require that the generator be capable of operating continuously at 0.90 pf over-excited and 0.95 pf under-excited at the higher output level.

Transformer reactance and tap settings must be coordinated with the RTO-West IES to optimize the Reactive Power capability (over- and under-excited) that can be provided to the network. Refer to IEEE Std. C57.116, *Guide for Transformers Directly Connected to Generator*s. The generator continuous Reactive Power capability shall not be restricted by main or auxiliary equipment, control and protection, or operating procedures.

Induction generators with solid-state inverters shall have Reactive Power capability similar to synchronous generators. Conventional induction generators may require switchable (while energized) shunt capacitor bank compensation. Large installations may require controllable compensation such as Static Var Compensators (SVCs). Induction generators without solid-state inverters shall provide as a minimum, Reactive Power capability equivalent to a synchronous generator of the same MPO (see Section B) unless alternate arrangements are made with the RTO-West.

O.3 EXCITATION SYSTEM

O.3.1 General

The excitation system is required to be a high gain, fast responding system capable of accepting external inputs from auxiliary devices such as power system stabilizers (PSSs). The excitation system shall be capable of providing both positive and negative field-forcing voltages to provide fast control of under- and over-voltages and to maximize the PSS's contribution to power system oscillation damping. Negative field current capability is not normally required except in special circumstances.

Synchronous generator excitation equipment shall follow industry best practice and applicable industry standards. Excitation equipment includes the exciter, automatic voltage regulator (AVR) , Power System Stabilizer (PSS) and excitation system limiters. Supplementary controls such as Line-Drop Compensation (LDC) may be required to meet transmission voltage schedules.

The excitation system nominal response shall be 2.0 or higher (for definitions see IEEE Standard 421.2). The excitation system nominal response defines combined response time and ceiling voltage. In some cases, the high initial response static type may be required to economically improve Power System dynamic performance and transfer capability. Automatic voltage regulators (AVRs) shall be continuously acting solid state analog or digital. Tuning shall be in accordance with Section III.C of the NERC Planning Standards. Tuning results must be included in commissioning test reports provided to RTO-West.

The excitation system shall be a high initial response type as defined by IEEE Standard 421.4 - 1990, capable of attaining 95% of the difference between the available ceiling voltage and rated load field voltage in 0.1 second or less. Ceiling voltage, defined as the maximum exciter voltage attainable under initial conditions of generator rated MVA, rated power factor, rated terminal voltage and rated speed, shall be greater than 1.6 times the rated output field voltage[1]. Negative ceiling [1] voltage capability shall also be provided. The excitation system shall be capable of producing the field current required for continuous operation at generator rated MVA, rated power factor, 1.05 pu terminal voltage and rated speed ("Excitation System Rated Current"). It shall also be capable of providing 1.6 times the excitation system rated current for 30 seconds ("exciter overload current rating").

All excitation system controls (including AVR, LDC and PSS), limiters (including OEL, UEL, V/Hz and TVL) and protective equipment and their settings must be approved by RTO-West before the generating units will be permitted to enter commercial service. Any subsequent changes to these settings must be approved by RTO-West.

The exciter control system shall have one or more "manual" control modes to facilitate generating unit tests. One such mode that must be provided is a fixed exciter output voltage mode because this mode is easy to model in simulation studies associated with determining and validating the parameters of the generator model. Other additional modes that may be useful include:

1. Constant exciter output current mode.
2. Constant exciter thyristor firing angle mode.

For test purposes (eg, saturation curve verification), the generator must be capable of operating at rated speed in manual excitation control mode and isolated from the electric system for at least 30 seconds at all terminal voltage levels between 30% and 120% of its nameplate terminal voltage rating.

O.3.2 Automatic Voltage Regulator (AVR)

Generators provide the major contribution to successful voltage control on integrated electric transmission systems. Shunt compensation is applied throughout the transmission network to aid in voltage control, and to keep generators reasonably close to unity Power Factor so that Reactive Power is available from generators during emergencies.

Voltage schedules are necessary for efficient and reliable power transmission and to maintain voltages at loads within normal ranges. The voltage schedules establish hourly operating requirements and may be set for seasons, holidays, days of the week, and time of day. These schedules may be changed at any time to meet transmission requirements, e.g., a line out of service. Generator owners must comply with RTO-West requests for changes in generator Mvar output or voltage setpoint provided the generators continue to operate within their capability.

The generator exciter must be equipped with an Automatic Voltage Regulator (AVR) set to control the generator terminal voltage. Under steady state conditions, the AVR shall be capable of automatically maintaining the generator terminal voltage, without hunting, to within plus or minus 0.1% of any set point within an operating range between plus 20% and minus 30% of the rated terminal voltage of the generator. This doesn't mean that the generator and its auxiliary equipment (exciter, transformer, etc) must be capable of continuous operation at these levels. This control capability is mainly for test purposes. This control capability will permit tests involving large temporary step changes in voltage setpoint to demonstrate proper dynamic performance of limiters, etc. The generator and its auxiliary equipment must be capable of operating for periods of at least 30 seconds at any generator terminal voltage level between 0.70 pu and 1.20 pu and at all possible combinations of real and reactive output levels within its capability curve.

RTO-West may request the provision of voltage regulator Line Drop Compensator (LDC) to regulate a virtual location 50–80% through the step-up transformer reactance.

Supplementary automatic control may be required to adjust the AVR setpoint to meet the RTO-West IES network side voltage schedule. If provided, this supplementary control must operate in a 10–30 second time frame, and may also balance Reactive Power output of the power plant generators.

O.3.3 Excitation System Limiters

The excitation system must be equipped with limiters that are well coordinated with the generator protective relays. The limiter settings must not unduly restrict the generator's operating range (terminal voltage and Mvar limits). The limiters must not overly protect the generating unit's components at the expense of system security.

Limiters shall be of the non-windup type. The output of each limiter shall immediately return to zero, and automatic voltage regulation resumed, upon the elimination of the cause of the overload. Limiters shall not switch the excitation system from automatic to manual voltage control.

The limiters must control the exciter output to avoid unnecessary operation of the generator's protective relays in the event of any sudden abnormal system condition that causes the AVR to attempt to exceed the generator Mvar limits in its efforts to maintain the pre-set voltage reference point. The generator voltage regulator must be equipped with the following limiters:

1. Over-Excitation Limiter (OEL): This limiter must prevent the generator field circuit from operating beyond the voltage and current capabilities of the exciter and generator field winding. An OEL with both a thermal-analogue element and an inverse-time element is preferred. The thermal-analogue element would ensure that the full steady-state (continuous) overexcited Mvar rating of the generator was available at all times by eliminating the need for a cool-down period following "field-forcing". The inverse-time element, which could have a stepped-shape, would allow temporary very high field current levels during faults and subsequent system oscillations. However, an OEL with a single inverse-time element is acceptable

provided the limit during the cool-down period following field-forcing is not less than 95% of the continuous current rating of the generator's field winding.

2. Under-Excitation Limiter (UEL): The UEL limits the exciter output level to (a) prevent operation at output levels which would cause equipment damage or failure (eg, over-heat the end region of the armature core), (b) prevent operation at excitation levels which would result in loss of synchronism during normal system conditions (ie, prevent steady-state electromechanical instability) and (c) coordinate with the generator's Loss-of-Field (LOF) protection.
3. Terminal Voltage Limiter (TVL): The TVL must not limit the generator terminal voltage to less than 99.5% of its maximum continuous capability. It must have an inverse-time characteristic to enhance transient stability by permitting short-time over-voltage during system disturbances. The setting of the TVL will need to be coordinated with the over-voltage capabilities of generator auxiliary equipment and other equipment connected to the RTO-West Integrated Electric System in the vicinity of the Requestor's generator.
4. Volts per Hz Limiter (VHL): The VHL lowers the generator terminal voltage during isolated operation at lower than normal generator speed. The terminal voltage limit is lowered in proportion to the terminal voltage frequency to prevent over-fluxing of the generator unit transformer during start-up and shut-down of the generator.

O.3.4 Power System Stabilizer (PSS)

The voltage regulator shall include a Power System stabilizer in accordance with the WSCC's Policy Statement on Power System Stabilizers that can be found on page 13 of Section IV of the 1999-Oct version of the WSCC's Operations Committee Handbook, that can be downloaded from the link, Operations Committee Handbook (October 1999) (http://206.71.72.50/handbooks/ochandbk.pdf). This document states, "PSS should be installed on all new generators, regardless of ownership or unit size, having suitable excitation systems as defined above". The "as defined above" phrase refers to the PSS suitability criteria document (1.8 MB PDF file) that can be downloaded from the link, Criteria to Determine Excitation System Suitability for PSS (http://www.wscc.com/files/pssexcit.pdf)

The PSS must be tuned in accordance with WSCC guidelines and other industry practice. The WSCC's "Test Procedure for Power System Stabilizer (PSS)" document provides guidelines for testing and tuning PSSs. This document is available from http://www.wscc.com/Certification/tprocpss.pdf.

The dual-input accelerating power type of stabilizer (Delta P–omega or variant) is preferred (Refer to Figure 16 of Section 8 (Power System Stabilizers) of IEEE Std 421.5-1992).

A power system stabilizer (PSS) must be provided to help damp power system local and inter-area oscillations. RTO-West will conduct initial system studies to identify the type of PSS required for each generator. The Requestor shall include the provision of the recommended PSS in the excitation system specifications of each generator. Once the generating unit equipment (ie, generator, turbine, exciter, step-up transformer, etc) characteristics have been provided by the various suppliers, RTO-West will conduct further studies to determine the optimum PSS settings. The recommended settings will

be implemented and confirmed by field tests during the commissioning of each generator.

O.4 AUTOMATIC SYNCHRONIZER

Generators shall have an automatic synchronizer to synchronize with the RTO-West IES. The automatic and manual synchronizing relay shall have slip frequency matching, voltage matching, phase angle acceptance and breaker closure time compensation.

O.5 GOVERNOR

All generators forming part of a plant that has a combined total maximum power output of 10 MW or greater must be equipped with speed governors on their prime movers. The governor droop shall be set to 5 percent. Each individual governor of a multi-generator plant may have a droop between 3% and 7% provided the weighted-average (weighted by generator MPO) droop setting for the plant is between 4.5% and 5.5%. Refer to Item F.2 of Section Y, References.

Governors must be operated unrestrained to regulate system frequency and to provide added system stability. The governor shall not have a deadband of more than +/-0.036 Hz (Refer to Item F.2 of Section Y, References.).

The performance requirements for the governor system for operation in the RTO-West IES shall generally be in accordance with Section 4 of IEEE Standard 125-1988 "IEEE Recommended Practice for Preparation of Equipment Specifications for Speed Governing of Hydraulic Turbines Intended to Drive Electric Generators" and with Section 4 of IEEE Standard 122-1991 "IEEE Recommended Practice for Functional and Performance Characteristics of Control Systems for Steam Turbine-Generator Units. Similar performance requirements shall apply to all types of Prime Movers (including reciprocating combustion engines and gas turbines).

A full-load rejection test must be performed as part of the generating unit's commissioning tests to demonstrate its ability to properly operate under load rejection conditions. Generally, this test would involve operating the unit at its maximum (short term) MW output capability level (MPO) and tripping the breaker or breakers connecting the unit to the system. The unit must not shutdown but must stay on line controlling the terminal voltage magnitude and frequency to within normal limits. This test can serve to verify the governor permanent droop setting. The final steady-state speed must be 63.0 Hz if the governor droop setting is 5%. If the generating unit cannot continuously operate at 63.0 Hz, supplemental controls (acting in the 20 to 30 second time frame) may be provided to return the generator to 60.0 Hz.

Required governor characteristics are provided in Section III.C, Generation Control and Protection, of the NERC Planning Standards. RTO-West realizes that some generating facilities will operate at maximum turbine output unless providing frequency control and spinning reserve Ancillary Services. However, even generators operating at their maximum turbine output level must have their governors operational to help control over-frequency for system disturbances involving loss of load.

P. INSULATION COORDINATION

Power System equipment is designed to withstand voltage stresses associated with expected operation. Adding or connecting new facilities can change equipment duty, and may require that equipment be replaced or switchgear, telecommunications, shielding, grounding and/or surge protection added to control voltage stress to acceptable levels. Connection studies include the evaluation of the impact on equipment insulation coordination. RTO-West may identify additional requirements to maintain an acceptable level of RTO-West IES availability, reliability, equipment insulation margins, and safety. Voltage stresses, such as lightning or switching surges, and temporary over-voltages may affect equipment duty. Remedies depend on the equipment capability and the type and magnitude of the stress. In general, stations with equipment, transformers and reactors, shall be protected against lightning and switching surges. Typically this includes station shielding against direct lightning strokes, surge arresters on all wound devices, and shielding with arresters on the incoming lines. The following requirements may be necessary to meet the intent of WSCC/NERC Reliability Criteria.

P.1 LIGHTNING SURGES

If the Requestor proposes to tap a shielded transmission line, the tap line to the substation must also be shielded. For an unshielded transmission line, the tap line does not typically require shielding beyond that needed for substation entrance. However, special circumstances such as the length of the tap line may affect shielding requirements. For certain Requestor service substations at 230 kV and below, RTO-West may require only an arrester at the station entrance in lieu of line shielding, or a reduced shielded zone adjacent to the station. These variations depend on the tap line length, the presence of a power circuit breaker on the transmission side of the transformer, and the size of the transformer. A special case to be noted is existing transmission lines built to a future requirement (230 kV for example) but used at a lower voltage. (138 kV for example).

P.2 SWITCHING SURGES

At voltages below 500 kV, modifications to protect RTO-West IES equipment from switching surges are not anticipated. However, the results of the *System Impact Study* identify the actual needs.

P.3 TEMPORARY OVERVOLTAGES

Temporary overvoltages can last from seconds to minutes, and are not characterized as surges. These overvoltages are present during islanding, faults, loss of load, or long-line situations. All new and existing equipment must be capable of withstanding these duties.

1) Islanding

A 'local Island' condition can expose equipment to higher-than-normal voltages. As described in Section V.5.3. RTO-West does not normally allow its facilities to become part of a 'local Island' for an extended duration.

2) Neutral Shifts

When generation or a source of 'back-feed' is connected to the low-voltage side of a delta-grounded wye Requestor service transformer, remote end breaker operations initiated by the detection of Faults on the high-voltage side can cause over-voltages that can affect personnel safety and damage equipment. This type of over voltage is commonly described as a neutral

shift and can increase the voltage on the unfaulted phases to as high as 1.73 per unit. At this voltage, the equipment insulation withstand-duration can be very short. Several alternative remedies are possible:

I. Provide an Effectively Grounded system on the high-voltage side of the transformer that is independent of other transmission system connections.

II. Size the high-voltage-side equipment to withstand the amplitude and duration of the neutral shift.

III. Rapidly separate the back-feed source from the step-up transformer by tripping a breaker, using either remote relay detection with pilot scheme (transfer trip) or local relay detection of over voltage.

Effectively Grounded is defined as an X_0/X_1 3 and R_0/X_1 1. Methods available to obtain an effective ground on the high-voltage side of the transformer include the following:

I. A transformer with the transmission voltage (RTO-West's) side connected in a grounded-wye configuration and low voltage (Requestor) side in closed delta.

II. A three-winding transformer with a closed-delta tertiary winding. Both the transmission and Distribution side windings are connected in grounded-wye.

III. Installation of a grounding transformer on the transmission voltage (RTO-West) side.

Any of these result in an Effectively Grounded system with little risk of damage to surge arresters and other connected equipment.

Q. SUBSTATION GROUNDING

Each substation must have a ground grid that is solidly connected to all metallic structures and other non-energized metallic equipment. This grid shall limit the ground potential gradients to such voltage and current levels that will not endanger the safety of people or damage equipment which are in, or immediately adjacent to, the station under normal and Fault conditions.

The ground grid size and type are in part based on local soil conditions and available electrical Fault current magnitudes. In areas where ground grid voltage rises would not be within acceptable and safe limits (due for example to high soil resistivity or limited substation space), grounding rods and grounding wells can be used to reduce the ground grid resistance to acceptable levels. Due to difficulty in retrofitting ground grid improvements, construction of the grid to projected ultimate duty for the site is recommended. RTO-West will specify the ultimate duty required.

New interconnection of transmission lines and/or generation may substantially increase Fault current levels at nearby substations. Modifications to the ground grids of existing substations may be necessary to keep grid voltage rises within safe levels. The interconnection study will determine if modifications are required and the estimated cost.

The ground grid must be designed to applicable ANSI and IEEE Standards relating to safety in substation grounding as referenced in Section Y.

R. INSPECTION, TEST, CALIBRATION AND MAINTENANCE

All transmission elements (i.e. lines, line rights of way, circuit breakers, control and protection equipment, metering, and telecommunications) shall be inspected and maintained in conformance with regional standards, taking into consideration geographical differences. The Requestor may be requested to annually certify that it has developed, documented, and implemented an adequate Transmission Maintenance and Inspection Plan (TMIP). The Requestor has full responsibility for the inspection, testing, calibration, and maintenance of its equipment, up to the location of change of ownership or the RTO-West Transmission System.

a) Pre-energization Inspection and Testing of Interconnection equipment

Before initial energization, the Requestor shall develop an Inspection and Test Plan for pre-energization and energization testing. RTO-West reviews and approves the test plan before the test. RTO-West may require additional tests; the costs of these tests are subject to negotiation. The Requestor shall make available to RTO-West all drawings, specifications, and test records of the Point of Interconnection equipment.

b) Transmission Maintenance and Inspection Plan (TMIP)

This applies to any transmission line segment or substation that is inserted into the existing RTO-West IES and owned by the Requestor. The intent of the maintenance requirements is to provide flexibility in the approach to maintenance, but require the description of certain specific maintenance practices. The TMIP shall provide descriptions of the various maintenance activities, schedules and condition triggers for performing the maintenance, and samples of any checklists, forms, or reports used for maintenance activities. The Requestor shall prepare a written description of, and update as necessary, its annual TMIP. The TMIP may be performance-based, time-based, or both, as may be appropriate. The TMIP shall:

- Include the schedule interval (i.e., every two years) for any time-based maintenance activities and a description of conditions that will initiate any performance-based activities;
- Describe the maintenance methods for each substantial type of component and shall provide any checklists or forms that may be required for the activity;
- Provide criteria to be used to assess the condition of a transmission facility or component;

R.1 TRANSMISSION LINE MAINTENANCE

The TMIP shall, at a minimum, describe the maintenance practices for all applicable transmission line activities including:

I. Patrols and inspections, routine, detailed and emergency.
II. Vegetation Management and Right-of-Way Maintenance.
III. Contamination control (insulator washing)

R.2 STATION MAINTENANCE

The TMIP shall describe the maintenance practices for all applicable substation facilities:

I. Circuit breakers,
II. Power transformers

III. Reactive devices (including but not limited to series and shunt capacitors, SVC, and TCSC synchronous condensors, shunt reactors, and tertiary reactors)

IV. Regulators

V. Protective Relaying and associated communications schemes

S. STATION SERVICE

Power that is provided for local use at a substation to operate lighting heating and auxiliary equipment is termed station service. Alternate station service is a backup source of power, used only in emergency situations or during maintenance when primary station service is not available. Station service power is the responsibility of the Requestor.

The station service requirements of the new facilities, including voltage and reactive requirements, shall not impose operating restrictions on the RTO-West IES beyond those specified in applicable NERC, WSCC, RTO and Northwest Power Pool (or successor) reliability criteria. Appropriate providers of station service and alternate station service are determined during the connection planning process. The Requestor must provide metering for station service and alternate station service, as specified by the metering section of this document or work out other acceptable arrangements.

T. ANCILLARY SERVICES

All loads and transmission facilities must be part of a Control Area. The Control Area provides critical Ancillary Services, including load regulation, load following, voltage control, scheduling, and dispatching, as defined by NERC, WSCC, and NWPP reliability policies and criteria.

All connections to the RTO-West IES also require a transmission contract. The Requestor must choose the Control Area in which the new facilities will be located and how all the necessary Ancillary Services will be provided. This must be done in the Ancillary Service exhibit of the transmission contract. Of particular importance is the Requestor's selection of the source for regulating and Contingency reserves, if needed. RTO-West will then determine the telemetering, controls, and metering that will be required to integrate the load or facility into the chosen Control Area and to provide the necessary Ancillary Services. If the Requestor chooses a self-provision or a third party provision of reserves, then special certification and deployment procedures must be incorporated into the RTO-West AGC system. The provision of the required Ancillary Services must meet all relevant NERC, WSCC, and NWPP reliability policies and criteria.

U. PERFORMANCE REQUIREMENTS

The following performance requirements can be satisfied by various methods. It is the responsibility of the Requestor to propose a preferred method for RTO-West concurrence.

U.1 ELECTRICAL DISTURBANCES

The new facilities shall be designed, constructed, operated, and maintained in conformance with this document, applicable laws and regulations, and standards to minimize the impact of the following:

a) Electric disturbances that produce abnormal power flows,
b) Power System Faults or equipment failures,
c) Overvoltages during ground Faults,
d) Audible noise, radio, television, and telephone interference,
e) Power System harmonics,
f) Voltage dips caused by motor starting and transformer energization, and
g) Other disturbances that might degrade the reliability of the interconnected RTO-West Transmission System.

U.2 SWITCHGEAR

a) All Voltage Levels

Circuit breakers, disconnect switches, and all other current-carrying equipment connected to RTO-West's transmission facilities shall be capable of carrying RTO-West specified normal and emergency load currents without damage. This equipment shall not become a limiting factor, or Bottleneck, in the ability to transfer power on the RTO-West IES.

All circuit breakers and other fault-interrupting devices shall be capable of safely interrupting Fault currents for any Fault that they may be required to interrupt. The circuit breaker shall have this capability without the use of intentional time delay in clearing, Fault reduction schemes, etc.

Application shall be in accordance with ANSI/IEEE C37 Standards. These requirements apply to all equipment connected to the RTO-West IES. Minimum fault-interrupting requirements are supplied by RTO-West, and are based on the greater of the Fault duties at the time of the interconnection request or those projected in long-range plans.

The circuit breaker shall be capable of performing other duties as required for the specific application. These duties may include: capacitive current switching, load current switching, and out-of-step switching (opening during a loss of synchronism condition whereby the phase angle of the voltage across the breaker is 180 degrees immediately after the circuit breaker opens).

The circuit breaker shall perform all required duties without creating transient overvoltages that could damage RTO-West equipment. Switchgear on the high side of a delta-grounded wye transformer that can interrupt Faults or load must be capable of the increased recovery voltage duty involving interruptions while ungrounded. The connection of a transmission line or load can coincidentally include other generating resources. When this system configuration is connected to the low-voltage side of a delta-grounded wye transformer, the high-voltage side may become ungrounded when remote end breakers open, resulting in high phase-to-ground voltages. This phenomena is described in Section P.2 under 'neutral shifts.'

b) Circuit Breaker Operating Times

Table U-1 Circuit Breaker Operating Times specifies the operating times typically required of circuit breakers on the RTO-West Transmission System. These times apply to equipment at or near the RTO-West Transmission System. System stability considerations may require faster opening times than those

listed. Circuit breaker interrupting time must coordinate with other circuit breakers and protective devices.

Table U-1 Circuit Breaker Operating Times

Voltage Class (kV L-L rms)	Rated Interrupting Time (Cycles)
300 kV to 500 kV	2
161 kV to 230 kV	4
100 kV to 160kV	4
50 kV to 69 kV	5

c) Other Fault-Interrupting Device Operating Times

Depending on the application, the use of other Fault-interrupting devices such as circuit switchers may be allowed. Fuses may be adequate for protecting the high voltage side of a high voltage delta low voltage grounded wye transformer. Trip times of these devices are generally slower, and current-interrupting capabilities are often lower than those of circuit breakers. These devices must coordinate with other protective devices operating times. Use of transformer fuses may result in 'single phasing' of low side connected loads.

U.3 TRANSFORMERS, SHUNT REACTIVE AND PHASE SHIFTERS

Transformer tap settings (including those available for under-load and no-load tap changers), reactive control setpoints, and phase shift angles must be coordinated with the RTO-West to optimize both reactive flows and voltage profiles. Automatic controls may be necessary to maintain these profiles on the interconnected system. Timed changes must be coordinated with time schedules established by the NWPP.

U.4 POWER QUALITY REQUIREMENTS

U.4.1 Voltage Fluctuations and Flicker

Voltage flicker is an increase or decrease in voltage over a short period of time, normally associated with fluctuating load. The characteristics of a particular flicker problem will depend on the characteristics of the load change.

The voltage flicker problem may arise during the start-up of an induction generator, as the large starting current may cause the voltage to drop considerably. All requesters shall take steps to minimize flicker problems from their generator(s) and /or load. Voltage dips more frequent than once per hour must be limited to conform to the connection requirements of the Utility.

In order to prevent Voltage fluctuations from causing serious disturbances to customer's equipment connected nearby on the grid, voltage fluctuation on a phase to phase and phase to ground basis shall not exceed +5% and -9% on a 60 Hz rms basis compared to the average in the immediately preceeding 1 second period.

The standards for voltage fluctuations at the point of connection of the Requestor's facility with the RTO are as follows:

Voltage Change	Maximum Rate of Occurrence
+/-3% of normal level	once per hour
+5/-6% of normal level	once per 8-hour work shift
Exceeding +5/-6%	pre-scheduled by RTO

U.4.2 Harmonics

Harmonics can cause telecommunication interference, increase thermal heating in transformers, disable solid state equipment and create resonant overvoltages. In order to protect equipment from damage, harmonics must be managed and mitigated. The new connection shall not cause voltage and current harmonics on the RTO-West IES that exceed the limits specified in IEEE Standard 519.

Single frequency and total harmonic distortion measurements may be conducted at the Point of Interconnection, or other locations on RTO-West's System to determine whether the new connection is the source of excessive harmonics. If the new connection results in harmonic voltage or currents exceeding the limits identified in IEEE Standard 519, the necessary equipment to reduce the harmonic voltage and currents to meet the standard is the responsibility of the Requestor.

Detailed harmonics standards and guidelines for their control are provided in Appendix C: Harmonics.

U.4.3 Voltage and Frequency Operation During Disturbances

Power System disturbances initiated by system events such as Faults and forced equipment outages, expose the system to oscillations in voltage and frequency. It is important that lines, loads and especially generators remain in service for dynamic (transient) oscillations that are stable and damped. To avoid large-scale blackouts that can result from excessive loss of generation or major transmission during a disturbance, under frequency load shedding has been implemented in the Pacific Northwest. When system frequency declines, loads are automatically interrupted in discrete steps, with most of the load shedding being initiated at frequencies between 59.1 Hz and 58.3 Hz. Load shedding attempts to stabilize the system by balancing the generation and load.

Each generator must be capable of continuous operation at 0.90 pu to 1.05 pu voltage and 59.5 to 60.5 Hz and limited time operation for larger deviations. Nearly all generators have inherent capability for off-nominal operation. Over/under voltage and over/under frequency relays are installed to protect the generators from extended off-nominal operation.

To insure that the generator is not tripped prematurely, the required time delays for setting these relays are presented in Table V-1: Generator Off-Nominal

Voltage Performance and Table V-2: Generator Off-Nominal Frequency Trip Settings of Section V.5.3, Generator Relay Coordination.

U.4.4 Phase Unbalance

Unbalanced phase voltages and currents can affect protective relay coordination and cause high neutral currents and thermal overloading of transformers and rotating machinery. To protect RTO-West and Requestor equipment, the contribution from the new facilities at the RTO-West IES shall generally not cause a nominal voltage unbalance greater than 1% nor a current unbalance greater than 5%. Phase Unbalance is the percent deviation of one phase from the average of all three phases.

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

Note: The Utility connection requirements may vary on a case by case basis, and the Requestor must conform to the Utility's requirements. The Utility's overall objective will be to limit voltage unbalance to 2%, 95% of the time.

U.4.5 Voltage Schedules

RTO-West maintains voltages according to the ANSI Standard C84.1. This allows for variances of ±5% off nominal for all voltage levels except for the 500 kV system that normally operates between 500 kV and 550 kV.

Voltage schedules are necessary to maintain voltage profiles across the transmission system to insure that reactive flows are kept low and that optimum use of reactive control facilities can be maintained. To this end a voltage schedule will be mutually developed between RTO-West and the Requestor, when appropriate, which will be coordinated via time changes developed by the NWPP for such coordination purposes.

U.4.6 Voltages During Disturbance

To avoid voltage collapse in certain areas of the Pacific Northwest, under voltage load shedding has also been implemented. Most of the load interruptions will occur automatically near 0.9 per unit voltage after delays ranging from 3.5 to 8.0 seconds. Depending on the type and location of any new load, the Requestor may be required to participate in this scheme.

When the connection involves tapping a transmission line, a 'local Island' may be created when the breakers at the ends of the transmission line open. This can leave generating resources and any other loads that also are tapped off this line isolated from the Power System. Delayed Fault clearing, overvoltages, Ferroresonance, extended under voltages, etc. can result from this 'local Island'

condition and cause equipment damage. If damage occurs due to the Requestor's facilities failure to detect the above type conditions, then the Requestor is responsible for the repair/replacement costs.

For the required off-nominal voltage performance of generators, see Table V-1: Generator Off-Nominal Voltage Performance.

U.4.7 Disturbance Monitoring

Unique and unanticipated protection problems can result from the changed system configuration due to interconnection with the Project. RTO-West may, at its discretion, install temporary monitoring equipment in the Requestor's facility to identify possible protection scheme problems and to provide power quality measurements of the new configuration. The monitor provides information similar to that of an oscillograph or fault recorder. The availability of current and voltage measurements determines the number of channels for the device.

The Requestor must make provision for access to PT and CT secondary windings for connecting this temporary monitoring equipment. Permanent monitoring equipment requirements are described in Section V.4.1.

If monitoring or relay performance indicates inadequate protection of the RTO-West IES, the owner of the Project will be notified of additional protection requirements.

Monitoring equipment is also installed to aid in the understanding of the electrical phenomena, such as overvoltages and ferroresonance that can be associated with these projects. Remote access to monitored quantities must be provided to RTO-West.

U.5 RELIABILITY AND AVAILABILITY

a) Maintaining service.

To minimize risk of overloads, instability, or voltage collapse, reliable operation of the interconnected Power System requires the following: reactive sources, control of real and reactive generation, adequate real and reactive reserves, and maintenance of transmission system voltages.

b) Transmission lines.

Key transmission lines and other facilities must be kept in service as much as possible. They may be removed from service for voltage control only after power flow studies, in accordance with WSCC requirements, indicate that system reliability will not be degraded below acceptable levels. The entity responsible for operating such transmission line(s) shall promptly notify other affected Control Areas, per the WSCC Procedure for Coordination of Scheduled Outages and Notification of Forced Outages or other applicable outages, when removing such facilities from and returning them back to service.

c) Switchable devices.

Devices frequently switched to regulate transmission voltage and reactive flow shall be switchable without de-energizing other facilities. Switches designed for

sectionalizing, loop switching, or line dropping shall be capable of performing their duty under heavy load and maximum operating voltage conditions.

d) Frequency and Duration of Outages.

Planned outages of significant system equipment shall be coordinated with all affected parties to minimize their impact on the remaining system. Automatic and forced outages must be responded to promptly, mitigating any impacts on the remaining system, and in a manner that treats all Requestor interruptions with the same priority. The design of the integrated system will be defined as the new RTO and NERC standards are finalized. The costs to implement the scheme/s will be born by the Requestor and RTO-West as they apply to their respective equipment.

U.6 KEY RELIABILITY AND AVAILABILITY CONSIDERATIONS

a) The new connection shall meet the NERC, NWPP and WSCC Minimum Reliability Standards for Planning and Operation.

b) Tools and spare equipment must be readily available to accomplish operations and maintenance tasks.

c) Shielding and EMI protection shall be provided to insure personnel safety and proper equipment functioning during disturbances such as Faults and transients.

d) Standardized design, planning and operating practices and procedures must be used so the new connection may be readily incorporated into the existing transmission network.

e) For reliable operation, the telecommunications, control and protection equipment must be redundant to the extent described in Section V.2 and Section X.

f) The equipment for the new connection shall have sufficient capabilities for both the initial operation and for long-range plans.

g) Operations and maintenance personnel must be properly trained for both normal and emergency conditions.

U.7 POWER FACTOR REQUIREMENTS

Each Requestor may be required to provide their own Reactive Power requirements to maintain adequate voltage level and ensure secure system operation.

Under normal system operating conditions, reactive power flows across interconnections between the RTO-West and the Requestor's facilities will be minimal. If reactive power flows are excessive, the RTO-West may require that the Requestor install compensating equipment such as fixed and/or switchable shunt capacitors, shunt reactors, Static Var Compensators (SVCs) or Statcoms, depending on the situation.

Requestors with generation will adjust their generator Mvar output (within the Mvar capability of the unit) or AVR setpoint in accordance with directions from the RTO-West. The *System Impact Study* will define how much Var support capability that is to be included in the unit rating.

U.8 ISOLATING, SYNCHRONIZING AND BLACK STARTS

a) Isolation

At the RTO-West Transmission System, the Requestor shall not energize a de-energized RTO-West line unless the appropriate Control Area Operator specifically approves the energization. Where the connection is to a radial load the circuit may be interrupted and reclosed by RTO-West. In cases where the connection breaks an existing path, an auto-isolation scheme may be required to sectionalize the connection to RTO-West Transmission System. If the connected facilities are networked or looped back to the RTO-West IES or where generation resources are present, a switching device must open to eliminate Fault contributions or neutral shifts. Once open, the device must not reclose until approved by the RTO-West transmission operator or as specified in the connection agreement.

b) Synchronization

The Requestor's system or portion of system with energized generators must synchronize its equipment to the RTO-West Transmission System. The exception to this is under large scale Islanding conditions where the RTO-West System will re-synchronize to neighboring systems over major Interties. Automatic synchronization shall be supervised by a synchronizing check relay, IEEE device 25.

c) Black Starts

Loads:

Loads that are scheduled and available for black starts are selected to avoid the trip out of generation units by exceeding frequency and voltage setpoints. This is accomplished by selecting voltage variable loads, avoiding motor start-up loads and imposing block size limits (50 MW). During black start restoration, tapped connections must be able to be opened to avoid interference with RTO-West restoration procedures on the RTO-West transmission path.

Generation:

RTO-West may require that a new generating plant be provided with black start capability.

Blackstart is the condition when one unit of a generation project starts up under local power, in isolation from the power system. Blackstart capability is needed in some rare circumstances, depending on the size and location of the Requestor's generator. It is generally not needed for small generators or for projects that are near other major generation. This capability is addressed in the planning and review process, and indicated on the Project Requirements Diagram.

Things to consider when determining blackstart requirements include the following:

- Proximity to major generation facilities (i.e., Can startup power be provided more efficiently from an existing plant?);
- Location on the transmission system (i.e., Is the Requestor's generator near major load centers and far from generation?);
- Cost of on-site start-up, and

- Periodic testing to ensure personnel training and capability.

U.9 RESPONSIBILITIES DURING EMERGENCY CONDITIONS

Each Load Control Area operator has the ultimate responsibility to maintain the frequency within its Control Area boundaries. All emergency operation involving the RTO-West IES must be coordinated with the RTO-West transmission operator. Each party, as appropriate, must participate in any local or regional Remedial Action Schemes. All loads tripped by under-frequency or under-voltage action must not be restored without the Load Control Area operator's permission unless they are automatically restored to correct frequency overshoot resulting from over-shedding of loads. All schedule cuts need to be coordinated with the appropriate Load Control Area operator, and need to be made promptly. All parties have the responsibility for clear communications and to report promptly any suspected problems affecting others.

V. PROTECTION REQUIREMENTS

V.1 INTRODUCTION

The protection requirements identified in this document are intended to achieve the following objectives:

a) To ensure safety of the general public, RTO-West and other utility personnel.

b) To minimize damage to the RTO-West IES and all equipment connected to it and to minimize damage to the property of the general public.

c) To minimize adverse operating conditions affecting RTO-West's System and customers.

d) Permit the Requestor to operate their system in a safe and efficient manner with minimum impact to the RTO-West System and other entities connected to the RTO-West IES.

e) Comply with NERC, WSCC and NWPP and RTO-West member's protection criteria in existence at the time of the connection request and as amended from time to time.

To achieve these objectives, certain protective equipment (relays, circuit breakers, etc.) must be installed. These devices ensure that Faults or other abnormalities initiate prompt and appropriate disconnection from the RTO-West IES. Protective equipment requirements depend on the plan of service. Significant issues that could affect these requirements include:

a) The location and configuration of the proposed connection.

b) The level of existing service and protection to adjacent facilities (including those of other RTO-West customers and potentially those of other utilities).

c) The coincidental connection of a new generation resource which was not previously connected to the RTO-West IES.

RTO-West makes the final determination as to the protective devices and identifies modifications and/or additions to the RTO-West IES that are required by the connection. RTO-West works with the Requestor to achieve an installation that meets the Requestor's and RTO-West's requirements. RTO-West cannot assume any responsibility for protection of the Requestor's system. Requestors are solely responsible for protecting their system and equipment in such a manner that Faults, imbalances, or other disturbances on the RTO-West IES do not cause damage to their facilities or the facilities of their customers.

V.2 PROTECTION CRITERIA

The protection system must be designed such that the Requestor's system or the faulted equipment is automatically isolated from the RTO-West IES for the following situations:

- Multi-phase or ground Faults within the Requestor's or connected utilities' system.
- Abnormal operating conditions such as equipment failures (e.g. single-phasing).
- System disturbances requiring isolation (e.g. load shedding).

V.2.1 General Protection Practices

The following summarizes the general protection practices as required by NERC and the WSCC and specific practices and applications as applied to RTO-West IES transmission lines and interconnections. The protection schemes necessary to integrate the new connection must be consistent with these practices and the equipment used to implement them.

V.2.1.1 All Voltages

a) Relays, breakers, circuit switchers, fuses, etc. are required at each point of connection to the RTO-West IES or at the connecting substation to isolate RTO-West equipment from the Requestor's system during Faults in the Requestor's system.

b) Requestor is not allowed to energize a de-energized line in the RTO-West IES without approval of the appropriate Control Area Operator.

c) Breaker reclose supervision (automatic and manual including SCADA) may be required at the connecting substation and/or electrically 'adjacent' stations; e.g., hot bus and dead line check, synchronization check, etc.

d) Dual batteries are not required but each set of relays must have its own separately protected DC source.

e) Relay settings shall not infringe upon RTO-West ability to operate at maximum transfer levels, even with system voltages as low as 0.8 per unit.

f) Redundant relays shall not be connected to a common current transformer secondary winding.

g) Redundant or overlapping relay systems are required such that no single protection system component failure would disable the entire relay system. Protection schemes shall be designed with sufficient number of test switches and isolating devices to provide ease of testing and maintenance without the necessity for lifting wires. Isolating switches shall be alarmed or operating and maintenance tagging procedures developed and followed to ensure switches are not inadvertently left in an open position.

h) Directional relay systems are required on all non-radial connections and may be required on radial connections to generators.

i) The RTO-West reserves the right to review and requires changes to protection system and settings for equipment connected to the RTO-West Transmission System.

j) The protection system security and dependability and their relative effects on the Power System must be carefully weighed when selecting the protection system.

k) Automatic under-frequency load tripping total trip time, including relay operate time and breaker operate time, shall not exceed WSCC requirements and shall never exceed 14 cycles.

l) Only one automatic reclose is necessary for most applications. Multi shot automatic reclosing may be required for automatic line sectionalizing schemes. The total number of automatic reclosures must not exceed three.

m) Breaker failure relays (BFR) are required on all CBs associated with transmission lines and generators. Total time for BFR scheme Fault clearing must not exceed 14 cycles. System requirements may dictate faster BFR operating times. Breaker failure relays do not have to be redundant. BFR schemes are not required on CBs connecting loads.

V.2.1.2 All Voltages Above 100 kV

a) Dual circuit breaker trip coils are required at 500 kV and above.

b) Redundant directional relay systems on transmission lines are required if a single point of failure could disable the entire relay system. Both relay systems shall contain an instantaneous tripping element capable of outputting a trip in 1.5 cycles or less for Faults within 80% of the line. If ground distance elements are used, the relay must include ground over current elements to provide tripping for high resistance ground Faults.

c) Redundant telecommunications schemes may be required if time-delayed Fault clearing can result in instability, Cascading or voltage problems. In some cases, an acceptable alternative to redundant transfer trip schemes may include the use of a directional comparison-blocking scheme.

d) Redundant relay and telecommunications schemes are required on all transmission lines 300 kV and above.

e) Availability of telecommunications schemes used for protection shall meet WSCC criteria (See Section X.2, Telecommunications Availability).

V.2.1.3 At or below 100 kV

a) Redundant or overlapping relays systems are required such that no single protection system component failure would disable the entire relay system and result in the failure to trip for a Fault condition.

b) Total Fault-clearing times, with or without a pilot scheme, must be provided for RTO-West review and concurrence. Breaker operating times, relay makes, types and models, and relay settings must be identified specifically.

V.3 PROTECTION FUNCTIONS

Protection systems must be capable of performing their intended function during Fault conditions. The magnitude of the Fault depends on the Fault type, system configuration, and Fault location. It may be necessary to perform extensive model line tests of the protective relay system to provide assurance

the selected relay system is capable of detecting Faults for various system configurations. Power System swings, major system disturbances and Islanding may require the application of special protective devices or schemes. The following discussion identifies the conditions under which relay schemes must operate.

V.3.1 Phase Fault Detection

Phase over current (type 50/51) and neutral over current (type 50/51-N) relays are provided to detect abnormally high currents. These non-directional relays are used to detect Faults on the Distribution class lines or serve as supervisory Fault detectors for transmission relays. They may also serve to backup other protective relays. Line differential relays may be a necessary consideration for some connections when coordination with other relays is not possible. Infeed detection to Faults within the Power System usually requires directional current-sensing relays to remove the contribution to the Fault from the RTO-West Transmission System. Zone-distance relays (type 21) usually serve this need. The distance relay is a good choice for this application since it is generally immune to changes in the source impedance.

V.3.2 Ground Fault Detection

Ground Fault detection has varying requirements. The availability of sufficient zero sequence current sources greatly affects the operation of the relay system to detect ground Faults. Ground Fault resistance also plays a significant part in the relay's ability to properly detect ground Faults. The same type of relays described in Section V.3.1 above are suitable for ground Fault detection. If ground Fault distance relays are used, backup ground time over current relays must also be applied to provide protection for the inevitable high resistance ground Fault.

V.3.3 Islanding

Islanding describes a condition where the Power System splits into isolated load and generation groups, usually when breakers operate for Fault clearing or system stability remedial action. Generally, the 'Islanded groups' do not have a stable load to generation resource balance. However, it is possible that, under unique situations, generator controls can establish a new equilibrium in an Islanded group.

Some utilities isolate their Distribution system and use local generation to feed loads during Power System outages. RTO-West does not allow Islanding conditions to exist that include its facilities, except for a controlled (temporary, area-wide) grid separation. When RTO-West customer loads are being served over another utility's transmission and Distribution system or where generation is also interconnected, implications of islanding must be addressed to minimize adverse impacts on these loads. While operating in an Islanded condition or during a system disturbance, power swings may result which can affect the operation of protective relays, especially distance relays. Out of step blocking is commonly available for distance relays to prevent them from operating during a power swing. However, the application of such schemes must be coordinated with RTO-West to ensure that the blocking of the distance elements will not result in inappropriate or undesirable formation of Islands.

V.3.4 Load Shedding

The proposed connection may require special load shedding schemes based upon RTO-West Load Control Area requirements. These may include under frequency load shedding, under voltage load shedding, or direct load tripping. The intent of load shedding is to balance the load to the available generation, reduce the possibility of voltage collapse, and to minimize the impact of a system disturbance. Tripping levels, restoration, and other details of load shedding schemes will be determined by RTO-West, following NERC, WSCC and NWPP criteria.

V.3.5 Generator Dropping

The proposed connection may also require additional logic to supply signals to existing special protection schemes including but not limited to line loss detection and generator dropping. These schemes are also designed to maintain the balance between system loads and available generation during and following a system disturbance. If the new connection includes generation not previously part of the RTO-West Load Control Area, the generation may also require additional special trip schemes.

V.3.6 Other Special Protection and Control Schemes

The location in the RTO-West IES, the amount of load transfer expected and various other system conditions may require other special protection schemes. The need for and type of schemes required will be determined as part of the system studies done following the request for a new connection. For example, RAS may be required for stability purposes or out-of-step tripping may be needed for controlled system grid separations. Special breaker tripping or closing schemes (e.g. staggered closing, point-on-wave closing) may be necessary to reduce switching transients. These special protection and control schemes may require stand alone relay systems or additional capabilities of particular substation equipment (e.g. independent pole operation of circuit breakers).

V.3.7 Synchronizing and Reclosing

If the connection is made to an existing line, automatic reclosing schemes at the remote line breakers may need to be modified. On transmission lines below 138 kV, automatic sectionalizing schemes may be installed to isolate a portion of the system that has a permanent Fault. This may include multi-shot automatic reclosing at remote terminals. A new Point of Interconnection must be compatible with such existing schemes. If the new connection results in the possibility of connecting a generation source to the RTO-West IES, special considerations may be required.

V.4 RELAY PERFORMANCE AND TRANSFER TRIP REQUIREMENTS

Relay systems are designed to isolate the transmission line and/or load facilities from the RTO-West IES. However, the performance (clearing time) of these local relay systems and the associated isolating devices (breakers, etc.) will vary. The protection equipment of the new connection must at least maintain the performance level of the existing protection equipment at that location. This may require transfer trip (pilot telecommunications) to ensure high-speed and secure Fault clearing. Other types of pilot tripping such as directional comparison, phase comparison or current differential may also be acceptable if the scheme chosen can achieve the total clearing times required.

Transfer trip is required when any of the following conditions apply to the new connection.

1. Transient or steady-state studies identify conditions where maintaining system stability requires immediate isolation of the Connection Point facilities from the power system.
2. Special operational control considerations require immediate isolation of the Connection Point.
3. Extended fault duration represents an additional safety hazard to personnel and can cause significant damage to power system equipment (e.g. lines, transformers).
4. Slow clearing or other undesirable operations (e.g., extended overvoltages, ferroresonance, etc.), which cannot be resolved by local conventional protection measures, will require the addition of pilot tripping using remote relay detection at other substation sites. This scenario is a distinct possibility should an RTO-West circuit that connects other customer loads become part of a 'local island' that includes a generator.
5. Relay operate times are adjusted to coordinate for faults based on the local configuration (e.g. three terminal lines), fault currents available, etc. Total clearing times must be less than those listed in Table 6-1. Otherwise, immediate isolation of the Connection Point is required. Refer to Section X-5 for telecommunication issues as they pertain to control and protection requirements.

V.4.1 Protection System Performance Monitoring

Depending upon the type and location of the connection, permanent monitoring equipment may be required. The monitoring equipment is intended to identify possible protection scheme problems and to provide power quality measurements. The monitoring equipment may provide information similar to that of an oscillograph or Fault recorder. The availability of current and voltage measurements determines the number of channels for the device. Sequential event recorders and/or annunciators may also be required to record and time tag operations of protection and other equipment. In some cases, it may be acceptable to utilize the recording and monitoring capabilities of a protective relay system to provide for system monitoring and event recording. See also Section U.4.7, Disturbance Monitoring.

The monitoring equipment may be connected to a GPS satellite receiver or other time source with equivalent accuracy. Remote access to monitoring equipment is required. RTO-West will supply a list of quantities to be monitored and the appropriate terminology when connections are made to the RTO-West IES. If monitoring or relay performance indicates inadequate protection of the RTO-West IES, the owner of the connected facilities will be notified of additional protection requirements or changes.

RTO-West may request limited remote telecommunications access to relay systems at the Requestor's nearest substation to the Point of Connection for querying the operational history and Fault data. Upon request, and if available, RTO-West will reciprocate by supplying the Requestor with limited access to the appropriate RTO-West relays.

V.5 PROTECTION SYSTEM SELECTION AND COORDINATION

V.5.1 Relays to be Installed for the Point of Interconnection

At the time of the connection request, RTO-West will supply the Requestor with an approved list of protective relay systems considered to be suitable for use at the RTO-West IES. The performance of protective relays applied at the connection that can directly affect the performance of the RTO-West IES must follow the recommendations from the supplied list. Should the Requestor select a relay system not on our approved list, RTO-West reserves the right to perform a full set of acceptance tests, possibly at the Requestor's expense, before granting permission to use the selected protection scheme. Alternatively, the relay vendor or a third party may be asked to perform thorough model line tests of the proposed relay system.

V.5.2 Protection System Coordination and Programming

The following are basic considerations that must be used in determining the settings of the protection systems. Depending upon the complexity and criticality of the system at the RTO-West Transmission System, complete model line testing of the protection system including the settings and programming may have to be performed before installation to verify the protection system performance.

1) Fault study models used for determining protection settings must take into account significant mutual and zero sequence impedances. Up to date Fault study system models shall be used.

2) Protection system applications and settings must not normally limit transmission use.

3) Protection systems must avoid tripping for stable swings on the interconnected transmission systems.

4) Protection system applications and settings must be reviewed whenever significant changes in generating sources, transmission facilities, or operating conditions are anticipated.

5) All protection system trip misoperations shall be analyzed for cause and corrective action taken.

6) Out of step blocking of protection distance (21) elements must be coordinated with out of step tripping or planned separation schemes. These must be reviewed by RTO-West IES Planners.

V.5.3 Generator Relay Coordination

Voltage and frequency relays used for protecting a generator and preventing a 'local Island' condition from persisting must meet the following requirements to allow proper coordination with the adjacent Power System(s). These relays are usually installed at the Generation Site or at the Point of Interconnection Substation. The ranges, settings, and delays below for both voltage and frequency relays are understood by RTO-West to be well within the capabilities of small and large modern steam turbines as well as other generators. RTO-

West will evaluate a Requestor's proposed alternative voltage/frequency settings based upon the impact on system performance and reliability. The settings must comply with existing NWPP requirements.

V.5.3.1 *Voltage Relays*

The over/under voltage relay setting/delays are intended to insure that generators trip when the connections to the Power System have been interrupted, preventing extended 'local Islanding.'

These requirements also insure that generators do not disconnect for dynamic (transient) oscillations on the Power System that are stable and damped. During severe system voltage disturbances it is critical that generators do not trip before the completion of all automatic under voltage load shedding. The *System Impact Study* will provide voltage relay settings. Table V-1: Generator Off-Nominal Voltage Performance provides the usual off-nominal voltage performance requirements of RTO-West. The over- and under-voltage limits are expressed in per unit of "normal terminal voltage". "Normal terminal voltage" is defined as the terminal voltage at which the generator would normally operate when delivering its Maximum Power Output (MPO) and the voltage at the interconnection point is at its nominal value. The nominal interconnection voltage, is defined as the most likely operating voltage during peak load conditions under normal system conditions. The nominal interconnection voltage will be specified by RTO-West.

Table V-1: Generator Off-Nominal Voltage Performance

Overvoltage	Undervoltage	Minimum Delay
<1.10 pu	>0.90 pu	continuous
-	≤0.90 pu	10.0 seconds
≥1.10 pu	-	5.0 seconds
≥1.20 pu	≤0.80 pu	2.0 seconds
≥1.25 pu	≤0.75 pu	0.8 second
≥1.30 pu	-	None

V.5.3.2 *Frequency Relays*

The following frequency ranges and minimum setting/delay requirements for over/under frequency relays (type 81) have been established by the WSCC Coordinated Off-Nominal Frequency Load Shedding and Restoration Program. The objective of these settings is to use the machine capability to support the Power System and prevent unnecessary loss of system load during disturbances, and ultimately, to help prevent system collapse. Generating resources must not trip off before load is shed by under frequency relays.

Table V-2: Generator Off-Nominal Frequency Trip Settings

Underfrequency Range	Overfrequency Range	Minimum Time Delay Setting
60.0-59.5 Hz	60.0-60.5 Hz	No Generator Tripping (Continuous)
59.4-58.5 Hz	60.6-61.5 Hz	3 minutes
58.4-57.9 Hz	61.6-61.7 Hz	30 seconds
57.8-57.4 Hz		7.5 seconds
57.3-56.9 Hz		750 milliseconds
56.8-56.5 Hz		120 milliseconds
Less than 56.4 Hz	Greater than 61.7 Hz	Instantaneous Trip

For generators that are not susceptible to damage for the frequency ranges listed above (e.g. typical hydro units), tripping at 61.7 and 56.4 Hz, with no intermediate steps is suggested. For steam generators and similar units, relay(s) with multiple frequency setpoints and discrete time delays could be used to realize the settings above.

Often, large generation resources are directly connected to a substation at the transmission level voltage and would not be part of the 'local Island' condition described in Section O. For these generators, the 61.7 Hz trip level may be raised and the 56.4 Hz trip level may be lowered. However, the minimum delays listed above for all frequency deviations from 60 Hz must be maintained. For those generators that can be part of a 'local Island', a maximum delay of 0.1 sec at 56.4 and 61.7 Hz must be used. This will help insure that the generator trips for the 'local Islanding' condition.

Voltage and frequency relays must have a dropout time no greater than 2 cycles. Frequency relays shall be solid state or microprocessor technology; electro-mechanical relays used for this function are unacceptable. Frequency relays with inverse time vs. frequency operating characteristics are not acceptable.

V.5.4 Required Protective Relays

This set of relays, to be installed for the integration of the Requestor's facility, has been developed in recognition of varied detection requirements. Relay performance under certain Fault scenarios is also a consideration in the selection of these relays. The specific relays used must be functionally consistent with, and complementary to, RTO-West general protection practices identified in Section V.2.1, General Protection Practices. The relays generally necessary to serve this purpose are:

- **i.** Phase overcurrent (non-directional) (type 50/51)
- **ii.** Neutral overcurrent (non-directional) (type 50/51-N)
- **iii.** Zone distance (type 21/21-N)
- **iv.** Directional ground overcurrent (type 67-N)
- **v.** Ground overcurrent (type 51-G) or ground Fault detection scheme (type 59-Z)

vi. Over/under voltage (type 59/27)
vii. Over/under frequency (type 81)
viii. Instantaneous overvoltage (ungrounded high-side) (type 59)
ix. Remote automatic breaker reclose supervision (type 79-X) (Hot Bus/Dead Line, Hot Bus/Hot Line with synchronism check)

Except for Item ix above, these relays are usually located at the substation that contains the step-up transformer. Some or all may be located elsewhere if the Point of Interconnection to the Requestor's facilities suggests an equally acceptable or more logical location. All relays shall be of 'utility grade' quality, subject to review by RTO-West.

V.6 COMMISSIONING TEST REQUIREMENTS FOR PROTECTION SYSTEMS

Thorough commissioning or installation testing of the protection system(s) is an important step for the installation of a new terminal or when changes to the protection system are made. The protection system includes the protective relays, the circuit breakers, instrument transformer inputs, and all other inputs and outputs associated with the protection scheme. The actual protection equipment used also will determine the type and extent of commissioning tests required. The following tests are the minimum tests that must be performed. They need to be performed on all protection schemes at the Point of Interconnection that could affect the performance of the RTO-West Transmission System.

V.6.1 Protective System Inputs

1) Current transformers -- check for proper ratio, polarity, connections, accuracy, and appropriate grounding for the circuit involved.
2) Current transformers -- verify that unused CT windings are properly shorted and that CT windings used for protection systems are not shorted.
3) Voltage transformers -- check for proper ratio, polarity, connections, accuracy, and appropriate grounding.
4) Verify all other inputs to the protection system including battery supplies, circuit breaker auxiliary switches, pilot channel inputs, etc

V.6.2 Protection System Settings

1) Check protection system settings and programming.
2) Perform acceptance testing of protection systems if not performed previously.
3) Perform calibration tests of the protection system using actual settings.
4) Verify that any changes in relay settings required for relay acceptance testing are returned to the desired, "as left" settings.

V.6.3 Protection System Drawings and Wiring

1) Verify switchboard panel and equipment wiring is intact and matches drawings.
2) Verify drawings are correct.

V.6.4 Relay System Operation

1) Verify proper relay system operation
2) Verify relay directionality
3) Verify relay coordination.

V.6.5 Protective System Outputs

1) Trip outputs: trip intended trip coil(s) and open breaker

2) Close outputs: energize close coils and close the breaker(s)
3) Verify relay outputs to pilot channel are functional.
4) Verify all other outputs such as breaker failure initiate, special protection scheme signals, alarms, event recorder points, etc. are functional.

V.6.6 Operational Tests
1) Perform trip tests to verify correct operation of the overall protection systems.
2) Test automatic reclosing.

V.6.7 Pilot schemes
1) Measure channel delays.
2) Check for noise immunity.
3) Check for proper settings, programming, etc.
4) Check transmit and receive levels.
5) If automatic channel switching or routing is utilized, check for proper relay operation for alternate routing.

V.6.8 In Service, Load and Directional Tests
1) Measure AC current and/or voltage magnitudes applied to the relay system.
2) Measure AC current and/or voltage phase angles applied to the relay system.
3) Test the relay system for proper directional operation where applicable.

Many utilities now use coordinated end-to-end tests to verify the overall operation of the protection system and the pilot channel as part of their commissioning tests. This is an acceptable method of operational testing. Modifications to a protection system also require testing similar to that listed above. The extent of testing and types of tests required depend upon the modifications made. Tests performed after modifications are required to ensure correct system operation.

The WSCC requires certain generator test data be made available for the western system database. Measured data must be made available within four (4) weeks of commercial operation.

W. SYSTEM OPERATION AND SCHEDULING DATA REQUIREMENTS

W.1 INTRODUCTION

All transmission arrangements for power schedules within, across, into or out of the RTO-West Load Control Area require metering and telemetering. Transmission arrangements with loads or new transmission facilities may include wheeling, voltage control, and Automatic Generation Control (AGC). The technical plan of service for interconnecting a load or new transmission facility, as shown on the Project Requirements Diagram, will include the metering and telemetering equipment consistent with the transmission contract provisions. Such metering and telemetering equipment may be owned, operated, and maintained by RTO-West or by other parties approved by RTO-West.
Revenue Metering, system dispatching, operation, control, transmission scheduling and power scheduling each have slightly different needs and requirements concerning metering, telemetering, data acquisition, and control. Specific requirements also vary depending upon whether the new connection is directly

connected to the RTO-West IES or electronically connected via telemetering that places the connection within or outside the RTO-West Load Control Area.

W.2 SYSTEM OPERATION REQUIREMENTS

W.2.1 Telemetering Requirements

RTO-West IES Dispatching requires telemetering data for the integration of new interconnections at adjacent Load Control Area boundaries. This typically consists of the continuous telemetering of MW and hourly quantities to the RTO-West. The following includes generic requirements based on connection size:

1) Telemetering is required for all normally closed interconnections at a Load Control Area boundary. For this case, telemetering of Real Power, energy, Reactive Power and voltage (MW, MWh, Mvar, kV) is required. Phase angle telemetry across the interconnected breaker may be required. High capacity interconnections may require redundant metering and telemetering.

2) For normally open or emergency tie connections, RTO-West determines telemetering needs on a case-by-case basis. Note that NERC requires telemetering for these connections.

3) For loads connected internally to the RTO-West Load Control Area, telemetering is not normally required. For interruptible loads, RTO-West determines telemetering needs on a case-by-case basis. Connecting Eccentric (Non-Conforming) Loads may require an interface to the RTO-West AGC system. Existing practices throughout North America usually require a warning signal of pre-loading in order to assure that adequate generation reserves are spinning before any sudden load change occurs. Any connected generation facility 5 MW or larger must furnish telemetering of MW, volts and MWh to the RTO-West.

4) Telemetering for interconnection of shared or jointly-owned loads or generation commonly use Dynamic Signals. These signals are usually a calculated portion of an actual metered value. The calculation may include adjustments for losses, changing ratios of customer obligations or shares, or thresholds and limits. Two-way Dynamic Signals are used when a customer request for MW change can only be met by an actual change in generation. In this case, a return signal is the official response to the request and its integrated value is designated the official meter reading. Previous integration intervals were one hour. Some types of Dynamic Signals may require shorter integration intervals. The integration interval is determined by the type of service provided consistent with RTO-West tariffs to properly account for transmission usage.

5) Additional data may be required if the facility provides Ancillary Services. The data requirements depend on the type of Ancillary Service provided.

W.2.2 Data Requirements for Load Control Area Services

Non-traditional sources are sometimes used for supplying Ancillary Services. If a load provides regulating or Contingency reserve services, data requirements for deployment of the reserves will be similar to those applied to generating resources. To the extent that a third party may externally supply regulating or Contingency reserve services at the RTO-West Load Control Area interconnecting boundary, data requirements for their deployment may be similar to those applied to generating resources. Technical discussions are necessary

before the specific data requirements can be determined. The following provides a brief overview of these requirements:

1) If RTO-West is purchasing supplemental AGC services, AGC interface is required on a long-term basis. Before purchasing supplemental services, an investigation into the capabilities, cost, and benefits of AGC control is required to determine the specific AGC requirements. Most supplemental services are scheduled and delivered using Dynamic Signals.

2) Ancillary Services requirements are also driven by how the interconnected customer chooses to meet these obligations. Either the Requestor or the entity making the transmission arrangements is liable for the Ancillary Services obligations associated with the connection. Most self-provided Ancillary Services are scheduled and delivered using dynamic signals. The responsible party may fulfill these obligations in any of the following ways:

i. Self-provide Ancillary Services by making resources available to RTO-West to deploy.
ii. Contract with a third party to make resources available to RTO-West to deploy.
iii. Contract with RTO-West to cover this Ancillary Services obligation.

3) Where a third party is providing Ancillary Services the following data is required with a sampling rate of once every four (4) seconds unless mutually agreed otherwise or other rate established by NERC:

i. Net instantaneous power transferred (MW)
ii. Instantaneous and total MVar transferred
iii. Operating Reserve capability during the next ten minutes
iv. MWh for last hour The Requestor must demonstrate that the means to satisfy whichever of the above options is chosen is technically sound, and meet all relevant reliability policies and criteria of NERC, WSCC and NWPP.

W.2.3 Supervisory Control and Data Acquisition (SCADA) Requirements

Interconnection may require RTO-West SCADA control and status indication of the power circuit breakers and associated isolating switches used to connect to the RTO-West Transmission System. SCADA indication of real and Reactive Power flows and voltage levels could also be required.

W.3 INTERCHANGE SCHEDULING REQUIREMENTS

A new load being integrated into the RTO-West IES must adhere to the scheduling requirements of the prevailing tariff under which it is taking transmission service from RTO-West. Customers may be required to provide RTO-West Transmission Scheduling with an estimate of the their hourly load, hourly generation schedules, and/or net hourly interchange transactions. These estimates will be used for both pre-scheduling and planning purposes. RTO-West will require customers to provide these estimates as necessary in order for RTO-West to manage the load/resource balance within the RTO-West Load Control Area and to determine usage of the RTO-West Transmission System. In the case of new transmission facilities, scheduling and accounting procedures are needed if the facility is part of an interface between the RTO-West Load Control Area and another Load Control Area. This scheduling and accounting of interchange between two Load Control Areas normally requires telemetered data from the RTO-West IES to the control centers of the load Control Area operators. This data is termed Interchange

Metering and telemetering and includes MW and MWh quantities. RTO-West requires that all Load Control Area transactions be prescheduled for each hour using the normal scheduling procedures. The end-of-hour actual interchange must be conveyed each hour to the RTO-West. This can be accomplished through the use of telemetering or data link provided by the Requestor. When the interconnection represents a shared or jointly owned interface to RTO-West, then a calculated allocation is usually required to divide up the total metered interchange. This non-physical interface is accomplished by Dynamic Signal. A two-way Dynamic Signal is required when a combined request and response interface is used. An example is supplemental AGC services. A one-way Dynamic Signal is required when a response (or following) interface is used. Moving a Control Area boundary is an example of this requirement.

W.3.1 Interchange Telemetering Requirements

Interchange telemetering generally consists of bi-directional meters and related telecommunications systems providing MW and MWh at or near the Control Area boundary. The MW and MWh measurements are telemetered on a continuous basis to the Energy Management System (EMS) at RTO-West. The MW measurement is used for AGC and the MWh measurement is used to track inadvertent interchanges. Interchange telemetering accuracy and calibration requirements are identical with those for Revenue Metering. The telemetering signal would follow a mutually agreed protocol and the quantities measured would be in digital form and be able to issue alarms when problems occur. Data sample rate must be at least every 2 seconds or other approved rate compatible with NERC and WSCC Policy. Typical alarms include but are not limited to:

1) Loss of meter potential

2) Loss of telemetering signal

W.3.2 Data Acquisition System

Loads such as steel rolling mills, wind tunnels, etc. require additional data to make generation control performance more predictable. Such additional data may include, but not be limited to, precursor signals of expected load changes, etc. SCADA control may also be required. Specific requirements and needs are determined for each load.

W.4 REVENUE AND INTERCHANGE METERING SYSTEM

All connections require Revenue Metering and data recording for the scheduling processes. Revenue Metering includes bi-directional active energy data (delivered and received MWh), bi-directional reactive energy data (4 quadrant MVarh) recorded on every 5 minutes. Interchange Metering includes bi-directional active energy, bi-directional reactive energy and voltage data as well as special telemetering requirements for scheduling purposes. The metering shall be located to measure the net energy flow into or out of each Control Area in the RTO-West IES as well as the net energy flow into or out of the total RTO-West IES. All recorders must be fully compatible with the RTO-West Billing Data Acquisition System. Demand data will be available to the customer or their agent. RTO-West will supply the Requestor with a list of pre-qualified metering systems should the Requestor desire to furnish, own and/or maintain the metering system. If the

selected system is not on the RTO-West pre-qualified list, RTO-West reserves the right to perform a full set of acceptance tests, possibly at the Requestor's expense, before granting permission to use the selected system. Other meters will be considered, subject to RTO-West approval, where a RTO-West authorized party performs the metering and telemetering functions.

W.4.1 Revenue and Interchange Metering Requirements

Three-element metering is acceptable for all locations in three-phase Power Systems. Two-element metering may be used in locations having no zero-sequence current path.

The Revenue Metering package shall include MWh recording compatible with the RTO-West RMS system .

The Interchange Metering package shall include MWh recording compatible with the RTO-West scheduling system "is the scheduling system different from the RMS system and the Billing Data Acquisition system?"

If the Requestor's facilities result in the addition of generation to the RTO-West IES not previously accounted for, there will be additional metering requirements.

Section X discusses telecommunications requirements for the RMS system.

W.4.2 Meter Accuracy

Revenue meters shall meet 0.2 Accuracy Class according to ANSI C12.20 and be calibrated to at least ±0.2% watt-hour accuracy at unity Power Factor for both full load and light load. Meters shall also be calibrated to ±0.5% watt-hour accuracy for 0.5 Power Factor at full load. Full load is defined as nominal voltage, 100% meter current test amps. Light load is nominal voltage, 10% meter current test amps.

W.4.3 Instrument Transformers

Instrument transformers shall be rated according to ANSI C57.13 and shall be 0.3 metering accuracy class at a standard burden which exceeds the actual connected Revenue Metering equipment burden and possible future monitoring equipment. Instrument transformers for metering need to be located such that the input to the metering and telemetering is not interrupted during possible switching configurations in the RTO-West IES.

W.4.4 Loss Compensation

Transmission system losses, such as those in transformers and/or transmission lines, often must be accounted for in the Revenue Metering process. The preferred Point Of Metering is at the Point of Connection, therefore no loss compensation is required. If the Requestor desires that the Point Of Metering be at a point other than the Point Of Connection loss compensation will be required. RTO-West will consider having the compensation performed by the meter provided both raw and compensated values are recorded.

W.4.5 Station Service Power

Depending upon its electrical source and electrical location, the station service power for the connecting substation facilities may require separate Revenue

Metering. The requirements of this Section W.4 apply to station service metering.

W.5 CALIBRATION OF REVENUE AND INTERCHANGE METERING FACILITIES

Calibration of Revenue and Interchange Meters shall be verified in accordance with local regulatory requirements (in Canada these are *Measurements Canada* requirements which presently require verification every 6 years). All interested parties or their representatives may witness the calibration tests. Calibration records shall be made available to all interested parties. The calibration standards used for calibration shall have their accuracy traceable to the National Institute of Standards and Technology (NIST) or equivalent. The calibration standards shall have been certified within twelve months before the actual meter calibration.

X. TELECOMMUNICATION REQUIREMENTS

X.1 INTRODUCTION

Telecommunications facilities shall be tailored to fulfill the control, protection, operation, dispatching, scheduling, and Revenue Metering requirements. As a minimum, telecommunications facilities must be compatible with, and have similar reliability and performance characteristics to, that currently used for operation of the RTO-West IES. The Requestor is required to upgrade their end of any communications, billing metering and protection equipment to stay compatible with RTO-West's system upgrades at the Requestor's cost.

Telecommunications facilities will be identified on the Project Requirements Diagram. Depending on the performance and reliability requirements of the control and metering systems to be supported, the facilities may consist of any or all of the following:

a) Microwave Systems

A microwave system requires transmitters, receivers, telecommunication fault alarm equipment, antennas, batteries, and multiplex equipment. It may also include buildings, towers, emergency Power Systems, mountaintop repeater stations and their associated land access rights, as needed to provide an unobstructed and reliable telecommunications path. Microwave path diversity, equipment redundancy, and/or route redundancy may be required to meet Power System reliability requirements by protecting against telecommunications outages caused by equipment failure or atmospheric conditions.

b) Fiber Optic Systems

A fiber optic system requires light wave transmitters, receivers, telecommunication fault alarm equipment, multiplex equipment, batteries, emergency Power Systems, fiber optic cable (underground or overhead) and rights-of-way. Cable route redundancy may be required to protect against cable breaks and resulting telecommunications outage.

c) Wireline Facilities

A wireline facility requires telecommunications cable (underground or overhead), high-voltage isolation equipment and rights-of-way. It may also include multiplex equipment, emergency Power Systems, and batteries, depending on the wireline technology employed. Cable route redundancy may be required to protect against cable breaks and resulting telecommunications outage.

d) Power Line Carrier Systems

A power line carrier system uses the actual power line conductor(s) as the transmission media. Coupling capacitors, line tuning units, and wave traps are connected to the circuit to connect the carrier transmitter and receiver to the power line. Power line carrier availability and performance is greatly affected by line outages. For this reason its use for control, data, and voice communications is limited. In some instances it can be used with line protective devices. This method is the least acceptable way to obtain information and for control.

X.2 TELECOMMUNICATIONS AVAILABILITY

X.2.1 Common Carrier

Dedicated telecommunication facilities are required for the operation of RTO-West IES critical control and protection functions. Common carrier telecommunications are not considered acceptable for this purpose due to lack of security. However, depending upon the reliability requirements, importance of the control and protection functions and the Point of Interconnection into RTO-West IES, common carrier telecommunications alternatives may be considered.

X.2.2 Transmission System

Telecommunications systems serving Transmission Systems shall be fully redundant with a service availability time equal to or exceeding the Power System availability goal. The design availability for telecommunications systems serving the transmission system shall be at least 99.95%. This is based on total outage time of 4.38 hours per year due to path or components. The design availability for telecommunications systems serving secondary transmission shall be at least 99.88%. This is based on total outage time of 10-1/2 hours per year due to path or components.

X.2.3 Alternate Routing

If alternately-routed telecommunications are required for Transmission System protective relaying schemes, the overall availability of the alternately-routed telecommunications shall be at least 99.95%. Availability is determined for the total path of the protective relaying circuit, from one end of the transmission line to the other. Options for achieving these availability requirements by utilizing two or more separate telecommunication methods, routes or systems are acceptable and may be considered. When alternately routed telecommunications for protective relaying schemes are required, a combination of two of the above telecommunications methods may be used to meet availability requirements.

X.3 VOICE COMMUNICATIONS

If the Point of Connection is within the RTO-West Load Control Area:

a) Voice Communications to the RTO-West IES operator are required whenever any type of telemetering is required.

b) A Dedicated, Direct, Automatic Ringdown Trunk (or equivalent) voice circuit between the appropriate RTO-West transmission operators and the Point of Connection operator or transmission operator may be required for:

1) Generation of 5 MW or greater,

2) Eccentric (Non-Conforming) Loads

3) Connected networks that include automatic generation dropping for RTO-West IES remedial action.

4) A non-radial interconnection to another electric utility with a transfer capability in either direction of 50 MW or greater.

c) **Independent Voice Communications** for coordination of system protection, control, and telecommunication maintenance activities between RTO-West and the Point of Connection must be provided, in addition to the voice telecommunications specified above.

X.4 DATA COMMUNICATIONS

Telecommunications for SCADA and Telemetering must function at the full performance level before, during and after any Power System fault condition. Telecommunications for RMS must function at the full performance level before and after any Power System fault condition.

a) **SCADA Requirements** typically include one or more dedicated circuits between the new Point of Interconnection and the appropriate RTO-West.
b) **AGC Interchange and Control Telemetering** for operations and scheduling applications typically require one or more dedicated circuits between the new Point of Interconnection and the appropriate RTO-West. Digital telecommunications capabilities of at least 9600 bits per second are required.
c) **Interutility Data Exchange** used for AGC purposes requires the same availability and alarm standards as analog, digital, or SCADA telemetering used for the same purpose.
d) **General Telemetering** for MWh and data acquisition systems typically require one or more dedicated circuits between the Point of Interconnection and the appropriate MWh or data acquisition system master computer.

X.5 TELECOMMUNICATIONS FOR CONTROL AND PROTECTION

Telecommunications for Control and Protection must function at the full performance level before, during, and after any Power System fault condition.

X.5.1 Transmission System

New connections to the RTO-West IES and connections which require remedial actions on the RTO-West System, shall have redundant (i.e. hot-standby or frequency-diversity) telecommunications systems. Alternately routed telecommunication circuits shall be used where feasible.

X.5.2 Speed of Operation

Throughput operating times of the telecommunications system must not add unnecessary delay to the clearing or operating times of protection or Remedial Action Schemes. Maximum permissible throughput operating times of control schemes are determined by system studies.

X.5.3 Equipment Compatibility

In order to provide maintainability and operability between the new connection and the RTO-West Transmission System, the protection systems and their supporting telecommunications system equipment (teleprotection) do not have to be identical but must be functionally compatible. The need or implementation of peripheral capabilities such as signal counters, test switches, etc. are not required to be identical to those used at RTO-West facilities. RTO-West will acknowledge the use of alternative equipment and/or technologies as proposed by the Requestor as long as the equipment is suitable for the purposes of the control application required.

The teleprotection systems, including transfer trip, must be engineered and tested to demonstrate that they perform their intended functions. When applying

sophisticated digital telecommunications systems to certain protection schemes, care must be taken to avoid combining approaches with inherent technical conflicts or incompatible methodologies.

X.6 TELECOMMUNICATIONS DURING EMERGENCY CONDITIONS

X.6.1 Emergency Conditions

The requirements above address the availability and redundancy for telecommunications systems and equipment to assure reliable operation of the RTO-West IES under normal telecommunications conditions. Normal conditions for telecommunications include both normal and emergency conditions for the transmission system. However, emergency conditions may develop that affect Power System telecommunications with or without directly affecting power transmission system facilities. Examples of telecommunications emergencies include the following:

1) Interruption of power service to telecommunications repeater and relay stations

2) Telecommunications equipment failure, whether minor or catastrophic

3) Interruption or failure of commercial, public telephone network facilities or services

4) Damage to telecommunications facilities resulting from accident, acts of vandalism, or natural causes.

Equipment redundancy and telecommunications route redundancy can protect against certain kinds of failure and telecommunications path interruption. A dedicated repair team must be maintained along with an adequate supply of spare components.

X.6.2 Backup Equipment

Where commercial, public telephone network facilities or services support important Power System voice telecommunications, a backup strategy must always be developed to protect against interruption of such services. Backup methodologies could include redundant services, self-healing services, multiple independent routes and/or carriers, and combinations of independent facilities such as wireline and cellular, fiber and radio, etc. Backup telecommunications system equipment such as emergency standby power generators with ample on-site fuel storage, and reserve storage battery capacity must be incorporated in critical telecommunications facilities. Backup equipment must be considered as well for certain non-critical voice telecommunications to assure continued operation of Power System telecommunications during interruption of power services.

X.6.3 Disaster Recovery

A disaster recovery plan must be in place for telecommunications restoration, and must be exercised periodically. The disaster recovery plan must include the ability to deploy transportable restoration equipment capable of temporarily bypassing or replacing entire telecommunication stations or major apparatus until permanent repairs can be made.

X.6.4 Telecommunications Security

The operation of Power System telecommunications facilities must be continuously monitored at a central alarm point so that trouble can be immediately reported, diagnosed, repaired and service restored. Power System

telecommunication sites and facilities must be secured against unauthorized access by means of locked gates, security fences, warning signs, security doors, and entry alarms.

Y. REFERENCES

A. Applicable National, State, Provincial and Local Codes
B. Uniform Building Code
C. Occupational Safety and Health Administration (OSHA)
D. Workers' Compensation Board of British Columbia Occupational Health and Safety Regulation.
E. ANSI – IEEE – NFPA.
E.1. ANSI/IEEE Std 80 - *Guide for Safety in AC Substation Grounding*
E.2. ANSI/IEEE Std 665 - *Guide for Generating Station Grounding*
E.3. IEEE STD 81 Part 1 - *Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System* & Part 2: *Guide for Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems.*
E.4. IEEE STD 100 - *IEEE Standard Dictionary of Electrical and Electronic Term*s,.
E.5. IEEE Std 367 - *Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault*
E.6. IEEE Std 519 - *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*
E.7. IEEE – 421.4 – *IEEE Guide for the Preparation of Excitation System Specifications*
E.8. IEEE - 487 - *Recommend Practice for the Protection of Wire-Line Communication Facilities Serving Electric Power Stations*
E.9. IEEE - 837 - *Standard for Qualifying Permanent Connections Used in Substation Grounding*
E.10. NESC C2 - *National Electrical Safety Code*
E.11. ANSI C84.1 – *Electric Power System and Equipment – Voltage Ratings (60Hz)*
E.12. NFPA 70 - *National Electrical Code*
F. NERC – NWPP - WSCC
F.1. NERC *Operating Standards*
F.2. NERC Operating Manual, Policy 1, Generation Control and Performance
F.3. NERC *Planning Standards*
F.4. NWPP *Operating Manual*
F.5. WSCC Reliability Criteria including:
F.5.1. Reliability Criteria for System Design
F.5.2. Power Supply Design Criteria
F.5.3. *Minimum Operating Reliability Criteri*a.
F.5.4. Reliability Management System

RTO-WEST
TRANSMISSION SERVICES

TRANSMISSION LINE CONNECTION INFORMATION

WHO SHOULD FILE THIS FORM:

Any customer expressing an interest in connecting a generator, transmission line or load to the RTO-West Integrated Electric System (IES).

INFORMATION:

This application will be used by the RTO-West to determine if a System Impact Study is required. This study is used to determine the location (RTO-West IES), equipment requirements (Requestor & RTO-West), system modifications, etc. needed to connect generators, transmission lines and/or loads. Parts 1 and 2 should be completed as soon as possible and returned to the RTO-West Representative. Part 3 must be completed if it is determined that a System Impact Study is required. Part 4 seeks information relating to generation. Following completion of the study, the Requestor will receive a preliminary estimate for the utility interface requirements that may be used in calculating the overall connection requirements. Please attach other pertinent information.

PART 1

REQUESTOR INFORMATION

Company

Mailing Address

City	County	State	9 Digit Zip Code

Phone Number Contact

CONNECTION DESIGN ENGINEER (As applicable)

Company

Mailing Address

City	County	State	9 Digit Zip Code

Phone Number Contact

ELECTRICAL CONTRACTOR (As applicable)

Company

Mailing Address

City	County	State	9 Digit Zip Code

Phone Number Contact

PART 2

Y.1.1.1 Preliminary Review Information

Type of connection

Radial Load Network Connection with Other Sources Present Generation

Comments:

Point of Interconnection

Identify the RTO-West Line or Substation

Type of Load

Identify the characteristics which best describe the type of load to be served.

More specific information may be required for loads such as those associated with arc furnaces, large motor, **etc.**

Load Data (at the time of energization and every year for 10 years)

Projected Peak Load

Summer Peak Load

Winter Peak Load

Anticipated Power Factor

Future Plans (Where known)

Modification or changes affecting the connection or connected equipment

PART 3

Study Data Requirements

One Line Diagram

Attach Diagram

Line Data

Positive and zero sequence: resistance (ohms/mile), reactance (ohms/mile) and susceptance (mhos/mile)

Conductor Rating @ Rise (amperes @ C) and Conductor Type

Line Length (miles)

System Data

(only applicable where generation resources are present or if the connection includes another network source.) Provide a system equivalent (R_1,X_1,R_0,X_0 in per unit on a 100 MVA base) at the proposed Point of Interconnection looking into the connecting system. These values should be determined such that the system model does not include the physical connection to the RTO-West IES. Assuming there are no other connections to the RTO-West IES at any other point, these quantities are available by computing a single line to ground 'bus fault' at the proposed Point of Interconnection.

Future Plans

Modification or changes affecting the connection or connected equipment

Shunt Reactive Equipment

Location, size, and rated voltage

More specific information is required for reactive with dynamic capability (STATCOM, SVC, TCSC, Sync Condensers, etc.)

PART 4

GENERATOR DATA

Manufacturer (If available) Model:

TYPE

Synchronous Induction Phases:Single Three Frequency (Hz)

Rated Output: Kilowatts Kilovolt-Ampere

Rated Power Factor % Rated Voltage Volts Rated Amperes: Amps

Energy Source (CCGT, Gas, Hydro, Wind, Co-Gen., Geothermal, etc.):

Plant Load (Auxiliaries) kW kVar

Net Maximum Power to RTO-West kW kVar

Operating Dates and Capacity: kW Date

Ultimate Output (Max.) kW Date

Estimated Peak and Energy Production (Ultimate Output)

January peak	kW	kWh
February peak	kW	kWh
March peak	kW	kWh
April peak	kW	kWh
May peak	kW	kWh
June peak	kW	kWh
July peak	kW	kWh
August peak	kW	kWh
September peak	kW	kWh
October peak	kW	kWh
November peak	kW	kWh
December peak	kW	kWh

PROJECT LOCATION

STATE COUNTY NEAREST COMMUNITY

TOWNSHIP RANGE SECTION

STREET ADDRESS

DATE **SIGNATURE**

NAME (Please Print or Type) TITLE

****ATTACH MAP** SHOWING PROJECT BOUNDARIES AND SUBSTATION LOCATION **

ELECTRICAL AND SYNCHRONOUS MACHINE INFORMATION

1. Electrical One-Line Diagram of the generation Project that includes proposed protective relaying, breaker and switching arrangements, ground sources (zero sequence), ground resistance (Project to remote earth), and assumed line parameters for and Project tie lines.

2. Shunt capacitors associated with the Project for Power Factor correction.

KV kVars

3. Step-up transformer nominal voltage [kV/kV/(kV)], impedance [% @ MVA],

MVA rating(s) [MVA], the electrical configuration (e.g.,delta-wye) [ ],

and taps and tap range [ ].

4. Station service load (both and kW and kVar) and the type of load (e.g., 70% motors and 30% heating).

kW kVa Load

5.The following machine data:

	MVA	Machine rating on which per unit (pu) data is based
	kV	Rated terminal voltage in kV (base voltage for per unit data)
	P.F.	Power Factor of machine
	H	Inertia constant of the machine, MW-sec./MVA
	Ra	Armature resistance, pu
	Xd	Direct axis unsaturated synchronous reactance, pu
	Xq	Quadrature axis unsaturated synchronous reactance, pu
	X'd	Direct axis unsaturated transient reactance, pu
	X'q	Quadrature axis unsaturated transient reactance, pu
	X"d	Direct axis unsaturated subtransient reactance, pu
	X"q	Quadrature axis unsaturated subtransient reactance, pu
	Xl	Stator leakage reactance, pu
	T'do	Direct axis transient open circuit time constant, sec
	T'qo	Quadrature axis transient open circuit time constant, sec
	T"do	Direct axis subtransient open circuit time constant, sec
	T"qo	Quadrature axis subtransient open circuit time constant, sec
	P max	Maximum power output of the turbine in MW
	S(1.0)	Saturation factor at 1.0 per unit of rated voltage, pu. S(1.0) is the per unit difference field current at 1.00 pu terminal voltage on the open-circuit saturation curve and the field current at 1.00 pu terminal voltage on the air gap line divided by the field current at 1.00 pu terminal voltage on the air gap line.
	S(1.2)	Saturation factor at 1.2 per unit of rated voltage, pu. S(1.2) is the per unit difference field current at 1.20 pu terminal voltage on the open-circuit saturation curve and the field current at 1.20 pu terminal voltage on the air gap line divided by the field current at 1.20 pu terminal voltage on the air gap line.

6. The type of exciter, block diagram, and parameters in IEEE, PTI or WSCC format.

7. The type of Power System stabilizer, block diagram and parameters in IEEE, PTI, or WSCC format.

8. The type of governor and turbine, block diagram and parameters in IEEE,PTI or WSCC format.

9. The turbine frequency versus time operation limits.

The completed Form is to be submitted to the Executive Director of Electric Transmission Services, RTO-West.

Z. APPENDIX A: GENERATOR TESTS & MODELS

RTO-WEST GENERATING UNIT TESTS

Testing and Model Validation Requirements

Regional Transmission Organization – West
Transmission Services

See PKTMP004.doc

AA. APPENDIX B: DEFINITIONS

RTO-WEST CONNECTION STANDARD

DEFINITIONS

Regional Transmission Organization – West (RTO-West)
Transmission Services

See PKTMP001.doc

BB. APPENDIX C: HARMONICS

RTO-WEST CONNECTION STANDARD

GUIDE AND REQUIREMENTS FOR HARMONIC CONTROL

Regional Transmission Organization – West (RTO-West)
Transmission Services

See PKTMP003.doc

CC. GENERAL REQUIREMENTS

1. Wherever possible, all documents shall be provided in both paper and electronic forms:
   a. The preferred format for reports and other documents is the current PC version of Microsoft® Word.
   b. The preferred format for data, drawing indexes and the like is the current PC versioin of Microsoft® Excel.
   c. The preferred formats for drawings are (in order of preference): (a) *Auto-CADD*® *.DXF format, (b) *Intergraph MicroStation*® *.DGN format.
2. Unless legibility will be a problem, all drawings must be submitted on either, 'A'-size (8.5" x 11"; 21.6cm x 27.9cm), or 'B'-size, sheets (11" x 17"; 27.9 cm x 43.2 cm).
3. The RTO-West review process is described in Section H.

DD. DISCLAIMER

This document was prepared solely for general guidance for entities wishing to connect generators, transmission lines or loads to the RTO-West Integrated Electric System (IES). Neither the Regional Transmission Organization - West (RTO-West) nor any of its employees or agents make any representations, express or implied, to any third parties as to:

1. **the merchantability or fitness for any particular purpose of,**
2. **the accuracy, completeness or usefulness of, or**
3. **property rights of any person in,**

any information, product or process disclosed in this document.
Neither the RTO-West nor any of its employees or agents accept any liability of any kind arising in any way out of the use of, or reliance by any third party on any information, product or process described in this document.
This report may be reproduced in whole or in part by any means whatsoever without the express written permission of the RTO-West provided such reproductions are on a not-for-profit basis.

Furthermore:

I. This document is not intended to be used as a design specification or as an instruction manual for the Requestor, its employees or agents, and this document shall not be used by the Requestor, its employees or agents for those purposes. Persons using information included in this document do so at no risk to the RTO-West and they rely solely upon themselves to insure that their use of all or any part of this document is appropriate in the particular circumstances.

II. The Requestor, its employees or agents must recognize that they are, at all times, solely responsible for the plant design, construction and operation. Neither the RTO-West nor any of its employees or agents shall be, nor become, the agent of the Requestor in any manner howsoever arising.

III. The advice by the RTO-West or any of its employees or agents that the Requestor's plant design or equipment meets certain limited requirements of the RTO-West does not mean, expressly or by implication, that all or any of the requirements of the law or other good engineering practices have been met by the Requestor in its plant, and such judgement shall not be construed by the Requestor or others as an endorsement of the design or as a warranty, by the RTO-West or any of its

employees or agents, of the design, equipment, processes, procedures or any part thereof.

---

[1] [1] NERC Planning Standards Section III, System Protection & Control, SubSection C, Generation Control and Protection,