Engineering & Operating Requirements for the Interconnection of Generating Facilities

ISSUING DIVISION: Energy Distribution **Signed by** Bob Streich's signature on file
SVP SPONSOR: Robert Streich, Asst. Director **Date Signed** November 18, 2004

SECTION: Protection Guidelines SD 1631

Scope: 4
Purpose: 4
References 4
Rescissions 4
Definition of Terms: 5
1. Generator Facility Design And Operating Requirements: 7
1.1. Generator Interconnection And Protection Requirements 7
1.1.1. Automatic Lockout Required. 7
1.1.2. Protective Functions Required. 7
1.1.3. No Unintended Islanding. 7
1.1.4. Drawings Required. 7
1.1.5. Required Delay on Reconnection. 7
1.1.6. Certified Equipment. 7
1.1.7. Purpose of Protective Functions. 8
1.1.8. Suitable Equipment Required. 8
1.1.9. Visible Disconnect Required. 8
1.1.10. Momentarily Paralleling Facilities Excluded 8
2. Interconnection Facilities 9
2.1. Prevention of interference 9
2.1.1. Normal voltage operating range 9
2.1.2. Flicker. 10
2.1.3. Frequency. 11
2.1.4. Harmonics. 11
2.1.5. Direct Current Injection. 11
2.1.6. Power Factor. 11
2.2. Control, Protection And Safety Equipment Requirements 12
2.2.1. Basic Requirements 12
2.2.2. Technology Requirements 12
2.2.3. Initial Review Process 13
2.2.4. Supplemental Generating Facility Requirements 13
2.2.5. Generating Facility types and conditions not identified. 14
3. Additional SVP Engineering & Operating Requirements 14
3.1. Design 14
3.1.1. Professional Electrical Engineer 14
3.1.2. Line Protection Relays 14

3.1.3.1. Over & Under Voltage Relay (Device 59 & 27) 17
3.1.3.2. Over & Under frequency Relay (Device 81O & 81U) 17
3.1.3.3. Ground Fault Sensing Scheme 17
3.1.3.4. Overcurrent relay with voltage restraint/voltage control or impedance relay 17
3.1.4. Disconnect Devices 17
3.1.4.1. Primary Metered Customers 17
3.1.4.1.1. Utility Connection Point (UCP) 18
3.1.4.1.2. Load Side of SVP's Metering 18
3.1.5. Switchgear 18
3.1.5.1. Securing Control & Operation 18
3.1.5.2. Location 18
3.2. Operation 18
3.2.1. Inspection & Testing 18
3.2.2. Independent Testing Agency 18
3.2.3. 24 hour contact 18
3.2.4. Generating Facilities Operating Instruction 18
3.2.5. Generating Facility Description of Operation 19
3.2.6. Generator Facility Planned Shutdowns 19
3.2.7. SVP designated changes 19
4. Certification And Testing Criteria 20
4.1. Introduction 20
4.2. Certified And Non-Certified Interconnection Equipment 21
4.2.1. Certified Equipment 21
4.2.2. Non-Certified Equipment 22
4.3. Type Testing 22
4.3.1. Type Tests and Requirements for Interconnection Equipment Certification. 22
4.3.2. Anti-Islanding Test 24
4.3.3. Non-Export Test 24
4.3.4. In-Rush Current Test 24
4.3.5. Surge Withstand Capability Test 24
4.3.6. Synchronization Test 24
4.4. Production Testing 25
4.5. Commissioning Testing 25
4.5.1. Where required 25
4.5.2. Other checks and tests that may need to be performed include: 25
4.5.3. Certified Equipment 26
4.5.4. Non-Certified Equipment 26
4.5.5. Verification of Settings 26
4.5.6. Trip Tests 27
4.5.7. In-Service Tests 27
4.6. Periodic Testing 27
4.7. Supplemental Testing Procedures 28
4.7.1. Non-Exporting Test Procedures 28

Discrete Reverse Power Relay Test 28
Discrete Under-Power Relay Test 30
Tests for Inverters and Controllers with Integrated Functions 32
4.7.2. In-Rush Current Tests Procedures 33
Locked-Rotor Method 33
Start-Up Method 33

Table 1 Trip Times at Respective Voltage Ranges 10
Table 2 - Line Protection Devices 15
Table 3 - Generator Protection Device Requirements 16
Table 4 - Type Tests and Requirements for Interconnection Equipment Certification 23

Scope:

This standard establishes criteria and requirements for interconnection of Generating Facilities with the Silicon Valley Power (SVP) electric power system.

Purpose:

This standard provides a uniform standard for interconnection of generating facilities with the SVP electric power system. It provides requirements for the performance, operation, testing, safety considerations, and maintenance of the interconnection.

The requirements shall be met at the point of common coupling (PCC), although devices used to meet these requirements can be located elsewhere. This standard applies to interconnection based on the aggregate rating of all the generating units that are within the local generating facilities.

References

- CPUC Rule 21 effective February 27, 2003

Rescissions

Definition of Terms:

- **CERTIFIED EQUIPMENT:** Equipment incorporated into the Facility or the Interconnection Facilities that has passed the tests for certification set forth in the Interconnection Procedures certified by SVP.
- **DEDICATED TRANSFORMER; DEDICATED DISTRIBUTION TRANSFORMER:** A transformer that provides electric service to a single customer. The customer may or may not have a generating facility.
- **DISTRIBUTION SYSTEM:** All electrical wires, equipment, and other facilities owned or provided by SVP, other than interconnection facilities, by which SVP provides distribution service to its customers.
- **GENERATING FACILITIES:** All generators, electrical wires, equipment, and other facilities owned or provided by producer for the purpose of producing electric power.
- **GROSS NAMEPLATE RATING:** The total gross generating capacity of a generator or generating facility as designated by the manufacturer(s) of the generator(s).
- **HOST LOAD:** Electrical power that is consumed by the customer at the property on which the generating facility is located.
- **INTERCONNECTION FACILITIES:** The electrical wires, switches and related equipment that are required in addition to the facilities required to provide electric distribution service to a customer to allow interconnection. Interconnection facilities may be located on either side of the UCP as appropriate to their purpose and design. Interconnection facilities may be integral to a generating facility or provided separately.
- **INTERCONNECTION STUDY:** A study to establish the requirements for interconnection of a generating facility with SVP's distribution system.
- **LINE SECTION:** That portion of SVP's distribution system connected to a customer bounded by automatic sectionalizing devices or the end of the distribution line.
- **NET NAMEPLATE RATING:** The gross nameplate rating minus the consumption of electrical power of a generator or generating facility as designated by the manufacturer(s) of the generator(s).
- **NON-ISLANDING:** Designed to detect and disconnect from a stable unintended island with matched load and generation. Reliance solely on under/over voltage and frequency trip is not considered sufficient to qualify as Non-Islanding.
- **PCC:** see UCP.
- **POINT OF INTERCONNECTION:** The electrical transfer point between a generating facility and the distribution system. This may or may not be coincident with the UCP.

- **PRODUCER:** The entity that executes an interconnection agreement with SVP. The producer may or may not own or operate the generating facility, but is responsible for the rights and obligations related to the interconnection agreement.
- **PROTECTIVE FUNCTION:** The equipment, hardware and/or software in a generating facility (whether discrete or integrated with other functions) whose purpose is to protect against unsafe operating conditions.
- **SHORT CIRCUIT CURRENT CONTRIBUTION RATIO:** The ratio of the generating facilities short circuit contribution to the short circuit contribution provided through SVP's distribution system for a three-phase fault at the high voltage side of the distribution transformer connecting the generating facility to SVP's system.
- **SIMPLIFIED INTERCONNECTION:** Interconnection conforming to the minimum requirements under standard SD1630, and SD1631.
- **STARTING VOLTAGE DROP:** The percentage voltage drop at a specified point resulting from In-rush Current. The Starting Voltage Drop can also be expressed in volts on a particular base voltage, (e.g. 6 volts on a 120 volt base, yielding a 5% drop).
- **SUPPLEMENTAL REVIEW:** A process wherein SVP further reviews an Application that fails one or more of the Initial Review Process screens. The Supplemental Review may result in one of the following: (a) approval of Interconnection; (b) approval of interconnection with additional requirements; or (c) cost and schedule for an interconnection study.
- **UCP:** The point of delivery of electricity to a Customer's premises as determined by SVP.
- **UNSAFE OPERATING CONDITIONS:** Conditions that, if left uncorrected, could result in harm to personnel, damage to equipment, loss of System Integrity or operation outside pre-established parameters required by the Interconnection Agreement.
- **VISIBLE DISCONNECT:** An electrical switching device that can separate the Generating Facility from SVP's Distribution System and is designed to allow visible verification that separation has been accomplished. This requirement can be met by opening the enclosure to observe the contact separation.

1. Generator Facility Design And Operating Requirements:

1.1. Generator Interconnection And Protection Requirements

1.1.1. Automatic Lockout Required.

The Protective Functions shall include an automatic means to prevent the Generating Facility from re-energizing a de-energized SVP Distribution System circuit.

1.1.2. Protective Functions Required.

The Protective Functions of a Generating Facility must include an over/under voltage trip function, and over/under frequency trip function, and a means for disconnecting the Generating Facility from SVP's Distribution System whenever a protective function initiates a trip.

1.1.3. No Unintended Islanding.

The Generating Facility as associated Protective Functions shall not contribute to the formation of an Unintended Island.

1.1.4. Drawings Required.

The Producer's protection and control diagrams for the interconnection shall be approved by SVP prior to completion of the Generating Facility Interconnection unless the Producer uses a protection and control scheme previously approved by SVP for system-wide application or uses only Certified Equipment.

1.1.5. Required Delay on Reconnection.

Protective Functions shall be equipped with automatic means to prevent reconnection of the Generating Facility with SVP's Distribution System unless SVP's Distribution System service voltage and frequency is of specified settings and is stable for at least 60 seconds.

1.1.6. Certified Equipment.

Certified Equipment contains certified functions that are accepted by all California Electric Corporations. Certified Equipment may be installed on SVP's Distribution System in accordance with an interconnection control and protection scheme approved by SVP.

1.1.7. Purpose of Protective Functions.

The Protective Functions and requirements of the Standard are designed to protect SVP's Distribution System and not the Generating Facility. A Producer shall be solely responsible for providing adequate protection for the Producer's Generating Facility and Interconnection Facilities connected to SVP's Distribution System. The Producer's protective equipment shall not impact the operation of other protective devices utilized on SVP's Distribution System in a manner that would affect SVP's capability of providing reliable service to its Customers.

1.1.8. Suitable Equipment Required.

Circuit breakers or other interrupting devices located at the Point of Common Coupling must be Certified or "Listed" (as defined in Article 100, the Definition Section of the National Electric Code) as suitable for their intended application. This includes being capable of interrupting the maximum available fault current expected at their location. The Generating Facility shall be designed so that the failure of any one device shall not potentially compromise the safety and reliability of SVP's Distribution System.

1.1.9. Visible Disconnect Required.

The Producer shall furnish and install a manual disconnect device that has a visible break to isolate the Generating Facility from SVP's Distribution System. The device must be accessible to SVP personnel and be capable of being locked in the open position. Generating Facilities with Non-Islanding inverters totaling one (1) kVA or less are exempt from this provision.

1.1.10. Momentarily Paralleling Facilities Excluded.

This section of this standard is not intended to address the requirements for Generating Facilities that parallel momentarily (60 cycles or less) or Generating Facilities that operate independently of SVP's Distribution System.

2. Interconnection Facilities

2.1. Prevention of interference

The Producer shall not operate equipment that superimposes a voltage or current upon SVP's Distribution System that interferes with SVP operations, service to SVP customers, or SVP communication facilities. If such interference occurs, the Producer must diligently pursue and take corrective action at its own expense after being given notice and reasonable time to do so by SVP. If the Producer does not take timely corrective action, or continues to operate the equipment causing interference without restriction or limit, SVP may, without liability, disconnect the Producer's equipment from SVP's Distribution System, in accordance with Section 8.0 in the Generator Interconnection Agreement. To eliminate undesirable interference caused by the operation of the Generating Facility, each Generating Unit in a Generating Facility shall meet the following criteria:

2.1.1. Normal voltage operating range.

The voltage operating range for a Generating Facility Unit shall be selected as a protection function that responds to abnormal Distribution System conditions and not as a voltage regulation function.

2.1.1.1. **Small systems (11 kVA or less)**.
Generating Units connected to a Generating Facility with a Gross Nameplate capacity of 11 kVA or less shall be capable of operating within the limits normally experienced on SVP's Distribution System. The operating window shall be selected in a manner that minimizes nuisance tripping and range between 106 volts and 132 volts (88-110%) on a 120-volt base. Generating Facilities shall cease to energize SVP lines whenever the voltage at the Point of Common Coupling deviates from the allowable voltage operating range.

2.1.1.2. **Large Systems (greater than 11k VA)**.
SVP may have specific operating voltage ranges for larger Generating Facilities, and may require adjustable operating voltage settings for these larger systems. In the absence of such requirements, the above principles of operating between 88% and 110% of the appropriate interconnection voltage should be followed.

2.1.1.3. **Voltage Disturbances**.

System voltage assumes a nominal of 120 V base. For the convenience of those wishing to translate these guidelines to voltage bases other than 120 volts, the limits will also be provided as approximate percentages. Generating Units should sense abnormal voltage and respond accordingly. The following conditions should be met, with voltages in RMS and measured at the Point of Common Coupling:

Table 1 Trip Times at Respective Voltage Ranges[1]

Voltage at Point of Common Coupling	Maximum Trip Time (Assuming 60 Cycles per Second)
Less than 60 Volts	10 Cycles
Greater than 60 volts but less than 106 volts	120 Cycles
Greater than 106 volts but less than 132 volts	Normal Operation
Greater than 132 volts but less than 165 volts	120 Cycles (30 Cycles for facilities greater than 11 kVA)
Greater than 165 volts	6 Cycles

2.1.2. Flicker.

Any voltage flicker at the Point of Common Coupling caused by the Generating Facility should not exceed the limits defined by the "Maximum Borderline of Irritation Curve" identified in IEEE 519 (IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems, IEEE STD 519-1992, Institute of Electrical and Electronic Engineers. This requirement is necessary to minimize the adverse voltage affects experienced by other customers on SVP's Distribution System. Induction Generating units may be connected and brought up to synchronous speed (as an induction motor) provided these flicker limits are not exceeded.

[1] Certain circuits will actually remain connected to SVP's Distribution System to allow sensing of electrical conditions for use by the "reconnect" feature. The purpose of the allowed time delay is to ride through short-term disturbances to avoid excessive nuisance tripping. For Generating Facilities with a Gross Nameplate Rating of 11 kVA capacity or less, the above set points are to be non-user adjustable. For Generating Facilities with a Gross nameplate Rating greater than 11 kVA, different voltage set points and trip times from those in Table 1**Error! Reference source not found.** may be negotiated with SVP.

2.1.3. Frequency.

SVP controls system frequency, and the Generating Facility shall operate in synchronism with SVP's Distribution System. Small Generating Facilities should have a fixed operating frequency range of 59.3-60.5 Hertz. The Generating Facility must cease to energize the system in a maximum of ten cycles should SVP remain outside of the frequency limits. The purpose of the time delay is to allow the Generating Facility to ride through short-term disturbances to avoid excessive nuisance tripping. SVP may require adjustable operating frequency settings for Generating Facilities larger than 11 kVA to assist the system during serious capacity shortages. For Generating Facilities large than 11 kVA, low frequency setting of 59.3 Hz and 58 Hz may be used with the consent of SVP.

2.1.4. Harmonics.

Harmonic distortion shall be in compliance with IEEE 519. Exception: The harmonic distortion of a Generating Facility located at a Customer's site shall be evaluated using the same criteria as the loads at that site.

2.1.5. Direct Current Injection.

Generating Facilities should not inject Direct Current greater than 0.5% of rated output current into SVP's Distribution System under either normal or abnormal operating conditions.

2.1.6. Power Factor.

Each Generating Unit in a Generating Facility shall be capable of operating at some point within a range of a power factor of 0.9 (either leading or lagging). Operation outside this range is acceptable provided the reactive power of the Generating Facility is used to meet the reactive power needs of on-site loads or that reactive power is otherwise provided under tariff to SVP. The Producer shall notify SVP if it is using the Generating Facility for power factor correction.

2.2. Control, Protection And Safety Equipment Requirements

2.2.1. Basic Requirements

2.2.1.1. Protective Function Requirements.

The Protective Functions of Generating Facility must include a visual open disconnect device, a fault-interrupting device, an over/under voltage trip function, and an over/under frequency trip function.

2.2.1.2. Limit Specific to Single-Phase Generating Facilities.

For single-phase Generating Facilities connected to a shared single-phase secondary, the maximum capacity shall be 20 kVA. Generating Facilities applied on a center-tap neutral 240-Volt service must be installed such that no more than 6 kVA of imbalance in capacity exists between the two sides of the 240-volt service. For dedicated distribution transformer services, the limit of a single-phase Generating Facility shall be the transformer nameplate rating.

2.2.2. Technology Requirements

2.2.2.1. Three-Phase Synchronous Generating Facilities.

For three-phase Generating Facilities, the Generating Facility circuit breakers shall be three-phase devices with electronic or electromechanical control. The Producer shall be responsible for properly synchronizing its Generating Facility with SVP's Distribution System by means of either a manual or automatic synchronizing function. Automatic synchronizing is required for all synchronous Generating Units, which have a Short Circuit Contribution Ratio (SCCR) exceeding 0.05. A Generating Unit whose SCCR exceeds 0.05 shall be equipped with Protective Functions suitable for detecting loss of synchronism and rapidly disconnecting the Generating Facility from SVP's Distribution System. Unless otherwise agreed upon by the Producer and SVP, synchronous Generating Units shall automatically regulate power factor, not voltage, while operating in parallel with SVP's Distribution System. Power system stabilization is specifically not required for Generating Facilities under 10 MW Gross Nameplate Capacity. Synchronizing means that at the time of voltage connection, the frequency difference shall be less than 0.2 Hz, the voltage difference shall be less than 10%, and the phase angle difference shall be less than 10 degrees.

2.2.2.2. **Induction Generators.**
Induction generator Generating Units do not require separate synchronizing equipment. Starting or rapid load fluctuations on induction generators can adversely impact SVP's Distribution System's voltage. Corrective step-switched capacitors or other techniques may be necessary and may cause undesirable ferroresonance. When these counter measures (e.g. additional capacitors) are installed on the Producer's side of the Point of Common Coupling, SVP must review these measures. Additional equipment may be required to resolve this problem as determined in an Interconnection Study.

2.2.2.3. **Inverter Systems.**
Utility-interactive inverters do not require separate synchronizing equipment. Non-utility-interactive or "stand-alone" inverters shall not be used for parallel operation with SVP's Distribution System.

2.2.3. Initial Review Process

SD 1632 defines the initial review process. The Initial Review process evaluates the specific characteristics of the Interconnection, including those specific to the location of the Generating Facility, and whether or not additional requirements are necessary.

2.2.4. Supplemental Generating Facility Requirements

2.2.4.1. Unintended Islanding for Generating Facilities that Fail the Export Screen.
Generating Facilities must mitigate their potential contribution to an Unintended Island. This can be accomplished by one of the following options: (1) incorporating certified Non-Islanding control functions into the Protective Functions, (2) verifying that local load sufficiently exceed the load carrying capability of the Generating Facility, or (3) incorporating transfer trip or an equivalent function in the Protective Functions.

2.2.4.2. Fault Detections

A Generating Facility with an SCCR exceeding 0.1 or that does not meet any one of the options for detecting Unintended Islands in 2.2.4.1 shall be equipped with Protective Functions designed to detect Distribution System Faults, both line-to-line and line-to-ground, and promptly remove the Generating Facility from SVP's Distribution System in the event of a fault. For a Generating Facility that cannot detect these faults within two seconds, transfer trip or an equivalent function may be required. Reclose-blocking of SVP's affected recloser(s) may also be required by SVP for Generating Facilities that exceed 15% of the peak load on the line Section.

2.2.5. Generating Facility types and conditions not identified.

In the event that SD-1631 does not address the interconnection requirements for a particular Generating Facility, SVP and Producer may agree upon the technical requirements to interconnect the Generating Facility.

3. Additional SVP Engineering & Operating Requirements

3.1. Design

3.1.1. Professional Electrical Engineer

The design of the Interconnection Facilities between SVP's Distribution System and the Facility shall be prepared by, or under the supervision of, a professional electrical engineer with applicable experience.

3.1.2. Line Protection Relays

Line protection relays must coordinate with the protective relays at the SVP breakers on which the Generating Facility is connected. The addition of any new generation facility to the SVP Power System must not degrade the existing protection and control schemes or cause existing SVP customers to suffer lower levels of safety and/or reliability. Table 2 lists the minimum protection that SVP will require.

Line Protection Devices	Device Number	12kV or Below	60 kV
Phase Overcurrent (Radial System)	50/51	X	X
Ground Overcurrent (Radial System)	50/51N	X	X
Phase Directional Overcurrent	67		X_1
Ground Directional Overcurrent or Transformer Neutral	67N or 50/51N		X_1
Distance Relay Zone 1 (phase and ground elements where applicable)	21Z1/ 21Z1N		X_1
Distance Relay Zone 2 (phase and ground elements where applicable)	21Z2/ 21Z2N		X_1
Direct Transfer Trip	TT	X_2	X_2

1. May be required on subtransmission or distribution interconnections depending on local circuit configurations, as determined by SVP.
2. Transfer Trip may be required on subtransmission or distribution level interconnections depending on SVP circuit configurations and loading, as determined by SVP.

Table 2 - Line Protection Devices

3.1.2.1. **Reclose Block**

SVP upon review of the interconnection functions of the Generating Facility may require, at customer expense, the installation of Reclose Blocking at the SVP side of the line to which the generating facility is connected. (Applies to substation breaker/recloser and line reclosers).

3.1.3. **Generator Protection And Control**

Generator Protection Device Requirements	Device Number	40 kW or Less	41 kW to 400 kW	401 kW and Larger
Phase Overcurrent	50/51	X_1	X_1	
Overvoltage	59	X	X	X
Undervoltage	27	X_2	X	X
Overfrequency	81O	X	X	X
Underfrequency	81U	X	X	X
Ground Fault Sensing Scheme (Utility Grade)	51N		X_3	X
Overcurrent With Voltage Restraint/Voltage Control or Impedance Relay	51V 21		X_4	X
Reverse Power Relay	32	X_5	X_5	X_5

1. Overcurrent protection must be able to detect a line-end fault condition. A phase instantaneous overcurrent relay that can see a line fault under sub-transient conditions is required. This is not required if a 51V relay is used.
2. For generators 40 kW or less, the undervoltage requirement can be met by the contactor undervoltage release
3. For induction generators and certified non-islanding inverters aggregating less than 100 kW, ground fault detection is not required. Ground fault detection is required for non-certified induction generators of 100 kW or larger capacity. For Synchronous generators over 40 kW, and induction generators aggregating over 100 kW, ground fault detection is required.
4. A group of generators each less than 400 kW but whose aggregate capacity is 400 kW or greater, must have an impedance relay or an overcurrent relay with voltage restraint located on each generator greater than 100 kW.
5. To insure power is never exported, a reverse power Protective Function must be implemented at the PCC. Default setting shall be 0.1% (export) of transformer rating, with a maximum 2.0 second time delay. The reverse power relays upon pick-up must trip the main breaker.

Table 3 - Generator Protection Device Requirements

3.1.3.1. Over & Under Voltage Relay (Device 59 & 27)

This protection is used to trip the circuit breaker when the voltage is above or below SVP's normal operating level. It is used for generator protection and backup protection in the event that the generator is carrying load that has become isolated from the SVP Power System.

3.1.3.2. Over & Under frequency Relay (Device 81O & 81U)

This protection is used to trip the circuit breaker when the frequency is above or below SVP's normal operating level. It is used for generator/turbine protection and backup protection.

3.1.3.3. Ground Fault Sensing Scheme

The ground fault sensing scheme detects SVP Power System ground faults and trips the generator breaker or the Generating Facility's main circuit breaker, thus preventing the Generating Entity's generator from continuously contributing to a ground fault. This scheme must be able to detect faults between the SVP system side of the dedicated transformer and the end of SVP's line.

For Transformers connected to the distribution system with a delta connection on the system side, a separate grounding transformer, is recommended, in addition to the appropriate relaying equipment.

3.1.3.4. Overcurrent relay with voltage restraint/voltage control or impedance relay

These relays are used to detect muli-phase faults and initiate a generator circuit breaker trip. The relays must be located on the individual generator feeder. A group of generators aggregating over 400 kW must have an impedance relay or an overcurrent relay with voltage restraint located on each generator greater than 100 kW. Generators equal to or greater than 400 kW must have an impedance relay or an overcurrent relay with voltage restraint. As determined by SVP, and overcurrent relay with voltage control may be acceptable if it can be set to adequately detect end-of-line faults.

3.1.4. Disconnect Devices

3.1.4.1. Primary Metered Customers

Primary Metering installations shall have a minimum of two gang-operated, lockable disconnect devices at the primary to facilitate establishing a visual open. Disconnect devices are necessary at the following locations.

3.1.4.1.1. Utility Connection Point (UCP)

The first disconnect switch shall be installed at the point of interconnection with SVP. This switch is SVP operated.

3.1.4.1.2. Load Side of SVP's Metering

The second switch shall be installed between the load side of SVP's metering and the Producer's Generating Facility (this switch is customer owned and operated). With SVP's approval, circuit switches with blades can double as the visual open disconnect between the metering transformer and the main transformer.

3.1.5. Switchgear

3.1.5.1. Securing Control & Operation

The design of the Generating Facilities Main Switchgear shall have pad lock provision for securing control and operation of the Main Switchgear for safety clearance purposes.

3.1.5.2. Location

The location of the Main Switchgear shall be accessible to SVP personnel without going through secured entry.

3.2. Operation

3.2.1. Inspection & Testing

SVP reserves the right to inspect the Generating Facilities at any time during the term of this agreement to determine if the generating facilities have been installed according to the design. Inspection may be required if SVP needs to determine if the installation has changed without design changes being submitted for approval.

3.2.2. Independent Testing Agency

SVP Reserves the right to request testing of the Generating Facility protective devices and interconnection equipment from a specified testing agency as required.

3.2.3. 24 hour contact

Customer will provide an on-site 24-hour/7 day per week emergency contact to SVP.

3.2.4. Generating Facilities Operating Instruction

Customer generators shall have clear step-by-step operating instructions at the site to break parallel in emergency situations if directed by SVP.

3.2.5. Generating Facility Description of Operation

The Producer must provide a detailed description of operation of the generation facility with the SVP Distribution System during normal, emergency, and planned shutdowns of the SVP Distribution System, and the Generating Facility itself. This document will be filed in SVP's engineering and control departments, and must be updated upon any design change to the Generating Facility.

3.2.6. Generator Facility Planned Shutdowns

The Producer shall notify SVP at least five (5) working days prior to planned shutdowns of any generator and immediately upon emergency loss of generator(s).

3.2.7. SVP designated changes

The Producer will comply with any design or operational procedures related to the Generating Facility that SVP may designate in the future.

4. Certification And Testing Criteria

4.1. Introduction

This section describes the test procedures and requirements for equipment used for the Interconnection of Generating Facilities to SVP's Distribution System. Included are Type Testing, Production Testing, Commissioning Testing, and Periodic Testing. The procedures listed rely heavily on those described in appropriate Underwriters Laboratory (UL), Institute of Electrical and Electronic Engineers (IEEE), and International Electrotechnical Commission (IEC) documents – most notably UL 1741 and IEEE 929, as well as the testing described in May 1999 New York State Public Services Commission Standardized Interconnection Requirements. These procedures and requirements were developed prior to the completion of IEEE P1547 Standard for Distributed Resources Interconnected with Electric Power Systems, and should be revisited once that standard is published.

The tests described here, together with the technical requirements is this standard, are intended to provide assurance that the Generating Facility's equipment will not adversely affect SVP's Distribution System and that a Generating Facility will cease providing power to SVP's Distribution System under abnormal conditions. The tests were developed assuming a low level of Generating Facility penetration or number of connections to SVP's Distribution System. At high levels of Generating Facility penetration, additional requirements and corresponding test procedures may need to be defined.

This section also provides criteria for "Certifying" Generators or inverters. Once a Generator or inverter has been Certified per this Certification process, it may be considered suitable for use as part of a Generating Facility Interconnected with SVP's Distribution System. Subject to the exception described in the section, SVP will not require a Producer to repeat the design review or test the Protective Functions of equipment that has been Certified. It should be noted that the Certification process is intended to facilitate Generating Facility Interconnections. Certification is not a prerequisite to interconnect a Generating Facility. The use of non-Certified Equipment may be acceptable subject to testing and approval by SVP as discussed below.

4.2. Certified And Non-Certified Interconnection Equipment

4.2.1. Certified Equipment

Equipment tested and approved by an accredited Nationally Recognized Testing Laboratory (NRTL) as having met both the Type Testing and Production Testing requirements described in this document is considered to be Certified Equipment for purposes of Interconnection with SVP's Distribution System. Certification may apply to either a prepackaged system or an assembly of components that address the necessary functions. Type Testing may be done in the manufacturer's factory or test laboratory, or in the field. At the discretion of the testing laboratory, field Certification may apply only to the particular installation tested. In such cases, some or all of the tests may need to be repeated at other installations.

When equipment is Certified by a NRTL, the NRTL shall provide to the manufacturer, at a minimum, a Certificate with the following information for each device:

Administrative:

1. The effective date of Certification or applicable serial number (range or first in series), and/or other proof that Certification is current;
2. Equipment model number(s) of the Certified Equipment;
3. The software version utilized in the equipment, if applicable;
4. Test procedures specified (including date or revision number); and
5. Laboratory accreditation (by whom and to what standard)

Technical (as appropriate)

1. Device ratings (kW, kVA, Volts, Amps, etc);
2. Maximum available fault current in Amps;
3. In-rush Current in Amps;
4. Trip points, if factory set (trip value and timing);
5. Trip point and timing ranges for adjustable settings;
6. Nominal power factor or range if adjustable;
7. If the device/system is Certified for Non-Exporting and the Method used (reverse power or underpower); and
8. If the device/system is Certified Non-Islanding

It is the responsibility of the equipment manufacturer to ensure that Certification information is made publicly by the manufacturer, the testing laboratory or by a third party.

4.2.2. Non-Certified Equipment

For non-Certified Equipment, some or all of the tests described in this Rule may be required by SVP for each Generating Facility and/or Interconnection Facilities. The manufacturer or a laboratory acceptable to SVP may perform these tests. Test results for Non-Certified Equipment must be submitted to SVP for the Supplemental Review. Approval by SVP for equipment used in a particular Generating Facility and/or Interconnection Facilities does not guarantee SVP's approval for use in other Generating Facility and/or Interconnection Facilities.

4.3. Type Testing

4.3.1. Type Tests and Requirements for Interconnection Equipment Certification.

Type Testing provides a basis for determining that equipment meets the specifications for being designated as Certified Equipment under this Rule. The requirements described in this Section cover only issues related to Interconnection and are not intended to address device safety or other issues outside the needs of the relationship between SVP and the Producer operating a Generating Facility.

The following table defines the test requirements by Generator or inverter technology. While UL 1741 was written specifically for inverters, the requirements are readily adaptable to synchronous Generators, induction Generators, as well single/multi-function controllers and protection relays. Until a universal test standard is developed, SVP or NRTL shall adapt the procedures referenced in the following table as appropriate and necessary for a Generating Facility and/or Interconnection Facilities or associated equipment performance and its control and protection system functions.

Type Test	Reference (1)	Inverter	Synchronous Machine	Induction Machine
Utility Interaction	UL 1741 – 39	X	X	X
DC Isolation	UL 1741 – 40.1	X	-	-
Simulated PV Array (input) Requirements	UL 1741 – 41.2	X	-	-
Dielectric Voltage Withstand	UL 1741 – 44	X	X	X
Power Factor	UL 1741 – 45.2.2	X	X	X
Harmonic Distortion	UL 1741 – 45.4	X	X	X
DC Injection	UL 1741 – 45.5	X	-	-
Utility Voltage and Frequency Variation	UL 1741 – 46.2	X	X	X
Reset Delay	UL 1741 – 46.2.3	X	X	X
Loss of Control Circuit	UL 1741 – 46.4	X	X	X
Short Circuit	UL 1741 – 47.3	X	X	X
Load Transfer	UL 1741 – 47.7	X	X	X
Surge Withstand Capability	4.3.5	X	X	X
Anti-Islanding	4.3.2	(2)	(2)	(2)
Non-Export	4.3.3	(3)	(3)	(3)
In-Rush Current	4.3.4	-	-	(4)
Synchronization	4.3.6	(5)	X	-

Table 4 - Type Tests and Requirements for Interconnection Equipment Certification

(1) References are to section numbers in either UL 1741 (Inverters, Converters and Charge Controllers for use in Independent Power Systems) or this Rule. References in UL 1741 to "photovoltaic" or "inverter" may have to be adapted to the other technologies by the testing laboratory to appropriately apply in the tests to other technologies.
(2) Required only if Non-Islanding designation.
(3) Required only if Non-Export designation is desired
(4) Required for Generators that use SVP power to motor to speed
(5) Required for all synchronous Generators as well as inverters that operate as voltage sources when connected to SVP.
X Required
- Not Required

4.3.2. Anti-Islanding Test

Devices that pass the Anti-islanding test procedure described in UL1741 Section 46.3 will be considered Non-Islanding for the purpose of these interconnection requirements. The test is required only for devices for which a Certified Non-Islanding designation is desired.

4.3.3. Non-Export Test

Devices that pass the Non-Export test procedure described in Section 4.7.1 will be considered Non-Exporting for the purpose of these Interconnection requirements. This test is required only for devices for which a Certified Non-Export designation is desired.

4.3.4. In-Rush Current Test

Generation equipment that utilizes SVP power to motor up to speed will be tested using the procedure defined in Section 4.7.2 to determine the maximum current drawn during this startup process. The resulting In-rush Current is used to estimate the Starting Voltage Drop.

4.3.5. Surge Withstand Capability Test

Interconnection equipment shall be tested for surge withstand capability (SWC), both oscillatory and fast transient, in accordance with the test procedure defined in IEEE/ANSI C62.45 using the peak values defined in IEEE/ANSI C62.41 Tables 1 and 2 for location category B3. An acceptable result occurs even if the device is damaged by the surge, but is unable to operate or energize SVP's Distribution System. If the device remains operable after being subject to the surge conditions, previous Type Tests related to SVP's protection and power quality will need to be repeated to ensure the unit will still pass those tests following the surge test.

4.3.6. Synchronization Test

This test verifies that the unit synchronizes within the specified voltage/frequency/phase angle requirements. It is applied to synchronous Generators and inverters capable of operating as voltage-source while connected to SVP's Distribution System. This test in not necessary for induction Generators or current-source inverters. The test will start with only one of the three parameters: (1) voltage difference between Generating Facility and SVP's Distribution System: (2) frequency difference; or (3) phase angle outside of the synchronization specification. Initiate the synchronization routine and verify that the Generating Facility is brought within specification prior to synchronization. Repeat the test five times for each of the three parameters. For manual synchronization with synch check or manual control with auto synchronization, the test must verify that paralleling does not occur until the parameters are brought within specifications.

4.4. Production Testing

As a minimum, the Utility Voltage and Frequency Variation Test procedure described in UL 1741 under Manufacturing and Production Tests, Section 68 shall be performed as part of routine production (100 percent) on all equipment used to interconnect Generating Facilities to SVP's Distribution System. This testing may be performed in the factory or as part of a Commissioning Test.

4.5. Commissioning Testing

4.5.1. Where required

Will be performed on-site to verify protective settings and functionality. Upon initial Parallel Operation of a Generating Facility, or any time interface hardware or software is changed that may affect the functions listed below, a Commissioning Test must be performed. An individual qualified in testing protective equipment (professional engineer, factory-Certified technician, or licensed electrician with experience in testing protective equipment) must perform Commissioning Testing in accordance with the manufacturer's recommended test procedure to prove the settings and requirements of this Rule.

SVP has the right to witness Commissioning Tests as described below, or to require written Certification by the installer describing which tests were performed and their results. Protective Functions to be tested during commissioning, particularly with respect to non-Certified Equipment, may consist of the following:

- Over and under voltage
- Over and under frequency
- Anti-Islanding function (if applicable)
- Non-Export function (if applicable)
- Inability to energize dead line
- Time delay on restart after utility source is stable
- Utility system fault detection (if used)
- Synchronization controls (if applicable)
- Other Interconnection Protective Functions that may be required as part of the Interconnection Agreement

4.5.2. Other checks and tests that may need to be performed include:

- Verifying final Protective Function settings
- Trip test
- In-service test

4.5.3. Certified Equipment

Generating Facilities qualifying for Simplified Interconnection incorporate Certified Equipment that have, at a minimum, passed the Type Tests and Production Tests described in this standard and are judged to have little or no potential impact on SVP's Distribution System. For such Generating Facilities, it is necessary to perform only the following tests:

a) Protective Function settings that have been changed after factory testing will require field verification. Tests shall be performed using injected secondary frequencies, voltages and currents, applied waveforms, a test connection using a Generator to simulate abnormal utility voltage or frequency, or varying the set points to show that the device trips at the measured (actual) utility voltage or frequency.

b) The Non-Islanding function will be checked by operating a load break disconnect switch to verify the Interconnection equipment ceases to energize SVP's Distribution System and does not re-energize it for the required time delay after the switch is closed.

c) The Non-Exporting function shall be checked using secondary injection techniques. This Function may also be tested by adjusting the Generating Facility output and local loads to verify that the applicable Non-Exporting criteria (i.e., reverse power or under power) are met.

4.5.4. Non-Certified Equipment

Non-Certified Equipment shall be subjected to the appropriate tests described in Type Testing (Section 4.3) as well as those described in Certified Equipment Commissioning Tests (Section 4.5.3). With SVP's approval, these tests may be performed in the factory, in the field as part of commissioning, or a combination of both. SVP, at its discretion, may also approve a reduced set of tests for a particular application or, for example, if it determines it has sufficient experience with the equipment.

4.5.5. Verification of Settings

If the testing is part of the commissioning process, then, at the completion of such testing, the Producer shall confirm all devices are set to SVP approved settings. This step shall be documented in the Commissioning Test Certification.

4.5.6. Trip Tests

Interconnection Protective Functions and devices (e.g., reverse power relays) that have not previously been tested as part of the Interconnection Facilities with their associated interrupting devices (e.g., contactor or circuit breaker) shall be trip tested during commissioning. The trip test shall be adequate to prove that the associated interrupting devices open when the protective devices operate. Interlocking circuits between Protective Function devices or between interrupting devices shall be similarly tested unless they are part of a system that has been tested and approved during manufacture.

4.5.7. In-Service Tests

Interconnection Protective Functions and devices that have not previously been tested as part of the Interconnection Facilities with their associated instrument transformers or that are wired in the field shall be given an in-service test during commissioning. This test will verify proper wiring, polarity, CT/PT ratios, and proper operation of the measuring circuits. The in-service test shall be made with the power system energized and carrying a known level of current. A measurement shall be made of the magnitude and phase angle of each Alternating Current (AC) voltage and current connected to the protective device and the results compared to expected values. For protective devices with built-in Metering functions that report current and voltage magnitudes and phase angles, or magnitudes of current, voltage, and real and reactive power, the metered values may be used for in-service testing. Otherwise, portable ammeters, voltmeters, and phase-angle meters shall be used.

4.6. Periodic Testing

Periodic Testing of Interconnection-related Protective Functions shall be performed as specified by the manufacturer, or at least every four years. All periodic tests prescribed by the manufacturer shall be performed. The Producer shall maintain periodic test reports or a log for inspection by SVP. Periodic Testing conforming to SVP test intervals for the particular line section may be specified by SVP under special circumstances. Interconnection Facilities that depend upon battery for Protection Function shall be checked and logged once per month for proper voltage. Once every four years, the battery must be either replaced or a discharge test performed.

4.7. Supplemental Testing Procedures

This section describes the additional Type Tests necessary to qualify a device as Certified for use on SVP's Distribution Systems. These Type Tests are not contained in Underwriters Laboratories UL 1741 Standard Inverters, Converters, and Controllers for Use in Independent Power Systems, or other referenced standards, but are considered necessary for Certification by SVP

4.7.1. Non-Exporting Test Procedures

The Non-Exporting test is intended to verify the operation of relays, controllers and inverters designed to limit the export of power and certify the equipment as meeting the requirements of Screen 1 (SD 1630), Option 1 and 2, of the review process. Tests are provided for discrete relay packages and for controllers and inverters that include the intended function.

a) **Discrete Reverse Power Relay Test**

This version of the Non-Exporting test procedure is intended for discrete reverse power and under power relay packages provided to meet the requirements of Options 1 and 2 of Screen 1. It should be understood that in the reverse power application, the relay will provide a trip output with power flowing in the export (toward the SVP distribution system) direction.

Step1: Power Flow Test at Minimum, Midpoint, and Maximum Pickup Level Settings

Determine the corresponding secondary pickup current for the desired export power flow of 0.5 secondary watts (the minimum pickup setting, assumes 5 Amps and 120V CT/PT secondary). Apply nominal voltage with minimum current setting at zero (0) degrees phase angle in the trip direction. Increase the current to pickup level. Observe the relay's (LCD or computer display) indication of power values. Note the indicated power level at which the relay trips. The power indication should be within 2% of the expected power. For relays with adjustable settings, repeat this test at the midpoint, and maximum settings. Repeat at phase angles of 90, 180, and 270 degrees and verify that the relay does <u>not</u> operate (measured watts will be zero or negative).

Step 2: Leading Power Factor Test

Apply rated voltage with a minimum pickup current setting (calculated value for system application) and apply a leading power factor load current in the non-trip direction (current lagging voltage by 135 degrees). Increase the current to relay rated current and verify that the relay does not operate. For relay's with adjustable settings, this test should be repeated at the minimum, midpoint, and maximum setting.

Step 3: Minimum Power Factor Test

At nominal voltage and with the minimum pickup (or ranges) determined in Step 1, adjust the current phase angle to 84 or 276 degrees. Increase the current level to pickup (about 10 times higher than at 0 degrees) and verify that the relay operates. Repeat for phase angles of 90, 180 and 270 degrees and verify that the relay does not operate.

Step 4: Negative Sequence Voltage Test

Using the pickup setting determined in Step 1, apply rated relay voltage and current at 180 degrees from tripping direction, to simulate normal load conditions (for three-phase relays, use I_a at 180, I_b at 60, and I_c at 300 degrees). Remove Phase 1 voltage and observe that the relay does not operate. Repeat for Phases 2 and 3.

Step 5: Load Current Test

Using the pickup setting determined in Step 1, apply rated voltage and current at 180 degrees from the tripping direction, to simulate normal load conditions (use I_a at 180, I_b at 300, and I_c at 60 degrees). Observe that the relay does not operate.

Step 6: Unbalanced Fault Test

Using the pickup settings determined in Step 1, apply rated voltage and two times rated current, to simulate an unbalanced fault in the non-trip direction (use V_a at 0 degrees, V_b and Vc at 180 degrees, I_a at 180 degrees, I_b at 0 degrees, and I_c at 180 degrees). Observe that the relay, especially single phase, does operate properly.

Step 7: Time Delay Settings Test

Apply Step 1 settings and set time delay to minimum setting. Adjust the current source to the appropriate level to determine operating time, and compare against calculated values. Verify that the time stops when the relay trips. Repeat at midpoint, and maximum delay setting.

Step 8: Dielectric Test

Perform the test described in IEC 414 using 2kV RMS for one minute.

Step 9: Surge Withstand

Perform the surge withstand test described in IEEE C37.90.1.1989 or the surge withstand test described in Section 4.3.5

b) **Discrete Under-Power Relay Test**

This version of the Non-Exporting test procedure is intended for discrete under-power relay packages and meets the requirements of Option 2 of Screen 1. A trip output will be provided when import power (toward the Producer's Load) drops below the specified level.

Note: For an under-power relay, pickup is defined as the highest power level at which the relay indicates that the power is <u>less</u> than the set level.

Step1: Power Flow Test at Minimum, Midpoint, and Maximum Pickup Level Settings

Determine the corresponding secondary pickup current for the desired power flow pickup level of 5% of peak load minimum pickup setting. Apply rated voltage and current 0 (zero) degrees phase angle in the direction of normal load current.

Decrease the current to pickup level. Observe the relay's (LCD or computer display) indication of power values. Note the indicated power level at which the relay trips. The power indication should be within 2% of the expected power. For relays with adjustable settings, repeat the test at the midpoint and maximum settings. Repeat at phase angles of 90, 180, and 270 degrees and verify that the relay operates (measured watts will be zero or negative).

Step 2: Leading Power Factor Test

Using the pickup current setting determined in Step 1, apply rated voltage and rated leading power factor load current in the normal load direction (current leading voltage by 45 degrees). Decrease the current to 145 percent of the pickup level determined in Step 1 and verify that the relay does not operate. For relays with adjustable settings, repeat the test at the minimum, midpoint, and maximum settings.

Step 3: Minimum Power Factor Test

At nominal voltage and with the minimum pickup (or ranges) determined in Step 1, adjust the current phase angle to 84 or 276 degrees. Decrease the current level to pickup (about 10 percent of the value at 0 degrees) and verify that the relay operates. Repeat for phase angles of 90, 180 and 270 degrees and verify that the relay operates for any current less than rated current.

Step 4: Negative Sequence Voltage Test

Using the pickup setting determined in Step 1, apply rated relay voltage and 25 percent of rated current in the normal load direction, to simulate light load conditions. Remove phase 1 voltage and observe that the relay does not operate. Repeat for Phases 2 and 3.

Step 5: Unbalanced Fault Test

Using the pickup settings determined in Step 1, apply rated voltage and two times rated current, to simulate an unbalanced fault in the normal load direction (use V_a at 0 degrees, V_b and Vc at 180 degrees, I_a at 0 degrees, I_b at 180 degrees, and I_c at 0 degrees). Observe that the relay, especially single phase, does operate properly.

Step 6: Time Delay Settings Test

Apply Step 1 settings and set time delay to minimum setting. Adjust the current source to the appropriate level to determine operating time, and compare against calculated values. Verify that the time stops when the relay trips. Repeat at midpoint, and maximum delay setting.

Step 7: Dielectric Test

Perform the test described in IEC 414 using 2kV RMS for one minute.

Step 8: Surge Withstand

Perform the surge withstand test described in IEEE C37.90.1.1989 or the surge withstand test described in Section 4.3.5

c) **Tests for Inverters and Controllers with Integrated Functions**
Inverters and controllers designed to provide reverse or under-power functions shall be tested to certify the intended operation of this function.

Two Methods are acceptable:

Method 1: If the inverter or controller utilizes external current/voltage measurement to determine the reverse or under-power condition, then the inverter or controller shall be functionality tested by application of appropriate secondary currents and potentials as described in the Discrete Reverse Power Relay Test, Section 4.7.1.a of the Standard.

Method 2: If external secondary current or voltage signals are not used, then unit-specific tests must be conducted to verify that power cannot be exported across the PCC for a period exceeding two seconds. These may be factory tests, if the measurement and control points are integral to the unit, or they may be performed in the field.

4.7.2. In-Rush Current Tests Procedures

This test will determine the maximum in-rush Current drawn by the Generator.

a) **Locked-Rotor Method**

Use the test procedure defined in NEMA MG-1 (manufacturer's data is acceptable if available)

b) **Start-Up Method**

Install and setup the Generating Facility equipment as specified by the manufacturer. Using a calibrated oscilloscope or data acquisition equipment with appropriate speed and accuracy, measure the current draw at the Point of Interconnection as the Generating Facility starts up and parallels with SVP's Distributions System. Startup shall follow the normal, manufacturer-specified procedure. Sufficient time and current resolution and accuracy shall be used to capture the maximum current draw within 5%. In-rush Current is defined as the maximum current draw for SVP during the startup process, using a 10-cycle moving average. During the test, the utility source, real or simulated, must be capable of maintaining voltage within +/- 5% of rated at the connection to the unit under test. Repeat this test 5 times. Report the highest 10-cycle current as the In-rush Current. A graphical representation of the time-current characteristic along with the certified In-rush Current must be included in the test report and made available to SVP.