

ISO Rules

Part 500 Facilities

Division 502 Technical Requirements

Section 502.1 Aggregated Generating Facilities Technical Requirements



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Applicability

1(1) Section 502.1 applies to ~~the ISO, and subject to the provisions of subsections 1(2), (3) and (4) to any:~~

- (a) ~~a new wind~~ **the legal owner of an aggregated generating facility to be directly connected to the transmission system, and to their legal owner; and or to a transmission facility within the service area of the City of Medicine Hat, including an aggregated generating facility situated within an industrial complex that is directly connected to the transmission system or to a transmission facility within the service area of the City of Medicine Hat, except as described in subsection 1(2);**
- (b) ~~a wind aggregated generating facility in existence and connected to the transmission system as of December 1, 2011, and to their legal owner, if such facilities were connected to the transmission system under the Wind Power Facility Technical Requirements dated November 15, 2004.~~ **the legal owner of a transmission facility; and**
- (c) **the ISO.**

(2) ~~Subject to subsection 1(3), the provisions of this section 502.1 do not apply to the legal owner of an aggregated generating facility that was energized and commissioned prior to April 7, 2017 in accordance with a previous technical requirement, technical standard, ISO rule or functional specification, but the legal owner of such an existing aggregated generating facility must remain compliant with all the standards and requirements set out in that previous technical requirement, technical standard, ISO rule or functional specification, and must also meet the applicable requirements set out in section 304.9 of the ISO rules, Wind and Solar Aggregated Generating Facility Forecasting and section 502.16 of the ISO rules, Aggregated Generating Facilities Operating Requirements. The legal owner of any existing wind aggregated generating facilities, who executed a Construction Commitment Agreement and completed the ISO's approval process for connection to the transmission system under the Technical Requirements for connecting generators (1999), is exempt from this section 502.1 but must remain in compliance with those 1999 requirements.~~

(3) ~~Where an aggregated generating facility directly connected to the transmission system or a transmission facility within the service area of the City of Medicine Hat described in subsection 1(2) undergoes one or more~~ **any existing wind aggregated generating facilities undergo any:**

- (a) ~~facilities-facility additions after April 7, 2017 such that the resulting in an increase in the cumulative gross real power capability of the aggregated generating facility accumulative real power capability is increased by an amount equal to or greater than five (5) MW; or~~
- (b) ~~facilities' equipment replacements after April 7, 2017 where the equipment replaced has a gross real power capability equal to or greater than of five (5) MW irrespective of whether the cumulative gross real power capability of the aggregated generating facility is increased, or more;~~

~~this section 502.1 applies in respect of the facility addition(s) or equipment replacement(s) as if the addition(s) or replacement(s) is a new aggregated generating facility; then the facilities addition or equipment replacement and associated real power will be subject to and must comply with the provisions of this section 502.1 in its entirety.~~

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(4) Notwithstanding subsection 1(2) ~~and (3) above~~, the ISO may require the legal owner of an aggregated generating facility or a transmission facility to comply with any specific provision or all of the provisions of this section 502.1, if the ISO determines that such compliance is necessary for the safe and reliable operation of the interconnected electric system ~~all new and existing wind aggregated generating facilities with a maximum authorized real power of five (5) MW or more must comply with the meteorological collection tower and measurement devices provisions contained in subsection 25 below and the historical data and records requirements contained in subsection 29 below.~~

Requirements

Functional Specification

2(1) The ISO may, ~~in accordance and consistent with this section 502.1 and any other applicable ISO rules, approve or issue~~ a written functional specification containing ~~further details, direction and discrete~~ work requirements and specifications for the design, construction and operation of ~~any wind an aggregated generating facilities facility~~ and associated ~~transmission system facility~~ connection facilities.

(2) The functional specification referred to in subsection 2(1) must be generally consistent with the provisions of this section 502.1, but may contain material variances approved of by the ISO based upon its discrete analysis of any one or more of the technical, economic, safety, operational and ~~system~~ reliability requirements of the interconnected electric system related to the specific facility project.

Successor to Prior Requirements

~~3 — Subject to subsection 4(2), the provisions of this section 502.1 succeed the Wind Power Facility Technical Requirements dated November 15, 2004, and those requirements no longer will be in force and effect as of December 1, 2011.~~

Maximum Authorized Real Power ~~for Wind Aggregated Generating Facilities~~

~~4~~3(1) The legal owner of ~~any new wind an aggregated generating facilities facility~~ must ~~submit to, upon receiving a request from~~ the ISO, ~~determine~~ the maximum authorized real power for ~~these wind the aggregated generating facilities facility~~, and ~~once the ISO approves the provide this~~ value to the ISO, it will form part of the functional specification for the project.

(2) The ~~maximum authorized real power~~ for any existing wind legal owner of an aggregated generating facilities facility must consider the aggregated generating facility capability and limitations under optimal conditions when determining the maximum authorized real power for the aggregated generating facility will be the "WPF Aggregated MW Capacity" as provided to the ISO under the requirements of section 5.1 set out in the *Wind Power Facility Technical Requirements* dated November 15, 2004.

~~(3) — In accordance with the illustration set out in Appendix 2, the ISO will determine the reactive power capability requirements for any wind aggregated generating facilities, based on the maximum authorized real power aggregated generating determined under this subsection 4.~~

Operating Voltage Requirements

~~5~~(1) The legal owner of any wind ~~aggregated generating facilities~~ must submit to the ISO the value to be used for rated root mean square phase-to-phase voltage at:

- (a) ~~the point of connection to the transmission system, based on the normal operating voltage levels at the specific location of the wind aggregated generating facilities; and~~

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~~(b) all collector busses.~~

~~(2) — Once that value is approved by the ISO, it will form part of the functional specification for the project.~~

~~(3) — The rated root mean square phase-to-phase voltage will be used in the application of this section 502.1 to determine and apply:~~

~~(a) the voltage ride-through requirements;~~

~~(b) voltage regulation; and~~

~~(c) the reactive power capability;~~

~~of the wind aggregated generating facilities.~~

Reactive Power Requirements

4(1) For the purposes of determining the dynamic reactive power requirements of this section 502.1, the legal owner of an aggregated generating facility must determine the root mean square phase-to-phase voltage value at the collector bus of the aggregated generating facility, to be used as the 1.00 per unit voltage value.

(2) An aggregated generating facility and any external dynamic reactive power resources approved under subsection 4(6) must have the capability to operate by both:

(a) manual control of the set point of the voltage regulating system of the aggregated generating facility; and

(b) automated action of the voltage regulating system of the aggregated generating facility.

(3) Subject to subsection 4(5), the dynamic reactive power capability of the aggregated generating facility must be in compliance with the following minimum requirements:

(a) 0.90 power factor, supplying dynamic reactive power; and

(b) 0.95 power factor, absorbing dynamic reactive power;

based on the maximum authorized real power of the aggregated generating facility over the entire real power operating range, down to the applicable minimum gross real power.

(4) Subject to subsection 4(5), an aggregated generating facility must not have limiters set to reduce the dynamic reactive power capability set out in subsection 4(3).

(5) The legal owner of an aggregated generating facility that has the capability to meet the dynamic reactive power requirements of this subsection 4 but that has stability concerns must submit in writing to the ISO:

(a) a request for a variance allowing for the reduction in the dynamic reactive power capability requirement set out in subsection 4(3)(b) due to aggregated generating facility stability concerns; and

(b) a detailed study in support of the request, which is specific to the aggregated generating facility at its location and completed by a qualified professional engineer, demonstrating that the dynamic reactive power capability set out in subsection 4(3)(b) should be reduced by a limiter because that dynamic reactive power capability will cause the aggregated generating facility to become unstable.

(6) The legal owner of an aggregated generating facility without the capability to meet the dynamic reactive power capability set out in subsection 4(3) must submit to the ISO in writing a request for a

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variance allowing for the use of an external dynamic reactive power resource to compensate for the lack of capability, such that the combined capability of the aggregated generating facility and the external dynamic reactive power resource meets the requirements of subsection 4(3).

Voltage Ride-Through Requirements

~~65(1)~~ Wind aggregated generating facilities with a maximum authorized real power amount equal to or greater than five (5) MW must meet For the purposes of determining the voltage ride-through requirements of this section 502.1, the legal owner of an aggregated generating facility must determine the root mean square phase-to-phase voltage value at the high voltage side of the transmission system step-up transformer of the aggregated generating facility, to be used as the 1.00 per unit voltage values specified in this subsection 6.

~~(2)~~ Each The legal owner of an wind aggregated generating facilities facility must ensure they are capable of the aggregated generating facility is designed to meet all of the following voltage ride-through requirements:

(a) continuous operation between greater than or equal to ninety percent (0.90%) and less than or equal to one hundred and ten percent (1.10%) 1.10 per unit of the root-mean-squared-rated phase-to-phase voltage at the point of connection value determined under subsection 5(1);

~~(3)~~ Subject to subsection 6(4), wind aggregated generating facilities must (b) not trip tripping or going off-line any wind turbine generator that is producing real power due to voltage dips, as a result of a voltage dip or a post-transient voltage rises described in Appendix 1, deviation resulting from normally cleared a disturbance on transmission system facilities faults, on any phase or combination of phases at or beyond the point of connection, in accordance with the timing requirements of Appendix 1; and

(c) the amount of time that the voltage of the aggregated generating facility remains at 0.0 per unit must be at least the normal clearing time for a three (3) phase fault at the specific location where the aggregated generating facility is connected to the transmission system or to a transmission facility within the service area of the City of Medicine Hat.

~~(43)~~ Notwithstanding any other provision of this subsection 6, wind5, an aggregated generating facilities are facility is not required to ride-through a fault on transmission system faults facilities that:

(a) cause an automatic a forced outage of a radial transmission line to connecting the wind aggregated generating facilities; facility to the transmission system or a transmission facility within the service area of the City of Medicine Hat;

(b) occurs on the wind aggregated generating facilities facility side of the point of connection, including the lower low voltage network and the substation; or

(c) results in the activation of a transfer trip or anti-islanding protection scheme to activate at the wind at the aggregated generating facilities facility which causes the aggregated generating facility to be disconnected from the transmission system or a transmission facility within the service area of the City of Medicine Hat.

Voltage Regulation

~~76(1)~~ The ISO will assess voltage regulation performance of wind An aggregated generating facilities facility at the collector busses in accordance with this subsection 7.

~~(2)~~ Wind aggregated generating facilities must be able to regulate voltage at the voltage regulation system or automatic voltage regulator point of control and as documented in the functional

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~~specification for the project~~, under both non-disturbance and disturbance conditions.

(2) An **aggregated generating facility** must be designed so that the point of control for the **voltage regulation system** or **automatic voltage regulator** is not at the high voltage side of the **transmission facility** step-up transformer.

(3) ~~Wind~~The **aggregated generating facilities** must have ~~at least one (1)~~ continuously variable, continuously acting, closed loop, centralized control **voltage regulation** ~~regulating system~~ or **automatic voltage regulator** that measures voltage compared to a set point, and will control reactive devices including ~~wind turbine generators~~ **generating units**, dynamic reactive power resources, capacitor and reactor banks.

(4) The **voltage regulation** ~~regulating system~~ must be continuously in service and controlling while the ~~wind aggregated generating facilities~~ are connected to the **transmission system** and regardless of the quantity of actual **real power** output from the ~~wind aggregated generating facilities~~.

(5) The **automatic voltage regulation** ~~system~~ **regulator** set point must be adjustable by the operator of the ~~wind aggregated generating facilities~~ to a percentage between ~~ninety five percent (95%)~~ and ~~one hundred and five percent (105%)~~ of ~~rated nominal~~ voltage at the point of control for the voltage regulating system or automatic voltage regulator.

(65) The **voltage regulation** ~~regulating system~~ or **automatic voltage regulator** must operate in a voltage set point control mode to the exclusion of any other modes.

(76) The **voltage regulation** ~~regulating system~~ or **automatic voltage regulator** must measure voltage that represents the overall voltage response of the ~~wind aggregated generating facilities~~.

(87) The **voltage regulation system** or **automatic voltage regulator** must be capable of:

(a) adjustable gain, or reactive droop compensation adjustable from ~~zero to ten percent (0% to 10%)~~; and

(b) reactive current compensation to compensate for any step-up transformers connected to the **transmission system** or a transmission facility within the service area of the City of Medicine Hat.

(98) The combined settings of the **voltage regulation** ~~regulating system~~ or **automatic voltage regulator** must be able to achieve a steady state voltage regulation of ~~plus or minus zero point five percent (+/- 0.5%)~~ of the voltage controlled by the **voltage regulation** ~~regulating system~~ or **automatic voltage regulator**.

(109) The ISO ~~will~~ must specify in the functional specification for the aggregated generating facility whether the reactive current compensation in the **voltage regulation** ~~regulating system~~ or **automatic voltage regulator** must be implemented, ~~which will form part of the functional specification for the project~~.

(11) The ISO may, upon no less than ninety (90) ~~days'~~ notice in writing to the **legal owner** of any commissioned ~~wind aggregated generating facilities~~, require a change to the setting of the reactive droop compensation gain or the reactive current compensation settings for those commissioned ~~wind aggregated generating facilities~~.

(1210) The **voltage regulation** ~~regulating system~~ or **automatic voltage regulator** must be calibrated such that a change in **reactive power** will achieve ~~ninety five percent (95%)~~ of its final value, no sooner than zero point one (0.1) seconds and no later than one (1) second following a step change in voltage.

(1311) When the **voltage regulation system** or **automatic voltage regulator** requires the switching of a shunt reactive device, the switching operation must be delayed by ten (10) seconds.

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External Voltage Regulation

~~8~~ — No wind ~~aggregated generating facilities~~ may use or rely upon any ~~voltage regulation system~~ or ~~reactive power~~ resources that are external to the wind ~~aggregated generating facilities~~ without the approval of the ~~ISO~~, which approval will form part of the functional specification for the project.

Wind Aggregated Generating Facilities Reactive Power Capability

~~9(1)~~ — Dynamic and non-dynamic ~~reactive power~~ requirements must be based on the rated voltage at the ~~collector busses~~.

~~(2)~~ — As illustrated in Appendix 2, the minimum continuous ~~reactive power~~ capability of any wind ~~aggregated generating facilities~~ to supply ~~reactive power~~ must meet or exceed plus zero point nine (+0.9) ~~power factor~~, based on the ~~gross real power~~ up to and including the ~~maximum authorized real power~~ of the wind ~~aggregated generating facilities~~.

~~(3)~~ — As illustrated in Appendix 2, the minimum continuous ~~reactive power~~ capability of any wind ~~aggregated generating facilities~~ to absorb ~~reactive power~~ must meet or exceed minus zero point nine five (-0.95) ~~power factor~~, based on the ~~gross real power~~ up to and including the ~~maximum authorized real power~~ of the wind ~~aggregated generating facilities~~.

~~(4)~~ — Continuous ~~reactive power~~ capability referred to in subsections 10 and 11 may be aggregated to meet the requirements set out in subsections 9(2) and (3).

~~(5)~~ — All ~~reactive power~~ resources used to vary the ~~reactive power~~ output of the wind ~~aggregated generating facilities~~ within the requirements set out in subsections 9(2) and (3) must be under control of the ~~voltage regulation system~~.

~~(6)~~ — The ~~operator~~ must not intentionally, and the control systems of wind ~~aggregated generating facilities~~ must not be designed to, reduce the ~~reactive power~~ capability from the dynamic reactive devices described in subsection 10, or the non-dynamic reactive resources described in subsection 11.

Dynamic Reactive Power Capability

~~10(1)~~ — As illustrated in Appendix 2, the minimum dynamic ~~reactive power~~ capability of any wind ~~aggregated generating facilities~~ must meet or exceed plus zero point nine five (+0.95) ~~power factor~~ based on the ~~gross real power~~ up to and including the ~~maximum authorized real power~~ of the wind ~~aggregated generating facilities~~.

~~(2)~~ — As illustrated in Appendix 2, the minimum dynamic ~~reactive power~~ capability of any wind ~~aggregated generating facilities~~ must meet or exceed minus zero point nine eight five (-0.985) ~~power factor~~ based on the ~~gross real power~~ up to and including the ~~maximum authorized real power~~ of the wind ~~aggregated generating facilities~~.

~~(3)~~ — Wind ~~aggregated generating facilities~~ must have ~~reactive power~~ resources that are continuously acting and continuously variable under control of the ~~voltage regulation system~~, and be able to respond to ~~transmission system~~ voltage fluctuations.

~~(4)~~ — For the purposes of subsections 10(1) and (2), a short term ~~reactive power~~ capability for a

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~~period of up to one (1) second will be deemed to meet the dynamic **reactive power** capability set out in these subsections.~~

~~(5) The short term **reactive power** capability referred to in subsection 10 (4) does not qualify for continuous **reactive power** described in subsection 9.~~

Non-Dynamic Reactive Power Capability

~~11(1) For any wind **aggregated generating facilities**, the MVA_r size of the individual shunt **reactive power** resources under control of the **voltage regulation system** must not be larger than the total range of the continuous capability of dynamic **reactive power** set forth in subsection 10.~~

~~(2) Any shunt **reactive power** resources installed in any wind **aggregated generating facilities** must be capable of being switched on no later than five (5) minutes after having been switched off.~~

Operator Availability

~~12 The **legal owner** of any wind **aggregated generating facilities** must have a designated and qualified **operator** available twenty four (24) hours a **day** every **day** for contact and communication with the **ISO**, in accordance with **ISO rules** and other communication policies and protocols.~~

Frequency and Speed Governing Requirements

7(1) An **aggregated generating facility** must have a continuously acting **governor system**, which must be designed:

- (a) to be continuously in service, free to respond to frequency changes and controlling the response to frequency changes while the **aggregated generating facility** is connected to the **transmission system** or a **transmission facility** within the service area of the City of Medicine Hat and is producing any **real power** as measured at the **collector bus**;
- (b) with a droop setting equal to or greater than 3% but less than or equal to 5%;
- (c) with a deadband, intentional plus unintentional, not exceeding plus or minus 0.036 Hz;
- (d) not to have an intentional time delay added to the control system;
- (e) with the capability of manual setpoint adjustments within a range of 59.4 Hz and 60.6 Hz;
- (f) to continuously monitor the frequency of the electric system or the speed of a synchronous **generating unit** at a sample rate of at least twenty (20) samples per second; and
- (g) with a resolution of at least 0.004 Hz.

(2) The **governor system** must override any power limits in effect at the time of the frequency excursion but only while the frequency remains outside of the deadband.

(3) An **aggregated generating facility** must be designed not to trip for under-frequency and over-frequency deviations for the minimum time frames as set out in Appendix 2.

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(4) Notwithstanding subsection 7(3), an **aggregated generating facility** that trips off in a shorter period than the minimum time set forth in Appendix 2 must have binding and firm arrangements to automatically and simultaneously trip off an amount of load in MW on the **interconnected electric system** equal to the anticipated generation loss in MW, at comparable frequency levels.

WECC Stability Control Requirements for an Aggregated Generating Facility Consisting of Directly Coupled Asynchronous Generating Units or Decoupled Generating Units

138 After December 1, 2011, if any WECC standards or policies specify the use of a power system stabilizer or similar functionality for ~~wind~~ an **aggregated generating facilities facility** using a ~~synchronous wind turbine generator~~ consisting of directly coupled asynchronous **generating units** or decoupled **generating units**, then based on those standards or policies the ISO ~~may~~, by written notice, to the legal owner ~~may~~, require the ~~wind~~ **aggregated generating facilities facility** consisting of directly coupled asynchronous **generating units** or decoupled **generating units** to use such a power system stabilizer.

WECC Stability Control Requirements for an Aggregated Generating Facility Consisting of Directly Coupled Synchronous Generating Units

9(1) The legal owner of an **aggregated generating facility** consisting of directly coupled synchronous **generating units** and with a **maximum authorized real power** greater than 67.5 MW must install power system stabilizers.

(2) Notwithstanding subsection 9(1), a power system stabilizer is not required to be installed on an **aggregated generating facility** consisting of directly coupled synchronous **generating units** if the closed loop phase lag between the **aggregated generating facility** voltage at the **collector bus** and the **automatic voltage regulator** reference input is greater than 135 degrees.

(3) Any pumped storage **aggregated generating facility** consisting of directly coupled synchronous **generating units** must be equipped with a power system stabilizer and be capable of operating in the pump mode while connected to the **transmission system** or a **transmission facility** in the service area of the City of Medicine Hat, and if the power system stabilizer does not produce negative damping, then the power system stabilizer must be designed to be in service in the pump mode.

(4) A power system stabilizer must:

- (a) be designed to be in continuous operation while the **aggregated generating facility** consisting of directly coupled synchronous **generating units** is on-line, except for when the **aggregated generating facility** consisting of directly coupled synchronous **generating units** is producing less **real power** than its design limit for effective power system stabilizer operation;
- (b) be reviewed and retuned if any **automatic voltage regulator** response parameters for the **aggregated generating facility** consisting of directly coupled synchronous **generating units** are modified;
- (c) be either:
 - (i) a dual input integral of accelerating **real power** type; or
 - (ii) a single input speed or frequency type;
- (d) provide a compensated frequency response of the excitation system and the **aggregated generating facility** consisting of directly coupled synchronous **generating units** such that, through the frequency range from 0.1 Hz to 1.0 Hz, the phase shift will not exceed plus or minus 30 degrees;

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- (e) be capable of output limits between plus or minus 5% of the operating voltage value submitted under subsection 4(1);
- (f) have the gain set to provide a gain margin of no less than 6 dB and no more than 10 dB; and
- (g) have the washout time constant set as low as possible while maintaining the compensated phase criteria.

(5) A power system stabilizer of the **real power** type is prohibited for an **aggregated generating facility** consisting of directly coupled synchronous **generating units**.

(6) The use of a single power system stabilizer for an **aggregated generating facility** consisting of directly coupled synchronous **generating units** must be approved by the **ISO** and detailed in the functional specification for the **aggregated generating facility**.

Transmission ~~System~~Facility Step-Up Transformer

1410(1) The voltage ratio, tap changer type, range and step size specifications for ~~any~~**the** transmission step-up transformer of ~~any wind~~**an aggregated generating facilities**~~facility~~ must be such that the **maximum authorized real power and reactive power** requirements specified in subsections ~~93 and 4~~ are fully available throughout the operating voltage range documented in the functional specification for the ~~project~~**aggregated generating facility**.

(2) The connection of ~~the wind turbine generator~~**a generating unit** step-up transformer, **transmission system**~~facility~~ step-up transformer or any combination of the two (2) transformers for ~~any wind~~**an aggregated generating facilities**~~facility~~ must be designed to provide:

- (a) a favorable circuit to block the transmission of harmonic currents; and
- (b) isolation of **transmission system**~~facilities~~ and ~~wind turbine generator~~**generating unit** side ground fault current contributions.

(3) ~~The wind~~**An aggregated generating facilities**~~facility~~ must utilize an effectively grounded wye connection on the high side of the **transmission system**~~facility~~ step up transformer.

Fault Interrupting Devices

Off Nominal Frequency Requirements

1451(1) ~~For wind~~**An aggregated generating facility** must be designed to:

- (a) account for the fault contributions from both the **transmission facilities** and the **aggregated generating facility**; and
- (b) **have** fault interrupting and momentary withstand ratings that are adequate to meet the maximum expected fault levels, with a margin for future anticipated fault levels as approved by the **ISO** in the functional specification for the **aggregated generating facility**~~have a requirement to protect equipment for off-nominal frequency operation, the legal owner must install protective relays so as to accommodate operation for the specified time frames shown in the Table set out in Appendix 3.~~

(2) **An aggregated generating facility** connecting to a **transmission facility** must provide the functionality and remote control capabilities to enable the **operator** of the **transmission facility** to open or trip any connecting breaker either at the **point of connection** or any **collector bus feeder breakers**, as applicable. ~~The trip setting of the protective relays must either:~~

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~~(a) be set to the requirements set out in Appendix 3 with respect to the frequency versus time setting; or~~

~~(b) automatically trip load to match the anticipated generation loss and at comparable frequency levels.~~

~~(3) Any frequency relays installed to protect equipment for off-nominal frequency operation must:~~

~~(a) be solid-state or microprocessor based;~~

~~(b) use a definite time characteristic; and~~

~~(c) not be disabled for transmission system voltages that are below eighty percent (80%) of the rated voltage without the approval of the ISO, which approval will form part of the functional specification for the project.~~

Over Frequency Control System Requirements

~~16(1) Any wind aggregated generating facilities must have an over frequency control system that continuously monitors the frequency of the transmission system at a sample rate of at least thirty (30) per second and a resolution of at least zero point zero zero four (0.004) Hertz, and the over frequency control system must automatically control the gross real power output of the wind aggregated generating facilities at all times.~~

~~(2) The over frequency control system may have an intentional deadband of up to zero point zero three six (0.036) Hertz.~~

~~(3) The over frequency control system must be designed and calibrated to reduce the gross real power output at the collector bus based on the capability of all on-line wind turbine generators producing real power during an over frequency excursion, and such reductions must be:~~

~~(a) proportional to the frequency increase by a factor of thirty three percent (33%) per Hertz of the gross real power output;~~

~~(b) at a rate of five percent (5%) of the gross real power output per second; and~~

~~(c) with no intentional time delay added to the control system.~~

~~(4) In accordance with subsection 15, for transmission system over frequency events greater than sixty one point seven (61.7) Hertz, wind aggregated generating facilities may trip due to the over frequency, but if the wind aggregated generating facilities remain connected to the transmission system then the over frequency control system must continue to ramp down the gross real power output in accordance with the requirements of this subsection 16.~~

~~(5) The over frequency control system requirements of this subsection 16 must have control priority over the power limiting control function and must reduce the gross real power output for an over frequency condition even when the requirements of subsection 18 are in effect.~~

Wind Aggregated Generating Facilities Facility Disconnection

~~1712(1) WindAn aggregated generating facilitiesfacility must have systems, controls and related procedures to electrically disconnect the wind aggregated generating facilitiesfacility from the transmission system or a transmission facility within the service area of the City of Medicine Hat either at:~~

~~(a) the point of connection; or~~

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(b) the **collector bus** feeder breakers; or

(c) ~~both of them;~~

as documented in the functional specification, after consultation ~~among the ISO, between~~ the **legal owner** of the ~~wind aggregated generating facilities~~**facility** and the **legal owner** of the applicable **transmission facility**.

(2) ~~Wind~~**An aggregated generating facilities****facility** connecting to a **transmission facility** must provide the functionality and remote control capabilities to enable the **operator** of the **transmission facility** to open or trip any connecting breaker either at the **point of connection** or any **collector bus** feeder breakers, as applicable.

Isolating Devices

~~13(1)(3) Once a connecting breaker or feeder breaker of any wind~~**An aggregated generating facilities****facility** ~~has been opened or tripped, then must be designed with manually operable isolation switches at all points of isolation, as documented in the~~ **operator** ~~may only electrically reconnect~~ ~~functional specification, after consultation between the~~ **legal owner of the aggregated generating facility** ~~and the legal owner of the applicable transmission facility after receiving approval from the ISO.~~

(2) The isolation switches must permit visual verification of electrical isolation and have the capability of being locked open with multiple locks.

Wind-Aggregated Generating Facilities~~Real~~**Facility Power and Ramp Rate Limitations**Quality

~~1814(1) Wind~~**An aggregated generating facilities****facility** ~~must have been designed to meet the control capability to limit the~~ **real** ~~following power output~~**quality requirements** at the **point of connection** ~~in accordance with any limits or instructions contained in any directive, and in any event the real power output;~~

(a) the **voltage** ~~must not exceed the tolerances described in this subsection 18;~~

~~(2) The real power control limit referred to in subsection 18(1) must be adjustable from the minimum operating output to the~~ **maximum authorized real power**, at an average resolution of one (1) MW.

~~(3) When a real power control limit is in effect in accordance with a directive and wind speed conditions at the wind aggregated generating facilities are increasing, then subject to subsection 18(4), the real power limiting controls of the wind aggregated generating facilities must be capable of keeping the one (1) minute average real power output from exceeding the wind aggregated generating facilities limit specified in the directive by two percent (2%) of the maximum authorized real power.~~

~~(4) If a wind gust results in the real power control limit set out in the directive being instantaneously exceeded, then the wind aggregated generating facilities will remain in compliance if the real power output at the point of connection does not exceed the real power control limit by more than five percent (5%) of the maximum authorized real power.~~

~~(5) Wind aggregated generating facilities must be equipped with ramp rate limiting controls.~~

~~(6) The ramp rate limiting controls must be capable of limiting the ramp up of the real power of the wind aggregated generating facilities, and must be adjustable such that the ramp rate does not exceed, in MW per minute, a range equal to five percent (5%) of the maximum authorized real power to twenty percent (20%) of the maximum authorized real power.~~

~~(7) The default setting for the ramp rate limiting controls must be set at ten percent (10%), unless otherwise approved by the ISO, which approval will form part of the functional specification for the project.~~

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~~(8) — Any difference in the real power at the point of connection and any collector busses must be compensated for in the real power limiting and ramp rate limiting controls.~~

Wind Aggregated Generating Facilities Power Quality

~~19(1) — Wind aggregated generating facilities must be designed and operated to meet or exceed the minimum power quality standards set out in this subsection 19.~~

~~(2) — With regard to voltage flicker as measured at the point of connection, the legal owner of any wind aggregated generating facilities must comply (i) be in compliance with the specifications set out in the version of the International Electrotechnical Commission 61000-3-7, Electromagnetic compatibility (EMC) – Part 3-7: Limits - Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems that is in effect as of the date of the ISO first ISO approved revision of approves the functional specification for the aggregated generating facility connection project; and~~

~~(3) — Upon request from (ii) be in compliance with the legal owners short and long term flicker limits as set out in the following Table 1:~~

Table 1
Short and Long Term Flicker Limits

	Planning Levels
<u>Pst</u>	<u>0.8</u>
<u>Plt</u>	<u>0.6</u>

where:

Pst is the magnitude of any new wind the resulting short term flicker level for the considered aggregation of flicker sources (probabilistic value); and

Plt is the magnitude of the resulting long term flicker level for the considered aggregation of flicker sources (probabilistic value);

and

(iii) meet the:

(A) 99% probability weekly value for Pst; and

(B) 95% probability weekly value for Plt

based on a measurement period of one (1) calendar week of normal operation of the aggregated generating facilities facility, the ISO must provide a written description of the specific harmonic impedance envelope at a proposed point of connection for those wind;

~~(b) the aggregated generating facilities facility must be in compliance with the specifications set out in-~~

~~(4) — With regard to harmonics as measured at the point of connection, the legal owner of any wind aggregated generating facilities must comply with the version of the IEEE Standard 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems – Section 11 that is in effect as of the date of the ISO first ISO approved revision~~

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~~of~~approves the functional specification for the **aggregated generating facility connection** project; and

~~(5) Any wind(c)~~ the aggregated generating facilities facility must ~~include systems and components designed to avoid introducing~~not introduce any resonance into the **transmission system**, with such design specifications to ~~apply to~~facility, including self-excitation of induction machines, transformer ferroresonance, resonant effects of capacitor additions and the capacitance of ~~collector~~the cables of the aggregated generating facility.

~~(6) Wind aggregated generating facilities must not cause any voltage unbalance on the transmission system, as measured at the point of connection, in excess of the value specified by the ISO, which will form part of the functional specification for the project.~~

Grounding

~~2015 Any wind~~An aggregated generating facilities facility must be designed ~~and constructed to take in to account that the~~operate within a transmission system that operates as an effectively grounded system.

Lightning and Other Surge Protection

~~2416(1) The lightning~~ An aggregated generating facility must be equipped with surge protection for any associated substation ~~equipment~~facilities associated with any wind aggregated generating facilities.

~~(2) The surge protection referred to in this subsection 16(1) must~~ operate under the following conditions~~be designed to take into account;~~

- ~~(a) lightning, including~~ the average isokeraunie~~ground flash density level for the site~~aggregated generating facility ~~location of the wind aggregated generating facilities;~~
- ~~(b) switching surges;~~
- ~~(c) neutral shifts;~~
- ~~(d) electrical islands; and to~~
- ~~(e) temporary over-voltages.~~

~~(3) The surge protection referred to in subsection 16(1) must~~ be compatible with the ~~connecting transmission facility~~ connected to the aggregated generating facility to ensure coordination of insulation levels.

Fault Interrupting Devices

~~22(1) Any wind aggregated generating facilities must be designed to:~~

~~account for the fault contributions from both the transmission system and the wind~~

~~(a) aggregated generating facilities; and~~

- ~~(b) have fault interrupting and momentary withstand ratings that are adequate to meet the maximum expected fault levels, with a margin for future anticipated fault levels as approved by the ISO which approval will form part of the functional specification for the project.~~

~~(2) The wind aggregated generating facilities must not use high voltage fuses at sixty (60) kilovolts or higher.~~

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Isolating Devices

~~23(1) — Any wind aggregated generating facilities must be designed with manually operable isolation switches at all points of isolation as documented in the functional specification, after consultation among the ISO, the legal owner of the wind aggregated generating facilities and the legal owner of the applicable transmission facility.~~

~~(2) — The isolation switches must permit visual verification of electrical isolation and have the capability of being locked open with multiple locks.~~

Supervisory Control and Data Acquisition Additional Requirements

~~24 — Deleted — see Revision History.~~

Meteorological Collection Tower and Measurement Devices and Availability Requirements

~~25(1) — Any wind aggregated generating facilities must have a meteorological collection tower and related devices installed in accordance with the provisions of this subsection 25.~~

~~(2) — The tower must be equipped with two (2) sets of weather measurement devices in accordance with the following:~~

~~(a) for any new wind aggregated generating facilities:~~

- ~~(i) — one device must take measurements at the wind turbine generator hub height; and~~
- ~~(ii) — the second device must take measurements at a height that the ISO specifies in the functional specification; and~~

~~(b) for any existing wind aggregated generating facilities, the measurements must be taken at heights specified by the ISO in writing after consultation with the legal owner.~~

~~(3) — The measurement devices must measure, on a ten (10) minute average value;~~

- ~~(a) wind speed in meters per second (m/s), with a precision for instantaneous measurements to the nearest zero point one (0.1) meters per second;~~
- ~~(b) wind direction in degrees from true north, with a precision for instantaneous measurements to the nearest one (1) degree;~~
- ~~(c) barometric pressure in HectoPascals (hPa), with a precision for instantaneous measurements to the nearest six (6) Pa; and~~
- ~~(d) ambient temperature in degrees Celsius (°C), with a precision for instantaneous measurements to the nearest zero point one (0.1) degrees Celsius.~~

~~(4) — Any wind aggregated generating facility must provide to the ISO the current and planned available capability down to the real power equivalent of one (1) wind turbine generator.~~

~~(5) — When the current or planned available capability that was provided to the ISO in accordance with subsection 25(4) changes, the wind aggregated generating facility must provide to the ISO the new current or planned available capability as soon as practicable.~~

~~(6) — The legal owner must submit to the ISO the data specified in this subsection 25 in the method and format the ISO specifies:~~

- ~~(a) in the functional specification for any new wind aggregated generating facilities; or~~
- ~~(b) in writing to the legal owner for any existing wind aggregated generating facilities.~~

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Wind Aggregated Generating Facilities Synchrophasor Measurement

~~26(1) — Any wind aggregated generating facilities must have equipment installed for synchrophasor measurements that complies with the specifications referenced in the functional specification for the project~~

Aggregated Generating Facility Synchrophasor Measurement

17(1) The legal owner of an aggregated generating facility must install a synchrophasor measurement system on the aggregated generating facility in accordance with this subsection 17.

(2) Synchrophasor measurements must take place at the following points:

- (a) all three (3) phase-to-ground voltages at each collector bus of the ~~wind aggregated generating facilities~~ facility;
- (b) all three (3) phase currents for each transmission ~~facility~~ step-up transformer on the low voltage side of the aggregated generating facility; and
- (c) all three (3) phase-to-ground voltages and currents at each point of connection of the ~~wind aggregated generating facilities~~ facility.

Wind Aggregated Generating Facilities Testing Post Connection

~~27(1) Following the connection of any wind aggregated generating facilities to the transmission system, the~~

(3) The legal owner must test the wind of an aggregated generating facility facilities in accordance with the provisions of subsection 27(2), must design a synchrophasor measurement system that is capable of downloading and must provide the test results and report as per the ISO document "Requirements retaining a record of the measurements set out in subsection 17(2) for Model Validation" no later a period of not less than sixty (60) days following one (1) calendar year from the date of the initial recording unless the ISO indicates otherwise in the functional specification for the aggregated generating facility upon which wind speed conditions reasonably will allow for the tests to be conducted.

~~(2) — The following specific tests must be completed:~~

- ~~(a) a voltage regulation system and reactive power response test, which demonstrates the ability of the wind aggregated generating facilities to control the collector bus and transmission system voltage in a stable manner, and which test consists of injecting a test signal to the voltage reference point of the voltage regulation system;~~
- ~~(b) a reactive power capability test, which demonstrates the ability of the wind aggregated generating facilities to provide continuous reactive power in accordance with subsection 9; and~~
- ~~(c) a voltage set-point capability test, which demonstrates the ability of the wind aggregated generating facilities to adjust the voltage set-point of the voltage regulation system to any applicable provisions of the ISO rules.~~

~~(3) — The ISO may specify the additional following tests in the functional specification for the project:~~

- ~~(a) a harmonic test which must demonstrate that harmonic levels for the wind aggregated generating facilities are within the specifications set out in subsection 19(4); and~~
- ~~(b) a voltage flicker test, which must demonstrate that the flicker levels for the wind aggregated~~

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- ~~generating facilities are within the specifications set out in subsection 19(2).~~
- ~~(4) The ISO, by written notice, may require the legal owner of any wind aggregated generating facilities to repeat any of the tests set out in this subsection 27 if:~~
- ~~(a) there is evidence that the results of the tests do not correlate with the actual response, except in instances where the lack of correlation was caused by equipment problems that were subsequently corrected; or~~
 - ~~(b) there are changes in any applicable NERC or WECC policy or standards requirements which necessitate a repeat of any of the tests.~~

~~Provision of Modeling Information from Wind Aggregated Generating Facilities~~

- ~~28(1) The legal owner must provide the ISO with power system studies which demonstrate that the wind aggregated generating facilities are capable of meeting the voltage ride-through requirements specified in subsection 6.~~
- ~~(2) The legal owner must provide a voltage regulation system model with validated data demonstrated by a physical performance test of at least one (1) voltage regulation system device used at the wind aggregated generating facilities.~~
- ~~(3) The legal owner must re-validate all model data if the ISO provides written notice that there is evidence that the modeled response of the wind aggregated generating facility does not correlate with the actual response, except in instances where the lack of correlation was caused by equipment problems that were subsequently corrected.~~

~~Wind Aggregated Generating Facilities Data and Records Requirements~~

- ~~29(1) Subject to the provisions of this subsection 29, the legal owner of any wind aggregated generating facilities must retain historical data and records consisting of ten (10) minute averaged meteorological data, including wind speed, wind direction, temperature, barometric pressure, and details on the height of the measurements.~~
- ~~(2) The legal owner must provide the historical data and records referred to in this subsection 29 to the ISO.~~
- ~~(3) Upon the ISO's written request, the legal owner must, subject to availability, provide such historical data and records for up to two (2) calendar years prior to the commissioning period for any new wind aggregated generating facilities, and the most recent two-year period for existing wind aggregated generating facilities.~~
- ~~(4) The legal owner in addition must provide the ISO with specific wind turbine generator data and records, including hub height, turbine land coordinates, turbine power curves, high wind speed cut-out and any applicable temperature cut-outs.~~
- ~~(5) The legal owner must provide to the ISO the data and records referred to in this subsection 29 in a method and format the ISO specifies, which for new wind aggregated generating facilities will be contained in the in the functional specification for the project.~~

Appendices

- Appendix 1 – ~~Voltage Ride-Through Requirements~~ *for Aggregated Generating Facilities*
- Appendix 2 – ~~Reactive Power Capability~~

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Appendix 3—Trip Settings of Off-Nominal Frequency Protective Relays

Revision History

Date	Description
xxxx-xx-xx	<u>Revised references to “wind aggregated generating facility” to “aggregated generating facility”; revised Applicability section; removed operating requirements, including testing post connection, modelling information, data and record requirements and operator availability; removed real power and ramp rate limitations and meteorological collection tower measurement devices and availability requirements; added frequency and speed governing and record retention period for synchrophasor measurement data requirements; revised reactive power, voltage ride through, voltage regulation, WECC stability control, disconnection, power quality and lightning surge protection requirements; clarified subsection 5(2)(a); revised Appendix 1 to apply to both wind and solar aggregated generating facilities and clarified voltage ride-through requirements for 1.10 per unit of the voltage value; removed Appendix 2, Reactive Power Capability; and revised Appendix 3, Trip Settings of Off-Nominal Frequency Protective Relays and moved to Appendix 2.</u>
2015-04-01	Subsections 25(4) and (5) were added to increase the accuracy of the wind power forecast by requiring the current and planned available capability.
2015-03-27	Replaced “effective date” with the initial release date in sections 1(1)(b), 3 and 13; and replaced the word “Effective” in the Revision History to “Date”.
2014-07-02	In subsection 7(11) deleted reference to “aggregated generation facilities” and replaced it with “aggregated generating facilities”; in subsection 25(2)(a)(ii) deleted the period at the end and replaced it with a semicolon and the word “and”; in subsection 29(3) deleted the words “two (2) year” and replaced it with “two-year”; and deleted references to “forced outage” and replaced it with “automatic forced outage”.
2013-09-24	Updated to remove bolding on the term “power system stabilizer”.
2011-12-01	Initial Release.

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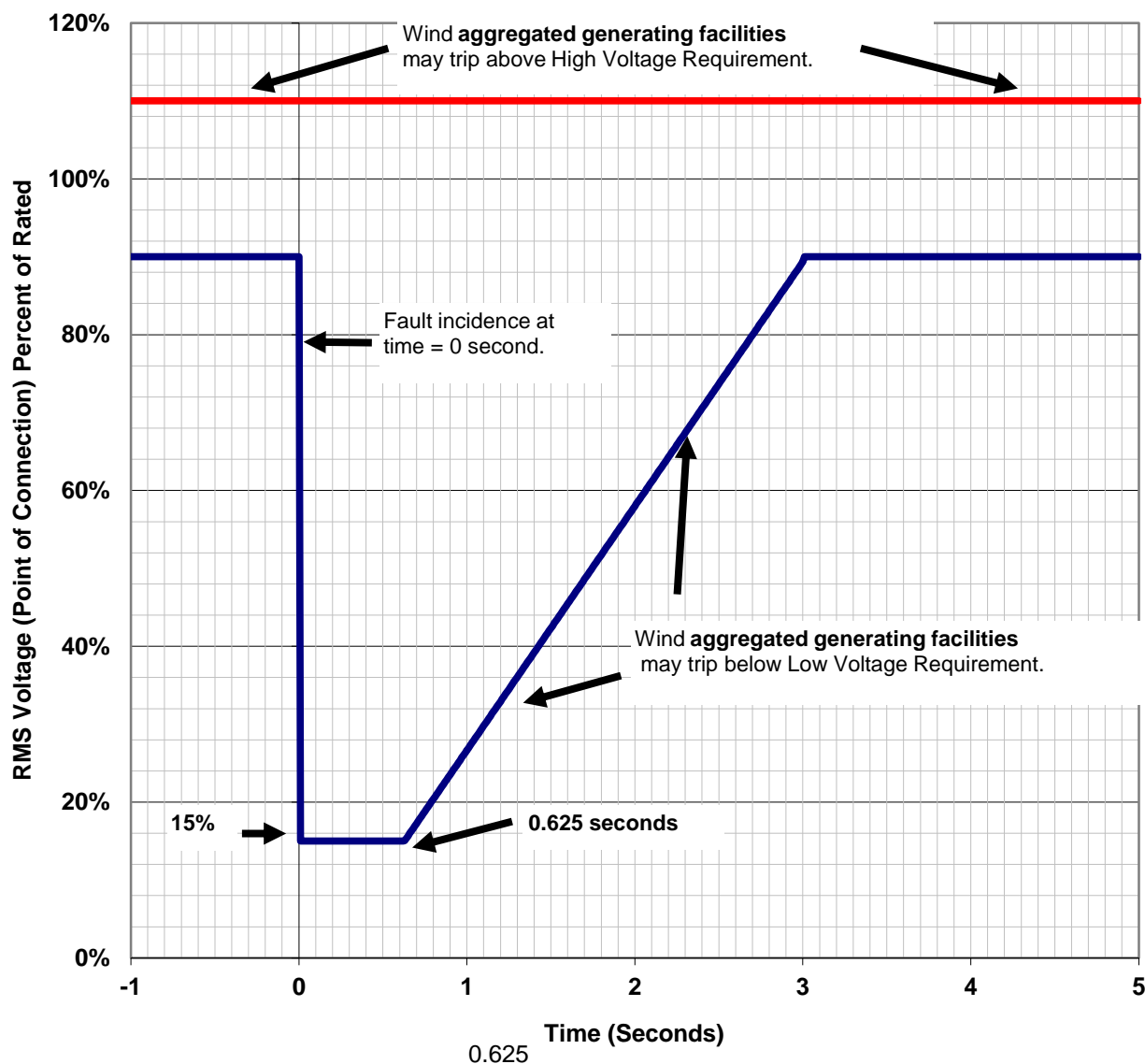
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Appendix 1 Voltage Ride-Through Requirements for Aggregated Generating Facilities

Voltage Ride Through Requirements

<u>High Voltage Ride Through Duration</u>		<u>Low Voltage Ride Through Duration</u>	
<u>Voltage (per unit)</u>	<u>Time (seconds)</u>	<u>Voltage (per unit)</u>	<u>Time (seconds)</u>
≥ 1.200	Instantaneous trip	< 0.45	0.15
≥ 1.175	0.20	< 0.65	0.30
≥ 1.15	0.50	< 0.75	2.00
> 1.10	1.00	< 0.90	3.00
≤ 1.10	Continuous operation	≥ 0.90	Continuous operation

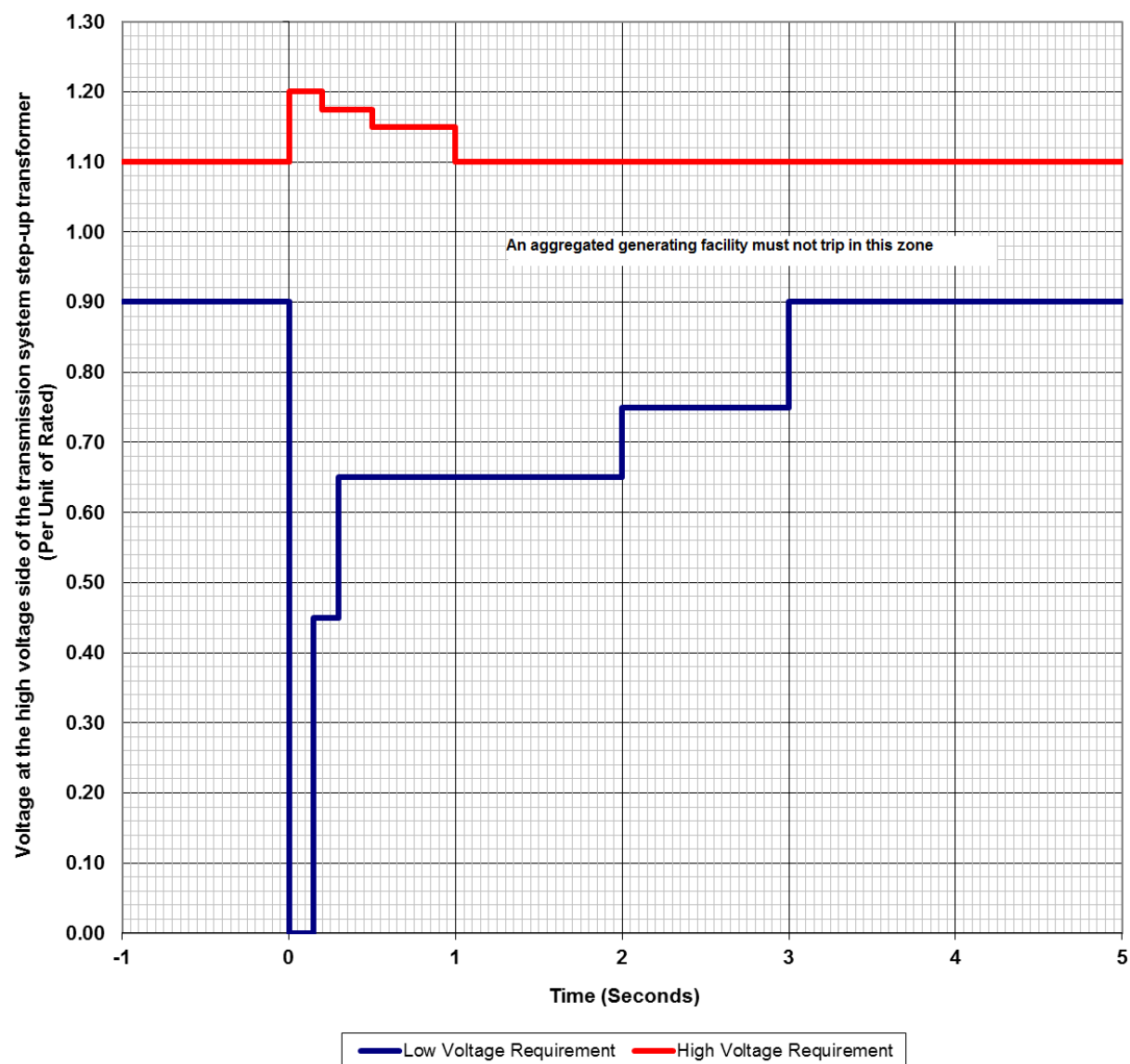


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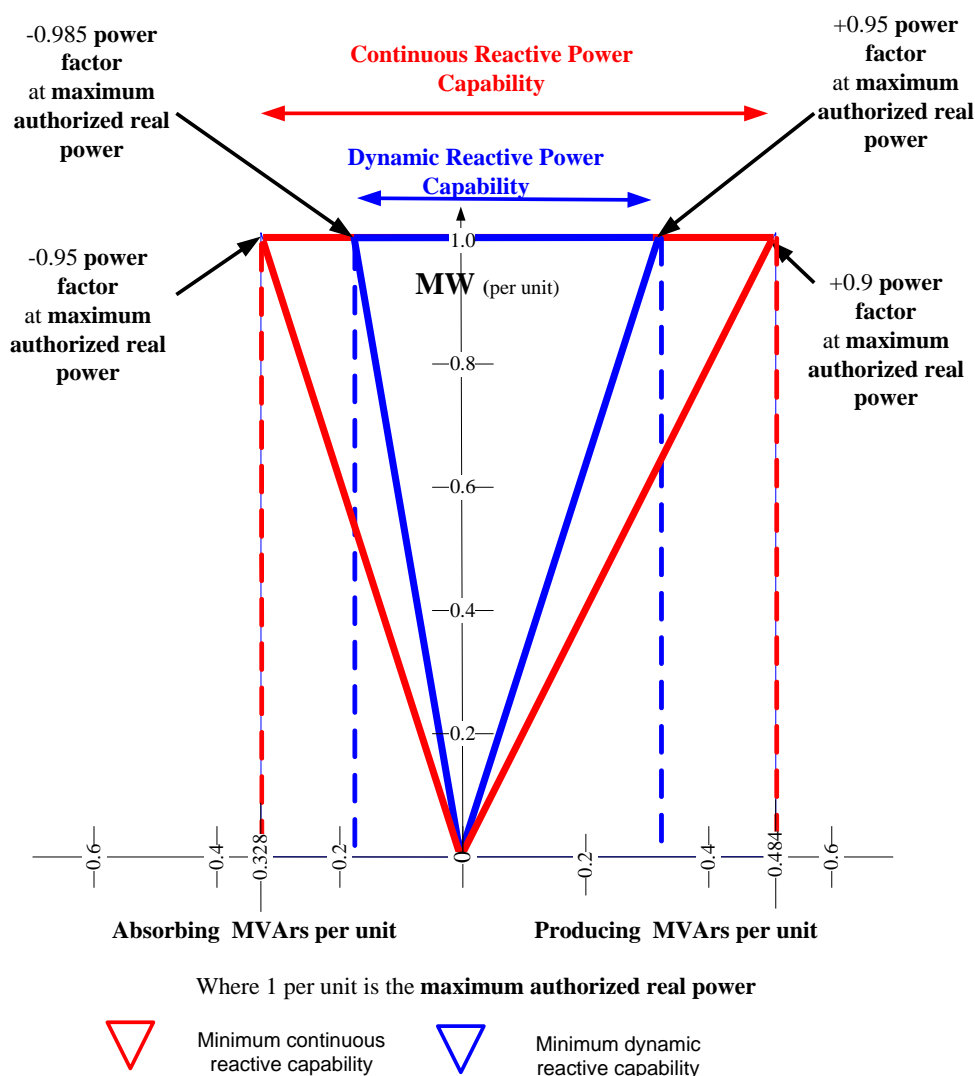
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Appendix 2 – Trip Settings of Off-Nominal Frequency Protective Relays

Reactive Power Capability

High Frequency Duration		Low Frequency Duration	
Frequency (Hz)	Time (seconds)	Frequency (Hz)	Time (seconds)
≥ 61.7	Instantaneous trip	≤ 57.0	Instantaneous trip
≥ 61.6	30	≤ 57.3	0.75
≥ 60.6	180	≤ 57.8	7.5
< 60.6	Continuous operation	≤ 58.4	30
		≤ 59.4	180
		> 59.4	Continuous operation



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