NorthWestern Energy - South Dakota

Steady-State & Post-Fault Voltage Criteria for 115 kV & Below

The steady-state voltage criteria listed in the tables below are based on the assumption that all switching has taken place, all generators and transformer Load Tap Changers (LTCs) have regulated voltages to set values, and capacitors or reactors are switched. The basis for the percent voltages is the designed operating voltage.

Table 1 – Maximum Upper Voltage Criteria

At Unregulated Load-Serving Bus

	Upper Operating Limit
Voltages	105%

As shown in Table 1 – Maximum Upper Voltage Criteria, the recommended upper voltage limit for a load-serving bus is 105% unless equipment rating dictates a different limit. For example, equipment used on 115 kV systems is typically rated for a nominal voltage of 120 kV or higher, so 126 kV or 105% of 120 kV nominal is permitted on 115 kV systems. NWSD follows the limit as outlined in the American National Standards Institute standards (i.e., ANSI C84.1). It is possible that a load-serving bus voltage may exceed the table value if conditions allow a higher voltage without harm to NWSD or customer equipment.

The allowable minimum percent voltage for any load-serving bus that is within a network configuration is shown in Minimum Allowable Percent Voltage at NWSD Unregulated Load-Serving Bus. It is possible that a load-serving bus voltage may fall below the table value if conditions allow a lower voltage without harm to NWSD or customer equipment. Table 2 considers FERC/NERC and WAPA criteria as applied to the bulk electric system buses (115 kV). This table is also applied on lower voltage transmission buses that are not part of the bulk electric system (69 kV & 34.5 kV).

The minimum allowable percent voltage for a load serving bus that is on a radial transmission system for an event on the radial line must only meet the existing system performance (N-0) shown in Minimum Allowable Percent Voltage at NWSD Unregulated Load-Serving Bus. Any unacceptable voltage performance must be mitigated in accordance with the criteria described below. The use of a Special Protection Scheme (SPS) is evaluated on a case-by-case basis, with no assurance that NWSD will accept or use a SPS. The values in Minimum Allowable Percent Voltage at NWSD Unregulated Load-Serving Bus assume that all other methods to control voltage have been explored (such as capacitors, reactors, and line switching, etc.).

Under emergency conditions, bus voltage between 90% and 110% of nominal is permitted for up to 30 minutes.

Table 2 - Min. Allowable % Voltage at NWSD Unregulated Load-Serving Bus

Minimum Allowable Percent Voltage at NWSD Unregulated Load-Serving Bus			
Nominal Voltage	Existing System (N-0)	First Contingency (N-1)	Second Contingency (N-2)
115 kV	95% - 105%	95% - 105%	90% - 110%
69 kV	95% - 105%	90% - 110%	90% - 110%
34.5 kV	95% – 105%	90% - 110%	90% - 110%

Note:
1. Percent voltage is measured from the nominal voltage.
2. 34.5 kV, 69 kV and radial 115 kV segments are not bulk electric system elements.

Steady-state & Post-fault Voltage Criteria for 115 kV

The allowable operating voltage range for the 115 kV transmission system is 100% to 110% of nominal, or 115 to 126.5 kV. This range is different from other voltage levels because equipment used on the 115 kV system is nominally rated at 120 kV or above. These criteria apply to both steady-state and post-fault conditions.

Thermal Ratings

Transmission conductor continuous summer ratings are based on 25°C (77°F) ambient air at 1.4 mph (2 ft/sec), 50°C conductor temperature rise, and 75°C (167°F) maximum operating temperature unless conditions dictate otherwise (e.g., some conductors and lines may be specifically designed for higher operating temperatures). Winter transmission conductor continuous thermal ratings are 125% of the summer rating, during the winter months November – February, or any time ambient temperatures are below 0°C (32°F).This rating is entered as Rate A in the power flow base cases. Unacceptable conductor loading can be mitigated by system improvements or, in some cases, a Special Protection Scheme (SPS) that changes system conditions to mitigate the overload. The use of an SPS to alleviate conductor overloading is evaluated on a case-by-case basis, with no assurance that NWSD will accept or use an SPS.

Emergency ratings for transmission conductors are developed on a case-by-case basis, and are dependent on conductor size, line voltage and available ground clearance under elevated conductor temperature conditions. Under emergency conditions for standard conductors (e.g. not "high temp" conductors), conductor temperatures are limited to 100°C (212°F) or less, and thermal ratings are limited to 125% of the seasonal rating for up to 30 minutes.

Transformer ratings are based on the following:

- For standard service conditions (24-hour average ambient air temperature of 30°C or 86°F, or less), the continuous rating is 100% of the highest operational nameplate rating. This rating is entered as Rate A in the power flow base case.
- For winter service conditions (November – February, or any time 24-hour ambient air temperature is less than 0°C, or 32°F), loading to 125% of the standard service condition rating may be allowed.
- Under emergency operating conditions, loading to 125% of the standard service condition rating may be allowed for up to 30 minutes during any season. Note this is the same as the winter rating, and under winter conditions this load level is permitted continuously.

Unacceptable transformer loading can be mitigated by transformer replacement, system improvements or, in some cases, an SPS that changes system conditions to mitigate the overload. The use of an SPS to alleviate transformer overloading is evaluated on a case-by-case basis, with no assurance that NWSD will accept or use an SPS.

General Minimum Equipment Specifications

The general minimum specifications for North Western Energy Transmission and Substation equipment are listed in Table 3 – T&S Equipment: General Minimum Specifications.

This table also summarizes the MVA or capacity, voltage, current, equipment Basic Impulse Level (BIL), Maximum Continuous Over Voltage (MCOV) for lightning arresters, and interrupt ratings of equipment as applicable and associated grounding requirements.

Voltage criteria for 115 kV, General Minimum Equipment specifications, Transmission Equipment Rating and Loading, Special Protection Scheme (SPS) Application, Voltage Ride Through, Harmonics, and Subsynchronous Resonance are outlined in NWSD's ETP Method Criteria and Process Business Practice 08-21-14 which is posted on NWSD's OASIS website.

Table 3 – T&S Equipment: General Minimum Specifications

Transmission and Substation Equipment: General Minimum Specifications			
	Nominal System voltages - kV		
	115 kV	**69 kV**	**34.5 kV**
MVA and Current Ratings *(1)	As Req'd	As Req'd	As Req'd
Equipment BIL (kV)	550	350	350
Maximum Design Voltage (kV) *(2)	121	72.5	72.5
Breaker Interrupt Current (kA)	40	40	40
Breaker and Switch Continuous Current (A) *(3)	1200	1200	1200
Arrester Duty Rating/MCOV (kV) *(4)	90/70	54/42	39/31.5
Substation Insulator Class	TR-286	TR-216	TR-214
Transmission Line BIL, wood (kV) *(5)	610	440	355
Transmission Line BIL, steel (kV) *(6)	695	525	440

Notes:
(1) Project and equipment specific as required to avoid thermal overloads
(2) At least 5% over nominal
(3) 2000 amp equipment is used in some applications
(4) For effectively grounded systems
(5) Insulator support hardware ungrounded
(6) Insulator support hardware grounded