# UMZAG Members Reliability Criteria Manual

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# Approval History

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# Introduction

This document outlines the specific UMZAG (Upper Missouri Zone Assessment Group) Bulk Electric System (BES) transmission reliability criteria which are to be used for UMZAG planning and operating studies.

This document provides deterministic criteria for use in UMZAG system studies so that a sound basis of comparison exists between UMZAG system performance studies. It also provides a set of evaluation criteria from which individual UMZAG members' study scopes, procedures, and reports can be produced.

This document sets forth the specific BES reliability criteria established by Transmission Owners in UMZAG. These specific reliability criteria are in addition to the general criteria outlined in the NERC Reliability Standards, and to Southwest Power Pool (SPP) planning criteria unless a variance has been granted. A variance is in place for UMZAG allowing the post contingent high voltage to go up to 1.10 p.u.

This document will be updated and/or revised as Transmission Owner and Transmission Provider criteria, operating limits, interface definitions, analysis techniques, utilities' operating practices, standards, and study philosophies evolve.

The capitalized terms in this document have the same definitions as in the NERC Reliability Standards. Any additional capitalized key words are defined in this document. All definitions are consistent with current NERC, UMZAG, and IEEE documents.

# Abbreviations and Definitions

## Terms and Definitions

| | |
|---|---|
| Automatic | Any operation not requiring human intervention. |
| Interface | A set of one or more transmission lines or other facilities on which flow measurements are made and totaled. Note that the total power flowing across an interface may not necessarily equal the net of the schedules between the areas connected along the interface, because other schedules flowing through an area may contribute to the interface measurement. |
| Pre-Disturbance/Pre-Contingency | Normal steady-state system operation. |
| Post-Disturbance/Post-Contingency | For dynamics: Period immediately following disturbance in which transients have damped but before permissible readjustments occur. Remedial Action Scheme (RAS) may operate if appropriate. |
| Voltage Instability: | Uncontrolled voltage excursions or voltage collapse on bus or group of buses with subsequent inability to recover to acceptable voltage levels. |

## UMZAG Member Company Abbreviations

| | |
|---|---|
| BEPC | Basin Electric Power Cooperative |
| CBPC | Corn Belt Power Cooperative |
| HCPD | Heartland Consumers Power District |
| MRES | Missouri River Energy Services (In UMZAG footprint) |
| NWE | NorthWestern Energy |
| WAPA | Western Area Power Administration |

## Other Abbreviations

| | |
|---|---|
| UMZ | Upper Missouri Zone |
| MISO | Midcontinent Independent System Operator |
| SPP | Southwest Power Pool |

# UMZAG SPECIFIC BULK TRANSMISSION RELIABILITY CRITERIA

# 1.0 Specific Planning and Operating Reliability Criteria

## 1.1 Voltage Criteria

Voltage criteria will be established by and be the responsibility of the Transmission Owner. The criteria parameters monitored in the study work shall be rounded to the nearest 0.01 p.u. to ensure consistent application of the criteria and to allow for small modeling variances. The initial transient period refers to the first 20 seconds after the contingency.

These voltage criteria can be utilized as guidelines for real-time operations, however depending upon operating conditions, the real-time voltages may vary outside of the recommended ranges below and the owner of the bus should be contacted for guidance on the application of these voltage criteria during real-time operations.

### 1.1.1 Pre-contingency Voltage Limitations

All steady state BES voltages in the study base case shall meet these criteria after all documented system adjustments have been made. These criteria are intended to be consistent with the NERC Reliability Standards, as applicable, and apply to the pre-contingency conditions.

| System | Facility | Maximum kV/p.u. | Minimum kV/p.u. |
|---|---|---|---|
| UMZ | Default for all buses | 1.05 p.u. | 0.95 p.u. |
| WAPA | Philip 230 kV bus | 244/1.06 | 219/0.95 |
| WAPA | Philip 230 kV tap | 244/1.06 | 219/0.95 |

### 1.1.2 Post Contingency Voltage Limitations

These criteria are intended to be consistent with the NERC Standards, as applicable, and apply to the post-contingency conditions prior to any operator intervention. All steady state BES voltages following contingencies in the power flow simulations must meet these criteria. Post contingency voltage deviations shall not exceed these limits.

| System | Facility | Maximum kV/p.u. | Minimum kV/p.u. |
|---|---|---|---|
| UMZ | Default for all buses | 1.10 p.u. | 0.90 p.u. |

### 1.1.3 Transient Period Voltage Limitations

All BES voltages in the simulation study shall meet these criteria:

| System | Facility | Maximum kV/p.u. | Minimum kV/p.u. | Max.Time below Min. kV/p.u. |
|---|---|---|---|---|
| UMZ | Default for all buses | 1.20 p.u. | 0.70 p.u. | 30 cycles |
| WAPA | Watertown 345 kV | 407/1.18 | 259/0.75 | 30 cycles |

The bus voltages in the UMZ area are allowed to increase to 1.3 p.u. for a duration up to 200 msec. unless otherwise noted.

The Miles City East and West 230kV bus voltages are allowed to increase to 1.3 p.u. for a duration up to 270 msec. during Miles City Converter Station block/bypass operation. Dynamic overvoltage devices (zinc oxide arresters) are installed on both the East and West Miles City 230 kV buses to clip the transient overvoltage to a 1.3 p.u. maximum. The surrounding area buses will also experience transient overvoltages (less than the 1.3 p.u. maximum and reduced based upon their electrical distance from Miles City) during this condition. These are acceptable. No specific overvoltage criteria for this condition are listed for the surrounding area buses due to the variance in the overvoltages for different system configurations.

## 1.2 Facility Loading Limits

Facility Loading Limits will be established by and be the responsibility of the Transmission Owner. The normal and emergency rating values supplied with the SPP power flow models should be used[1]. The normal rating is the continuous rating unless noted (e.g. dynamic ratings could be an example where the normal rating is different from the continuous rating).

Some systems have specifically identified higher dynamic ratings for some facilities under certain conditions. These are documented through applicable operating guides. These ratings may differ from the normal and emergency ratings that are included in the SPP power flow models.

1 The normal rating and emergency ratings are currently included as "Rate A" and "Rate B" respectively in the SPP power flow models. The conductor rating is sometimes included as "Rate C" in the SPP power flow models.

## 1.3 Transient Period Damping Criteria

Angular stability is indicated by positive damping. Synchronism is maintained if all post-disturbance generating unit angular responses exhibit positive damping. This principal is properly stated in the Transmission Working Group (TWG) approved SPP Disturbance Performance Requirements, that: "transient and dynamic stability assessments are generally performed to assure adequate avoidance of loss of generator synchronism and prevention of system voltage collapse within the first 20 seconds after a system disturbance." Further, the SPP Disturbance Performance Requirements reiterate that its requirements "provide a basis for evaluating the system response". The SPP Disturbance Performance Requirements do not state criteria that will assure the attenuation of inter-area modal content within a specified duration, nor establish criteria to classify system angular response as "well damped", "poorly damped", or any increment between. The UMZ will follow the latest Transmission Working Group (TWG) approved SPP Criteria, detailed in the Southwest Power Pool Disturbance Performance Requirements document as criteria for acceptable positive damping.

## 1.4 Relay Encroachment and Out-of-Step Margins

### 1.4.1 Canada-USA Out-of-Step (OOS) Relay Margin Security Parameters

| Relay | Steady State | | Dynamic |
|---|---|---|---|
| | Pre | Post | |
| OOS relay at Drayton 230 kV bus, monitoring the Drayton to Letellier 230 kV line | 110% | 50% | 25% |
| OOS relay #1 at Moranville 230 kV bus monitoring the Moranville to Richer 230 kV line | 110% | 50% | 25% |

The definitions of these specific relay margin calculations are shown in Figure 1.4.1.

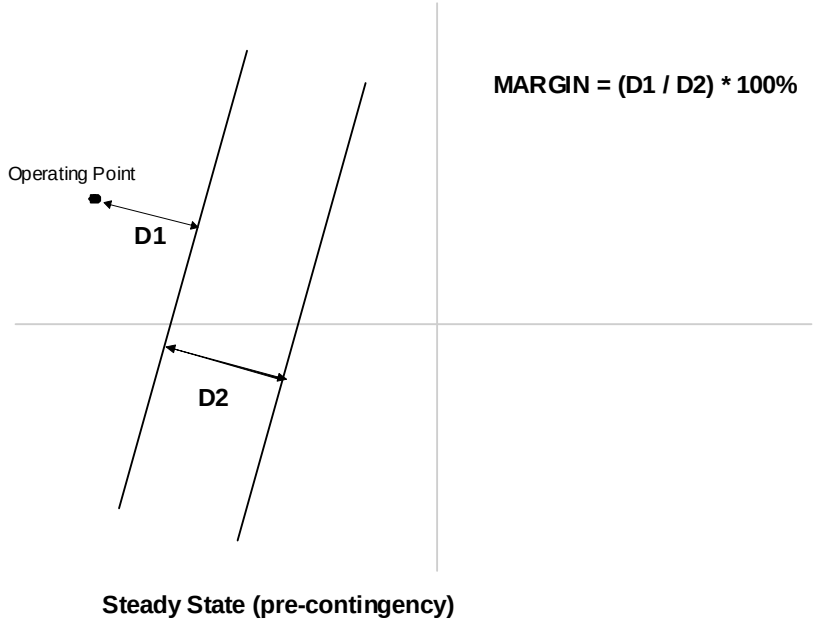


**Figure 1.4.1** - Relays at Drayton and Moranville

### 1.4.2 Distance Relaying - Apparent Impedance Transient Criteria

The transient apparent impedance swings on all lines shall be monitored, after fault clearing, against a three-zone mho (or offset impedance) circle characteristic with the following zones:

Circle A = 1.00 x Line Impedance
Circle B = 1.25 x Line Impedance
Circle C = 1.50 x Line Impedance

Apparent impedance transient swings into the inner zones (Circles A or B) are considered unacceptable, unless documentation is provided showing the actual relays will not trip for the event.

## 1.5 Voltage Stability Criteria

Voltage stability is the characteristic of a power system to return all bus voltages to equilibrium following a disturbance from initial voltage operating points. Voltage instability is indicated by a load flow Jacobian matrix that approaches singular or has constituent power balances that do not minimize using iterative methods. In conventional load flow software used for steady-state analysis, voltage instability manifests as a diverged solution state. Therefore, the key indicator of voltage instability for part or all of a simulated power system is the failure of a load flow solution to converge. It is critical to re-simulate any load flow solution that fails to converge to ensure that the potential for voltage instability is legitimate and not simply an artifact of an iterative solution method. If, upon re-simulating, a load flow solution (either pre- or post-Contingent) fails to converge, the degree of voltage stability should be further evaluated against the following criteria.

When indicated, additional voltage stability analysis shall evaluate voltage versus power transfer or system demand (P-V curve). Sufficient margin is maintained by operating at or below $P_{limit}$. $P_{limit}$ is determined by developing P-V curves for those buses that have the largest contribution to voltage instability due to the most limiting NERC P1 disturbance, per NERC TPL standards. $P_{limit}$ is calculated as the lesser of:

- (0.9) * Pcrit[2] (shown below in Figure 1.5.1 as point “a”) where Pcrit is defined as the maximum power transfer or system demand (nose of P-V curve) or
- The maximum power transfer or system demand which does not result in a post-contingency voltage violation as defined in this manual.

2 Calculated in this manner, $P_{limit}$ defines the voltage stability limits based on a 10% margin from the nose point (or point before voltage collapse occurs). For the purposes of Transmission System Planning Studies the 10% margin will be utilized for screening purposes to identify potential areas on the system where insufficient margin may exist.

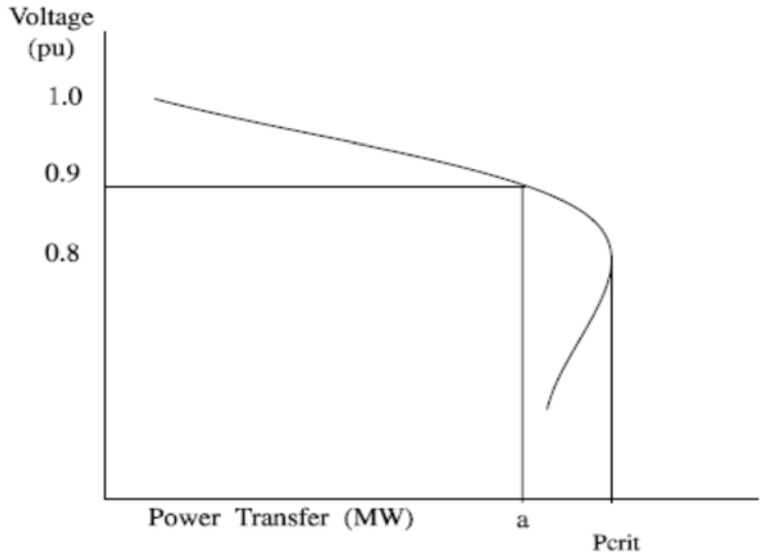


**Figure 1.5.1** – P-V Curve

## 1.6 Cascading

Steady state simulations will be utilized to identify potential Cascading. This is determined by progressively greater instances of overloading. Transmission lines and transformers that are found to overload beyond their expected relay trip points will be taken out of service and a new solution attempted. This process will be repeated until either no elements overload past their expected relay trip points or the process has been repeated at least three (3) times and continues to result in elements overloading past their expected relay trip points. Continuation of overloaded elements past three iterations shall indicate possible Cascading. Furthermore, an event could potentially result in Cascading if four or more elements[3] are taken out of service during this process (not including the elements tripped to clear the fault or in response to the expected operation of a Remedial Action Scheme, including UVLS). If the amount of load lost is greater than 1000 MW before the last overloaded element is taken out of service or divergence occurs, this shall indicate than an event could potentially result in Cascading.

Cascading may also be evaluated in transient stability studies by screening the results and identifying any generators, transmission lines and transformers that will trip (due to excessive loading, power swings or abnormal system voltages) following a given fault. A potential Cascading outage will have occurred for instances where four or more elements[3] (generators, transmission lines or transformers) are taken out of service. Elements tripping to clear the fault or in response to the expected operation of a Remedial Action Scheme (including UVLS), do not count. Also, an event could result in Cascading if the amount of load lost is greater than 1000 MW before the last element is taken out of service.

3 Elements are defined as transmission lines, transformers and generators. All elements within a protective zone would be considered a single element (i.e., a three-terminal line is considered a single element). Elements do not include shunt devices.

## 1.7 Islanding

Uncontrolled separation has occurred when the system as the result of dynamic instability breaks up into individual islands as the result of coherent clusters of buses loosing synchronism between each other. To identify possible uncontrolled separation, bus angles for high voltage buses (BES) within the UMZ will be monitored for increasing angle spread across the system to screen for islanding events.