SPP 2010

TPL Compliance Report

December 31, 2010

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SPP Southwest Power Pool

SPP 2010 TPL Compliance Report

(2010 NERC Compliance Reporting for TPL-001, 002, 003, and 004 standards)

Objective

In compliance with the 2010 NERC TPL Reliability Standards, the objectives of this report are:

1.) To identify overloaded branches (100% of rate A) under normal conditions.

2.) To identify branch violations (100% of rate B) under various contingency events.

3.) To identify voltage performance (0.95 pu - 1.05 pu) under normal conditions.

4.) To identify voltage violations (0.9 pu – 1.05 pu) under various contingency events.

5.) To identify line overloads due to single generator outage.

6.) The following four categories of contingencies were evaluated:

Category A: System intact, no disturbance

Category B: Loss of a single element

Category C: Loss of two or more elements (normal clearing, manual system adjustments between events), bus faults, single line to ground (SLG) fault with breaker failure, etc.

Category D: Extreme events, loss of two or more elements, three-phase fault with breaker failure, loss of tower with three or more circuits, loss of all generation in a station, etc.

Entities Involved

The following entities registered with SPP Regional Entity were included in these studies.

Entity Name	Registered Function
Arkansas Electric Cooperative Corporation (AECC)	DP,GOP,GO,LSE,PSE,RP,TO
American Electric Power (AEPW) ➢ East Texas Electric Cooperative (ETEC) ➢ Tex-La Electric Cooperative of Texas, Inc (TEXL)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP DP,LSE,PSE,RP,TO,TP DP,LSE,PSE,RP,TO,TP
Board of Public Utilities (KACY)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP
City Utilities of Springfield, MO (SPRM)	DP,GOP,GO,LSE,RP,TOP,TO,TP
Cleco Corporation (CELE)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP,TSP
Empire District Electric Company (EMDE)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP
Grand River Dam Authority (GRDA)	BA,GOP,GO,LSE,PSE,RP,TOP,TO,TP
Independence Power and Light (INDN)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP
Kansas City Power & Light Company (KCPL)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP
KCPL – Greater Missouri Operations (KCPL-GMO)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP,TSP
Lafayette Utilities System (LAFA)	BA,DP,GOP,GO,LSE,PSE,TOP,TO,TP
Louisiana Energy & Power Authority (LEPA)	BA
Lincoln Electric System (LES)*	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP
Mid-Kansas Electric Company, LLC (MKEC)	DP,GOP,GO,LSE,PSE,RP,TO,TP,TSP
Midwest Energy, Inc (MIDW)	DP,LSE,PSE,TOP,TO,TP
Nebraska Public Power District (NPPD)*	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP,TSP
Oklahoma Gas & Electric Company (OKGE)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP
Oklahoma Municipal Power Authority (OMPA)	DP,GOP,GO,LSE,PSE,RP
Omaha Public Power District (OPPD)*	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP
Southwestern Power Administration (SWPA)	BA,PSE,RP,TOP,TO,TP,TSP
Southwestern Public Service Company (SWPS)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP,TSP
Sunflower Electric Power Corp (SUNC)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP,TSP
Westar Energy, Inc (WERE)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP,TSP
Western Farmers Electric Coop (WFEC)	BA,DP,GOP,GO,LSE,PSE,RP,TOP,TO,TP,TSP

BA : Balancing Authority
DP : Distribution Provider
GOP : Generator Operator
GO : Generation Owner
LSE : Load Serving Entity
PSE : Purchasing-Selling Entity
RP : Resource Planner
TOP : Transmission Operator
TO : Transmission Owner
TP : Transmission Planner
TSP : Transmission Service Provider

*Midwest Reliability Organization (MRO) is the current Regional Entity for these entities.

Summary

SPP staff has conducted various analyses to comply with NERC TPL standard requirements and are summarized here.

NERC TPL Standard	Key Requirement	SPP Analysis
TPL-001	Category A	SPP MDWG Models, Regional Reliability Assessment
TPL-002	Category B	Near-Term, Long-Term Mitigation Analysis, Stability Analysis, Regional Reliability Assessment
TPL-003,004	Category C, D	N-2 and selected N-3 reliability analyses, Stability Analysis

Each of these analyses is discussed below.

Assessments

MDWG Models (TPL-001, Category A)

Power flow models are developed by the Model Development Working Group for an annual series of SPP cases.

In January 2010, SPP created 16 power flow models in coordination with SPP members through the Model Development Working Group (MDWG). This set of models go through a validation process in several iterations until all models meet requirements as stated in the SPP MDWG Procedure Manual.

MDWG PF Manual

The 2010 SPP MDWG power flow models reflect system condition, for selected years between years 2010 and 2021. These models are verified on a quarterly basis to reflect more up-to-date information using the Model On Demand (MOD) program. The SPP 2010 MDWG B1 and B2 Final MOD models used for the compliance assessment have no thermal overloads or voltage violations under N-0, or normal system conditions. In order to achieve this, the SPP members listed below have identified transmission projects as mitigation plans:

Area	No. of Projects
AEPW	10
CELE	10
EMDE	5

GRDA	1
KCPL	5
LES	3
MIDW	5
MIPU	8
MKEC	7
NPPD	7
OKGE	10
OPPD	2
SPS	36
SUNC	6
SWPA	4
WERE	31
WFEC	6

In summary, the 2010 MDWG B1 and B2 Final MOD models address the requirement of the TPL-001 standard.

Load Flow: Near-term Mitigation (TPL-002, Category B)

The Near-term mitigation study was conducted to address NERC's TPL-002 standard. The powerflow cases used in this report were created from the SPP 2010 MDWG B1 Final MOD Base Case series. The N-1 contingency analysis was run for each of the seasonal models from the 2010 series case; winter, spring, summer, and fall. Only the thermal overloads and voltage violations that were not mitigated by the OPM module of the POM software were sent to the members and mitigation plans were submitted for each of the overloads and violations. The background material for the Near-term mitigation study is inserted below.

2010 Near-Term TPL Compliance Report

Load Flow: Long-term Mitigation (TPL-002, Category B)

The Long-term mitigation study was conducted to address NERC's TPL-002 standard. The powerflow cases used in this report were created from the SPP 2010 MDWG B2 Final MOD Base Case series. The N-1 contingency analysis was run for the 2016 winter peak model and the 2021 summer peak model. All of the thermal overloads and voltage violations were sent to the members and mitigation plans were submitted for each of the overloads and violations. There were no thermal overloads or voltage violations under N-0, or normal conditions. The background material for the Long-term mitigation study is inserted below.

2010 Long-Term TPL Compliance Report

Load Flow: N-2 Study (TPL-003, Category C)

This analysis was conducted to address NERC's TPL-003 standard. SPP staff ran a detailed N-2 contingency analysis on the SPP system. This analysis was run as a part of the Near-term mitigation analysis and the Long-term mitigation analysis. Part of the N-2 contingency list was gathered by each member. The other part of the contingency list was created through the POM software based on the following selection rules:

(N-2) Category	Selection Rule
Branch-Branch	Same Zone
Branch-Generator	Same Area
Generator-Generator	All Modeled

All of the thermal overloads and voltage violations were sent to the members and mitigation plans were submitted for each of the overloads and violations.

Load Flow: Selected N-3 Study (TPL-004, Category D)

This analysis was conducted to address NERC's TPL-004 standard. SPP staff received a list of Category D events which were included in the contingency list for the Near-term mitigation analysis. The powerflow cases used in this report were created from the SPP 2010 MDWG B1 Final MOD Base Case series. The contingency analysis was run for each of the seasonal models from the 2010 series case; winter, spring, summer, and fall. All of the thermal overloads and voltage violations were sent to the members and mitigation plans were submitted for each of the overloads and violations.

Regional Reliability Assessment (TPL-001 through TPL-002)

This analysis was conducted to create a reliable long-range transmission expansion plan for the SPP footprint that protects long-term firm transmission service. The assessment reviews normal conditions (no contingency) and single contingency outage (N-1) scenarios using NERC Reliability Standards, SPP Criteria, and local planning criteria. It also coordinates appropriate mitigation plans to meet the SPP region's reliability needs. The powerflow cases used in this analysis were created from the SPP 2010 MDWG Base Case series. The generation dispatch in these cases is the same as in the MDWG cases, except for generation without a FERC-filed Interconnection Agreement and generation without Transmission Service.

The 2010 Regional Reliability Assessment, inserted below, includes only the reliability portion of the 2010 SPP Transmission Expansion Plan report. The planned system upgrades are tracked to ensure reliability projects are built in time to meet system needs. The timing of the upgrades are individually listed in the Project List spreadsheet and are discussed as a whole in the 2010 Regional Reliability Assessment report.

2010 Regional Reliability Assessment

Stability Study (TPL-001 through TPL-004)

The MDWG 2010 Series 2011 Light Load and 2016 Summer Load Cases were tested to be stable during normal system conditions.

The Stability Study is conducted for one seasonal light load (MDWG 2010 Series 2011 Light Load Case) case within the near-term planning window and selected events for one seasonal peak load case (MDWG 2010 Series 2016 Summer Case) for long term planning window. This assessment provides findings on potential events which could lead to instability within the SPP footprint for all categories (A, B, C and D) of events. A list of fifty-two NERC Category B, C and D events were simulated in this assessment and are listed below in Table 1. These events were submitted by SPP members and include reliability type contingencies and tower outages (events) to analyze for powerflow and stability performance.

Table 1: NERC Category B, C, and D Events.

Event	Contingency
B1 Note 1	Rose Hill to Wolf Creek 345 kV 3-phase fault. No reclosing
B2 Note 1	Benton to Wolf Creek 345 kV 3-phase fault. No reclosing
B3 Note 1	Wolf Creek to LaCygne 345 kV 3-phase fault. No reclosing.
B4	Jeffrey Energy Center (JEC) to Hoyt 345 kV, No fault. Trip line. No reclosing.
B5	JEC Auburn 230 kV 3-phase fault. No reclosing
B7	Plant X to Tolk 230 kV line 3-phase fault -- no reclosing
B8	Tolk to Eddy 345 kV line outage -- typical reclosing
B9	Yoakum to Sundown 230 kV line outage with typical reclosing.
B10	Tolk to TUCO 230 kV line 3-phase fault, no reclosing
B11	Potter 345/230 kV transformer 3-phase fault, no reclosing
B12	Iatan to Stranger Creek 345 kV 3-phase fault. Reclosing on Iatan breaker only.
B13	Iatan to St. Joseph 345 kV 3-phase fault. Reclosing on Iatan breaker only.
B14	3-Ø fault at S3451 on T3 transformer. Normal clearing.
B15	3-Ø fault at S1211 on the S1211-S1220 line. Normal clearing.

B16	3-Ø fault at S1206 on the S1206-S1232 line. Normal clearing.
B17	3-Ø fault at S3458 on the S3458 - Cooper line. Normal clearing.
B18	Longwood to El Dorado 345 kV 3-phase fault
B19	3PH fault at GGS on GGS-Sweetwater 345 kV Circuit #1; Normal clearing; No reclose attempts
B20	3PH fault at GGS on GGS-Red Willow 345 kV; Normal clearing; No reclose attempts
B21	3PH fault at GGS on GGS-North Platte 230 kV Circuit #1; Normal clearing; No reclose attempts
B22	3PH fault at GGS on high side of GGS 345/230 kV T-1 transformer; Normal clearing; No reclose attempts
B23	Brookline to Monett to Flint Creek 345 kV 3-phase fault, reclosing on one terminal only and rotated every year (549984 – 547481 – 506935).
C1	3-Ø fault on Auburn-JEC 230 kV; followed by 3-Ø fault on Hoyt-JEC 345 kV.
C2	Prior outage of GRDA 1 – Flint Creek 345 kV with a 3-Ø fault near GRDA 1 on GRDA – Tulsa 345 kV.
C3	Prior outage of Fairport-St Joe 345kV with a 3-phase fault near Cooper on Cooper - St Joe 345 kV. No Reclosing.
C4	Prior outage of Holcomb generating unit with an outage of Mingo – Red Willow 345 kV line.
C5 Note 1	3-Ø fault on Benton - Wolf Creek 345 kV line with no reclosing; Reduce Wolf Creek output to 950 MW (Transmission Operating Directive 300); 3-phase fault on LaCygne - Wolf Creek 345 kV line with no reclosing)
C6	Summit to Smoky Hills 230 kV 3-Ø fault and outage followed by Circle to Mullergren 230 kV 3-Ø fault, no reclosing.
C7	Knoll to Smoky Hills 230 kV 3-Ø fault and outage followed by Circle to Mullergren 230 kV 3-Ø fault, no reclosing.
C8	Prior outage of Tolk to Roosevelt #1 230 kV circuit with a 3-phase fault near Roosevelt on the Tolk to Roosevelt #2 230 kV circuit -- no reclosing.
C9	Iatan to St. Joseph 345 kV 3-Ø fault, reclosing on Iatan breaker only, then Iatan to Stranger Creek 345 kV 3-Ø fault, reclosing on Iatan breaker only. Creek 345 kV 3-phase fault, reclosing on Iatan breaker only
C10 Note 1	3-Ø fault on Wolf Creek-LaCygne 345 kV line; Reduce Wolf Creek output to 950 MW (Transmission Operating Directive 302); 3-Ø fault on Wolf Creek-Benton 345 kV line, no reclosing.

C11	DLG fault at the S3451 end of the S3451-S3459 and S3451-S3454 lines. Normal clearing. 1358.24 -10176.72 MVA
C12	SLG fault at the S3451 end of the S3451-Raun line, followed by a stuck breaker and the opening of transformer T4 at S3451.
C13	SLG fault at S1206 on the S1206 - S1232 line, followed by a stuck breaker and the opening of the S1206 - S1201 line.
C14	SLG fault at GGS on GGS-Sweetwater 345 kV Circuit #2, Stuck Breaker (GGS 3322), Drop GGS-Red Willow 345 kV line; Delayed clearing; No reclose attempts
C15	Prior Outage of Brookline – Monett - Flint Creek 345 kV with a 3-phase fault near Brookline on Brookline - Morgan 345 kV, with reclosing first at Morgan and then Brookline
C16	3-phase fault and outage of the Brookline - Southwest Power Station (SWPS) 161 kV line followed by a 3-phase fault near SWPS on the SWPS - Southwest Treatment Plant - SPRM Battlefield 161 kV line, no reclosing (549969 – 549954, 549954 – 549960 – 549959)
C17 Note 1	SLG fault 10% away from Wolf Creek on the Wolf Creek-LaCygne 345 kV line At 4 cycles, trip the LaCygne end. At 12 cycles trip the Wolf Creek end and clear the fault (Assume 4 cycles for 345 kV normal clearing and 8 more cycles for breaker failure).
D1	3-Ø fault on Holcomb – SETAB 345 kV with breaker failure taking out the 345-115 kV auto-transformer.
D2	Jeffrey Energy Center (JEC) to Hoyt 345 kV 3-Ø fault, no reclosing, and trip JEC Unit #2
D3	3-Ø fault on Auburn-Jeffery Energy Center (JEC) 230 kV; followed by 3-Ø fault on Hoyt-JEC 345 kV, no reclosing, and trip JEC Unit#2
D4	Run fault on GRDA1 345 kV bus for 5 cycles. Then open Flint Creek end of Flint Creek-GRDA1 345 kV line, but stuck breaker 9580 at GRDA1. Run for 25 cycles and then drop GRDA 345/161 transformer #1 & breaker 9080 (GRDA bkr 500T opens correctly)
D5	Loss of Flint Creek 161 kV bus
D6	Loss of Ft. Smith 500/345/161 kV Substation
D7	Loss of AEP's NW Texarkana 345 kV bus
D8	3-Ø fault at the S3451 on T3 transformer, followed by a stuck breaker and the opening of the S3451-S3459 line.
D9	3-Ø fault at S3458 on the S3458 - Cooper line, followed by a stuck breaker and the opening of the west bus at S3458.
D10	Loss of the entire substation S3456, including the transformer to the 161-kV level.

D11	Valliant to Welsh to NW Texarkana 345 kV 3-phase fault
D12	NE Station to Tulsa North 345/138 kV double circuit 3-phase fault
D13	Simultaneous SLG fault on GGS-Sweetwater 345 kV Circuit #1 and 3PH fault on GGS-Sweetwater 345 kV Circuit #2 at cross point; Normal clearing; Reclose far end

Note 1: Wolf Creek Generation Station was not scheduled to be in service in the MDWG 2010 Series 2011 Light load case. SPP Staff worked with WESTAR Energy to develop a case to simulate the unit being in service due to past results of dynamic simulations in the vicinity of the generation station.

SPP members provided staff with twenty-two category B events that were to be evaluated for transient stability. Twenty-one of the twenty-two events were stable for a five cycle clearing time (unless otherwise specified by the SPP Member) in the initial evaluation using the MDWG 2010 Series 2011 Light Load Case. After additional simulations, staff determined that the remaining event, B3, was stable for a 4.0 cycle clearing time with the existing generator dispatch. Coordination with Westar Energy System Protection staff has confirmed that clearing time of up to 3.6 cycles are achievable on the EHV system in that area with the current relay configurations. The transmission system became stable for a 4.5 cycle fault once the generation at Wolf Creek was lowered to 1085 MW. The detailed results of the Dynamic Simulations are contained in Appendix A under Table 4: Member Submitted NERC Category B Detailed Results.

SPP members provided staff with seventeen category C events that were to be evaluated for transient stability. Fifteen of the seventeen events were stable for a five cycle clearing time (unless otherwise specified by the SPP Member) in the initial evaluation using the MDWG 2010 Series 2011 Light Load Case. After additional simulations, staff determined that the remaining event, C5 and C10, were stable for a 4 & 4.5 cycle clearing times respectively with the modified generator dispatch. Coordination with Westar Energy System Protection staff has demonstrated that clearing times of up to 3.6 cycles are achievable on the EHV system in that area with the current relay configurations. An operating guideline currently exists for the redispatch of the Wolf Creek Unit under certain system conditions that reduces it output to 950 MWs. To ensure transmission system stability for events C5 and C10, the Transmission Operating Guideline redispatch to 950 MWs should be lowered to 900 MWs. The detailed results of the Dynamic Simulations are contained in Appendix A under Table 5: Member Submitted NERC Category C Detailed Results.

SPP members provided staff with thirteen category D events that were to be evaluated for transient stability. Nine of the thirteen events were stable for a clearing time as specified by the SPP Member in the initial evaluation using the MDWG 2010 Series 2011 Light Load Case. Due to the severity of the event simulations, the units that were made unstable due to this simulation were tripped offline. The NER Category D Events were shown to be stable when this methodology was applied to them. The detailed results of the Dynamic Simulations are contained in Appendix A under Table 6: Member Submitted NERC Category D Detailed Results.

SPP also conducted a transient stability screening of the SPP Transmission system Footprint for one seasonal light load case within the near-term planning window and one seasonal peak load case for long term planning window. There were four contingencies that could potentially cause stability issues

from the short term planning model and are listed in Table 2. There was one contingency that could potentially cause stability issues from the long term planning model and are is also listed in Table 2.

Table 2: Transient Stability Screening	
Event	**Contingency**
SCR11L-1	Apply fault on bus 337321 and outage branch from Bus 337321 to Bus 503309
SCR11L-2	Apply fault on bus 500250 and outage branch from Bus 500250 to Bus 507760
SCR11L-3	Apply fault on bus 520920 and outage branch from Bus 520920 to Bus 520957
SCR11L-4	Apply fault on bus 520957 and outage branch from Bus 520957 to Bus 520999
SCR16S-1	Apply fault on bus 337321 and outage branch from Bus 337321 to Bus 503309

All but two instability problems discovered by the Stability Study were addressed by prescription of breakers with faster clearing time, or by a change in system dispatch.

Additionally, SPP also conducted a transient stability study of the unstable NERC Category B, C, and D Events of the SPP Transmission system Footprint from the near term model study with a long term planning model (MDWG 2010 Series 2016 Summer Case). There were seven unstable events from the SPP Member Submitted Events that were evaluated using the MDWG 2010 Series 2011 Light Load Case. Four of the seven events (B3, C5, C10, & D8) were stable for the clearing time as specified by the SPP Member in the initial evaluation using the MDWG 2010 Series 2016 Summer Load Case. Events D1 & D9 were made stable using the methodology of tripping the unstable unit and making sure that the rest of the transmission system remained stable. Event D4 was still found to be unstable due to the length of the fault being applied to the system. SPP Staff verified with the GRDA that a 15 cycle stuck breaker time was a more realistic scenario. Event D4 was found to be stable by applying the methodology of tripping the unit that was made unstable by the event offline with a more realistic stuck breaker cycle time. The detailed results of the Dynamic Simulations are contained in Appendix A under Table 8: 2016 Summer Review of Member Submitted Unstable Events from 2011 LL Study.

The background material for the 2010 Stability Study is inserted below less the plots due to the size of the file. The stability plots will be provided on an as requested basis.

2010 SPP Stability Report