UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

MANDATORY RELIABILITY STANDARDS FOR THE BULK POWER SYSTEM	**)**	**Docket No. RM06-16-___**

COMPLIANCE FILING OF THE NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION IN RESPONSE TO PARAGRAPH 145 OF ORDER 693-A

Rick Sergel
President and Chief Executive Officer
David N. Cook
Vice President and General Counsel
North American Electric Reliability Corporation
116-390 Village Boulevard
Princeton, NJ 08540-5721
(609) 452-8060
(609) 452-9550 – facsimile
david.cook@nerc.net

Rebecca J. Michael
Attorney
North American Electric Reliability Corporation
1120 G Street, N.W.
Suite 990
Washington, D.C. 20005-3801
(202) 393-3998
(202) 393-3955 – facsimile
rebecca.michael@nerc.net

November 13, 2007

TABLE OF CONTENTS

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

MANDATORY RELIABILITY STANDARDS	**)**	**Docket No. RM06-16-___**
FOR THE BULK POWER SYSTEM	**)**	

COMPLIANCE FILING OF THE NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION IN RESPONSE TO PARAGRAPH 145 OF ORDER 693-A

I. INTRODUCTION

In its July 19, 2007, Order on Rehearing (Order 693-A),[1] the Federal Energy Regulatory Commission (Commission) directed the North American Electric Reliability Corporation (NERC) to collect the frequency and magnitude of load in Underfrequency Load Shedding (UFLS) systems from applicable entities for the summer of 2007, from July 19, 2007 through September 30, 2007.[2] In addition, the Commission directed NERC to perform an analysis as to the ability of the existing system to provide the required last resort function within 90 days of the date of the order.[3] The Commission indicated that

[1] *Mandatory Reliability Standards for the Bulk-Power System*, 118 FERC ¶ 61,218, FERC Stats. & Regs. ¶ 31,242 (2007) (Order No. 693), *order on reh'g*, *Mandatory Reliability Standards for the Bulk-Power System*, 120 FERC ¶ 61,053 (Order No. 693-A) (2007).

[2] Order 693-A at P 145: "While the Commission will not enforce compliance with PRC-006-0, the possible reduction in the amount of load available for underfrequency load shedding can negatively impact the Reliable Operation of the Bulk-Power System. Because of the importance of the UFLS programs and the fact that there currently are no Commission-approved Reliability Standards by which to judge individual UFLS programs, the Commission believes it is important to monitor the current UFLS programs so that we can consider if they provide an adequate safety net for the Bulk-Power System. Therefore, the Commission directs the ERO to collect the frequency and magnitude of load in UFLS systems from applicable entities for this summer, from date of order through September 30, 2007, and perform an analysis as to the ability of the existing system to provide the required last resort function within 90 days of this order. This analysis should consider if the existing UFLS plans together provide an adequate safety net for the Bulk-Power System."

[3] *Id.*

this analysis should consider if the existing UFLS plans together provide an adequate safety net for the Bulk-Power System.[4]

This filing provides a status report on activities undertaken to date by NERC in response to the Commission's directives and other activities directly related to UFLS programs.

II. NOTICES AND COMMUNICATIONS

Notices and communications with respect to this filing may be addressed to the following:

Rick Sergel
President and Chief Executive Officer
David N. Cook*
Vice President and General Counsel
North American Electric Reliability Corporation
116-390 Village Boulevard
Princeton, NJ 08540-5721
(609) 452-8060
(609) 452-9550 – facsimile
david.cook@nerc.net

Rebecca J. Michael*
Attorney
North American Electric Reliability Corporation
1120 G Street, N.W.
Suite 990
Washington, D.C. 20005-3801
(202) 393-3998
(202) 393-3955 – facsimile
rebecca.michael@nerc.net

*Persons to be included on the Commission's service list are indicated with an asterisk.

III. BACKGROUND OF UFLS STANDARDS PROJECT

In November 2006, NERC initiated a Standards Authorization Request (SAR) to review and revise four standards related to UFLS:

PRC-006 Development and Documentation of Regional Reliability Organizations' UFLS Programs

PRC-007 Assuring Consistency with Regional UFLS Programs

[4] *Id.*

PRC-008 UFLS Equipment Maintenance Programs

PRC-009 UFLS Performance Following an Underfrequency Event

As stated in the SAR, the purpose of revising these four standards was to:

1. Provide an adequate level of reliability for the North American bulk power system by ensuring that the standards are complete and the requirements are set at an appropriate level to ensure reliability.
2. Ensure they are enforceable as mandatory reliability standards with financial penalties, by ensuring that (i) the applicability to bulk power system owners, operators, and users, and as appropriate particular classes of facilities, is clearly defined; (ii) the purpose, requirements, and measures are results-focused and unambiguous; and (iii) the consequences of violating the requirements are clear.
3. Incorporate other general improvements described in the standards development work plan.
4. Consider comments received during the initial development of the standards and other comments received from electric reliability organization (ERO) regulatory authorities and stakeholders.
5. Satisfy the standards procedure requirement for five-year review of the standards.

After reviewing and incorporating comments from the first 30-day posting of the draft SAR, the standards drafting team posted a second draft for a 30-day comment period commencing February 8, 2007. Following consideration of the comments received, the NERC Standards Committee solicited members to serve on a standards

drafting team for these standards. Notably, in response to comments on the second draft SAR, PRC-008 was removed from the list of standards to be revised in association with Project 2007-01 and placed into a project with all the relay maintenance and testing standards.

As part of its effort to develop revised standards, the standards drafting team solicited information from each Regional Entity regarding its respective current UFLS programs and the status of analyses being done to determine if these programs provide an adequate safety net for the bulk power system.

IV. SUMMARY OF CURRENT REGIONAL UFLS PROGRAMS[5] AND ANALYSIS ACTIVITIES

Texas Regional Entity (Texas RE)

Current Program:

25% of system load shed in three stages:

- 59.3 Hz – 5% (2007 Summer Peak – 3,134 MW)
- 58.9 Hz – 10% (2007 Summer Peak – 6,268 MW)
- 58.5 Hz – 10% (2007 Summer Peak – 6,268 MW)

Maximum fixed time delay of 30 cycles

Load tripped within 40 cycles including all relay and breaker operating times

Not intended to create electrical islands within ERCOT

UFLS in addition to Load Acting as Resources (LaaR) which sheds load at a minimum frequency of 59.7 Hz

Analysis Activities and Findings:

[5] The MW load shed at each step is based on projected August 2007 Net Internal Demand as reported in the NERC 2007 Summer Assessment.

Extensive study to verify compliance with NERC Planning Standards

- Modeled actual load shedding relays and locations
- Tested all three stages of UFLS
- Evaluated UFLS scheme for both peak and off-peak system conditions
- Simulated under frequency event by tripping generation

The ERCOT UFLS scheme is adequate

- Effectively arrested system frequency decline
- Allowed frequency to recover within acceptable limits
- No excessive high voltages were observed
- Simulation results did not suggest any conditions that could lead to cascading outages or the creation of electrical islands

Florida Reliability Coordinating Council (FRCC)

Current Program:

UFLS Step	Frequency (Hz)	Time Delay[1] (seconds)	Load Shed (%)	Load Shed (MW)
A	59.7[2]	0.28	9	3,944
B	59.4	0.28	7	3,068
C	59.1	0.28	7	3,068
D	58.8	0.28	6	2,629
E	58.5	0.28	5	2,191
F	58.2	0.28	7	3,068
L	59.4	10.0	5	2,191
M	59.7	12.0	5	2,191
N	59.1	8.0	5	2,191

Notes:
1. Time Delay = Intentional delay + relay delay + breaker delay
2. FPL has 2/3 of Step A set at 59.82 hertz as an aid to system stability. This high set Step A is concentrated in the Miami area.

Analysis Activities and Findings:

- Florida system can experience transmission separations and underfrequency load shedding following the outage of 500 kV transmission corridors or generating plants.
- Simulations of these types of severe multiple contingencies demonstrate the FRCC UFLS program and the controlled transmission separation Special Protection Systems (SPS) operate as intended and result in a successful frequency recovery.
- The lowest frequency conditions occur for an outage of the Crystal River plant during light load conditions.
- FRCC reliability studies have used loss of an entire generating plant plus an additional large generating unit as a test disturbance for design of the FRCC's UFLS program.

Midwest Reliability Organization (MRO)

Current Program:

30% of system load shed in three stages:

- 59.3 Hz – 10% (2007 Summer Peak – 4,154 MW)
- 59.0 Hz – 10% (2007 Summer Peak – 4,154 MW)
- 58.7 Hz – 10% (2007 Summer Peak – 4,154 MW)

Analysis Activities and Findings:

- Study findings in 2007 across broader MRO geography.
- Collected technical references.
- Load shedding requirements were determined (% to shed).
- Desired performance was defined.
- Single bus equivalent inertia dynamic model allowed rapid prototyping.

- Analysis was based on a range of damping and inertia assumptions.
- From simulations and calculations, number of blocks and relay setting were worked out.
- Work iterated towards the best compromise, and recommendations were made.
- Generation tripping set points and time delays were established after the fact to coordinate with load shedding and actual times spent below 60 Hz.
- Identified potential islands and quantified each island in terms of load, generation, inertia, *etc*.
- Reviewed areas that have special requirements or unique characteristics.
- Studied the data to see if 30% load shedding is adequate.
- Investigated the behavior of wind generation.
- Investigated gas turbine issues.
- Reviewed the existing Canadian UFLS programs.
- Estimated the range of system based inertia.
- 30% load shedding is adequate for the U.S. portion of MRO.
- Study results shall be considered in standards development for an enforceable UFLS standard; no proposed changes until vetted through approved standard development process.

- Study recommended that MRO should consider five blocks at 6% each, as shown below:

High Speed Blocks	Frequency (Hz)	Load (%)	Load[6] (MW)	Relay Time (Cycles)*	Max. Breaker Time (Cycles)
1	59.3	6	2,449	6	8
2	59.1	6	2,449	6	8
3	58.9	6	2,449	6	8
4	58.7	6	2,449	6	8
5	58.4	6	2,449	6	8
The following two delay blocks are a subset of block 5 using logic of the form: trip IF (58.4 Hz for 6 cy) OR IF (X Hz for Y cy), with the second trip times and delays defined below.**					
Delayed Blocks	Frequency (Hz)	Load (%)	Load[3] (MW)	Relay Time + Intentional Delay (Cycles)	Max. Breaker Time (Cycles)
1	58.7	2	816	500	8
2	59.5	2	816	2400	8

* 6 cycle minimum detection time recommended for relay security purposes to prevent false trips.
** As an alternative, utilities can implement the delay blocks as independent blocks, which increases the total load shedding obligation to 34%.

Northeast Power Coordinating Council (NPCC)

Current Program:

25% of system load shed in two stages:

- 59.3 Hz – 10% (U.S. only 2007 Summer Peak – 5,998 MW)
- 58.8 Hz – 15% (U.S. only 2007 Summer Peak – 8,997 MW)

Analysis Activities and Findings:

- Last completed UFLS Assessment performed in 2006; recommendations approved in May 2007.

[6] U.S. portion of MRO only.

- For most islands, the existing NPCC UFLS program is adequate for arresting frequency decline before generation would trip off line.
- As a follow up to the 2003 blackout investigation, sensitivity analyses showed that under-voltage inhibition of relays is not expected to interfere with operation of the UFLS program.
- The frequency decline in islands containing the boiling water reactor nuclear plants with motor-generator (M-G) sets supplying critical station load is arrested above the trip threshold of the nuclear plant protective relays.

Reliability*First* Corporation (RFC)

Current Program:[7]

- ECAR – five 5% blocks at 59.5, 59.3, 59.1, 58.9, and 58.7 Hz
- MAIN – three 10% blocks at 59.3, 59.0, and 58.7 Hz
- MAAC – three 10% blocks at 59.3, 58.9, and 58.5 Hz

Using 25% total load shed for RFC total yields 44,500 MW.

Analysis Activities and Findings:

- 2006 UFLS Study
- All RFC ties to external regions tripped simultaneously.
- At same instant, certain amount of generation within RFC also tripped to produce a generation deficit.
- Deficits of 14, 22 and 28 percent were simulated in this manner.
- Turbine-governor modeling adjustments were made within RFC to achieve a realistic value of frequency bias.

[7] Using legacy criteria of ECAR, MAIN, and MAAC.

- Existing legacy region UFLS schedules as implemented by RFC members effective in halting and restoring system frequency for generation deficits up to 25 percent.
- Implementation of the regional UFLS schedules correlates well with the legacy schedules as specified.
- Results of studies investigating various uniform UFLS schedules throughout RFC were inconclusive in that no particular uniform schedule was seen to be superior to existing legacy schedules.

SERC Reliability Corporation (SERC)

Current Program:

The SERC regional UFLS program accommodates the UFLS programs of the five SERC subregions. The subregional plans satisfy the regional program in:

- Minimum load shed capability of 30%
- Approximately equal steps
- Minimum number of set points: 3
- Acceptable frequency range: 59.5 – 58.4 Hz
- First set point no lower than 59.3 Hz
- Range between set points at least 0.2 Hz but no greater than 0.5 Hz

Subregion	Block	Frequency (Hz)	Load Shed (%)
Central	1	59.5	6
	2	59.3	6
	3	59.1	6
	4	58.9	6
	5	58.7	6
Delta	1	59.3	10
	2	59.0	10
	3	58.7	10
Gateway	1	59.3	10
	2	59.0	10
	3	58.7	10
Southeastern	1	59.5	10
	2	59.2	10
	3	58.8	10
	4	58.4	10
VACAR	1	59.3	10
	2	59.0	10
	3	58.5	10

Total load shed by UFLS = 57,988 MW

Analysis Activities and Findings:

- Current study completed in September 2007
- 2006 study was repeated with addition of new members into SERC
- Powertech Labs used TSAT to perform time domain simulations.
- SERC simulated as an island.
- SERC UFLS schemes designed with adequate frequency set points, delay times, and tripping blocks for possible generation/load imbalances of up to 30%.
- For higher imbalances (40%), system will be unable to maintain stability with UFLS schemes alone as presently applied.

SERC system has acceptable voltage and circuit loading conditions following a generation/load imbalance event with UFLS operation.

Southwest Power Pool, Inc. (SPP)

Current Program:

Three 10% blocks at 59.3, 59.0, and 58.7 Hz (Total load = 12,532 MW)

Analysis Activities and Findings:

- 2006 assessment performed by Powertech Labs.
- SPP members closely adhere to a coordinated load shedding scheme. Also, there are no unusual protection requirements that necessitate special coordination with other NERC regions.
- The relay database and simulation result showed SPP members have a generally consistent UFLS program.
- The analysis proved that the SPP UFLS program is indeed effective in arresting frequency decline under conditions of severe mismatch between load and generation
- Recommended to investigate if any of the generating units have over-speed protections with settings around 61.0 Hz.
- Next study is due in 2011.

Western Electricity Coordinating Council (WECC)

Current Program:

Block	Frequency (Hz)	Tripping Time*	Load Shed (%)	Load Shed (MW)
1	59.1	14 cycles	5.3	7,032
2	58.9	14 cycles	5.9	7,828
3	58.7	14 cycles	6.5	8,625
4	58.5	14 cycles	6.7	8,890
5	58.3	14 cycles	6.7	8,890
Additional automatic load shedding to correct underfrequency stalling				
	59.3	15 sec	2.3	3,052
	59.5	30 sec	1.7	2,256
	59.5	60 sec	2.0	2,654
Load automatically restored from 59.1 Hz block to correct frequency overshoot				
	60.5	30 sec	1.1	1,460
	60.7	5 sec	1.7	2,256
	60.9	15 cycles	2.3	3,052

* Tripping time includes relay and circuit breaker times.

The values in the table above are minimum requirements. WECC Policy 2D states, “Additional load can be tripped at frequencies higher than 59.1 Hz provided it does not violate the WECC Minimum Operating Reliability Criteria (MORC) or adversely impact neighboring systems. Frequency overshoot must be adequately addressed."

Within WECC, entities are allowed to trip more load at higher frequency levels, but they have to run studies to demonstrate that it does not cause problems and does coordinate with neighbors. Some entities within WECC have opted to trip more load sooner, and have provided supporting studies to demonstrate compliance with WECC Policy 2D.

Analysis Activities and Findings:

The Coordinated WECC Off-Nominal Frequency Load Shedding and Restoration Plan (UFLS Program) was developed and implemented in 1997 in response to WECC grid-wide July and August 1996 disturbances.

The WECC UFLS Program was re-evaluated in 2001 to test its continued effectiveness to arrest frequency excursions.

Study Assumptions:

- Loss of California Oregon Intertie (COI) with the operation of Northeast-Southeast (NE/SE) Separation Scheme
    - Loss of 3-500 kV lines between California and Pacific Northwest (COI)
    - Triggered the NE/SE Separation Scheme
    - Created 2 islands – Southern and Northern
- Summer Base Case for the Southern Island
- Winter Base Case for the Northern Island
- Simulate underfrequency event in both islands through tripping 30% resources within each island

Study Conclusions:

- For scenarios studied, a 30% resource loss resulted in a frequency decline to 57.7 Hz as the lowest frequency.
- Within both the Southern and Northern islands, the coordinated WECC UFLS Program was shown to be effective in arresting a frequency decline.
- During study simulations, the load controllers on generator governors are returning the generators to their original set-point during an off-nominal

frequency excursion. This results in a simulated slower frequency recovery. Removal of the load controller model during the off-nominal frequency simulation resulted is a faster system recovery to normal frequency than when the load controller model was activated.

- Evaluation of the use of Figure 6 of the ANSI/IEEE C37.106-1987 to create a composite curve for generator operation during frequency excursions of the frequency versus time to trip curves revealed a discrepancy between WECC composite curve and the IEEE curves in ANSI/IEEE C37.106-1987. A potential concern of lack of sufficient margin between the anti-stall load setting and the allowed tripping of generators.

Tasks to Include in Next Program Evaluation:

- Further investigation required of the load controller model to verify that the response is correctly capturing actual system response characteristics.
- Review and verify whether Figure 6 of the ANSI/IEEE C37.106-1987 reflects the worst case composite curve for generator operation during frequency excursions In addition, the generator composite curve should be updated to include the latest generator technology. The composite curve only includes unit-damage curve for steam units.

On-Going Activities

In conjunction with its work on UFLS standards (NERC Standards Project 2007-01), NERC is using its standards development process to develop an UFLS continent-wide standard supported by regional standards. The UFLS standard drafting team is drafting the continent-wide standard as well as a set of performance characteristics that

each Regional Entity will be required to incorporate into a regional standard for implementing an automatic UFLS program to arrest and recover declining bulk power system frequency. Such regional standards are envisioned to include, as a minimum:

- Identification of the functional entities responsible for implementing the UFLS program;
- Identification of the functional entities responsible for determining the system boundaries and conditions for which specific performance requirements would apply and any predetermined credible islands within or between regions;
- Specification of the technical design parameters of the regional UFLS program that are required to meet the performance requirements for underfrequency conditions resulting from an imbalance between load and generation of at least 25 percent within an interconnection, region, or predetermined credible island; and
- Identification of the functional entities responsible for verifying through dynamic simulation that the technical design parameters of the regional UFLS program are adequate to meet the stated performance requirements.

In the meantime, NERC will continue to follow the progress of studies currently underway within the regions to ensure that the results are shared among the regions.

IV. CONCLUSION

For the foregoing reasons, NERC respectfully requests that the Commission accept this compliance filing submitted in response to Paragraph 145 of Order 693-A.

Respectfully submitted,

Rick Sergel
President and Chief Executive Officer
David N. Cook
Vice President and General Counsel
North American Electric Reliability Corporation
116-390 Village Boulevard
Princeton, NJ 08540-5721
(609) 452-8060
(609) 452-9550 – facsimile
david.cook@nerc.net

/s/ Rebecca J. Michael
Rebecca J. Michael
Attorney
North American Electric Reliability Corporation
1120 G Street, N.W., Suite 990
Washington, D.C. 20005-3801
(202) 393-3998
(202) 393-3955 – facsimile
rebecca.michael@nerc.net

CERTIFICATE OF SERVICE

I hereby certify that I have served a copy of the foregoing document upon all parties listed on the official service list compiled by the Secretary in this proceeding.

Dated at Washington, D.C. this 13th day of November, 2007.

/s/ Rebecca J. Michael
Rebecca J. Michael

Attorney for North American Electric Reliability Corporation