NERC

NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Frequency Response Standard Background Document

Frequency Response Standard Drafting Team

July 2011

to ensure the reliability of the bulk power system

116-390 Village Blvd., Princeton, NJ 08540
609.452.8060 | 609.452.9550 fax
www.nerc.com

Table of Contents

Introduction

This document provides background on the development, testing and implementation of BAL-003-1 - Frequency Response Standard (FRS). The intent is to explain the rationale and considerations for the Requirements and their associated compliance information.

The original Standards Authorization Request (SAR) approved by the Industry presumed there is presently sufficient Frequency Response in all the North American Interconnections. The underlying goal of the SAR was to update the Standard to make the measurement process more objective and to provide information to Planners and Operators such that the Industry would better understand the unexpected trends in Frequency Response. This objective data would provide the underlying model data needed by Industry to determine if reliability limits were being approached. The Standard would also lay the process groundwork for a transition to a performance-based Standard if reliability limits were approached.

In Order No. 693, the FERC directed additional changes to BAL-003-0. This document explains how those directives are met by BAL-003-1.

The document also provides good practices and tips for operators with regard to Frequency Response.

This document will be periodically updated by the FRS Drafting Team until the Standard is approved (expected to occur during Spring of 2012). Once approved, this document will then be maintained and updated by NERC and the NERC Resources Subcommittee.

Background and Rationale by Requirement

Requirement 1

R1. Each Balancing Authority or Reserve Sharing Group shall achieve a Frequency Response Measure (FRM) (as detailed in Attachment A and calculated on FRS Form 1) that is equal to or more negative than its Frequency Response Obligation (FRO).

Background and Rationale

R1 is intended to meet the following primary objectives:

- Determine whether a Balancing Authority (BA) has sufficient Frequency Response for reliable operations.
- Provide the feeder information needed to calculate CPS limits and Frequency Bias Settings.

With regard to the first objective, FRS Form 1 and the process in Attachment A provide the method for determining the Interconnections' necessary amount of Frequency Response and allocating it to the Balancing Authorities. The field trial for BAL-003-1 is testing an allocation methodology based on the amount of load and generation in the BA. This is to accommodate the

wide spectrum of BAs from generation-only all the way to load-only. The BA allocation methodology may change based on field trial results.

Attachment A proposes the following Interconnection event criteria as a basis to determine an Interconnection's Frequency Response Obligation:

- Largest category C loss-of-resource (N-2) event
- Largest total generating plant with common voltage switchyard
- Largest loss of generation in the interconnection in the last 10 years

Given the fact that the Interconnections currently have sufficient Frequency Response, few BAs should encounter problems meeting R1, particularly with the options the Standard provides with regard to obtaining Frequency Response.

With regard to the second objective above (determining Frequency Bias Settings and CPS limits), Balancing Authorities have been asked to perform annual reviews of their Frequency Bias Settings by measuring their Frequency Response, dating back to Policy 1. This obligation was carried forward into BAL-003-0. While the associated training document provided useful information, it left many of the details to the judgment of the person doing the analysis.

The FRS Form 1 and FRS Form 2 provide a consistent, objective process for calculating Frequency Response to develop an annual measure, the FRM.

FERC Order No. 693 directed NERC to define the number of Frequency Response surveys that were conducted each year and to define a necessary amount of Frequency Response. R1 addresses both of these directives:

- There is a single annual survey of 25-30 events each year.
- The FRM calculated on FRS Form 1 is compared by NERC against the FRO determined 12 months earlier (when the last FRS Form 1 was submitted) to verify the Balancing Authority provided its share of Interconnection Frequency Response.

FERC Order No. 693 also directed the Standard should identify methods for Balancing Authorities to obtain Frequency Response. R1 allows Balancing Authorities to participate in Reserve Sharing Groups (RSGs) to provide or obtain Frequency Response. These may be the same RSGs that cooperate for BAL-002 or may be RSGs that form for the purposes of BAL-003.

If BAs participate as an RSG for BAL-003, compliance is based on the sum of the participants' performance.

Two other ways that BAs could obtain Frequency Response is through Supplemental or Overlap Regulation:

- No special action is needed if a BA provides or receives supplemental regulation. If the regulation occurs viaae Pseudo Tie, the transfer occurs automatically as part of Net Actual Interchange (NIa) and in response to information transferred from recipient to provider.~~.~~
- If a BA provides Overlap Regulation, its FRS Form 1 will include the Frequency Bias Setting as well as peak load and generation of the ~~entire~~ combined Balancing Authority Areas~~footprint~~. The FRM event data will be calculated on the sum of the provider's and recipient's performance.

InWith regard to the Violation Severity Levels of R1, tThe impact ofcaused by a BA's not having enough frequency response depends on two factors:

- Does the Interconnection have sufficient response?
- How short is the BA is in providing its FRO?

The VSL takes these factors into account.

Requirement 2

R2. Each Balancing Authority not receiving Overlap Regulation Service shall implement the Frequency Bias Setting (fixed or variable), using the results from the calculation methodology detailed in Attachment A and validated by the ERO, into its Area Control Error (ACE) calculation beginning on the date specified by the ERO to ensure effective coordinated secondary control.

Background and Rationale

Attachment A of the Standard discusses the process NERC will follow to validate the BAs' FRS Form 1 data and publish the official Frequency Bias Settings. Historically, it has taken multiple rounds of validation and outreach to confirm the BAs' data due to transcription errors, misunderstanding of instructions, etc. While BAs historically submit their Bias Setting data by January 1, it often takes one or more months to complete the process.

The target is to have BAs submit their data by January 10. The BAs are given 30 days to assemble their data since the BAs are dependent on being provided with FRS Form 1 byfrom NERC, there may be process delays in getting the forms out, and the forms rely on identifying frequency events through November 30 of the preceding year.

Frequency Bias Settings generally change little from year to year. Given the fact that BAs can encounter staffing or EMS change issues coincident with the date NERC sets for new Frequency Bias Setting implementation, the standard provides a 24 hour window on each side of the target date.

To recap the annual process:

1. NERC will post the official list of frequency events to be used for this Standard in early December. FRS Form 1s for each Interconnection will be posted shortly thereafter.

2. The Balancing Authority submits its revised annual Frequency Bias Setting value to NERC by January 10.

3. NERC and the Resources Subcommittee validate Frequency Bias Setting values, perform error checking, and calculate, validate, and update CPS2 L10 values. This data collection and validation process can take as long as two months.

4. Once the L10 and Frequency Bias Setting values are validated, NERC posts the values for the upcoming year and also informs the Balancing Authorities of the date on which to

implement revised Frequency Bias Setting values. Implementation typically would be on or about March 1st.

Requirement 3

R3. Each Balancing Authority not receiving Overlap Regulation Service shall operate its Automatic Generation Control (AGC) in Tie Line Bias mode, unless such operation would have an Adverse Reliability Impact on the Balancing Authority's Area.

Background and Rationale

This requirement serves several functions. The primary reason for operating in Tie Line Bias is so ACE is calculated properly for performance purposes. Even if a BA temporarily operated in manual mode, as long as CPS is properly calculated and the BA met CPS, it is operating reliably.

There are legitimate reasons for taking AGC out of Tie Line Bias or operating manually including:

- Telemetry problems that lead the operator to believe ACE is significantly in error.
- The frequency input to AGC is not reflective of the BA's true frequency (such as if the control center were operating a local generator and disconnected from the Interconnection).
- During restoration (where one BA might be controlling frequency while another to which it is connected is managing interchange between them).
- For training purposes.
- Many AGC systems will automatically switch to an alternate mode if the EMS determines Tie Line Bias control could lead to problems.
- For single BA Interconnections, Flat Frequency and Tie Line Bias are equivalent.

Because it is rare that temporary operation out of Tie Line Bias can lead to reliability problems, the VSLs for this requirement are structured accordingly.

Requirement 4

R4. Each Balancing Authority that is performing Overlap Regulation Service shall increase its Frequency Bias Setting in its ACE calculation by summing the Frequency Bias Settings to approximate the response for the combined area being controlled.

Background and Rationale

This requirement reflects the operating principles first established by NERC Policy 1 and is similar to Requirement R6 of the approved BAL-003-0 standard. Overlap Regulation Service is a method of providing regulation service in which the Balancing Authority providing the regulation service incorporates another Balancing Authority's actual interchange, frequency response, and schedules into the providing Balancing Authority's AGC/ACE equation.

As noted earlier, a BA that is providing Overlap Regulation will report the sum of the Bias Settings in its FRS Form 1. Balancing Authorities receiving Overlap Regulation Service have an ACE and Frequency Bias Setting equal to zero (0).

Requirement 5

R5. Balancing Authorities shall have a monthly average Frequency Bias Setting whose absolute value is at least equal to the minimum percentage of the Balancing Authority's estimated yearly peak demand if serving native load, and yearly peak generation if not serving native load, per 0.1 Hz change, as specified by the ERO in accordance with Attachment B.

Background and Rationale

BAL-003-0 standard requires a minimum Frequency Bias Setting equal in absolute value to 1% of the Balancing Authority's estimated yearly peak demand (or maximum generation level if native load is not served). For most Balancing Authorities this calculated amount of Frequency Bias is significantly greater in absolute value~~less~~ than their actual Frequency Response Characteristic (which represents an over-bias condition); resulting in over-control since a larger magnitude response is realized. This is especially true in the Eastern Interconnection where this condition requires excessive secondary frequency control response which degrades overall system performance and increases operating cost as compared to requiring an appropriate balance of primary and secondary frequency control response.

Balancing Authorities were given a minimum Frequency Bias Setting obligation because there had never been a mandatory Frequency Response Obligation. This historic "1% of peak/0.1Hz" obligation, dating back to NERC's predecessor, NAPSIC, was intended to ensure all BAs provide some support to Interconnection frequency.

The ideal system control state exists when the Frequency Bias Setting of the Balancing Authority exactly matches the actual~~natural~~ Frequency Response c~~C~~haracteristic of the Balancing Authority~~the system~~. If this is not achievable, over-bias is significantly better from a control perspective than under-bias with the caveat that Frequency Bias is set relatively close in magnitude to the Balancing Authority~~system~~ actual Frequency Response characteristic~~C~~. Setting the Frequency Bias to better approximate the Balancing Authority~~system~~ natural Frequency Response Characteristic will improve the quality and accuracy of ACE control, CPS & DCS and general AGC System control response. This is the technical basis for recommending an adjustment to the long standing "1% of peak/0.1Hz" Frequency Bias Setting. Attachment B is intended to bring the Balancing Authorities'~~s'~~ Frequency Bias Setting closer to their~~its~~ natural Frequency Response. Attachment B balances the following objectives:

- Bring the Frequency Bias Setting and Frequency Response closer together.
- Ensure there is no negative impact~~Since the Frequency Bias Setting impacts~~ on other Standards (CPS, BAAL and to a lesser extent DCS)~~,~~ by adjustments in the minimum Frequency Bias Setting, by accommodating only minor~~Attachment B accommodates minor~~ adjustments~~. in the minimum Frequency Bias Setting to ensure there are no negative side effects.~~

- ~~Control theory also notes that over-Bias is better than under-Bias, the Attachment B process d~~Does not allow the Frequency Bias Setting minimum to drop below natural Frequency Response, because under-biasing could affect an Interconnection adversely.~~.~~

Finally, for~~with regard to~~ BAs using variable bias, FRS Form 1 has a data entry location for the previous year's average monthly bias. The Balancing Authority and NERC can compare this value to the previous year's Frequency Bias Setting minimum to ensure R5 has been met.

How this Standard Meets the FERC Order No. 693 Directives

FERC Directive

The following is the concluding paragraph of Order No. 693.

Accordingly, the Commission approves Reliability Standard BAL-003-0 as mandatory and enforceable. In addition, the Commission directs the ERO to develop a modification to BAL-003-0 through the Reliability Standards development process that: (1) includes Levels of Non-Compliance; (2) determines the appropriate periodicity of frequency response surveys necessary to ensure that Requirement R2 and other requirements of the Reliability Standard are being met, and to modify Measure M1 based on that determination and (3) defines the necessary amount of Frequency Response needed for Reliable Operation for each balancing authority with methods of obtaining and measuring that the frequency response is achieved.

Levels of Non-Compliance

The present use of VRFs and VSLs are an equally effective way of assigning compliance elements to the standard.

Determine the appropriate periodicity of frequency response surveys necessary to ensure that Requirement R2 and other Requirements of the Reliability Standard are met

BAL-003 V0 R2 (the basis of Order No. 693) deals with the calculation of Frequency Bias Setting such that it reflects natural Frequency Response.

The drafting team has determined that a sample size on the order of at least 25-30 events is necessary to have a high confidence in the estimate of a BA's Frequency Response. Selection of the frequency excursion events used for analysis will be done via a method outlined in Attachment A to the Standard.

On average~~In general~~, these events will represent the largest 2-3 "clean" frequency excursions occurring each month~~, with a representative distribution between on-peak and off-peak events~~.

Since Frequency Bias Setting is an annual obligation, the survey of the at least 25-30 frequency excursion events will occur once each year.

Define the necessary amount of Frequency Response needed for Reliable Operation for each balancing authority with methods of obtaining and measuring that the frequency response is achieved

Necessary Amount of Frequency Response

The drafting team has proposed the following approach to defining the necessary amount of frequency response. In general, the goal is to avoid triggering the first step of under-frequency load shedding (UFLS) in the given Interconnection for reasonable contingencies expected. The methodology for determining each Interconnection's and Balancing Authority's obligation is outlined in Attachment A to the Standard.

It should be noted that the standard cannot guarantee that there will never be a triggering of UFLS as the magnitude of "point C" differs throughout an interconnection during a disturbance and there are local areas that see much wider swings in frequency.

The contingency protection criterion is the largest reasonably expected contingency in the Interconnection. This can be based on the largest observed credible contingency in the previous 10 years or the largest Category C event for the Interconnection.

The Safety Margin included addresses the difference between Points B and C and accounts for variables.

For multiple BA interconnections, the Frequency Response Obligation is allocated to BAs based on size. Initially this allocation will be based on the following calculation:

(Projected BA peak load + iInstalled cCapacity)/2

This allocation methodology is being evaluated as part of the field trial of the standard.

Methods of Obtaining Frequency Response

The drafting team believes the following are valid methods of obtaining Frequency Response:

- Supplemental regulation.
- Overlap regulation.
- Contractual service (The drafting team has developed an approach to obtain a contractual share of Frequency Response from Adjacent Balancing Authorities. See FRS Form 1). While the final rules with regard to contractual services are being defined, the current expectation is that NERC and the associated Region(s) should beare notified beforehand and that the service be at least 6 months in duration.
- ~~May obtain Frequency Response t~~Through a tariff (e.g. Frequency Response and regulation service).
- ~~May obtain Frequency Response f~~From generators through an interconnection agreement.

- ~~May c~~Contract with an internal resource or loads (The drafting team encourages the development of a NAESB business practice for Frequency Response service for linear (droop) and stepped (e.g. LaaR in Texas) response).

Measuring that the Frequency Response is Achieved

FRS Form 1 and the underlying data retained by the BA will be used for measuring whether Frequency Response was provided. FRS Form 1 will provide the guidance on how to account for and measure Frequency Response.

Going Beyond the Directive

The drafting team believes each Interconnection has sufficient Frequency Response. If margins decline, there may be a need for additional standards or tools. The drafting team and the Resources Subcommittee are working with NERC on its Frequency Response Initiative to develop processes and good practices so the Interconnections are prepared. These good practices and tools are described in the following section.

The drafting team is also evaluating an analytical tool that will use CPS-source data to confirm whether the Interconnections are operating reliably with regard to Primary Control and Frequency Response.

Good Practices and Tools

Good Practices

- Providing guidelines on measuring frequency responsive reserves.
- Developing good practices for operating during conservative and emergency operations.

Tools

- Providing tools to BAs that can be used to evaluate generator performance.

These tools will be posted on the NERC website.

Field Trial

This section is a summary of the Field Trial activities that have been or will be conducted by NERC, the NERC Resources Subcommittee and the FRS Drafting Team.

1. The NERC BA recommendation (alert) and observations.√
2. The NERC governor recommendation (alert) and observations.√
3. The 2011 bias calculation √
    1. Evaluate measurement methodology√
    2. Serve as initial training for BAs√
    3. Evaluate median, mean, regression and possibly other~~as~~ measures√
    4. Evaluate sample size (to address the directive of frequency of surveys) √
    5. Evaluate impact of inclusion/exclusion of internal contingencies √
    6. Improve FRS Form 1√
4. Create supporting process for FRS Form 1 √
    1. For Interconnection benchmarking (proving adequacy of frequency response)
    2. Evaluating trend
    ~~3.~~ Test process for developing candidate list for FRS Form 1
    ~~4.~~3. ~~Evaluating on-peak vs. off-peak interconnection response (to determine if off-peak events should be included on FRS Form 1 and to what extent).~~
5. 2012 bias calculation
    1. Further refinement of items in 2011 bias calculation
    2. Test the FRO allocation methodology
    3. Test approach for handling variable bias
    4. Evaluate 12 month vs. 24 month rolling average approach to performance
6. Evaluate reduction in bias setting floor below 1% (initially 0.8% in 2012) to evaluate impact on frequency and calculated CPS and BAAL performance.
7. Evaluate effectiveness of administrative process to support the standard.
8. Evaluate supplemental process tool that uses CPS source data to confirm that the Interconnections have sufficient Frequency Response.