

### **Purpose**

Planning Authorities (PAs), Transmission Planners (TPs), and Reliability Authorities (RAs) identify System Operating Limits (SOLs) via various planning and operating studies and real-time experience. The resultant SOLs define the boundary of reliable operations for the Bulk Electric System (BES).

While there are different valid procedures for establishing SOLs, Reliability Standard FAC-010-1 establishes a specific set of criteria that all SOLs must meet — including SOLs used in both the operating and planning horizons. FAC-010-1 requires that the:

- PA have a SOL Methodology for use in its PA Area for developing SOLs applicable to the planning horizon.
- RA have a SOL Methodology for use in its RA Area for developing SOLs applicable to the operations horizon.

Reliability Standard FAC-011-1 requires that these entities apply the applicable SOL Methodology in the development of SOLs and requires the distribution of those SOLs to those entities that have requested those limits and have a reliability-related need for those limits. The RA is responsible for developing SOLs used in the operations horizon and the PA and TP are responsible for developing SOLs used in the planning horizon.

While sometimes treated as two separate types of operating limits, Reliability Standard FAC-010-1 recognizes that there is a subset of SOLs, called Interconnection Reliability Operating Limits (IROLs) that, if violated<sup>1</sup>, could lead to instability, uncontrolled separation, or could initiate Cascading Outages.

Most SOLs, if violated, result in clearly predictable consequences confined to the facility or facilities that experience the violation of the SOL (e.g. thermal rating). In the worst credible case, the consequences of a fault while violating a limit are confined to a well-defined set of BES facilities and will not jeopardize the reliable operation of the BES beyond the portion of BES facilities identified in the studies.

The purpose of this Job Aid is to assist in the identification of the subset of SOLs that are also IROLs as required under proposed Reliability Standard FAC-010-1.

### **Background**

#### **Stratification of System Operating Limits**

Industry comments have indicated a need to stratify SOLs into two categories:

The first category of SOLs includes those limits that, if violated, or violated when the BES is subject to a fault or a loss of a BES facility, would result in clearly predictable consequences (e.g., thermal limits). These consequences would be confined to a well-defined set of BES facilities and in the worst credible case, would be contained to a predetermined and predictable portion of the BES, and thus would not jeopardize the reliability of the BES.

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<sup>1</sup> Where a limit is protecting the BES from Voltage Collapse, the condition of violating the limit may "lead to instability, uncontrolled separation, or initiate Cascading Outages". In other cases, the BES must be subject to a fault or the loss of a BES element(s) while exceeding a limit in order to "lead to instability, uncontrolled separation, or initiate Cascading Outages".

## Supporting Reference for Identification of Interconnection Reliability Operating Limits

The second category of SOLs includes those limits that, if violated (e.g. voltage collapse limits), or violated when the BES is subject to a fault or a loss of a BES facility, could result in unpredictable outcomes such as instability, uncontrolled separation, or the initiation of Cascading Outages that could jeopardize the reliable operation of the BES.

### **Clarification of Definitions**

The development of quantifiable and measurable performance standards requires examination of some existing NERC terms and their definitions and, in several instances, requires development of new terms with unambiguous definitions. An understanding of the following terms is critical to the identification of IROLs:

- Cascading Outages
- System Operating Limits (SOL)
- Interconnection Reliability Operating Limits (IROL)
- Interconnection Reliability Operating Time Limit ( $T_v$ )

### **Definition of Cascading Outages**

The definition of “Cascading” included in Version 0 Standards is as follows:

The uncontrolled successive failure of system elements triggered by an incident at any location within the Interconnection. Cascading results in widespread electric service interruption that cannot be restrained from sequentially spreading beyond an area predetermined by appropriate studies.

Although this definition provides a general description of a Cascading event suitable for a ‘best efforts’ industry environment, the phrases, “widespread electric service interruption”, “beyond an area” and “appropriate studies” render the application of this existing definition as unquantifiable and, therefore, unacceptable in the development of measurable performance standards subject to mandatory compliance measures.

In attempting to apply the definition of ‘Cascading’, many in the industry have asked for explicit understanding of the term “widespread”. Typical questions received include:

- Is a Cascading event “widespread” if the interruption is contained within a metropolitan area, a single Control Area, a single Reliability Authority Area, or a single Balancing Authority Area?
- Does an event need to affect adjacent Reliability Authority Areas or Balancing Authority Areas to be classified as widespread?
- Is a Cascading event a “widespread” event if the service interruption goes beyond the “an area predetermined by appropriate studies”? What if the area impacted by such an actual event is just one bus beyond the area predetermined by “appropriate” studies?

The industry’s questions indicate that the existing definition is simply not explicit enough.

To remedy the shortcomings of the following definition of “Cascading Outages” has been proposed by the Determine Facility Ratings Drafting Team:

<p><b>Cascading Outages:</b> The uncontrolled and unplanned successive loss of system elements triggered by an incident at any location.</p>
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## Supporting Reference for Identification of Interconnection Reliability Operating Limits

The proposed definition of “Cascading Outages” simplifies the previous definition and removes the ambiguous phrases. Any incident (e.g. a fault, misoperation, or switchmen’s error) that initiates an uncontrolled and successive loss of system elements is a Cascading Outage. However, if an incident results in either a planned successive loss of system elements (e.g. by design), or the consequential loss of system elements is clearly restricted to a predetermined and predictable portion of the BES, that incident would not be a Cascading Outage under the proposed definition.

### **Definition of System Operating Limits**

The V0 definition of an SOL is:

The value (such as MW, MVar, Amperes, Frequency or Volts) that satisfies the most limiting of the prescribed operating criteria for a specified system configuration to ensure operation within acceptable reliability criteria. System Operating Limits are based upon certain operating criteria. These include, but are not limited to:

- Facility Ratings (Applicable pre- and post-Contingency equipment or Facility Ratings)
- Transient Stability Ratings (Applicable pre- and post-Contingency Stability Limits)
- Voltage Stability Ratings (Applicable pre- and post-Contingency Voltage Stability)
- System Voltage Limits (Applicable pre- and post-Contingency Voltage Limits)

### **Definition of Interconnection Reliability Operating Limit**

Those SOLs with potentially severe consequences are IROLs. The Determine Facility Ratings Drafting Team has proposed a replacement for the V0 definition of an IROL:

V0 definition of IROL:

The value (such as MW, MVar, Amperes, Frequency or Volts) derived from, or a subset of the System Operating Limits, which if exceeded, could expose a widespread area of the Bulk Electric System to instability, uncontrolled separation(s) or Cascading outages.

Drafting Team’s proposed definition of IROL:

<p><b>Interconnection Reliability Operating Limit (IROL):</b> A System Operating Limit that, if violated, could lead to instability, uncontrolled separation, or Cascading Outages that adversely impacts the reliability of the Bulk Electric System.</p>
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The DFR SDT’s definition recognizes that IROLs are **always** a subset of SOLs, and also recognizes that operating too far beyond a limit can have adverse consequences affecting the reliability of the BES. To reflect this, the DFR SDT’s definition of an IROL uses the phrase, ‘if violated ‘ rather than the phrase, ‘if exceeded’.

### **Definition of IROL $T_v$**

A definition related to the IROL is the IROL  $T_v$ , where  $T_v$  is the maximum amount of time that an IROL can be violated without undue degradation of the reliability of the BES. This term is expressed in units of time from zero seconds to a maximum of 30 minutes. The Determine Facility Ratings Drafting Team’s proposed definition of IROL  $T_v$  is:

**Interconnection Reliability Operating Limit  $T_v$**  : The maximum time that an Interconnection Reliability Operating Limit can be violated before the risk to the Interconnection or other Reliability Authority Area(s) becomes greater than acceptable. Each Interconnection Reliability Operating Limit's  $T_v$  shall be less than or equal to 30 minutes.<sup>2</sup>

### **Identification of Interconnection Reliability Operating Limits (IROLs)**

The first step in identifying IROLs is to develop a set of SOLs. Draft Standard FAC-010-1 requires that the Planning Authority (PA) and the Reliability Authority (RA) have a methodology for developing SOLs that meets a list of specific criteria. This methodology requires the PA and RA to analyze the state of the BES under pre-contingency conditions, following a variety of single contingencies, and following applicable credible multiple contingencies.

To establish the boundary conditions for the development of SOLs, Reliability Standard FAC-010-1 requires the PA and RA to consider the conditions present or expected to be present when the limit is used. This includes consideration of conditions such as the expected load, known outages, power transfers, generation dispatch, etc. The PA and RA must be able to verify that when operating within SOLs under these varying conditions, the BES will demonstrate transient, dynamic and voltage stability; all Facilities will be within their Facility Ratings and within their thermal, voltage and stability limits.

Once the PA and RA have developed a set of SOLs, the set of SOLs must be stratified to identify the subset of SOLs that are also IROLs. To do this, the PA and RA may need to conduct a series of sequential studies in which previous results are the starting point for subsequent analyses. If the series results in instability, uncontrolled separation, or Cascading Outages, then the SOL is also an IROL.

In the simplest case, the PA and RA would identify all SOLs in a planning or operational assessment for the period under study (e.g., 5-year planning study, next summer, or next day assessments). The PA and RA would then stratify the SOLs by the potential impact if the limit is violated. If the worst case result of exceeding a SOL is:

- Potential loss of equipment life, impacting customers connected directly to, or in series with, the overloaded element, then this SOL is not an IROL.
- Instability, uncontrolled separation, or the initiation of Cascading Outages beyond planned extent that could jeopardize the reliable operation of the BES, then this is an IROL.

Proposed Reliability Standard FAC-011-1 requires that when IROLs are distributed, the RA must also provide the following supporting information to the Reliability Authorities, Transmission Operators, Transmission Planners and Transmission Service Providers who need those limits. (Note that this supporting information is easy to collect during the studies used to determine if an SOL should also be an IROL.):

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<sup>2</sup> Although the phrase, “. . . risk to the interconnection or other Reliability Authority Area(s) becomes greater than acceptable. . . “ may seem vague, the draft Determine Facility Ratings, System Operating Limits and Transfer Capabilities Standard requires that both the methodology for identifying SOLs and IROLs and the associated limits must be shared between Planning Authorities, and between Reliability Authorities. In addition, the proposed standard includes a provision that requires an entity to be responsive to other entities that submit written technical comments on the methodology used to develop the limits. This peer review was intended to ensure that the entities that would be most impacted by the limits would be able to help determine what constitutes ‘acceptable risk’.

## **Supporting Reference for Identification of Interconnection Reliability Operating Limits**

- Identification and status of the transmission facility(ies) that are critical to the derivation of the limit (e.g. critical generation status, transmission facility outages, load level etc.)
- The value of the IROL (typically in terms of MW or MVA) and its associated  $T_v$ .
- The contingency or contingencies that established the IROL
- The type of limitation represented by the IROL. (e.g. voltage collapse, angular stability, Cascading Outage)

### **Setting IROL $T_v$**

To determine how to set each IROL's  $T_v$ , determine how long the limit can be violated before the risk to the BES is 'unacceptable.' This duration may not be any longer than 30 minutes. The  $T_v$  for IROLs, that may result in instability may be just seconds.

### **Changes to SOLs and IROLs**

Depending upon the study horizon, the list of SOLs and their associated magnitudes (e.g. MW or MVA) could change over the Planning, pre-seasonal, next-day, and real-time horizons. These changes could be the result of ambient temperature, status of the topology of the transmission system, generation availability, etc. Similarly, the list of IROLs and their associated magnitudes (e.g., MW or MVA) could change over the Planning, pre-seasonal, next-day, and real-time horizons. Thus, an SOL may be an IROL only during peak load condition (for example) and during lighter load conditions that SOL may not be an IROL (e.g., exceeding the limit during off-peak conditions will not lead to instability, uncontrolled separation, or Cascading Outages.)

Reliability Standard FAC-011-1 requires that the PA and RA provide SOLs and IROLs to other entities, in accordance with schedules provided by those entities. Thus, if a TOP monitors a facility that is subject to an SOL, the TOP is obligated to provide its RA with a schedule for updating those SOLs, and the RA is obligated to provide updated SOLs in accordance with that schedule.

In reality, each PA and RA has different tools and procedures available to identify and update its SOLs and IROLs. The PA and RA can each develop a "Master list" of SOLs and IROLs from planning and pre-seasonal transmission assessments and can distribute these sets of limits to all entities that indicate a need for this information. Because FAC-010-1 requires that SOLs be established that reflect the current or expected conditions, the RA may need to update its values for SOLs and IROLs on a frequent (or continual) basis.

Assuming that the RA developed a "Master list" of SOLs, the RA needs to update this set of SOLs and IROLs to reflect expected operating conditions, including next day and near real-time conditions. These updated sets of limits need to be distributed according to the schedules provided by the entities that indicated a need for those limits. (This includes other RAs, TOPs, PAs, and TSPs.)

### **Coordination Between RAs**

Reliability Standards FAC-010-1 and FAC-011-1 do not require RAs to jointly develop either their SOL Methodologies or to jointly develop their SOLs or IROLs. However, FAC-010-1 does require the PA and the RA to be responsive to technical comments received on their SOL Development Methodology and Reliability Standard FAC-011-1 does require PAs and RAs to provide IROLs and their associated supporting information to all entities that have a reliability-related need for these limits. This includes all entities that monitor these limits or include these limits in studies or analyses. The Facility Rating SDT added the requirement in FAC-010-1 to ensure that RAs would be responsive to their peers.

## **Supporting Reference for Identification of Interconnection Reliability Operating Limits**

Here's an example of how this is expected to work:

- RA #1 develops and distributes its SOL Methodology to RA #6.
- RA #6 reviews the SOL Methodology and thinks there is a technical error in RA #1's SOL Methodology.
  - RA #6 may send documented comments to RA #1 to advise RA #1 of the alleged error.
  - If RA #6 does send documented comments to RA #1, then RA #1 is required to respond to RA #6 within 30 days of receipt of RA #6's note.
  - RA#1's response is required to include a statement that indicates whether or not the SOL Methodology has been changed.
  - If RA #1 decides not to change its SOL Methodology based on the comments received from RA #6, then RA #1 must provide an explanation for that decision in the written response to RA #6.
- RA #1 is required to keep the note it received from RA #6 and its response to that note for three years.
- RA #1 is required to make the documented comments and associated responses available to its Compliance Monitor.

The SDT felt that no RA will risk having documentation that showed it had ignored a technical challenge to its SOL Methodology.