NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

NERC Glossary Definitions: System Operating Limit and SOL Exceedance Rationale

Introduction

The standard drafting team ("SDT") for *Project 2015-09 Establish and Communicate System Operating Limits* developed these rationales to explain the modifications to the definition of the term "System Operating Limit" ("SOL ") and the definition for the new term "SOL Exceedance" to be incorporated into the Glossary of Terms Used in NERC Reliability Standards ("NERC Glossary"). As discussed below, the purpose of the proposed new and modified term is to provide greater clarity and consistency in establishing SOLs and develop a common understanding of what it means to exceed SOLs.

Background

The use of SOLs is a foundational concept in NERC's Reliability Standards as operating within SOLs for the pre- and post-Contingency state is a primary aspect of reliable Bulk Electric System ("BES") operations. An SOL is currently defined in the NERC Glossary as:

> *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 Ratings 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)*

As discussed in the whitepaper prepared by the SDT for Project 2014-03 Revisions to TOP and IRO Standards (the "Project 2014-03 Whitepaper"), which developed the currently-effective Transmission Operations ("TOP") and Interconnection Reliability Operations and Coordination ("IRO") Reliability Standards, while the term SOL is used extensively in the NERC Reliability Standards, there is significant confusion with, and many widely varied interpretations and applications of, the term SOL. While the Project 2014-03 SDT did not seek to modify the SOL definition, they drafted the Project 2014-03 Whitepaper to describe their understanding of the SOL term/concept and to "bring clarity and consistency to the notion of establishing SOLs, exceeding SOLs, and implementing Operating Plans to mitigate SOL exceedances." The Project 2014-03 Whitepaper served as the conceptual basis for the development of the currently-effective TOP/IRO Reliability Standards.

As described in the Project 2014-03 Whitepaper, the central principles of the SOL concept in NERC's Reliability Standards is to:

1. Know the Facility Ratings, voltage limits, transient Stability limits, and voltage Stability limits, and

2. Ensure that they are all observed in both the pre- and post-Contingency state by performing a Real-time Assessment.

The first principle (i.e., know the Facility Ratings, voltage limits, and stability limits) is accomplished through the definition of SOL and Reliability Standards FAC-011 and FAC-014. The SOL values used in operations are determined pursuant to methodologies required by the Facilities Design, Connections and Maintenance ("FAC") group of Reliability Standards. Specifically, currently-effective Reliability Standard FAC-011-3 requires each Reliability Coordinator (RC) to have a documented methodology for developing SOLs (and criteria for identifying Interconnection Reliability Operating Limits ("IROLs")) within its Reliability Coordinator Area. Further, under currently-effective Reliability Standard FAC-014-2, TOPs must establish SOLs consistent with the RC's methodology and RC must determine which of those SOLs are IROLs.

The second principle (i.e., observing the SOLs in both the pre- and post-Contingency state) is accomplished through the requirements in the TOP/IRO Reliability Standards. Pursuant to the construct in the currently-effective TOP/IRO Reliability Standards approved in Order No. 817,[1] TOPs and RCs must assess system conditions, identify expected or actual SOL exceedances (including for the subset of SOLs designated as IROLs) and take steps to address any such exceedances to avoid the possibility of further deterioration in system conditions. Specifically, during the operations planning time horizon, RCs and TOPs must perform Operational Planning Analyses ("OPAs") to assess whether the planned operations for the next-day will exceed SOLs (including IROLs) within their area.[2] If the OPA identifies any potential exceedances, the RC and TOP must have an Operating Plan to address the exceedance.[3] Additionally, in Real-time, RCs and TOPs must perform Real-time Assessments ("RTAs") every 30 minutes to determine whether there are any expected or actual exceedances of SOLs (including IROLs) based on Real-time conditions.[4] If the RTA identifies any such exceedances, the RC and TOP must initiate an Operating Plan to mitigate the SOL exceedance.[5] If there is an expected or actual IROL exceedance identified in the RTA, the exceedance must be resolved within the IROL T_v, which can be no longer than 30 minutes.[6]

Following the development of the currently-effective TOP/IRO Reliability Standards, NERC initiated a periodic review of the requirements in the Facilities Design, Connections, and Maintenance ("FAC") group of Reliability Standards addressing SOLs. The periodic review team identified a need to revise or develop

[1] *Transmission Operations Reliability Standards and Interconnection Reliability Operations and Coordination Reliability Standards*, Order No. 817, 153 FERC ¶ 61,178 (2015).

[2] IRO-008-2, Requirement R1; TOP-004-2, Requirement R1.

[3] IRO-008-2, Requirement R2; TOP-004-2, Requirement R2.

[4] IRO-008-2, Requirement R4; TOP-001-3, Requirement R13.

[5] IRO-008-2, Requirement R5; TOP-001-3, Requirement R14.

[6] IRO-009-2, Requirements R1-R4; TOP-001-3, Requirement R12.

new definitions to be incorporated into the NERC Glossary to provide greater clarity and consistency in establishing SOLs and promote a common understanding of what it means to exceed SOLs. The periodic review team recognized that while the project 2014-03 Whitepaper provided clarity on the SOL concept, reliability would be further enhanced by (1) revising the SOL definition in the NERC Glossary, and (2) developing a new defined term SOL Exceedance. These two enhancements help to better align the definitions in the NERC Glossary with the Project 2014-03 Whitepaper and better support the SOL exceedance concept used in the TOP/IRO Reliability Standards. Subsequently, to address the issues identified in the periodic review, NERC initiated Project 2015-09 to revise the requirements for, and definitions related to, the methodology used for establishing and communicating SOLs.

The definition of SOL and the Reliability Standards that address SOLs – FAC-010, FAC-011, and FAC-014 – have remained essentially unchanged since their initial versions were approved and adopted in 2007. Since that time, many improvements have been made to the body of reliability standards, specifically those in the TPL, TOP, and IRO family of standards. The former TPL-001, -002, -003, and -004 Reliability Standards have been replaced with TPL-001-4, all of the TOP standards were replaced with the currently effective TOP-001, TOP-002, and TOP-003, and several IRO standards have been replaced as well. The definition of SOL and the FAC standards that address SOLs are inextricably linked to many of the TPL, TOP, and IRO standards, as they all address in some manner the foundational reliability concept of acceptable system performance. One of the primary objectives of Project 2015-09 is to make changes to the SOL definition and the related FAC standards to create better alignment with the currently effective TPL, TOP, and IRO standards. The SDT's proposal to revise the definition of SOL improves clarity, reduces redundancy, and creates better alignment and continuity with the currently effective TOP and IRO standards. In addition to revising the SOL definition and developing a definition for a new NERC Glossary term SOL Exceedance, the SDT for Project 2015-09 also developed a definition for a new NERC Glossary term System Voltage Limit to provide additional clarity and a common understanding as to the meaning of system voltage limits.

Modifications to SOL Definition

The Project 2015-09 SDT proposes to define the term System Operating Limit (SOL) as:

Facility Ratings, System Voltage Limits, and stability limits used in the operation of the BES.

The SDT's intent was to simplify and clarify the SOL definition by eliminating ambiguities such that SOLs are easily identifiable and easily measurable. The currently-effective SOL definition states that SOLs "are based upon certain operating criteria." The modified definition eliminates the phrase "are based upon" to more accurately state that the SOLs are the actual operating parameters which are to be observed for the pre- and post-Contingency states, leaving no confusion as whether a Facility Rating, stability limit, or voltage limit is an SOL. The unambiguous language in the modified definition should help facilitate a more consistent application of the SOL concept within the electric industry.

Facility Ratings, System Voltage Limits, and stability limits are the three types of operating criteria included in the existing SOL definition and carried forward into the modified definition that must be accounted for

to ensure reliable operations. Facility Ratings must be established in accordance with Reliability Standard FAC-008-3. System Voltage Limits, as discussed below, is proposed to be defined as "the maximum and minimum steady-state voltage limits (both normal and emergency) that provide for acceptable System performance." Stability limits includes both transient stability limits and voltage stability limits. The intent of using the "stability limit" term (as opposed to the NERC Glossary term "Stability Limit") is to allow for a number of different types of stability-related limitations or phenomena, including, but not limited to, sub-synchronous resonance (SSR), phase angle limitations, transient voltage limitations on equipment, and weighted short-circuit ratio (WSCR). The Glossary term "Stability Limits" is not appropriate for use in the revised definition because its use is limited to a maximum power flow value. While some entities may use maximum power flow values as a means by which to prevent instability, this approach represents only one particular method and may be too restrictive for some entities. Reliability tools allow entities to monitor and control parameters other than maximum power flow values in order to demonstrate acceptable stability performance.

Unlike the existing SOL definition, the proposed definition includes the phrase "used in operations" to distinguish those Facility Ratings, voltage limits, and stability limits that are used in planning. The SDT determined that the SOL concept should be limited to the operational time horizon and thus proposes to retire FAC-010-3. The Facility Ratings, voltage limits, and stability criteria used in the planning horizon are developed according to FAC-008-3 and TPL-001-4 and, as a result, there was no additional reliability need to require Planning Authorities to develop SOLs to be used in the planning horizon. The SDT concluded, however, that there was a reliability need to coordinate the Facility Ratings, voltage limits, and stability criteria used in planning with those used in operations. The SDT developed proposed Reliability Standard FAC-015-1 to address that issue.

Furthermore, as discussed in detail below, the SDT determined that references to "most limiting criteria", "specified system configuration", "acceptable reliability criteria", and "pre- and post-contingency" in the currently-effective definition of SOL were adding to industry confusion as to what constitutes an SOL. These phrases are no longer necessary since they are reliable operations concepts that are addressed in the new TOP/IRO Reliability Standards, the proposed FAC-011-4 Requirement R4, and further reinforced with the proposed definition of SOL Exceedance.

Most limiting Criteria – The SDT concluded that removing the "most limiting criteria" concept in favor of designating all Facility Ratings, System Voltage Limits, and stability limits as SOLs is better aligned with the requirements in the TOP/IRO Reliability Standards. As noted above, under the TOP/IRO Reliability Standards, each RC and TOP must perform Operational Planning Aanalysis (OPAs) and Real-time Assessments (RTAs) to assess conditions in the day ahead and Real-time horizon and, if it identifies any actual, expected or potential SOL exceedance, take appropriate mitigating action to maintain pre- and post-contingency reliable operations. Under the currently-effective SOL definition, RCs and TOPs must initially determine which operating parameter is the most limiting at that point in time to be designated as the SOL and then determine if there are any actual, potential, or expected exceedances of that SOL. The SDT understands that this has caused some confusion within industry. Specifically, it may be unclear in Real-time operations when an SOL ceases to be an SOL because it is no longer the "most limiting criteria."

Confusion is introduced when the most limiting criteria (and thus the SOL) changes from one RTA to the next.

The SDT determined that it is more straightforward to simply categorize all Facility Ratings, System Voltage Limits, and stability limits as SOLs. In performing OPAs and RTAs, RCs and TOPs should be assessing conditions as it relates to any operating parameter or reliability limit, not the most limiting parameter or limit based on a particular prior analysis. Under the new TOP and IRO requirements, RCs and TOPs are assessing conditions to determine whether there are any actual, potential, or expected exceedances of any Facility Rating, System Voltage Limit, or stability limit, which would necessarily include the most limiting of those parameters/limits. In this manner, the "most limiting criteria" concept is subsumed within the requirements of the TOP/IRO Reliability Standards and it is not necessary that it be included in the SOL definition. In short, the proposed SOL definition creates a simplified approach. There is no need to continuously identify and communicate the ever-changing "most limiting" criteria. Entities must simply operate – and plan to operate – to prevent any exceedance of a Facility Rating, System Voltage Limit, and stability limit.

The SDT determined that the removal of the "most limiting criteria" from the SOL definition represents an improvement to reliability. The "most limiting criteria" can adversely impact reliability by masking instability risks that may exist slightly beyond the point of the most limiting condition. To illustrate, where prior studies indicate that a thermal limitation is the "most limiting criteria," if the studying entity does not study the performance of the system appreciably beyond this thermal limitation to reasonably expected stressed conditions, it cannot be safely concluded that a more significant instability risk does not exist slightly beyond the point where the "most limiting criteria" exists. Because actions may be taken in the actual system conditions that mitigate thermal and voltage limitations identified as a "most limiting criteria", it may be necessary to identify where subsequent operation may approach a point of instability. Consistent with this concept, the RC and its TOPs have the responsibility of identifying instability risks in accordance with the Reliability Coordinator's SOL Methodology, as required by FAC-011-4 Requirement R4.

Specified System Configuration – The SDT proposes to remove reference to a "specified system configuration" as that concept is also subsumed within the TOP/IRO Reliability Standards. Specifically, in performing OPAs and RTAs, RCs and TOPs must consider specified system conditions such as transmission and generation outages, generation output levels, and load levels. Further, the majority of Facility Ratings and System Voltage Limits are not dependent upon system configuration whereas stability limits are frequently dependent on system configuration. System configuration for the establishment of stability limits is addressed in proposed FAC-011-4, Requirement R4. Because the "specified system condition" is addressed within the definition of OPA and RTA, and because it is also addressed in FAC-011-4 requirement R4 for instability issues, including the phrase "specified system configuration" in the definition of SOL is redundant, unnecessary, and may cause confusion.

Acceptable Reliability Criteria – As with the above two components, the "acceptable reliability criteria" concept is best addressed through requirement language. The SDT determined that the SOL definition should focus simply on what constitutes an SOL and the requirements should focus on methodologies for establishing those SOLs and on ensuring that they are honored in OPAs and RTAs to provide for reliable

operations. Requirement R4 of proposed FAC-011-4 requires the RC to specify stability performance criteria in its SOL Methodology for single Contingencies and for identified multiple Contingencies. Further, the proposed definition of SOL Exceedance addresses stability performance and specifies the reliability criteria for Facility Ratings and System voltage limits for the pre- and post-Contingency states. Taken together with the requirement to study the limits in OPAs and RTAs, the revised FAC-011 and the new definition of SOL Exceedance addresses operation within acceptable reliability criteria.

Pre- and Post-Contingency – The current SOL definition specifies for each of the listed operating limits that it is for pre- and post-contingency states. The SDT determined that the SOL definition need not include such specificity. First, the definitions of OPA and RTA include pre- and post-Contingency analysis. As OPAs and RTAs are the mechanisms in the Reliability Standards for determining potential SOL exceedances (OPA) and actual SOL exceedances (RTA),[7] and because the pre- and post-Contingency states are included in the definition of OPA and RTA, there is no need to duplicate the "pre- and post-Contingency" language in the definition of SOL. Additionally, the pre- and post-Contingency concept is inherent in the definition of some SOLs. For example, many stability limits are defined to prevent instability for specified Contingency events. Accordingly, the pre- or post-contingency nature of an established stability limit would be covered by FAC-014-4 Requirement R4 instead of through the SOL definition. Furthermore, the pre- and post-Contingency operating conditions are addressed in the proposed definition of SOL Exceedance as it relates to Facility Ratings, System voltage Limits, and stability limits.

One aspect of the improved clarity of the revised definition of SOL is seen in its intended use. Under the revised definition, SOLs are intended to be used as an input into the OPA and RTA process.[8] The OPA and RTA process itself examines SOLs for the pre- and post-Contingency states and determines whether the SOLs are being exceeded. Accordingly, while SOLs are an input to the OPA and RTA process, SOL exceedance is the output of the OPA and RTA process. The proposed definition of SOL Exceedance is discussed below.

Lastly, as with the currently-effective SOL definition, the proposed SOL definition does not include reference to IROLs. IROLs, as currently defined, are a subset of SOLs that, if exceeded, "could lead to instability, uncontrolled separation, or Cascading outages that adversely impact the reliability of the BES." The determination of when an SOL should be designated as an IROL is most appropriately addressed in the RC's SOL methodology. There is no need to mention IROLs in the definition of SOL.

SOL Exceedance Definition

Many of the TOP/IRO Reliability Standards use the phrase "SOL exceedance" or otherwise reference the concept of "exceeding an SOL." As discussed above, the actual, potential, or expected exceedance of an SOL as identified by OPAs and RTAs requires applicable RCs and TOPs to develop Operating Plans and take

[7] In Order No. 705 (at P 162), the Commission stated that system performance is determined through studies, stating "the Commission believes that to demonstrate the pre- and post-contingency performance metrics required by [FAC-010-1] Requirements R2.1-R2.2 an assessment or analysis would need to be performed. As such, Requirements R2.1-R2.2 provide for actions that go beyond NERC's characterization of the subject of the requirements as limited to a list of topics that must be included in a methodology. Therefore, we conclude that these Requirements are more Docket No. RM07-3-000 - 79 - properly treated as implementation or operational requirements that may have a direct impact on reliability."

[8] Some Reliability Coordinators and Transmission Operators may establish stability limits in the context of an OPA or RTA. For entities who adopt this approach, the stability SOL would be established – and its exceedance determined – as part of the OPA or RTA.

mitigating action in accordance with those Operating Plans to address the exceedance. Without a clear and consistent understanding of what it means to exceed an SOL, however, RCs and TOPs may apply the requirements in the TOP/IRO Reliability Standards inconsistently, which could result in widely varying reliability performance. For example, TOP-001-3 Requirement R14 states:

> R14. Each Transmission Operator shall initiate its Operating Plan to mitigate a SOL exceedance identified as part of its Real-time monitoring or Real-time Assessment.

The initiation of a TOP's Operating Plan per Requirement R14 depends completely on that particular TOP's interpretation of what it means to exceed an SOL. One TOP might interpret SOL exceedance to not include the post-Contingency state when identifying SOL exceedance; rather, it would look only to pre-Contingency (or actual) flows to make that determination. Such an interpretation, however, compromises reliability and is not consistent with the intent behind the SOL exceedance concept, as described in the Project 2014-03 Whitepaper, upon which the TOP/IRO Reliability Standards are based. Nevertheless, because there is no definition of the phrase "SOL exceedance" or specific requirements on how to identify an SOL exceedance, nothing prevents a Transmission Operator from adopting such an interpretation.

To ensure there is a common understanding of what it means to exceed an SOL, the Project 2015-09 SDT proposes to add the term SOL Exceedance to the NERC Glossary with the following definition:

> *An operating condition or analysis result characterized by any of the following, as determined in Real-time monitoring, Real-time Assessments (RTA) or Operational Planning Analysis (OPA):*
>
> *The pre-Contingency state indicates any of the following:*
>
> - *Actual flow through a Facility is above the Facility's Normal Rating*
> - *Actual bus voltage is outside normal System Voltage Limits*
> - *A stability limit established to prevent instability without a Contingency is exceeded*
> - *A stability limit established to prevent the Contingency from resulting in instability is exceeded*
>
> *The calculated post-Contingency state indicates any of the following:*
>
> - *Flow through a Facility is above the Facility's highest Emergency Rating, or above a Facility Rating for which there is not sufficient time to reduce the flow to established acceptable levels should the Contingency occur*
> - *Bus voltage is outside the highest or lowest emergency System Voltage Limit, or outside a System Voltage Limit for which there is not sufficient time to bring the bus voltage to established acceptable levels should the Contingency occur*
> - *Defined stability performance criteria are not met*

The following is a discussion of each of the components in the proposed SOL Exceedance definition:

Component #1 – *An operating condition or analysis result characterized by any of the following, as determined in Real-time monitoring, Real-time Assessments (RTA) or Operational Planning Analysis (OPA):*

The TOP/IRO Reliability Standards require the RC and the TOP to perform OPAs to assess whether its planned operations for the next day will exceed any of its SOLs. Per the definition of OPA, these assessments must address both the pre-Contingency state and the post-Contingency state based on expected system conditions. If the OPA identifies an SOL exceedance, the TOPs and RC are required to develop an Operating Plan(s) to address the SOL exceedances identified in the OPA. SOL exceedances are also identified as part of Real-time monitoring and RTAs. Per the definition of RTA, these assessments must address both the pre-Contingency state and the post-Contingency state using real-time data. If Real-time monitoring or the RTA identifies an SOL exceedance, the TOPs and RC are required to implement an Operating Plan to address that SOL exceedance. Accordingly, an SOL exceedance is fundamentally an identified operating condition or an expected or potential operating conditioned determined by an analysis of system conditions or expected system conditions.

Component #2 – *The pre-Contingency state indicates any of the following; The calculated post-Contingency state indicates any of the following*

As is discussed in the Project 2014-03 Whitepaper, unacceptable system performance for either the pre- or the post-Contingency state translates to an SOL exceedance. Consistent with the Project 2014-03 Whitepaper, the proposed definition of SOL Exceedance is based on the system performance requirements described in FAC-011-3 Requirement R2.1 and R2.2, which address both the pre- and post-Contingency states.

The proposed definition refers to the "*calculated* post-Contingency state." That is because when OPAs and RTAs are performed, RCs and TOPs use the analysis tools or processes to determine, or calculate, how the system is expected to perform in response to Contingency events.

The proposed definition does not specify whether the post-Contingency state is applicable to single Contingencies or multiple Contingencies. The SDT intends for this issue to be addressed in the RC's SOL Methodology. Currently-effective Reliability Standards FAC-011-3 Requirement R2.2 provides that acceptable system performance for the post-Contingency state is applicable to the single Contingencies specified in Requirements R2.2.1 through R2.2.3. These same single Contingencies are addressed in proposed FAC-011-4 Requirement R5.1.1. Nevertheless, some RCs establish stability limits for certain multiple Contingency events. Per proposed FAC-011-4, Requirements R5.3 and R5.4, the RC's SOL Methodology is required to specify which multiple Contingencies are required to be included for the establishment of stability limits and for stability performance in OPAs and RTAs.

Component #3 – *The pre-Contingency state indicates: … Actual flow through a Facility is above the Facility's Normal Rating*

The SDT determined that any persistent exceedance of a Normal Rating should be regarded as an SOL exceedance, even if the exceedance occurs for an acceptable duration.[9] This approach accomplishes the intended reliability objective of triggering the appropriate action (i.e., implementing an Operating Plan to address the exceedance). If such an exceedance is identified during an OPA, the relevant TOP or RC must have an Operating Plans to mitigate the SOL Exceedance. If identified in an RTA, an actual SOL Exceedance triggers the implementation of Operating Plans to mitigate the SOL Exceedance. The specifics and the timing of those mitigating actions must be contained in the Operating Plan.

Component #4 – *The pre-Contingency state indicates: … Actual bus voltage is outside normal System Voltage Limits*

The language in this component mirrors the language in the preceding bullet applicable to Facility Ratings. The same concepts described above apply.

Component #5 – *The pre-Contingency state indicates: … A stability limit established to prevent instability without a Contingency is exceeded*

The SDT concluded that it is possible to establish a limit to prevent instability from occurring without a Contingency. For example, transfer analyses might indicate that at a certain level of MW transfer over a Facility, the knee of a PV curve is reached without a Contingency. While such limits might not be as common as those that are associated with a Contingency, it is possible for such pre-Contingency instability conditions to occur, therefore it is included in the SOL Exceedance definition as these instances should be addressed in an Operating Plan. Such limits are often established through studies performed one or more days prior to Real-time, though the value of such a limit may be calculated in Real-time. If the TOP or RC does not establish this type of stability limit, then this component of the SOL Exceedance definition would not apply to that TOP or RC.

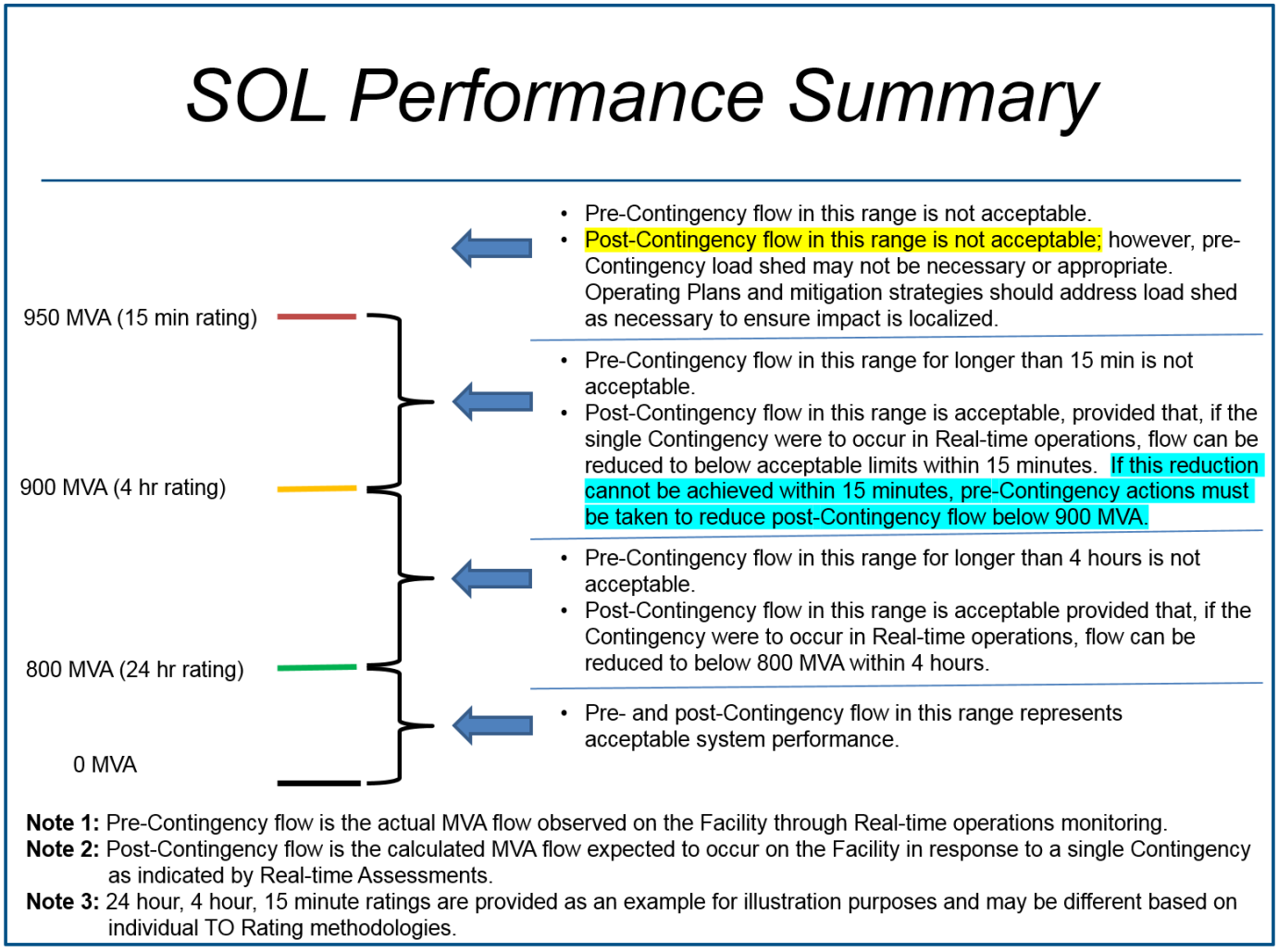
Component #6 – *The pre-Contingency state indicates: … A stability limit established to prevent the Contingency from resulting in instability is exceeded*

The majority of stability limits are established to prevent instability from occurring in the event of certain Contingencies. When the system is operated within this type of stability limit, it is expected that the system would remain stable should any of the identified Contingencies occur. Conversely, when this type of stability limit is being exceeded, the system is not expected to remain stable should any of the identified Contingencies occur. While this type of stability limit is monitored in the pre-Contingency state, it actually addresses post-Contingency instability. For example, a transmission interface might have a voltage stability limit of 1000 MW to prevent Contingency X from resulting in voltage instability. If flow on the interface is kept below 1000 MW, the system is expected to remain stable should Contingency X occur; however, if flow on the interface exceeds 1000 MW, the system is expected to experience voltage instability should Contingency X occur. These types of stability limits are typically established through studies performed one or more days prior to Real-time; however, the value of these limits may be calculated in real-time.

[9] Emergency Ratings will always equal to or greater than the Normal Rating.

Component #7 – *The calculated post-Contingency state indicates: … Flow through a Facility is above the Facility's highest Emergency Rating, or above a Facility Rating for which there is not sufficient time to reduce the flow to established acceptable levels should the Contingency occur*

The SDT concluded that the two instances contained within this item provide additional clarity that could prevent inaccurate interpretations of what it means to exceed an SOL. The intent behind this component of the definition is to reflect the concepts described in the Project 2014-03 Whitepaper with regard to Facility Rating exceedances, specifically, the two highlighted items in the diagram below. The portion of the definition that states, *"Calculated post-Contingency flow through a Facility is above the Facility's highest Emergency Rating"* is intended to specifically address the operating state highlighted in yellow. This operating state is considered an SOL Exceedance because this designation accomplishes the desired outcome by triggering mitigating action through the implementation of an Operating Plan. In this scenario, the System Operator has no time to implement post-Contingency mitigation actions (i.e., actions that occur after the Contingency event occurs); therefore, pre-Contingency mitigation actions consistent with the Operating Plan must be taken to reduce the calculated post-Contingency flow. The portion of the definition that states, *"…or above a Facility Rating for which there is not sufficient time to reduce the flow to established acceptable levels should the Contingency occur"* is intended to address the operating state highlighted in light blue. Again, in this scenario, the System Operator does not have adequate time to implement post-Contingency mitigation actions ; therefore, pre-Contingency mitigation actions consistent with the Operating Plan must be taken to reduce the calculated post-Contingency flow. This operating state is also considered an SOL Exceedance because this designation accomplishes the desired outcome by triggering mitigating action through the implementation of an Operating Plan.



Component #8 – *The calculated post-Contingency state indicates: … Bus voltage is outside the highest or lowest emergency System Voltage Limit, or outside a System Voltage Limit for which there is not sufficient time to bring the bus voltage to established acceptable levels should the Contingency occur*

The language in this component mirrors the language in the preceding bullet applicable to Facility Ratings. The same concepts described above apply. Regarding time-based System Voltage Limits, the proposed definition acknowledges that time-based System Voltage Limits are used by some TOPs and RCs. The proposed definition provides the operational flexibility for the use of time-based voltage limits in the same manner that time-based Facility Ratings are used.

As an example, a TOP could have a NORMAL System Voltage Limit of +/- 5%, an EMERGENCY System Voltage Limits of +7% and -10%, and an additional short term EMERGENCY HIGH System Voltage Limit of +10% for 15 minutes. Applying a 15 minute time value to the short term EMERGENCY HIGH System Voltage Limit of +10% could allow post-Contingency operator action to mitigate a concern as opposed to enforcing pre-Contingency action plan. In this example, a calculated post-Contingency voltage above 107% of normal but below 110% could be resolved with post-contingent action, which could be described in the Operating Plan.

Component #9 – The calculated post-Contingency state indicates: … Defined stability performance criteria are not met

The requirements in FAC-011-4 and FAC-014-4 address the establishment of stability limits and IROLs:

1. FAC-011-4 Requirement R4, Part 4.1 requires the RC's SOL Methodology to specify the stability performance criteria that is to be used for the establishment of stability limits.
2. FAC-011-4 Requirement R4 Part 4.2 requires that stability limits are established to meet the criteria specified in Part 4.1 for the Contingencies identified in Requirement R5.
3. FAC-014-3 Requirement R1 requires the RC to establish IROLs in accordance with the SOL Methodology.
4. FAC-014-3 Requirement R2 requires the TOP to establish SOLs in accordance with the SOL Methodology.
5. FAC-014-3 Requirement R4 requires the RC to establish stability limits when the limit impacts more than one Transmission Operator in its Reliability Coordinator Area in accordance with its SOL Methodology.

The end result of these requirements is that stability limits – some of which may be IROLs – will be established in accordance with the RC's SOL Methodology. These stability limits are addressed through the third and fourth bullets in the pre-Contingency state section of the SOL Exceedance definition which state:

> The pre-Contingency state indicates any of the following:
>
> - A stability limit established to prevent instability without a Contingency is exceeded
> - A stability limit established to prevent the Contingency from resulting in instability is exceeded

Accordingly, if any defined stability limit is exceeded, the third and fourth bullets in the pre-Contingency section addresses those as SOL Exceedances. These stability limits can be determined prior to Real-time, or they can be determined in Real-time through the use of Real-time stability tools. With the adoption of technology implementations, some TOPs and RCs are using stability analysis tools to calculate stability limits in Real-time using the actual system conditions as an input to the analysis. Such implementations bring a significant improvement to the accuracy of stability limits. However, regardless of when the stability limit is calculated, the above bullets apply regarding when an actual SOL Exceedance of these stability limits occurs.

However, some implementations of Real-time tools in operations, particularly transient stability tools, present a challenge to the historical paradigms of operating within established limits. For example, Real-time transient stability tools have the ability to assess actual system conditions to determine whether the system is expected to be transiently stable (or to meet certain transient performance criteria) for a set of modeled Contingencies. Real-time transient stability tools give TOPs and RCs the ability to determine in Real-time whether or not a given Contingency would result in acceptable damping or acceptable transient voltage response. When such tools are used to determine acceptable transient system performance, the tools may not calculate "an SOL" (a stability limit) in the traditional sense, i.e., the tools may not calculate a value that, if operated within, prevents the system from exceeding transient performance criteria should

the critical Contingency occur (which would be monitored under the fourth bullet under the pre-Contingency section of the SOL Exceedance definition). Rather, these tools can be used in a manner to indicate when the transient performance criteria are being, or are expected to be, met.

Modern technology implementations of stability analysis tools have the ability to inform System Operators at any moment in Real-time whether the system is "stable" or whether it is "unstable" for the next Contingency event without the use of a traditional "SOL value". For entities that use such tools as an additional mechanism to determine Real-time instability (above and beyond monitoring any defined stability limits established per the Requirements referenced in items 1-5 listed above), if defined stability performance criteria are not being met, an Operating Plan should be implemented to mitigate the condition. Such an approach represents a significant improvement in the accuracy of monitoring for acceptable stability performance in response to Contingencies; however, such an approach may not utilize an "SOL value" (a defined stability limit value) that is monitored in the traditional sense. This type of assessment, while not utlilizing a defined SOL value, does evaluate for acceptable system stability performance (i.e., post-Contingency stable operations), and as such, should be integrated into the definition. The SDT believes that operating entities should be encouraged to integrate new technologies to improve the accuracy of its reliability assessments, and that any instance of not meeting stability performance criteria as indicated by these technologies should be considered as an SOL Exceedance because it triggers the appropriate response of the implementation of an Operating Plan to mitigate the condition. It is important that the SOL Exceedance definition be "technology neutral" by addressing the techniques used to identify unacceptable stability performance in addition to the conventional or historical methods of performing studies, establishing a defined limit based on those studies, and then operating within that defined limit in Real-time.

If the TOP or RC does not utilize Real-time stability tools to determine the system's response to Contingency events and to evaluate that response against defined stability performance criteria, but solely utilizes a more traditional approach for establishing stability limits (i.e., limit "values") to address system instability, then the third bullet in the post-Contingency section of the proposed SOL Exceedance definition would not apply to that TOP or RC, and the fourth bullet under the pre-Contingency section of the SOL Exceedance definition would govern stability performance.

It should be noted that the third bullet in the post-Contingency section is going above and beyond the other components of the SOL Exceedance definition that addresses traditionally defined stability limits (the fourth bullet under the pre-Contingency section of the SOL Exceedance definition). The third bullet under the post-Contingency section is included in the definition of SOL Exceedance to enhance reliability by requiring that any operating condition characterized as "unstable" as determined by Real-time stability analysis tools is also regarded as an SOL Exceedance in order to trigger the implementation of an Operating Plan to address the condition. It important to note that TOPs and RCs that use Real-time stability analysis tools in this manner are also required to monitor any traditionally defined stability limits and to consider any exceedance of those limits under the the third and fourth bullets under the pre-Contingency section of the SOL Exceedance definition.