# Transmission Planning Technical Guide
# Appendix F

# Stability Task Force Presentation to
# The Reliability Committee


System Planning
December 23, 2013

# EC Criteria for 3-phase Breaker Failure contingencies

Acceptability of Transient and Dynamic System Response To Extreme Contingencies Involving Three Phase Faults With Delayed Clearing

The critieria included in this Appendix was presented to the NEPOOL Reliability Committee (RC) at their September 19, 2000 meeting. The RC expressed concern with certain aspects of the proposed criteria and the formalization of the practice into hard and fast implementation criteria. The RC recommended that the STF should continue to use the criteria as a guide applying good judgment on a case-by-case basis.

**Submitted by the STF to The RC**

**Acceptability of Transient and Dynamic System Response To**
**Extreme Contingencies Involving Three Phase Faults With Delayed Clearing**

The following responses are considered unacceptable responses to an extreme contingency involving a three phase fault with delayed clearing:

- Transiently unstable response resulting in wide spread system collapse.
- Transiently stable response with undamped or sustained power system oscillations.
- A net loss of source within New England in excess of 2200 MW resulting from any combination of the loss of synchronism of one or more generating units, generation rejection initiated by a Special Protection System, tripping of the New Brunswick-New England tie, or any other defined system separation.

The following response can be considered acceptable to an extreme contingency involving a three phase fault with delayed clearing:

- A net loss of source above 1400 MW and up to 2200 MW, resulting from any combination of the loss of synchronism of one or more generating units, generation rejection initiated by a Special Protection System, tripping of the New Brunswick-New England tie, or any other defined system separation, if supported by studies, on the basis of acceptable likelihood of occurrence, limited exposure to the pre-contingent operating conditions required to create the scenario, or efforts to minimize the likelihood of occurrence or to mitigate against the consequence of the contingency.

<u>Background</u>

NEPOOL criteria call for planning studies to be conducted to determine the effect of extreme contingencies on bulk power system performance as a measure of system strength. Criteria also state that plans or operating procedures will be developed where appropriate to reduce the probability of occurrence or to mitigate the consequences that are indicated as a result of simulations of such contingencies. In past cases where simulations have indicated a high likelihood of a total system collapse as a result of a three phase fault with delayed clearing, such as establishment of the Northern New England-Scobie+394 interface, NEPOOL has elected to enforce limitations on system transfers to prevent the consequence of such contingencies.

Transient and dynamic system responses to contingencies are classified into three categories; namely oscillatory, loss of source, and system separation. Both acceptable and unacceptable system responses may exhibit one or more of these characteristics. In order to ensure consistent treatment of three phase faults with delayed clearing in planning studies, the following definitions of acceptable bulk power system response are recorded. In summary, an oscillatory response is acceptable if a minimum damping criterion is met. A loss of source or system separation is acceptable if the event is well defined and the net loss of source on the Eastern Interconnection is limited through transmission system design or system operation to an acceptable level.

The following text and attached diagram are used to define acceptable bulk power system response to extreme contingencies involving a permanent three phase fault on any generator, transmission circuit, transformer, or bus section, with delayed fault clearing and with due regard to reclosing (Section 5 d. of the NEPOOL Reliability Standards). While these contingencies typically are simulated with delayed clearing resulting from failure of a circuit breaker to operate, the delayed clearing could also result from a relay system or signal channel malfunction.

<u>Oscillatory</u>: The NEPOOL damping criterion must be met to ensure small signal stability of the power system. System damping is characterized by the damping coefficient, zeta ($\zeta$). The damping coefficient provides an indication of the length of time an oscillation will take to dampen. The NEPOOL damping criterion requires a minimum damping coefficient of 0.03 to demonstrate acceptable damping. A damping coefficient of 0.03

corresponds a to 1% settling time of one minute or less for all oscillations with a frequency of 0.4 Hz or higher. [The envelope of the oscillation will dampen to 1% of its original value.] Conformance with the criterion may be demonstrated with the use of small signal eigenvalue analysis to explicitly identify the damping ratio of all questionable oscillations. Alternately, conformance may be demonstrated with time domain analysis; running a transient stability simulation for sufficient time that only a single mode of oscillation remains. A 50% reduction in the magnitude of the oscillation must then be observed over four periods of the oscillation. Note that the NEPOOL Damping Criterion must be met for all design contingencies, as well as extreme contingencies.

Loss of Source: The magnitude of a potential loss of source within New England must be limited to prevent adverse impacts on the bulk power system. Adverse impacts may occur when the magnitude of the loss in New England exceeds the capability of the NYPP and PJM systems to transfer replacement power to New England. It is unlikely that the New England system would survive following a collapse of the NYPP or PJM systems. A limitation is placed on the maximum loss of source for a design contingency by joint agreement of NYPP, PJM, and ISO-NE. This inter-regional loss of source limit ranges from a low of 1200 MW and has been tested up to 2200 MW, and is dependent on system conditions within NYPP and PJM. Historically the limit has been in the range of 1200 MW to 1500 MW during most hours. Recognizing that a three phase fault with delayed clearing is an extreme contingency, it is appropriate to consider higher limits for extreme contingency testing.

NEPOOL has routinely accepted a loss of source up to 1400 MW as an acceptable response to an extreme contingency. For a loss of source up to 1400 MW, action is not required to minimize the likelihood of occurrence of the contingency, nor is action required to mitigate against the consequence of the contingency. A threshold of 1400 MW is consistent with the existing 1400 MW ME-NH interface limit. This interface stability limit is based on a design contingency. However, there exist extreme contingencies near this interface that would resu lt in a ME-NH separation, and a net 1400 MW loss of source.

For a loss of source greater than 1400 MW, NEPOOL design practice has required action where appropriate to minimize the likelihood of occurrence of the contingency, or to mitigate against the consequence of the contingency. A loss of source above 1400 MW resulting from a three phase fault with delayed clearing can be acceptable if supported by studies, on the basis of:

- limited likelihood of occurrence,
- limited exposure to the pre-contingent operating conditions required to create the scenario, or
- significant efforts to minimize the likelihood of occurrence or to mitigate against the consequence of the contingency.

It is preferred that design measures be taken to limit the exposure to a loss of source resulting from a three phase fault with delayed clearing, for the benefit of mitigating overall system risk. These measure may include but are not limited to:

- circuit breaker replacement or upgrade to obtain IPT capability,
- circuit breaker additions,
- protection system modifications,
- detection and tripping of unstable resources, and
- limited substation reconfiguration.

**Submitted by the STF to The RC**

**Acceptability of Transient and Dynamic System Response To Extreme Contingencies Involving Three Phase Faults With Delayed Clearing**

There is a very high likelihood that source contingencies above 2200 MW would result in a system collapse. Therefore, a loss of source contingency in excess of 2200 MW is not allowed regardless of how small the likelihood of occurrence. This upper threshold is consistent with the largest possible loss of source contingency in New England, which results from a bipolar trip of the Phase II HVdc interconnection while the Chester SVC is unavailable. At rated power transfer, this would result in a loss of 2000 MW over the HVdc interconnection, accompanied by a 200 MW generation rejection in New Brunswick initiated by the Keswick Power Relays; a net loss of source of 2200 MW.

Where the resources involved in a loss of source are contained behind an interface over which transfer levels can be readily observed and controlled, transfer limits based on a three phase fault with delayed clearing must be respected when the potential loss of source would exceed 2200 MW. For three phase faults with delayed clearing involve resources for which the potential loss cannot be readily observed or controlled, design measures must be taken to reduce the potential loss of source to a level at least below 2200 MW, although further mitigation is anticipated where appropriate.

Tripping of generation lost due to a loss of synchronism must be modeled based on actual protective relays that will operate to trip the unit.

<u>System Separation</u>: The effect of a system separation must be controlled to ensure that an acceptable system response is obtained. To model the affect of the system separation, line tripping associated with the system separation must be modeled based on actual protective relays that will trip the lines. Simulations must be run for sufficient duration beyond the system separation to adequately identify the response of both portions of the system. The remaining portion of the Eastern Interconnection must not suffer a net loss of source greater than the limits established above, and system damping must meet the NEPOOL damping criterion. The need for the isolated portion of the system to meet the above criteria is established on a case by case basis. Factors influencing acceptability for the isolated portion depend on the size of the isolated system and the consent of the affected parties.

NEPOOL Stability Task Force
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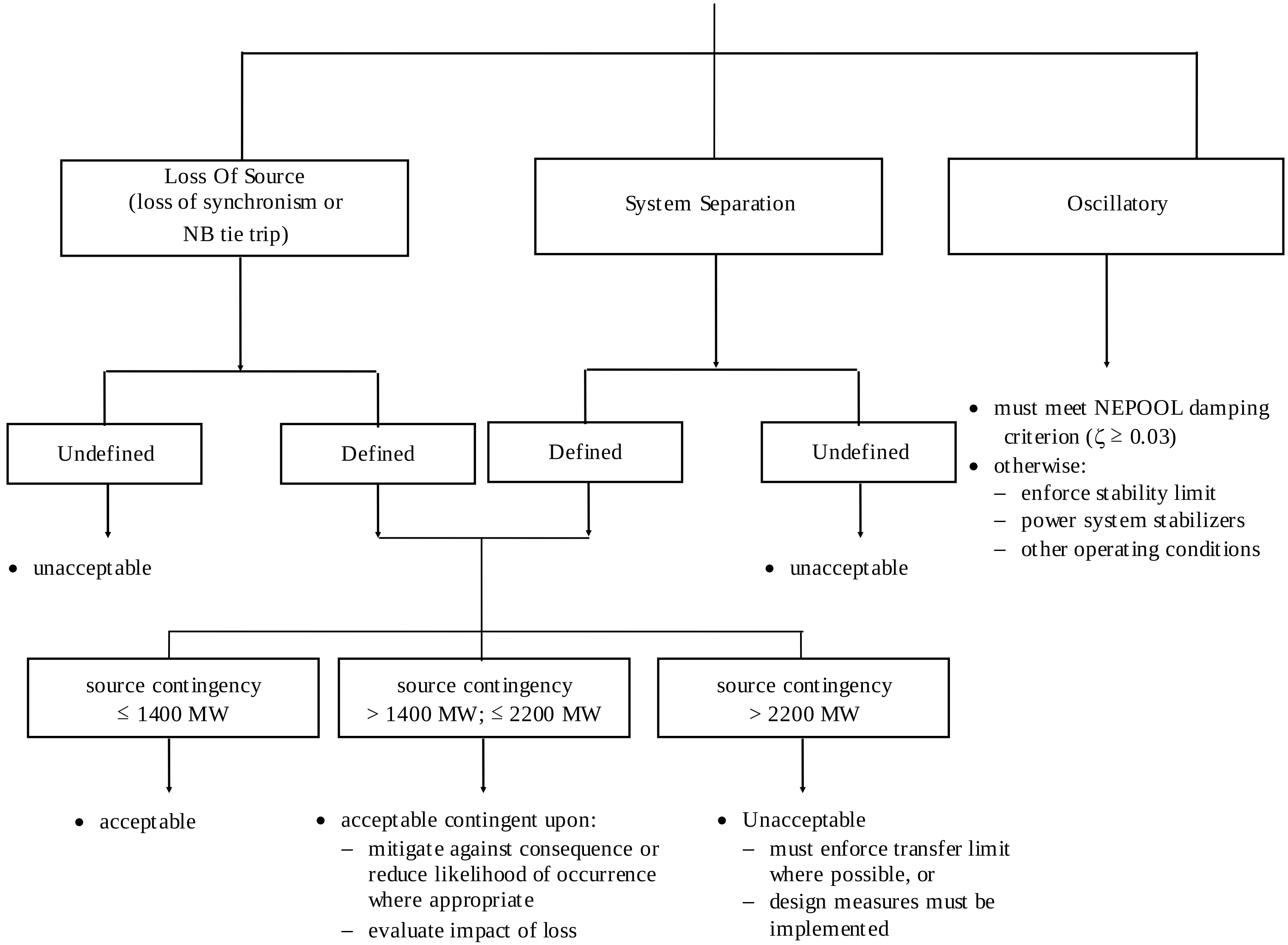


Note: Simulations that exhibit more than one response characteristic must meet the criterion for all categories