ColumbiaGrid Transient Stability Contingency Naming Convention

Draft Version 1

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1. Introduction

A transient stability contingency name generally includes key information to describe a simulated stability contingency. For example, it may state where the fault happens, how severe the fault is, and how some protection devices respond to the fault. Reading these data from a contingency name, an engineer can easily understand a simulation plot. As proposed by ColumbiaGrid members, naming contingencies by following a convention can help to facilitate the data sharing among all ColumbiaGrid members.

In this document, naming convention of transient stability contingencies are discussed based on the members' suggestion in 2016 October planning meeting. In particular, the naming structure is designed to address the following two key issues:

1. Why certain information should be included in a contingency name
   Contingency names showed in the transient stability simulation plots are normally the only source of information to describe the simulation that a reader may see. A user who views the plots should be able to read a contingency name and understand the key information such as fault type, fault location, remedial action etc.

2. What is the key information a contingency name should include
   Various faults and remedy actions can be simulation in the same location for study purpose. A contingency should be named properly to provide clear and concise information to distinguish similar contingencies

ColumbiaGrid uses PowerWorld Simulator to perform the System Assessment. In PowerWorld, a transient stability name consists of two parts: Category and Name. Both part can be included in a simulation plot. Examples of contingency name are showed in Table 1.

Table 1. Example Contingencies

#	Category	Contingency Name
1	P3.2,P4.3,Extreme	GEN: 3PH@SUB_A 10%, SUB_A-SUB_B #5 115kV + Gen GGG#1, Stuck Breaker #111, Delayed Clearing in 10 cycles, with RAS
2	CIP-14	SUB: 3PH@SUB_A, Stuck Breaker All, Remote Clearing in 23 cycles
3	P1, P3	GEN: TRIP@GEN_A, with RAS to Open Shunt B

2. Contingency Category

A contingency category is normally a phrase to define the contingency type, following certain category definition rules. For example, NERC TPL-001-4 has specified categories of P0-P7 for utilities to meet the reliability compliance requirement. Some example of the categories are showed in the Table 1.

2.1 NERC TPL Category

NERC TPL-001-4 defines categories P0-P7 for transient stability contingencies to allow the study of various type of events. Below is a summary of the event categories that need to be studied and the submittal needed to meet the standards.

2.2 User Specified Category

Besides NERC TPL Category P0-P7, it is possible a contingency may fall into other categories which a user would specify for certain study purpose. For example, a user may simulate some severe contingencies for screening purpose, or for other compliance requirement, such as CIP-14. Used in this way a category can help users to better distinguish a contingency with other established categories. Among all these user specified categories, “extreme” category are more often encountered, it is listed as follows:

Extreme

This is a category for certain severe or unusual contingencies that are not covered by P0-P7. It may includes

1. P0-P7 Contingencies with more severe fault level, e.g., 3 phase fault instead of single line to ground fault.
2. Fault events to be simulated without a planned remedial action
3. Fault events with multiple fault elements and/or long fault clearing time

A user may, based on the application, define other user specified category as needed. For example, the following table lists several categories used by member utilities in various studies:

Category	Explanation
CIP-14	Severe Contingency that was simulated for CIP-14 compliance
SUBSTATION	Contingency that removes a whole substation with all elements connect to it
BF_500KV	Breaker failure contingency on 500 kV system

2.3 Category Naming Rules

Based on the discussion in 2016 October planning meeting, when a user define a category, he should adopt the following rules to make it consistent among utilities:

a) **For any TPL contingency, it should have at least one category named as P0 ~ P7.**

Example: Contingency #2 in Table 1, with it is category as "CIP-14", it doesn't include any P0 ~ P7 category. So it should not be considered as a valid TPL contingency.

b) **If a contingency doesn't belong to any TPL category, it should not be evaluated for TPL-001-4 compliance requirement**

Example: Contingency #2 in Table 1, with it is category as CIP-14, instability of the simulation doesn't constitute a violation to TPL requirement.

c) **A TPL category can use a 2nd level category. Levels should be separated by ".", instead of "-".**

Example: Contingency #1 in Table 1, it use a category as P3.2, means it is the 2nd elements in category P3: Loss a generator followed by loss of a transmission circuit. It is not recommend to define the category as P3-2.

d) **A contingency may have multiple categories, each categories should be separated with comma ",". Multiple categories should be listed in an increasing order.**

Example: Users assign 3 categories for contingency # 1 in Table 1. It belongs to TPL category P3.2, TPL category 4.3. It also belongs to extreme contingency category. In the increasing order, the category becomes "P3.2, P4.3, Extreme"

e) **Special category other than "P0-P7" are allowed at the utilities own discretion.**

Example: Contingency #2 in Table 1, with it is category specified as CIP-14, it is defined as a NERC CIP-14 contingency for CIP-14 compliance study purpose.

f) **If a contingency belongs to both TPL categories P0~P7 and a special category, TPL category should always be listed before special category.**

Example: Contingency # 1 in Table 1, it belongs to TPL categories and extreme category. It is not accurate to assign category as: "Extreme, P3.2, P4.3", because "P3.2" and "P4.3" should always listed before category "Extreme".

g) For TPL contingencies simulating a more severe fault (for screening purpose), such as P4 contingency with 3 phase fault, one can use category: “P4,Extreme” or just “Extreme” (if a SLG version contingency exists) to distinct it from a SLG “P4” contingency.

Example: Contingency # 1 in Table 1, it simulates a 3 phase fault contingency, severe than the stability requirement of category P3.2 and P4.3: single line to ground fault. It is therefore also an “Extreme” category contingency.

3. Contingency Name

A contingency name may include many pieces of information relevant to describing the contingency event. Even though deciding which part of information to include in a name can be merely a decision from the engineer who create the contingency, several rules should be followed to make contingency name precise and concise. These rules are:

- A contingency name should at least show the location, fault severity and type of event

- If two or more contingencies have the similar information such as location, severity, etc., more pieces of information should be included in the name to help better distinguish them

- Depend on the application and information security requirement, more or less parts of information can be included into the name. For example, the fault clearing time can be excluded in the name if this information is considered as protected information.

In this section, various part of information and their naming rules are discussed in detail. A user can determine what part of information to include in a contingency name.

3.1 Contingency Type

Conventionally, a stability contingency name always starts with a contingency type to categorize various types of contingencies. With the NERC TPL-001-4 requirements published, a refined category list has been introduced (P0-P7) to replace most of the contingency type used. In practice, however, people found the contingency type is still quite convenient to use compared to the P0-P7 category. This is mainly due to the fact that a user specified word of contingency type is more clear and straightforward to describe the type of event than the symbolized categories. For example, a contingency type “GEN” would be easier to understand as a generator related fault than using P3.2. For this reason, in our approach, we will still keep the contingency type as an essential part of contingency name.

A contingency type, or more precisely fault object, is normally defined by either:

a. The element where the fault happens, or
b. The most important element being impact by the fault.

This implies that a contingency type can be either a cause or a consequence of fault events. For example, a fault on a step up transformer may cause a generator tripping. The contingency type for this event are typically named as “GEN” instead of “Transformer” (or “TFM”) to indicate the most important consequence of the fault. On the other hand, a fault at a transformer that only open this device will typically be named as “Transformer” (or “TFM”) type.

Naming a contingency type for transient stability are similar to most of the power flow contingency naming convention. A user can refer to the Power Flow contingency naming convention for details on how to define a contingency type. Some example contingency types used for transient stability are included as follows:

For where the fault applied

Contingency type	Description
BUS	Fault applied at a segment of bus bar or breaker
SUB	Fault applied at a substation element, normally lead to the partial or full substation failure
HVDC	Fault applied to single or multiple pole of a HVDC, converter station or controls
TFM	Fault applied to a transformer, or a transformer failure
LINE	Fault applied at a transmission circuit
TOWER	Fault applied at towers where all elements on that tower are impacted
N-1	Fault applied to a single elements without a specified type
N-2	Fault applied to two elements, or one elements failure causes another element to fail
N-3	Fault applied to three elements, or one or two elements failure causes other elements to fail

For the impacted elements

Contingency type	Description
HVDC	HVDC action, such as open, close, runback, etc.
SHUNT	A shunt action, such as open or close, switching, etc.
GEN	A generator protection action, such as tripping, run-back, etc.
LOAD	A load action, such as trip, shed or reclose
DER	A distributed energy resources action, such as trip, shed, reclose, etc.
MOTOR	A motor action, such as trip, restart, stall etc.

3.2 Fault Severity

In transient stability studies, a same fault event may be simulated with different level of severity. For example, a line fault may be simulated with 3 phase to ground fault, line to line to ground fault, single line to ground fault. Typically all these types of simulation are important: the less severe fault such as single line to ground fault can happen in a much larger possibility than the severe ones. Some protection devices may also respond to the different level of severity differently. Therefore, this information should be included in the names of contingencies.

The following fault severity is recommended to be used:

Fault Severity	Description
3PH	3 phase to ground fault
LLG	Line to line to ground fault
SLG	Single line to ground fault

For an event without a fault, this part can be used to describe the action of the devices:

Fault Severity	Description
Drop	Drop a load, generation, capacitor etc.
Trip	Trip of load, generation, capacitor, HVDC, etc.
Reduce	Reduce generation, HVDC setpoint, etc.
Increase	Increase generation, HVDC setpoint, etc.
Open	Open a single element without fault
Close	Close a single element without fault
Bypass	Bypass a series capacitor, etc.

In reality, an event may include multiple fault severity. Moreover, one type of severity can evolve into others. For example, an initial 3 phase to ground fault with a breaker stuck on one line end will become a single line to ground fault after the other two line breaker opened. For these type of events, based on the discussion in 2016 October planning meeting, the fault severity will adopt the initial type. In the above example, the fault severity will be “3PH”, rather than “SLG”.

3.3 Fault Location

To better understand a fault event, a location of the fault should be specified in the contingency name. The rules for defining the location are:

a) **“@” should be use as a symbol to indicate a location. It separates the fault severity and the near end bus name. A percentage can be used to indicate the percentage distance to the near end**

In the table 1, item #1, “@SUB_A 10%” is to define the fault location is close to substation A end, at 10% to bus SUB_A in the line.

b) **For multi-terminal elements such as branches, it should include both ends Bus name, kV, circuit ID, it is at user’s discretion to include breaker numbers.**

In the table 1, item #1, “3PH@SUB_A 10% SUB_A-SUB_B #5 115kV” indicates that a 3 phase fault is applied the 115 kV transmission line from substation A to substation B, circuit #5.

c) **For multiple elements that being impacted by the fault, it is at utilities discretion to include it or not. If it is included, a “+” should be used to indicate and connect multiple elements.**

In the table 1, item #1, “+ Gen GGG#1” is used to indicate there are a generator “GGG#1” was also impacted by this fault.

3.4 Breaker/ Fault Actions

The breaker/relay action can also be included to distinguish contingencies with different breaker/relay actions triggered. These actions, depends on the application, include: Normal Clearing, with Reclosing, Delayed Clearing, Stuck Breaker, with RAS, etc.

In the table 1, item #1, “Stuck Breaker #111, Delayed Clearing in 10 cycles, with RAS” gives some clear indication of how relay respond to the fault and what is the protection action involved.

It is also strongly recommend to include the clearing time in the part to help reader understand the clearing time. However, as breaker clearing time are typically CEII, it is at utilities discretion to exclude it from the contingency name.

4. Summary

To define a contingency, the following elements are required:

- Category
- Contingency Type
- Fault severity
- Location

For clarification purpose:

- Use “@near end” to indicate the location and near end elements
- Use “ + another element” to show multiple elements being impacted
- Use breaker/relay actions to distinguish normal clearing, delayed clearing, etc.
- Using clearing time to distinguish same fault with different clearing time