NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Project 2021-03 TOCC Field Test

Questionnaire 2 Power Flow Instruction Document

February 2022

Purpose

The purpose of this document is to provide instructions for entities participating in the Project 2021-03 Standard Drafting Team field test. The goal of the power flow study types in this field test is to evaluate system responses to specific conditions by means of Steady-State power flow runs. These conditions are provided for each study type, beginning on the next page.

Please complete each field requested in this document as it pertains to the study(ies) performed. All requested data should be entered into the tables provided.

Software Used

Detail the name and version of the software used to conduct the power flow study(ies).
Example: PSS/E Version 34.7

Name	
Version #	

Model(s) Used

Models used should include all BPS system elements for your entity's system as well as all BPS system elements of each neighboring system. As a goal of this study is to evaluate potential impacts in the current topology of the system, models are expected to be within the current or near-term timeframe. Consider near-term as 1-3 year models or 1-5 year models, as available. Add rows if more than 1 model is used.
Example: Eastern Interconnection 2020 MMWG series model, year 3

Description of models(s) used	

Case(s) Used

Cases considered for study should include various stressed system conditions. Intentional intrusions into cyber assets causing larger system impacts may align with stressed system conditions to expand the adverse effects on the BPS. Provide a brief description of the case(s) selected for study along with a brief justification on the appropriateness for the case(s) studied. Add rows for additional cases/scenarios studied.
Example: Year 1 and year 2 Summer Peak Load case;
Example: Year 1 and year 2 shoulder (fall season), light load, high wind scenario
Example: Year 1 extreme weather condition

Case Description and justification for use	
Case Description and justification for use	
Case Description and justification for use	

Criteria Used

Criteria used for this field test should be consistent with criteria used by entity's Transmission Planner or Reliability Coordinator for assessing instability, Cascading, and uncontrolled separation. Provide technical justification if other criteria are used. If certain criteria below are not used, please indicate the criteria is not used instead.

Formatting Instructions

Do not delete text or change formatting of tables. Additional rows should be added to each table as needed to accommodate your results. Unused rows may be left empty or can be deleted.

Additional Notes

Each study type will include a field for additional notes. Please use this field to consolidate any additional pertinent material on selection justifications, explanations for items/choices that are not collected in provided tables. These additional notes may also be used to provide clarity on entity-specific system conditions, nuance, or other issues.

Power Flow Study Type 1

Goal: Evaluate system response for violations of thermal and voltage rating criteria in Steady-State.
Area to be evaluated: Entity's own system as well as all neighboring systems.
Study conditions: All breakers/switches that can be operated remotely from the entity's BES Cyber System are simultaneously opened.
Guidance for conducting in power flow program:

1) Create 1 or more sub-areas that comprise all affected buses per study conditions.
2) Lock generator response, tap changes, and shunts.
3) Set monitors on newly created tie-lines from sub-area(s) and neighboring buses.
4) Open newly created tie-lines, solve case.

Criteria Evaluated

Voltage: Provide voltage magnitude threshold as well as voltage deviation threshold.
Example: Voltage Magnitude threshold = 0.95 p.u., Voltage Deviation threshold = 5% change from initial voltage; Rationale based on TP's criteria used in TPL studies

Voltage Criteria	Description	Rationale / Technical Justification
A		
B		

Thermal: Provide ratings used for evaluating thermal overloads. Include % and time. Include additional details of rating such as "ambient-adjusted" specifications if used. Additional rows provided if evaluating multiple ratings.
Example: Rating A = 100% of continuous summer rating, Rating B = 100% of 15 minute emergency rating

Thermal Rating	Description	Rationale / Technical Justification
A		
B		

Total Load Loss: Provide total load loss criteria (if used) for evaluating Cascading or instability.
Example: 500MW total loss of load

Total load loss criteria (MW)	

Total Generation Loss: Provide total generation loss criteria (if used) for evaluating Cascading or instability.
Example: 700MVA total loss of generation

Total generation loss criteria (MVA)	

Transfer Analysis: Describe the method of any transfer analysis conducted.

Q-V Analysis: Describe the method of any Q-V analysis conducted.

Results

Did the case solve after applying the study conditions?

Yes/No?	

What calculation method was used to solve the case?

Power flow calculation method used	

How many iterations did the solution take to solve?

Number of iterations	

Identify any voltage criteria violations on monitored buses. Maintain a record of model bus names and numbers, but do not provide in this record. In your own records, retain a mapping to the violation #s prepopulated in this record for future reference. Add additional rows and violation #s as needed.

Violation #	Initial Voltage p.u.	Final Voltage p.u.	Delta change % (Final-Initial)/Initial *100
V1			
V2			
V3			
V4			
V5			

Identify any thermal criteria violations on monitored buses. Maintain a record of model bus names and numbers but do not provide in this record. In your own records, retain a mapping to the violation #s prepopulated in this record for future reference. Add additional rows and violation #s as needed.

Violation #	Rating Violated	Initial Rating MVA	Final Rating MVA	% Above Rating Threshold
T1				
T2				
T3				
T4				
T5				

Total Load Loss (MW)

Total Generation Loss (MVA)

Transfer Analysis Results: Describe notable impact (adverse or beneficial) on neighboring transfer paths/flowgate capabilities. Adjust the table as needed for your results.

Q-V Analysis: Provide the results of any voltage instability identified. Maintain a record of generator/bus used for this analysis but do not provide in this record. In your own records, retain a mapping to the generator/bus #s prepopulated in this record for future reference. Add additional rows and generator/bus #s as needed.

Generator/Bus	Voltage (p.u.)	Actual MVARs
01		
02		

Additional Notes: Provide any additional information that you find as pertinent information to include with your results that do not fit in a table above.

Power Flow Study Type 2

Goal: Evaluate system response for violations of thermal and voltage rating criteria in Steady-State.
Area to be evaluated: Entity's own system as well as all neighboring systems.
Study conditions: All lines and autotransformers which an entity is capable of interrupting through-flow from the entity's BES Cyber System are operated sequentially.
Guidance for conducting in power flow program:

1) Identify all affected lines and autotransformers per the study conditions.
2) Operate each line/auto, beginning with the most heavily loaded line/auto to the least loaded in sequential order. Solve cases between each operation.
3) Allow generator responses, tap changes, and shunts to switch between each sequential operation and Steady-State case solution (i.e. allow system enough time stabilize).
4) Monitor all affected neighboring buses.
5) Open additional lines if criteria thresholds are violated. Note to use appropriate thermal ratings based on loading time for this study (such as a 15 minute emergency rating versus a 2-hour emergency rating)
6) Evaluate total/aggregate number of thresholds violated, total load loss, and total generation loss against Cascading criteria.
7) Continue through all operations.

Criteria Evaluated

Voltage: Provide voltage magnitude threshold as well as voltage deviation threshold.
Example: Voltage Magnitude threshold = 0.95 p.u., Voltage Deviation threshold = 5% change from initial voltage; Rationale based on TP's criteria used in TPL studies

Voltage Criteria	Description	Rationale / Technical Justification
A		
B		

Thermal: Provide ratings used for evaluating thermal overloads. Include % and time. Include additional details of rating such as "ambient-adjusted" specifications if used. Additional rows provided if evaluating multiple ratings.
Example: Rating A = 100% of continuous summer rating, Rating B = 100% of 15 minute emergency rating

Thermal Rating	Description	Rationale / Technical Justification
A		
B		

Total Load Loss: Provide total load loss criteria (if used) for evaluating Cascading or instability.
Example: 500MW total loss of load

Total load loss criteria (MW)	

Total Generation Loss: Provide total generation loss criteria (if used) for evaluating Cascading or instability.
Example: 700MVA total loss of generation

Total generation loss criteria (MVA)	

Cascading: Following an operation per the instructions, provide the conditions for declaring Cascading conditions.
Example: Total number of sequential line/bus operations that occur following an event. Operations may be due to subsequent voltage or thermal violations.

Description of Cascading Criteria	

Transfer Analysis: Describe the method of any transfer analysis conducted.

Q-V Analysis: Describe the method of any Q-V analysis conducted.

Results

Did the case solve for all operations identified in the study conditions?

Yes/No?	

If "No," include additional details per this table:

Number of operations successfully performed before the case failed to solve:	
Number of potential operations remaining:	

What calculation method was used to solve the case?

Power flow calculation method used	

At any point, what was the highest number of iterations the solution took to solve?

Max number of iterations	

Identify any voltage criteria violations on monitored buses. Maintain a record of model bus names and numbers but do not provide in this record. In your own records, retain a mapping to the violation #s prepopulated in this record for future reference. Add additional rows and violation #s as needed.

Violation #	Initial Voltage p.u.	Final Voltage p.u.	Delta change % (Final-Initial)/Initial *100
V1			
V2			
V3			
V4			

V5			

Identify any thermal criteria violations on monitored buses. Maintain a record of model bus names and numbers but do not provide in this record. In your own records, retain a mapping to the violation #s prepopulated in this record for future reference. Add additional rows and violation #s as needed.

Violation #	Rating Description	Initial Rating MVA	Final Rating MVA	% Above Rating Threshold
T1				
T2				
T3				
T4				
T5				

Total Load Loss (MW)

Total Generation Loss (MVA)

Cascading: Provide the results of any Cascading condition that occurred.
Example: 5 additional lines opened following the operation of line 7. All 5 sequential trips were due to violation exceedances of thermal rating B. Additional overloads were not investigated following the declaration of a Cascading condition.

Transfer Analysis Results: Describe notable impact (adverse or beneficial) on neighboring transfer paths/flowgate capabilities. Adjust the table as needed for your results.

Q-V Analysis: Provide the results of any voltage instability identified. Maintain a record of generator/bus used for this analysis but do not provide in this record. In your own records, retain a mapping to the generator/bus #s prepopulated in this record for future reference. Add additional rows and generator/bus #s as needed.

Generator/Bus	Voltage (p.u.)	Actual MVARs
01		
02		

Additional Notes: Provide any additional information that you find as pertinent information to include with your results that do not fit in a table above.

Power Flow Study Type 3

Goal: Evaluate system response for violations of thermal and voltage rating criteria in Steady-State.
Area to be evaluated: Entity's own system as well as all neighboring systems.
Study conditions: Study a broad range of system conditions following a wider range of probable Contingencies.
Guidance for conducting in power flow program:

1) Refer to the TPL-001-4 Planning Assessment results for affected system elements in the area to be evaluated.
2) Consider evaluating all extreme events such as those identified for Steady State in Table 1 of TPL-001-4.

Criteria Evaluated

Voltage: Provide voltage magnitude threshold as well as voltage deviation threshold.
Example: Voltage Magnitude threshold = 0.95 p.u., Voltage Deviation threshold = 5% change from initial voltage; Rationale based on TP's criteria used in TPL studies

Voltage Criteria	Description	Rationale / Technical Justification
A		
B		

Thermal: Provide ratings used for evaluating thermal overloads. Include % and time. Include additional details of rating such as "ambient-adjusted" specifications if used. Additional rows provided if evaluating multiple ratings.
Example: Rating A = 100% of continuous summer rating, Rating B = 100% of 15 minute emergency rating

Thermal Rating	Description	Rationale / Technical Justification
A		
B		

Total Load Loss: Provide total load loss criteria (if used) for evaluating Cascading or instability.
Example: 500MW total loss of load

Total load loss criteria (MW)	

Total Generation Loss: Provide total generation loss criteria (if used) for evaluating Cascading or instability.
Example: 700MVA total loss of generation

Total generation loss criteria (MVA)	

Contingencies Evaluated: Provide a description for each Contingency or set of Contingencies run.
Example: Contingency C01 = loss of generator followed by loss of line, all applicable assets

Contingency #	Description
C01	
C02	
C03	
C04	
C05	
C06	
C07	
C08	
C09	
C10	

Results

Did the case solve for all operations identified in the study conditions?

Yes/No?	

If "No," include additional details per this table:

Number of operations successfully performed before the case failed to solve:	
Number of potential operations remaining:	

What calculation method was used to solve the case?

Power flow calculation method used	

At any point, what was the highest number of iterations the solution took to solve?

Max number of iterations	

Identify any voltage criteria violations on monitored buses. Maintain a record of model bus names and numbers but do not provide in this record. In your own records, retain a mapping to the violation #s prepopulated in this record for future reference. Add additional rows and violation #s as needed. Also include a brief description of the Contingency that caused the violation. Do not use bus/line names in the description; only describe in generic terms what operated.
Example of Contingency Description: Loss of tower line 42; tower had three 230kV circuits

Violation #	Initial Voltage p.u.	Final Voltage p.u.	Delta change % (Final-Initial)/Initial *100	Description of Contingency
V1				
V2				
V3				
V4				
V5				

Identify any thermal criteria violations on monitored buses. Maintain a record of model bus names and numbers but do not provide in this record. In your own records, retain a mapping to the violation #s prepopulated in this record for future reference. Add additional rows and violation #s as needed. Also include a brief description of the Contingency that caused the violation. Do not use bus/line names in the description; only describe in generic terms what operated.

Violation #	Rating Description	Initial Rating MVA	Final Rating MVA	% Above Rating threshold	Description of Contingency
T1					
T2					
T3					
T4					
T5					

Additional Notes: Provide any additional information that you find as pertinent information to include with your results that do not fit in a table above.