Large Loads – Requirement Philosophy

Topic Change

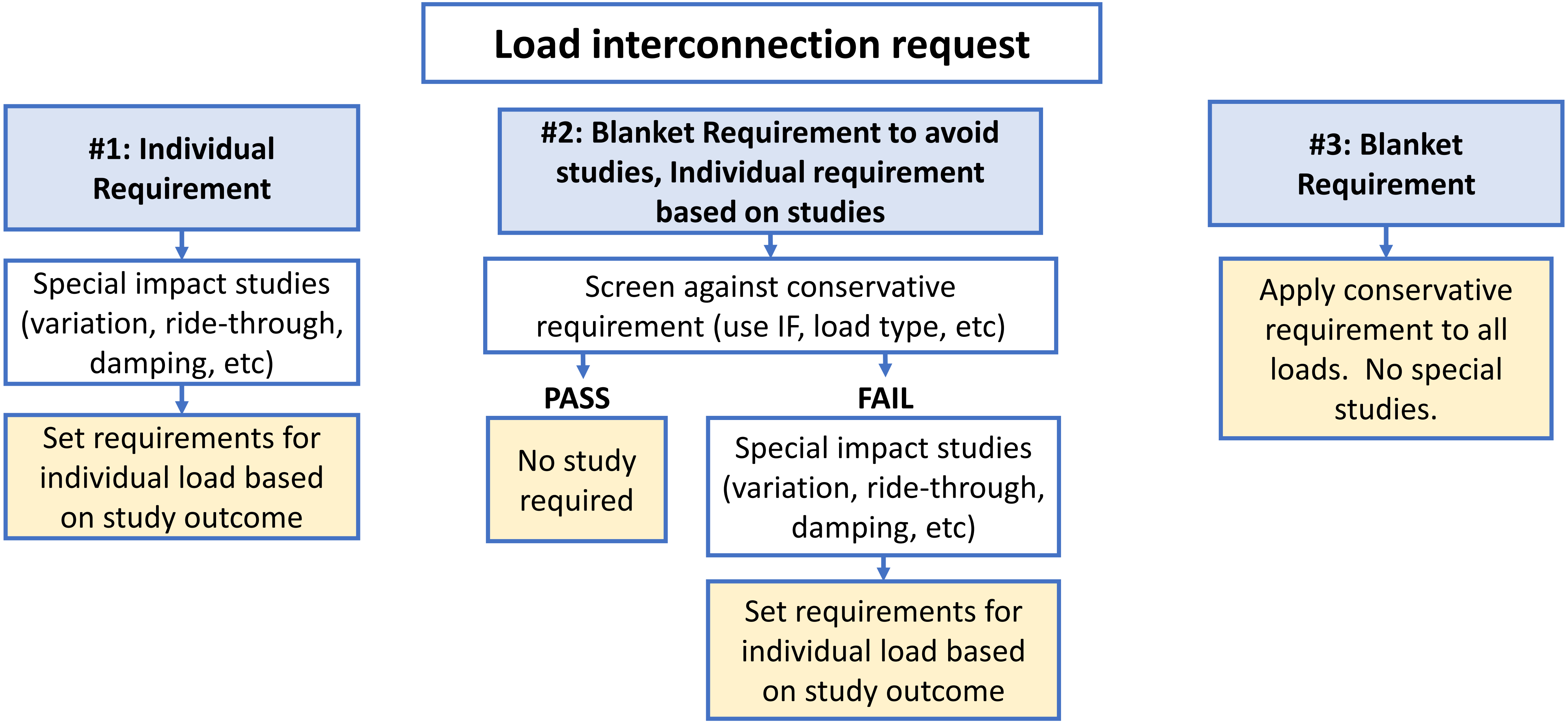
Summary of reliability risk categories

- The following are categories of risk that may drive requirements:
  - **Active power variation**
    - Synchronous generator damage
    - Flicker
    - Machine mode oscillations
    - Interarea oscillations
  - **Ride-through failure**
    - Load rejection overvoltage
    - VAR adequacy
    - Resource adequacy
  - **Passive damping**
    - SSCI instability

Also consider…

- Power factor requirements
- Modeling requirements
- Test and verification requirements
- (future) Voltage control? Frequency control? Damping?

Competing Philosophies for Requirements:



Requirement Philosophy Pros and Cons:

#1: Individual Requirement

Pros:
- Maximum load flexibility

Cons:
- Very heavy study burden
- Re-study may be needed if grid or load changes
- You may find yourself with zero margin

#2: Blanket Requirement to avoid studies, Individual requirement based on studies

Pros:
- Expedited time frames for remote projects over alternative #1

Cons:
- Study burden still heavy
- Re-evaluation may be needed if grid or load changes
- Possibility to miss issues depending on screening approach
- You may find yourself with zero margin again

#3: Blanket Requirement

Pros:
- No study required.
- Accommodates future changes to the grid

Cons:
- Possibility to over-constrain loads, which costs money and may make theoretically good projects unfeasible.
- Possibility to miss issues if requirements are set incorrectly

Some additional study challenges

- Data is **very hard** to get for load
  - Limits on load variation
  - Harmonic profiles
  - Sufficiently detailed models to quantify damping
  - Ride-through capability
- Data is **very hard or impossible** to get for synchronous machines
  - Multi-mass data
  - Physical design limits
- Studies require specialist skills (EMT experts with special training)

Framework alternatives – Active Power Variation

1. Limit harmonic/sub-harmonic content in load active power.

Pros:

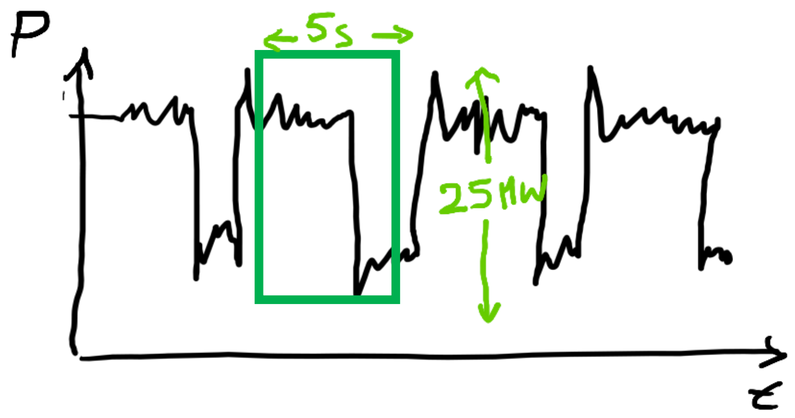
- Can target frequency ranges and limit magnitudes according to equipment limits
- Allows varied load profiles provided key frequencies aren't introduced

Cons:

- Requires very careful specification of frequency content measurement
- Requires understanding of how frequencies interplay with each other
- Requires understanding of how duration of perturbations interacts with magnitude of perturbations.
- May be more difficult to monitor and enforce, and more difficult to conceptualize.
- Data center loads may not be able to avoid certain frequencies.

Framework alternatives – Active Power Variation

2. Limit absolute variation magnitude.



Pros:

- Conceptually simple to understand
- Addresses multiple concerns
- Allows any type of load variation within the magnitude limit.

Cons:

- Hard to choose a single value that protects equipment adequately and doesn’t over-constrain load shapes.

Framework considerations – Ride through

- You can use a ride-through profile (similar to IBR FRT curves) but…
  - Does that mean no-trip or no-temporary-reduction (eg. UPS pickup)?
  - If temporary reduction is allowed, how fast should they return? 1s?
    - Note: Consider frequency, load-rejection overvoltage, dynamic voltage control, and how many loads may trip together for a common event.
  - Load rejection of multiple collocated loads could cause significant temporary overvoltage.   **How can we fix this?**
- Consider that many or maybe most loads will not be able to initially meet this criteria, particularly if you don't allow temporary reduction.

Example requirement: ATC

- Load Interconnection Guide, rev 15 – published August 22, 2025 (pages 32-35)
- ATC Planning Criteria, V25 – published August 28, 2025 (pages 34-37)
- Uses a blanket requirement, but allows studies to prove exceptions.

#2: Blanket Requirement to avoid studies, Individual requirement based on studies

- Uses absolute variation magnitude limit:

  <25 MW over any 5 second period

ATC	Criteria	Department:	System Planning
		Document No:	PLG-CR-0001-V25
Title: Transmission System Planning Criteria		Issue Date:	August 28, 2025
		Previous Date:	February 4, 2025

ATC

Load Interconnection Guide

Revision 15.0
August 22, 2025

Example Criteria: ATC (Loads >200 MW)

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9.2 Voltage Ride Through

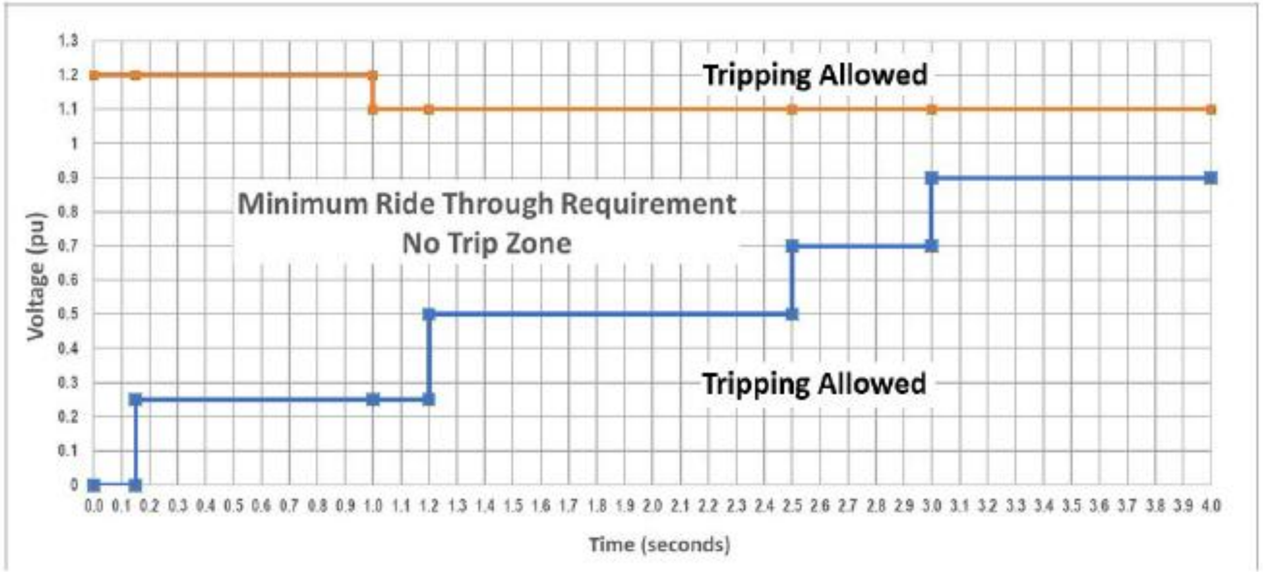


Figure 9.2-1: Voltage Ride Through Curve for Large Loads

POI Voltage (pu)	Minimum ride-through time (s)
V > 1.20	May ride-through or trip
V > 1.10	1
V > 1.05	Continuous
V < 0.90	3
V < 0.70	2.5
V < 0.5	1.2
V < 0.25	0.15

Note 1: Load must ride through 3 voltage deviation events within 10 seconds

Note 2: POI Voltage is at the connection point to the ATC transmission system. For ride-through, the relevant voltage is the lowest (in the case of undervoltage) or highest (in the case of overvoltage) magnitude fundamental frequency phasor component of the applicable voltages at the POI relative to the nominal voltage. Instantaneous phase voltages may exceed these levels.

Note 3: Load should not trip for instantaneous transients due to normal system events such as faults, energization or switching.

Example Criteria: ATC (Loads > 200 MW)

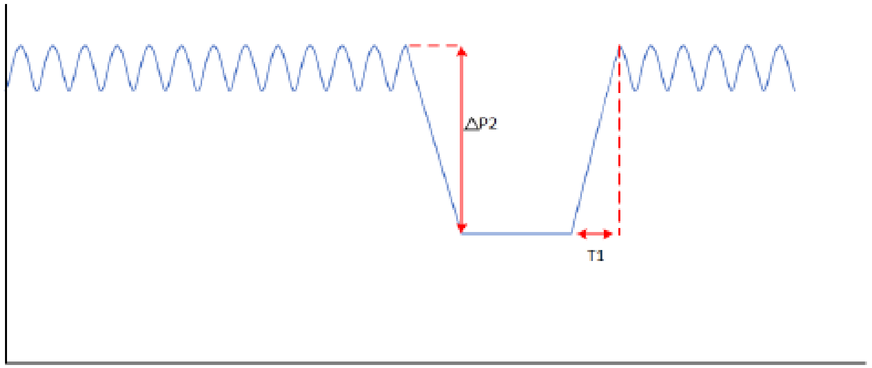
Table 9.1-1: Active Power Oscillation Criteria Limits

Constant	Limit	Unit
ΔP2	25	MW
T1	5	seconds
P3	50	MW
R2	0.5	MW/second (MW/s)

9.1 Load Active Power Oscillations & Ramp Rate Limits

Customer's equipment/facility shall be designed and operated within the maximum allowable variation limit of steady state (continuous load operation) active power oscillations as follows and as measured at the point of connection to the ATC transmission system. Note that these values are the total aggregate values for all sites at a given point of interconnection, or at multiple sites if oscillations are driven by common processes across multiple sites.

Criterion 1: Repetitive changes in load active power must be <ΔP2 for any period of time <T1 seconds calculated using a sliding time window.



Criterion 2: Any change (increase or decrease) in active power >P3 MW should be limited to <R2 MW/s.

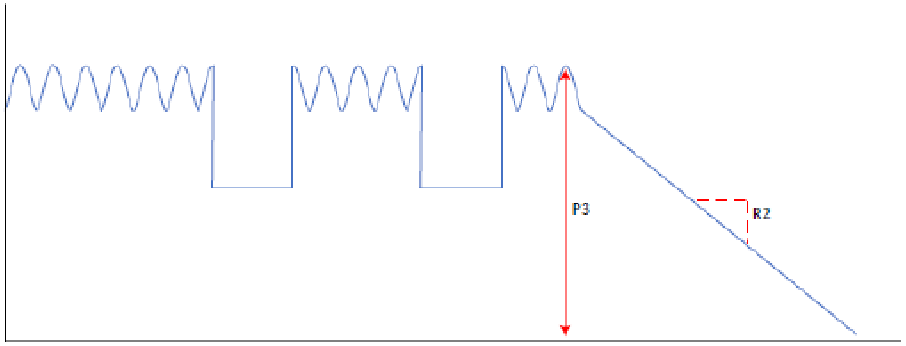


Figure 9.1-4: Active Power Criterion for P3 and R2 Example