Manual No. 029

Business Practices Manual

Minimum Project Requirements for Competitive Transmission Projects

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CONTENTS

1. Introduction

This introduction to the Midcontinent Independent System Operator, Inc. (MISO) *Business Practices Manual (BPM) for Minimum Project Requirements for Competitive Transmission Projects* includes basic information about this BPM and the other MISO BPMs. The first section (Section 1.1) of this Introduction identifies the other BPMs that are available. The second section (Section 1.2) is an introduction to this BPM. The third section (Section 1.3) identifies other documents in addition to the BPMs, which can be used by the reader as references when reading this BPM.

1.1. Purpose of MISO Business Practices Manuals

The BPMs developed by MISO provide background information, guidelines, business rules, and processes established by MISO for the operation and administration of the MISO markets, provisions of transmission reliability services, and compliance with the MISO settlements, billing, and accounting requirements. A complete list of MISO BPMs is available for reference through MISO's website. All definitions in this document are as provided in the MISO Tariff, the NERC Glossary of Terms Used in Reliability Standards, or are as defined by this document.

1.2. Purpose of this Business Practices Manual

The purpose of this BPM is to ensure the Competitive Transmission Facilities are adequate, prudent, and robust from an operational and planning standpoint. Therefore, this BPM describes MISO's process for developing minimum load ratings, minimum short-circuit interrupting ratings, substation bus configuration constraints, and high-level minimum protection system requirements for Competitive Transmission Projects. These minimum requirements are then incorporated, as applicable, into each Request for Proposal posted for each Competitive Transmission Project. When included in a Request for Proposal, these minimum project requirements shall apply only to the Competitive Transmission Facilities (facilities subject to the Competitive Transmission Process) specified within the Request for Proposal.

It is important to emphasize that this BPM is not an engineering specification, engineering design document, or engineering calculation document for a specific facility. Development, oversight, and approval of final engineering specifications, designs, engineering calculations, and other engineering documents for specific facilities is the sole responsibility of the Selected Developer. Furthermore, this document does not waive, supersede, override, or otherwise take the place of any applicable federal, state, or local laws, regulations, or codes (including the National Electrical Safety Code) governing the engineering, design, construction, and maintenance of electric transmission facilities; applicable industry standards regarding electric transmission facilities; or Good Utility Practice as defined in the MISO Tariff.

It is expected that Selected Developers will consider all applicable ANSI, IEEE, CIGRE, ASCE, ASME, and ASTM standards in the engineering, design, material selection, equipment selection, construction, and commissioning of Competitive Transmission Facilities. To the extent that compliance with such standards is required by applicable laws and regulations, then such standards are mandatory. To the extent that compliance with such standards is voluntary only and not required by applicable laws and regulations, then the Selected Developer may, at their discretion, disclose in their Proposals if and when their Proposal will not comply, on a substantive basis, with one or more specific standards, an explanation as to why their Proposal is not complying with such standards, and a statement that non-compliance with such standards will not result in any significant adverse impacts that would be avoided by full and complete compliance with the standards so that MISO can consider such information during the evaluation process.

1.3. References

Other reference information related to this BPM includes:

- MISO Open Access Transmission, Energy and Operating Reserve Markets Tariff (Tariff)
- Agreement of the Transmission Facilities Owners to Organize The Midcontinent Independent Transmission System Operator, Inc., a Delaware Non-Stock Corporation (Transmission Owners Agreement)
- BPM-020 Transmission Planning
- BPM-027 Competitive Transmission Process
- NERC Reliability Standards applicable to transmission planning

1.4. MISO Planning Contacts

For information on MISO planning staff contact details for minimum project requirements associated with Competitive Transmission Facilities, contact Client Services and Readiness:

https://www.misoenergy.org/engage/client-services/

2. Definitions

2.1. Absolute Transmission Circuit Limit

An MVA loading limit above which a Transmission Circuit cannot be loaded for any period of time. This limit is the lesser of i) the Relay Trip Load Level and, ii) the Maximum Power Transfer Limit. This limit is an upper bound on all other Transmission Circuit ratings.

2.2. Adequacy Validation Rating

A summer or winter MVA or ampere load rating calculated for a Transmission Circuit Conductor associated with a Competitive Transmission Line Facility based on a MISO specified methodology. This rating is calculated to verify that the actual Transmission Circuit Conductor specified by the Selected Developer provides adequate load capacity in accordance with Good Utility Practice based on a common facility rating methodology.

2.3. Circuit Breaker Assembly

Applicable to circuit breakers in a ring bus, breaker-and-a-half bus, and double-breaker bus configuration. Consists of a circuit breaker and all conductor and load carrying equipment electrically in series with the circuit breaker (where "in series" means it carries the same current level as the circuit breaker or a current level proportional to the current level carried by the circuit breaker). The following are substation load carrying elements typically in series with a Circuit Breaker:

- Bus Conductor
- Jumper Conductor
- Lead Conductor
- Connectors
- Disconnect Switches
- Circuit Breaker Bushings
- Current Transformers (bushing or standalone)
- Current Transformer Secondary Elements (only elements that monitor circuit breaker flows):
    - Breaker Failure Relay Overcurrent Fault Detectors
    - Breaker Ammeters
    - Breaker Current Transducers

2.4. Emergency Conditions

One of two operating states where i) at least one normally energized Transmission Element is forced out-of-service, ii) at least one Generation Element and/or switchable Transmission Element (e.g., shunt capacitor bank, series capacitor bypass breaker, etc.) is needed but is unavailable due to an unplanned outage, and/or iii) the system is otherwise configured in an abnormal state due to an unplanned event (e.g., a normally closed breaker is open, a normally open breaker is closed, etc.).

2.5. Fault Level Design Margin

A multiplying factor between 110% and 125%, determined pursuant to Section 4.2.7 of this BPM, that is used to ensure the Minimum Short-circuit Current Design Level specified for Transmission System Buses at Competitive Substation Facilities is sufficient to account for system growth that could potentially result in increased maximum available fault current at one or more specific Transmission System Buses over time.

2.6. Generation Element

One or more generating units, associated generator step-up transformers, associated generator lead lines, and, if applicable, associated generator collector systems (e.g., wind farm collector system, etc.) that ultimately interconnect to the Transmission System via a single terminal at the interconnecting transmission substation.

2.7. Maximum Allowable Emergency Operating Temperature

The maximum temperature allowed for an overhead Transmission Circuit Conductor during Emergency Conditions. This temperature is less than or equal to the Maximum Conductor Sag Temperature and greater than or equal to the Maximum Allowable Normal Operating Temperature. The degree to which this temperature exceeds the Maximum Allowable Normal Operating Temperature is a function of the amount of risk the asset owner is willing to assume with regard to the accelerated loss of tensile strength and/or accelerated creep elongation that may occur when operation above the Maximum Allowable Normal Operating Temperatures is permitted during Emergency Conditions.

2.8. Maximum Allowable Normal Operating Temperature

The maximum temperature allowed for an overhead Transmission Circuit Conductor under Normal Conditions that ensures continuous operation at this temperature will not reduce the expected life span of the conductor via accelerated loss of tensile strength or accelerated creep elongation. This temperature is less than or equal to the Maximum Conductor Sag Temperature and the Maximum Allowable Emergency Operating Temperature.

2.9. Maximum Conductor Sag Temperature

The maximum temperature allowed for an overhead Transmission Circuit Conductor to ensure applicable state code, local code, and National Electrical Safety Code (NESC) clearance requirements are satisfied when operating at this temperature.

2.10. Maximum Power Transfer Limit

The maximum amount of electrical power that can be theoretically transferred across a specific Transmission Circuit given the Transmission Circuit series reactance and assuming the sending-end and receiving-end voltage magnitudes are equal to the nominal operating voltage level. This transfer level occurs at an angular displacement of 90 degrees between the sending-end and receiving-end terminal voltages and cannot be exceeded.

2.11. Minimum Short-circuit Current Design Level

The floor specified in the RFP for the maximum available three-phase symmetrical short-circuit fault current at each Transmission System Bus associated with a Competitive Substation Facility. The Selected Developer should prepare Competitive Proposals such that Transmission System Buses at Competitive Substation Facilities are designed for the Minimum Short-circuit Current Design Level including: i) circuit breaker interrupting ratings, ii) momentary and short-term current ratings for switchgear and other load carrying equipment at the bus, iii) ground grid design and iv) structural design of buses including, but not limited to, bus conductors, supporting insulators and support structures. This floor represents an absolute design minimum, and does not supersede any standard, law, regulatory requirement or Good Utility Practice that would necessitate a higher short-circuit current design level.

At the time of RFP generation, MISO will consult with the applicable interconnection Transmission Owner(s) to discuss the RFP specified minimum short circuit design requirements and any local system stability concerns. Preliminary studies may indicate the need for MISO to specify independent pole operation capability and clearing time capabilities for circuit breakers in the RFP.

2.12. Normal Conditions

One of two operating states where all Transmission Elements and Generation Elements are operated in their normal configuration or otherwise available if needed. Elements in an abnormal state due to an approved planned outage or to support the current state of the system (e.g., capacitor bank switched off-line under light load conditions, etc.) will also be considered Normal Conditions.

2.13. Relay Trip Load Level

The minimum MVA load level at a Transmission Circuit terminal that is necessary to cause a relay trip of the Transmission Circuit terminal. A Relay Trip Load Level applies only when a line trip does not require the pickup of a non-load responsive relay element. Determination of the Relay Trip Load Level is based on the type of limiting load responsive relay element, the relay settings and instrument transformer ratios, and other criteria typically outlined in NERC PRC-023 (i.e., maximum and minimum load flow angles of ±30° respectively and a terminal voltage of 0.95 per unit if the load responsive relay element is an impedance relay element, as well as required setting margins of 15% to account for relay operating tolerances due to possible instrument transformer error and potential relay setting error and/or drift).

2.14. Series Compensation Device

A series capacitor, series reactor, or similar series FACTs device connected between two Transmission System Buses, a Transmission System Bus and a Transmission Circuit terminal, or a Transmission System Bus and a Transmission Transformer terminal, and used generally to alter the impedance of a Transmission Circuit or Transmission Transformer, control the flow of power on the transmission system, and/or control the available fault current level on the transmission system.

2.15. Shunt Compensation Device

A shunt capacitor bank, shunt reactor bank, static VAR compensator (SVC), static synchronous compensator (STATCOM), synchronous condenser, or other shunt device installed for the purpose of controlling voltage and power factor via injecting or withdrawing reactive power into and out of the transmission system. Additionally, a Storage As Transmission-Only Asset (SATOA) could be installed as a shunt compensation device to resolve a Transmission Issue identified in MTEP.

2.16. Substation Terminal Equipment

All load carrying equipment within a substation that is in series with a two-terminal Transmission Circuit, one leg of a three-terminal Transmission Circuit, a Transmission Transformer winding, or a Generation Element that terminates at the substation (where "in series" means it carries the same current level as the Transmission Circuit, Transmission Circuit leg, Transmission Transformer Winding, or Generation Element or a current level proportional to the current level carried by the Transmission Circuit, Transmission Circuit leg, Transmission Transformer winding, or Generation element). Non-conductor terminal equipment should be based on continuous current nameplate ratings. The following are substation load carrying elements typically in series with a Transmission Circuit, Transmission Transformer winding, or Generation Element:

- Bus Conductor
- Riser Conductor
- Jumper Conductor
- First Span Conductor
- Connectors
- Line, Transformer or Generator Switches
- Wave Traps
- Circuit Breakers (if straight bus configuration)
- Circuit Breaker Disconnect Switches (if straight bus configuration)
- Circuit Breaker Leads (if straight bus configuration)
- Circuit Breaker Bushings (if straight bus configuration)
- Circuit Breaker Current Transformers (if straight bus configuration)
- Standalone Current Transformers
- Current Transformer Secondary Elements (only elements that monitor Transmission Circuit, Transmission Transformer winding, or Generation Element flows and are not connected to monitor the residual zero sequence flow of all three current transformers):
    - Line, Transformer or Generator Phase Protective Relay Elements
    - Line, Transformer or Generator Ammeters
    - Other Line, Transformer or Generator Flow Meters
    - Line, Transformer or Generator Current Transducers

2.17. Substation Terminal Equipment Ampere Rating

Applies to each substation terminal of a two terminal Transmission Circuit, the connected substation terminal of a specific three-terminal Transmission Circuit leg, the terminal of a Transmission Transformer winding, or the substation terminal of a Generation Element and is equal to the lowest ampere rating of all Substation Terminal Equipment associated with (i.e., in series with) a specific Transmission Circuit, Transmission Circuit leg, Transmission Transformer winding, or Generation Element.

2.18. Summer Emergency Ampere Rating

Applies to a two-terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the lesser of the i) maximum amount of electrical current, expressed in amperes, that can be carried by each Transmission Circuit Conductor on a steady-state basis under summer ambient conditions without exceeding the Maximum Allowable Emergency Operating Temperature, ii) lowest nameplate continuous current rating for all Transmission Circuit Switching Devices installed on the Transmission Circuit (or leg), or iii) the lowest Substation Terminal Equipment Ampere Rating for any substation terminal associated with the Transmission Circuit (or leg).

2.19. Summer Emergency MVA Rating

Applies to a two terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the lesser of i) the Summer Emergency Thermal MVA Rating or ii) the Voltage and Stability Loadability Rating, if applicable.

2.20. Summer Emergency Thermal MVA Rating

Applies to a two terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the MVA that is transferred when i) the voltages are balanced, ii) the voltage magnitudes are equal to the nominal operating voltage level, iii) the phase currents are balanced, and iv) the phase current magnitudes are equal to the Summer Emergency Ampere Rating.

2.21. Summer Normal Ampere Rating

Applies to a two-terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the lesser of the i) maximum amount of electrical current, expressed in amperes, that can be carried by each Transmission Circuit Conductor on a steady-state basis under summer ambient conditions without exceeding the Maximum Allowable Normal Operating Temperature, ii) lowest nameplate continuous current rating for all Transmission Circuit Switching Devices installed on the Transmission Circuit (or leg), or iii) the lowest Substation Terminal Equipment Ampere Rating for any substation terminal associated with the Transmission Circuit (or leg).

2.22. Summer Normal MVA Rating

Applies to a two terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the lesser of i) the Summer Normal Thermal MVA Rating or ii) the Voltage and Stability Loadability Rating, if applicable.

2.23. Summer Normal Thermal MVA Rating

Applies to a two terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the MVA that is transferred when i) the voltages are balanced, ii) the voltage magnitudes are equal to the nominal operating voltage level, iii) the phase currents are balanced, and iv) the phase current magnitudes are equal to the Summer Normal Ampere Rating.

2.24. Terminal Equipment Rating Class

An industry standard continuous current rating that applies to substation equipment such as circuit breakers, switches, wave traps, current transformer primaries, and other similar equipment. Several terminal equipment rating classes are available for various voltage levels. Table 1 in Appendix A is a summary of the most common Terminal Equipment Rating Classes currently used in North America and the Terminal Equipment Rating Classes to be used by MISO in determining minimum project requirements.

2.25. Transmission Circuit

An AC three-phase electrical circuit operating at a transmission voltage level and containing two or more substation terminals that is used to transfer electrical energy between the terminating substations and is associated with a single zone of protection within the transmission system.

2.26. Transmission Circuit Conductor

The conductor or set of bundled or paralleled conductors associated with any one of the three phases of a Transmission Circuit that is used to transport electrical energy between the terminals of the Transmission Circuit.

2.27. Transmission Circuit Switching Device

A non-fault interrupting switch in series with the Transmission Circuit Conductors, located external to a substation, and typically mounted on a transmission structure.

2.28. Transmission Element

A Transmission Circuit, Transmission Physical Bus, Transmission Transformer, Series Compensation Device, Shunt Compensation Device, transmission bus-tie breaker, or HVDC converter.

2.29. Transmission Line Facility

One or more Transmission Circuits and associated facilities (right-of-way, structures, conductors, shield wires, insulators, and hardware) extending from one location to another, where such locations could be substation terminals or other points. A Transmission Line Facility can contain multiple Transmission Circuits (i.e., several Transmission Circuits can be carried on common structures) and a Transmission Circuit can be installed on multiple Transmission Line Facilities (i.e., several single and multi-circuit Transmission Line Facilities can carry the same Transmission Circuit).

2.30. Transmission Physical Bus

A physical bus made up of conductors operating at a transmission voltage level and located within a substation for the purpose of physically interconnecting the terminals of three or more Transmission Elements and/or Generation Elements directly. A Transmission Physical Bus is associated with only one zone of protection. Examples of Transmission Physical Buses are single-zone straight buses or one of the two main buses in a breaker-and-a-half or double-breaker bus configuration. A Transmission Physical Bus is always part of a Transmission System Bus and sometimes may correspond to an entire Transmission System Bus.

2.31. Transmission System Bus

An electrical hub made up of one or more elements located within a substation for the purpose of interconnecting the terminals of three or more Transmission Elements and/or Generation Elements directly or through zero impedance devices. A Transmission System Bus may span multiple zones of protection. Examples of Transmission System Buses are straight buses, multiple straight buses interconnected by normally closed tie breakers, ring buses, breaker-and-a-half buses, and double breaker buses. A Transmission System Bus may or may not include one or more Transmission Physical Buses.

2.32. Transmission Transformer

A multi winding power transformer, autotransformer, voltage regulating transformer, or phase angle regulating transformer connected between at least two or more Transmission System Buses or between a Transmission System Bus and a Transmission Circuit terminal, Series Compensation Device terminal, Shunt Compensation Device terminal, or HVDC Converter terminal. Generator step-up transformers, station service transformers, station auxiliary transformers, transformers serving the distribution system, and transformers serving transmission level end-use load are not defined as Transmission Transformers.

2.33. Voltage and Stability Loadability Rating

A maximum MW rating for a Transmission Circuit based on voltage and stability considerations rather than conductor thermal loading considerations. This rating defaults to the Absolute Transmission Circuit Limit, which is an upper bound on this rating, unless there are special circumstances where planning studies determine a lower rating for specific facilities is appropriate.

2.34. Winter Emergency Ampere Rating

Applies to a two-terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the lesser of the i) maximum amount of electrical current, expressed in amperes, that can be carried by each Transmission Circuit Conductor on a steady-state basis under winter ambient conditions without exceeding the Maximum Allowable Emergency Operating Temperature, ii) lowest nameplate continuous current rating for all Transmission Circuit Switching Devices installed on the Transmission Circuit (or leg), or iii) the lowest Substation Terminal Equipment Ampere Rating for any substation terminal associated with the Transmission Circuit (or leg).

2.35. Winter Emergency MVA Rating

Applies to a two terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the lesser of i) the Winter Emergency Thermal MVA Rating or ii) the Voltage and Stability Loadability Rating, if applicable.

2.36. Winter Emergency Thermal MVA Rating

Applies to a two terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the MVA that is transferred when i) the voltages are balanced, ii) the voltage magnitudes are equal to the nominal operating voltage level, iii) the phase currents are balanced, and iv) the phase current magnitudes are equal to the Winter Emergency Ampere Rating.

2.37. Winter Normal Ampere Rating

Applies to a two-terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the lesser of the i) maximum amount of electrical current, expressed in amperes, that can be carried by each Transmission Circuit Conductor on a steady-state basis under winter ambient conditions without exceeding the Maximum Allowable Normal Operating Temperature, ii) lowest nameplate continuous current rating for all Transmission Circuit Switching Devices installed on the Transmission Circuit (or leg), or iii) the lowest Substation Terminal Equipment Ampere Rating for any substation terminal associated with the Transmission Circuit (or leg).

2.38. Winter Normal MVA Rating

Applies to a two terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the lesser of i) the Winter Normal Thermal MVA Rating or ii) the Voltage and Stability Loadability Rating, if applicable.

2.39. Winter Normal Thermal MVA Rating

Applies to a two terminal Transmission Circuit or to each leg of a three-terminal Transmission Circuit and is equal to the MVA that is transferred when i) the voltages are balanced, ii) the voltage magnitudes are equal to the nominal operating voltage level, iii) the phase currents are balanced, and iv) the phase current magnitudes are equal to the Winter Normal Ampere Rating.

3. Competitive Transmission Line Facilities

This section discusses the minimum project requirements applicable to Competitive Transmission Line Facilities.

3.1. Request for Proposal Specifications

Listed below are the minimum Request for Proposal specifications for Competitive Transmission Line Facilities which will be included in all Request for Proposals and additional Request for Proposal specifications for Competitive Transmission Line Facilities which may be included in some Request for Proposals depending on specific circumstances.

3.1.1. Minimum Request for Proposal Specifications

The Request for Proposal (RFP) shall always specify the following requirements for each new Transmission Circuit associated with a Competitive Transmission Line Facility:

- Nominal Operating kV
- Terminal Locations (Substation and Transmission System Bus)
- Minimum Summer Emergency Ampere Rating
- Minimum Summer Emergency MVA Rating
- Minimum Winter Emergency Ampere Rating
- Minimum Winter Emergency MVA Rating
- Minimum Summer Normal Ampere Rating
- Minimum Summer Normal MVA Rating
- Minimum Winter Normal Ampere Rating
- Minimum Winter Normal MVA Rating

3.1.2. Additional Request for Proposal Specifications

A Request for Proposal (RFP) may specify the following additional information for each new Transmission Circuit associated with a Competitive Transmission Line Facility when determined appropriate based on specific circumstances:

- Maximum Positive Sequence Impedance for Transmission Circuits.
  This parameter will typically be specified under one of the following two scenarios only:
  - Transmission Circuits where planning reliability analyses determines that potential voltage or stability issues are possible based on excessive length of the circuit relative to the operating voltage and/or the strength of the system at the terminals and thus a maximum impedance constraint is required for the Transmission Circuit.
  - Transmission Circuits where a maximum impedance constraint is necessary to ensure the project performs as expected with regard to congestion relief.
- Fiber Optic Communications Channels
  The use of overhead fiber optic shield wires (OPGW) for communications assisted protection schemes will be specified if required by the interconnecting incumbent Transmission Owners that own the substation terminals. Specifications will include the number of physical channels and the number of fiber optic pairs per physical channel.

3.2. Methods for Determining Minimum Project Requirements of Competitive Transmission Line Facilities

This subsection describes the methods that will be used by MISO staff to determine the minimum load ratings and other minimum project requirements applicable to Competitive Transmission Line Facilities. When analyzing potential Competitive Transmission Projects, the MISO planning groups will use this BPM to establish Transmission Circuit ratings within the applicable planning models. Should potential Competitive Transmission Projects be recommended in MTEP, then upon approval of MTEP, the Request for Proposal will specify minimum Transmission Circuit ratings established within the planning process in accordance with this BPM.

3.2.1. Minimum Transmission Circuit Emergency Load Ratings

Minimum emergency load ratings will be determined by MISO for each Transmission Circuit associated with a Competitive Transmission Line Facility for both the summer and winter seasons.

3.2.1.1. Minimum Transmission Circuit Emergency Ampere Ratings

The minimum Transmission Circuit emergency ampere ratings will be determined by MISO as follows:

- Scenario 1: Single Interconnecting Transmission Owner
  If the new Transmission Circuit is connected to a single incumbent Transmission Owner system at all terminals and the incumbent Transmission Owner has a single standard emergency ampere rating for newly constructed Transmission Circuits at the applicable voltage level, then the minimum emergency ampere rating will be set equal to the Transmission Owner's standard emergency ampere rating.

  If the new Transmission Circuit is connected to a single incumbent Transmission Owner system at all terminals and the incumbent Transmission Owner has multiple standard emergency ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum emergency ampere rating will be set equal to the greater of i) the Transmission Owner's lowest standard emergency ampere rating and ii) the minimum emergency ampere rating listed in Table 2A of Appendix A for the applicable voltage level.

  If the new Transmission Circuit is connected to a single incumbent Transmission Owner system at all terminals and the incumbent Transmission Owner has no standard emergency ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum emergency ampere rating will be set equal to the minimum emergency ampere rating listed in Table 2A of Appendix A for the applicable voltage level.

  Should the Transmission Owner have one or more standard emergency MVA rating levels for newly constructed Transmission Circuits at the applicable voltage level but no standard emergency ampere ratings, MISO will infer standard emergency ampere ratings based on the following formula:

Inferred Standard Emergency Ampere Rating

*= (Standard Emergency MVA Rating * 1000)*

*/ (Nominal kV * $3^{1/2}$)* *(1)*

It is important to note that MISO reserves the right to specify a higher minimum emergency ampere rating than what would be determined by the procedure above if a higher minimum emergency ampere rating is necessary to ensure the project adequately addresses the Transmission Issues that drive the justification of the project.

- Scenario 2: Multiple Interconnecting Transmission Owners

  If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems and each of the incumbent Transmission Owners have a single standard emergency ampere rating for newly constructed Transmission Circuits at the applicable voltage level, then the minimum emergency ampere rating will be set equal to the greatest of the individual Transmission Owner's standard emergency ampere ratings.

  If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems, designated as TO System A and TO System B, and TO System A has a single standard emergency ampere rating for newly constructed Transmission Circuits at the applicable voltage level while TO System B has multiple standard emergency ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum emergency ampere rating will be set equal to the greater of i) the standard emergency ampere rating for the applicable voltage level for TO System A , ii) the lowest standard emergency ampere rating for the applicable voltage level for TO System B, and iii) the minimum emergency ampere rating listed in Table 2A of Appendix A for the applicable voltage level.

  If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems, designated as TO System A and TO System B, and each of the Transmission Owners have multiple standard emergency ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum emergency ampere rating will be set equal to the greater of i) the lowest standard minimum emergency ampere rating for TO System A for the applicable voltage level, ii) the lowest standard minimum emergency ampere rating for TO System B for the applicable voltage level, and iii) the minimum emergency ampere rating listed in Table 2A of Appendix A for the applicable voltage level.

  If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems, designated as TO System A and TO System B, and TO System A has a single standard emergency ampere ratings for newly constructed Transmission Circuits at the applicable voltage level while TO System B has no standard emergency ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum emergency ampere rating will be set equal to the greater of i) the standard minimum emergency ampere rating for TO System A for the applicable voltage level and ii) the minimum emergency ampere rating listed in Table 2A of Appendix A for the applicable voltage level.

If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems, designated as TO System A and TO System B, and TO System A has multiple standard emergency ampere ratings for newly constructed Transmission Circuits at the applicable voltage level while TO System B has no standard emergency ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum emergency ampere rating will be set equal to the greater of i) the lowest standard minimum emergency ampere rating for TO System A for the applicable voltage level and ii) the minimum emergency ampere rating listed in Table 2A of Appendix A for the applicable voltage level.

If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems and neither of the incumbent Transmission Owners have standard emergency ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum emergency ampere rating will be set equal to the minimum emergency ampere rating listed in Table 2A of Appendix A for the applicable voltage level.

Should either or both of the Transmission Owners have one or more standard emergency MVA rating levels for newly constructed Transmission Circuits at the applicable voltage level but no standard emergency ampere ratings, MISO will infer standard emergency ampere ratings based on the formula represented by equation (1) above.

It is important to note that MISO reserves the right to specify a higher minimum emergency ampere rating than the rating that would be determined by the procedure above if a higher minimum emergency ampere rating is necessary to ensure the project adequately addresses the Transmission Issues that drive the justification of the project. In addition, should a proposed Transmission Circuit interconnect with a non-MISO transmission owner at one or more terminals, the process described above for considering MISO Transmission standards in determining minimum emergency ratings shall also consider non-MISO transmission owner standards on a comparable basis.

3.2.1.2. Minimum Transmission Circuit Emergency Thermal MVA Rating Requirements

The minimum Transmission Circuit emergency thermal MVA ratings will be determined by MISO using the following formulae:

$$SETMVA' = (NOKV * SEAR' * 3^{1/2}) / 1000 \qquad (2)$$

where

SETMVA' = Minimum Summer Emergency Thermal MVA Rating

NOKV = Nominal Operating kV ($\phi\phi$)

SEAR' = Minimum Summer Emergency Ampere Rating

$WETMVA' = (NOKV * WEAR' * 3^{1/2}) / 1000$ (3)

where

WETMVA' = Minimum Winter Emergency Thermal MVA Rating

WEAR' = Minimum Winter Emergency Ampere Rating

3.2.1.3. Minimum Transmission Circuit Emergency MVA Rating Requirements

The minimum Transmission Circuit emergency MVA ratings will be determined by MISO as the lesser of the emergency thermal MVA ratings and the Voltage and Stability Loadability Rating. The Voltage and Stability Loadability Rating will default to the Absolute Transmission Circuit Limit unless planning studies determine that a lower rating is appropriate for the Transmission Circuit to ensure reliability and stability.[1] In determining the Absolute Transmission Circuit Limit, MISO will calculate it as equal to the estimated Maximum Power Transfer Limit since the Relay Trip Load Level will not yet be known[2]. The estimated Maximum Power Transfer Limit will be determined by MISO as follows based on a worst case sending-end and receiving-end voltage magnitude of 0.95 per unit, an angular displacement of 90°, and the estimated positive sequence reactance used to model the Transmission Circuit in the power flow and production costs models:

$$MPTL^{*} = 0.9025 * NOMKV^{2} / X_{1}LINE^{*} \quad (4)$$

where

$MPTL^{*}$ = *Estimated Maximum Power Transfer Limit (MW)*

$X_{1}LINE^{*}$ = *Estimated Positive Sequence Line Reactance* (Ω)[3]

The Absolute Transmission Circuit Limit will be set equal to the estimated Maximum Power Transfer Limit and the Voltage & Stability Loadability Rating will be set equal to the lesser of the Absolute Transmission Circuit Limit and any voltage and stability limit identified in the planning process. These calculations are summarized by equations (5) and (6) as follows:

[1] It is important to note that voltage and stability loadability limits are often applied to interfaces rather than individual Transmission Circuits, and if planning studies determine that such a rating should be applied to an interface as a result of the project rather than to the Transmission Circuit in question, the Voltage and Stability Loadability Rating for the Transmission Circuit will default to the Absolute Transmission Circuit Limit.

[2] This requires the substation terminal owners, who have the responsibility to protect the Transmission Circuit, to design a protection system that is compliant with PRC-023-4 based on the minimum emergency load ratings specified in the Request for Proposal. This may necessitate the use of schemes other than the substation owner's standard schemes, such as schemes with non-load responsive relay elements or load encroachment features.

[3] In cases where MISO specifies a maximum positive sequence reactance in the Request for Proposal for the Transmission Circuit in question, this value will be set equal to the specified maximum reactance.

*ATCL = MPTL** (5)

where

ATCL = Absolute Transmission Circuit Limit

VSLR = Minimum {ATCL, PIVSL} (6)

where

VSLR = Voltage & Stability Loadability Rating

PIVSL = Planning Identified Voltage and Stability Limit

NOTE: VSLR = ATCL if there is no PIVSL

The seasonal minimum emergency MVA ratings will be set equal to the minimum of the appropriate seasonal minimum emergency thermal MVA ratings and the Voltage & Stability Loadability Rating as illustrated in equations (7) and (8) below:

SEMVA' = Minimum {SETMVA', VSLR} (7)

where

SEMVA' = Minimum Summer Emergency MVA Rating

WEMVA' = Minimum {WETMVA', VSLR} (8)

where

WEMVA' = Minimum Winter Emergency MVA Rating

3.2.2. Minimum Transmission Circuit Normal Load Ratings

Minimum normal load ratings will be determined by MISO for each Transmission Circuit associated with a Competitive Transmission Line Facility for both the summer and winter seasons.

3.2.2.1. Minimum Transmission Circuit Normal Ampere Ratings

The minimum Transmission Circuit normal ampere ratings will be determined by MISO as follows:

- Scenario 1: Single Interconnecting Transmission Owner

If the new Transmission Circuit is connected to a single incumbent Transmission Owner system at all terminals and the incumbent Transmission Owner has a single standard normal ampere rating for newly constructed Transmission Circuits at the applicable voltage level, then the minimum normal ampere rating will be set equal to the Transmission Owner's standard normal ampere rating.

If the new Transmission Circuit is connected to a single incumbent Transmission Owner system at all terminals and the incumbent Transmission Owner has multiple standard normal ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum normal ampere rating will be set equal to the greater of i) the Transmission Owner's lowest standard normal ampere rating and ii) the minimum normal ampere rating listed in Table 2B of Appendix A for the applicable voltage level.

If the new Transmission Circuit is connected to a single incumbent Transmission Owner system at all terminals and the incumbent Transmission Owner has no standard normal ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum normal ampere rating will be set equal to the minimum normal ampere rating listed in Table 2B of Appendix A for the applicable voltage level.

Should the Transmission Owner have one or more standard normal MVA rating levels for newly constructed Transmission Circuits at the applicable voltage level but no standard normal ampere ratings, MISO will infer standard normal ampere ratings based on the following formula:

$$\textit{Inferred Standard Normal Ampere Rating} = (\textit{Standard Normal MVA Rating} * 1000) / (\textit{Nominal kV} * 3^{1/2}) \qquad (9)$$

It is important to note that MISO reserves the right to specify a higher minimum normal ampere rating than what would be determined by the procedure above if a higher minimum normal ampere rating is necessary to ensure the project adequately addresses the Transmission Issues that drive the justification of the project.

- Scenario 2: Multiple Interconnecting Transmission Owners

If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems and each of the incumbent Transmission Owners have a single standard normal ampere rating for newly constructed Transmission Circuits at the applicable voltage level, then the minimum normal ampere rating will be set equal to the greatest of the individual Transmission Owner's standard normal ampere ratings.

If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems, designated as TO System A and TO System B, and TO System A has a single standard normal ampere rating for newly constructed Transmission Circuits at the applicable voltage level while TO System B has multiple standard normal ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum normal ampere rating will be set equal to the greater of i) the standard normal ampere rating for the applicable voltage level for TO System A , ii) the lowest standard normal ampere rating for the applicable voltage level for TO System B, and iii) the minimum normal ampere rating listed in Table 2B of Appendix A for the applicable voltage level.

If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems, designated as TO System A and TO System B, and each of the Transmission Owners have multiple standard normal ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum normal ampere rating will be set equal to the greater of i) the lowest standard minimum normal ampere rating for TO System A for the applicable voltage level, ii) the lowest standard minimum normal ampere rating for TO System B for the applicable voltage level, and iii) the minimum normal ampere rating listed in Table 2B of Appendix A for the applicable voltage level.

If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems, designated as TO System A and TO System B, and TO System A has a single standard normal ampere ratings for newly constructed Transmission Circuits at the applicable voltage level while TO System B has no standard normal ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum normal ampere rating will be set equal to the greater of i) the standard minimum normal ampere rating for TO System A for the applicable voltage level and ii) the minimum normal ampere rating listed in Table 2B of Appendix A for the applicable voltage level.

If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems, designated as TO System A and TO System B, and TO System A has multiple standard normal ampere ratings for newly constructed Transmission Circuits at the applicable voltage level while TO System B has no standard normal ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum normal ampere rating will be set equal to the greater of i) the lowest standard minimum normal ampere rating for TO System A for the applicable voltage level and ii) the minimum normal ampere rating listed in Table 2B of Appendix A for the applicable voltage level.

If the new Transmission Circuit is connected between two different incumbent Transmission Owner systems and neither of the incumbent Transmission Owners have standard normal ampere ratings for newly constructed Transmission Circuits at the applicable voltage level, then the minimum normal ampere rating will be set equal to the minimum normal ampere rating listed in Table 2B of Appendix A for the applicable voltage level.

Should either or both of the Transmission Owners have one or more standard normal MVA rating levels for newly constructed Transmission Circuits at the applicable voltage level but no standard normal ampere ratings, MISO will infer standard normal ampere ratings based on the formula represented by equation (9) above.

It is important to note that MISO reserves the right to specify a higher minimum normal ampere rating than the rating that would be determined by the procedure above if a higher minimum normal ampere rating is necessary to ensure the project adequately addresses the Transmission Issues that drive the justification of the project. In addition, should a proposed Transmission Circuit interconnect with a non-MISO transmission owner at one or more terminals, the process described above for considering MISO Transmission Standards in determining minimum normal ratings shall also consider non-MISO transmission owner standards on a comparable basis

In no case should the minimum normal ampere rating exceed the minimum emergency ampere rating. Therefore, the minimum normal ampere rating will be capped at the minimum emergency ampere rating in all cases.

3.2.2.2. Minimum Transmission Circuit Normal Thermal MVA Rating Requirements

The minimum Transmission Circuit normal thermal MVA ratings will be determined by MISO using the following formulae:

*SNTMVA' = (NOKV * SNAR' * $3^{1/2}$) / 1000 (10)*

where

SNTMVA' = Minimum Summer Normal Thermal MVA Rating

NOKV = Nominal Operating kV ($\phi\phi$)

SNAR' = Minimum Summer Normal Ampere Rating

*WNTMVA' = (NOKV * WNAR' * $3^{1/2}$) / 1000 (11)*

where

WNTMVA' = Minimum Winter Normal Thermal MVA Rating

WNAR' = Minimum Winter Normal Ampere Rating

3.2.2.3. Minimum Transmission Circuit Normal MVA Rating Requirements

The minimum Transmission Circuit normal MVA ratings will be determined by MISO as the lesser of the i) normal thermal MVA ratings and the ii) applicable emergency MVA rating as determined in Section 3.1.2.3 above.

The seasonal minimum normal MVA ratings will be set equal to the minimum of the appropriate seasonal minimum normal thermal MVA ratings and the seasonal emergency MVA ratings as illustrated in equations (12) and (13) below:

SNMVA' = Minimum {SNTMVA', SEMVA'} *(12)*

where

SNMVA' = Minimum Summer Normal MVA Rating

WNMVA' = Minimum {WNTMVA', WEMVA'} *(13)*

where

WNMVA' = Minimum Winter Normal MVA Rating

3.2.3. Transmission Circuit Emergency Load Rating Duration

Transmission Circuit emergency load ratings are long-term emergency ratings and as such will not be limited to any specific duration (see BPM-020, Section 4.3). Therefore, in performing the risk assessment to determine Maximum Allowable Emergency Operating Temperature, the RFP Respondent must consider the probability of contingencies, including the potential duration of such contingencies, that could risk exposing the Transmission Circuit Conductor to temperatures in excess of the Maximum Allowable Normal Operating Temperatures for sustained periods of time should there be a prolonged contingency duration[4]. For Transmission Circuits limited by Maximum Conductor Sag Temperatures, there is no reason for a duration limit since the method for calculating ratings assumes the conductor temperature, and thus the conductor sag, has reached a new equilibrium state.

Therefore, no duration limitations shall be specified for emergency load ratings with the exception that duration limitations can be specified for the optional short-term ratings, if specified in Request for Proposal, where such short-term ratings are designed to allow time for short-term system adjustments following a contingency.

3.2.4. Transmission Circuit Minimum Load Rating Exceptions

When specific circumstances warrant, MISO may elect to waive the methods in this BPM for determining minimum Transmission Circuit load ratings. Examples of situations where such requirements may be waived include i) situations where the loading of the Transmission Circuit will be limited by another element and further expansion to is not feasible (e.g., a Transmission Circuit in series with a limiting Transmission Transformer where it is not feasible to add additional Transmission Circuits or Transmission Transformers at the point where the proposed Transmission Circuit interconnects with the limiting Transmission Transformer, etc.), ii) an underground Transmission Circuit or an overhead Transmission Circuit in series with a limiting underground Transmission Circuit where additional capability is not needed and the incremental cost of meeting the minimum rating requirements in this BPM would be cost prohibitive, and iii)

[4] There is no requirement for the Maximum Allowable Emergency Operating Temperature to be greater than the Maximum Allowable Normal Operating Temperature (although it cannot be less), thus any decision to allow a higher Maximum Allowable Emergency Operating Temperature and the selection of such a temperature must consider the fact that there will be no expectation that emergency load ratings will be constrained to any specific duration within the operating horizon.

similar specific situations where it is not feasible or prudent to follow the minimum rating requirements of this BPM. Any waiver of the minimum rating requirements of this BPM must be initiated by the applicable MISO planning group responsible for recommending the Competitive Transmission Project, approved by the Competitive Transmission Executive Committee, and incorporated into the scope of the Competitive Transmission Project to be included in MTEP for consideration by the MISO board.

3.3. Minimum Requirements Applicable to Competitive Transmission Line Facilities to Ensure Adequate Load Capability

The Selected Developer will be responsible for determining the actual load ratings for Competitive Transmission Line Facilities pursuant to their role as a MISO and NERC Transmission Owner based on their NERC compliant facility rating methodology. The Competitive Transmission Line Facility shall be engineered, designed, and constructed such that actual ratings determined by the Transmission Owner in accordance with their facility rating methodology will be equal to or greater than the corresponding minimum ratings specified in the Request for Proposal.

To ensure that the facility ratings methodologies employed by all RFP Respondents to determine Transmission Circuit Conductor load ratings are based on reasonable assumptions regarding ambient operating conditions, the RFP Respondent must calculate and include in their Proposal all applicable Adequacy Validation Ratings for Transmission Circuit Conductors. The Adequacy Validation Ratings must be based on the methodology described below and such Adequacy Validation Ratings must also be equal to or greater than the minimum ratings specified in the Request for Proposal. It is important to note that the Adequacy Validation Ratings calculated by the RFP Respondent and included in the Proposal will not represent an upper bound or cap on the actual ratings determined by the Selected Developer based on their own facility rating methodology, but instead will be a design constraint that must be satisfied for the Competitive Transmission Line Facility.

3.3.1. Calculation of Emergency Ampere Adequacy Validation Ratings for Transmission Circuit Conductors

Adequacy Validation Ratings are focused on the Transmission Circuit Conductor. While Transmission Circuit loading may sometimes be limited by Substation Terminal Equipment or Transmission Circuit Switching Device ratings rather than the rating of the Transmission Circuit Conductor, such equipment is typically rated based on the nameplate continuous rating rather than a rating methodology. Furthermore, Substation Terminal Equipment is considered part of the substation rather than part of the Transmission Circuit from a facility standpoint and is thus addressed elsewhere in this document. Therefore, emergency ampere Adequacy Validation Ratings are determined for the conductor only based on the rating methodology described below.

The emergency ampere Adequacy Validation Rating methodology must use the conductor rating calculation method outlined in the IEEE 738 standard. There are two options available to a Selected Developer for determining the emergency ampere Adequacy Validation Rating. The first option (Option 1) includes a more conservative maximum wind speed assumption coupled with a less restrictive design clearance buffer. The second option (Option 2) includes a less conservative maximum wind speed assumption coupled with a more restrictive design clearance buffer. Under Option 1, the maximum wind speed assumption is zero (0.0) feet per second and there is no minimum restriction on the design clearance buffer. Under Option 2, the maximum wind speed assumption is two (2.0) feet per second and the minimum design clearance buffer is three (3.0) feet. If Option 2 is used by the Selected Developer to determine emergency ampere Adequacy Validation Ratings, the Selected Developer must certify within their Proposal that the Competitive Transmission Line Facility will be engineered and designed based on a design clearance buffer equal to or greater than three (3.0) feet. Tables 5A through 5D in the Appendix specify the input parameters to be used by the Selected Developer to determine the emergency ampere Adequacy Validation Ratings. The applicable table is determined as follows:

- If Option 1 is selected and the Selected Developer uses IEEE 738 in their own conductor facility rating methodology[5], then Table 5A should be used to determine the emergency ampere Adequacy Validation Ratings.
- If Option 1 is selected and the Selected Developer does not use IEEE 738 in their own conductor facility rating methodology, then Table 5B should be used to determine the emergency ampere Adequacy Validation Ratings.
- If Option 2 is selected and the Selected Developer uses IEEE 738 in their own conductor facility rating methodology, then Table 5C should be used to determine the emergency ampere Adequacy Validation Ratings.
- If Option 2 is selected and the Selected Developer does not use IEEE 738 in their own conductor facility rating methodology, then Table 5D should be used to determine the emergency ampere Adequacy Validation Ratings.

3.3.2. Calculation of Emergency Thermal MVA Adequacy Validation Ratings

The emergency thermal MVA Adequacy Validation Ratings will be calculated by the RFP Respondent using the following formulae:

$$SETMVA = (NOKV * SEAR * 3^{1/2}) / 1000 \qquad (14)$$

where

SETMVA = Summer Emergency Thermal MVA Adequacy Validation Rating

SEAR = Summer Emergency Ampere Adequacy Validation Rating

[5] A Selected Developer's conductor facility rating methodology could be a methodology, or portion thereof, historically used by the Selected Developer to calculate conductor ratings for overhead Transmission Circuits or could be a methodology specifically developed solely for Competitive Transmission Projects or the Competitive Transmission Project in question. In any case, the Selected Developer's conductor facility rating methodology must utilize the IEEE 738 rating methodology in order to qualify the Selected Developer to use Table 5A or 5C for calculation of emergency ampere Adequacy Validation Ratings.

*WETMVA = (NOKV * WEAR * $3^{1/2}$) / 1000 (15)*

where

WETMVA = Winter Emergency Thermal MVA Adequacy Validation Rating

WEAR = Winter Emergency Ampere Adequacy Validation Rating

3.3.3. Calculation of Emergency MVA Adequacy Validation Ratings

The Emergency MVA Adequacy Validation Ratings will be calculated by the RFP Respondent using the following formulae:

SEMVA = Minimum {SETMVA, VSLR} (16)

where

SEMVA = Summer Emergency MVA Adequacy Validation Rating

VSLR = Voltage & Stability Loadability Rating

(as determined by MISO and specified in the Request for Proposal)

WEMVA = Minimum {WETMVA, VSLR} (17)

where

WEMVA = Winter Emergency MVA Adequacy Validation Rating

3.3.4. Calculation of Normal Ampere Adequacy Validation Ratings

The normal ampere Adequacy Validation Ratings of a Transmission Circuit shall be calculated in a similar manner as the emergency ampere Adequacy Validation Ratings as detailed in the sections below.

The normal ampere Adequacy Validation Rating methodology must use the conductor rating calculation method outlined in the IEEE 738 standard. There are two options available to a Selected Developer for determining the normal ampere rating. As with the emergency ampere Adequacy Validation Rating, the first option (Option 1) includes a more conservative maximum wind speed assumption coupled with a less restrictive design clearance buffer. The second option (Option 2) includes a less conservative maximum wind speed assumption coupled with a more restrictive design clearance buffer. As with the emergency ampere Adequacy Validation Ratings, under Option 1, the maximum wind speed assumption is zero (0.0) feet per second and there is no minimum restriction on the design clearance buffer. Under Option 2, the maximum wind speed assumption is two (2.0) feet per second and the minimum design clearance buffer is three (3.0) feet. If Option 2 is used by the Selected Developer to determine normal ampere Adequacy Validation Ratings, the Selected Developer must certify within their Proposal that the Competitive Transmission Line Facility will be engineered and designed based on a design clearance buffer equal to or greater than three (3.0) feet. Tables 5E through 5H in the Appendix specify the input parameters to be used by the Selected Developer to determine the normal ampere Adequacy Validation Ratings. The applicable table is determined as follows:

- If Option 1 is selected and the Selected Developer uses IEEE 738 in their own conductor facility rating methodology[6], then Table 5E should be used to determine the normal ampere Adequacy Validation Ratings.
- If Option 1 is selected and the Selected Developer does not use IEEE 738 in their own conductor facility rating methodology, then Table 5F should be used to determine the normal ampere Adequacy Validation Ratings.
- If Option 2 is selected and the Selected Developer uses IEEE 738 in their own conductor facility rating methodology, then Table 5G should be used to determine the normal ampere Adequacy Validation Ratings.
- If Option 2 is selected and the Selected Developer uses IEEE 738 in their own conductor facility rating methodology, then Table 5H should be used to determine the normal ampere Adequacy Validation Ratings.

3.3.5. Calculation of Normal Thermal MVA Adequacy Validation Ratings

The normal thermal MVA Adequacy Validation Ratings shall be calculated by the RFP Respondent using the following formulae:

$$SNTMVA = (NOKV * SNAR * 3^{1/2}) / 1000 \qquad (18)$$

where

SNTMVA = Summer Normal Thermal MVA Adequacy Validation Rating

[6] A Selected Developer's conductor facility rating methodology could be a methodology, or portion thereof, historically used by the Selected Developer to calculate conductor ratings for overhead Transmission Circuits or could be a methodology specifically developed solely for Competitive Transmission Projects or the Competitive Transmission Project in question. In any case, the Selected Developer's conductor facility rating methodology must utilize the IEEE 738 rating methodology in order to qualify the Selected Developer to use Table 5E or 5G for calculation of normal ampere Adequacy Validation Ratings.

SNAR = Summer Normal Ampere Adequacy Validation Rating

*WNTMVA = (NOKV * WNAR * $3^{1/2}$) / 1000 (19)*

where

WNTMVA = Winter Normal Thermal MVA Adequacy Validation Rating

WNAR = Winter Normal Ampere Adequacy Validation Rating

3.3.6. Calculation of Normal MVA Adequacy Validation Ratings

The normal MVA Adequacy Validation Ratings shall be calculated by the RFP Respondent using the following formulae:

SNMVA = Minimum {SNTMVA, SEMVA} (20)

where

SNMVA = Summer Normal MVA Adequacy Validation Rating

WNMVA = Minimum {WNTMVA, WEMVA} (21)

where

WNMVA = Winter Normal MVA Adequacy Validation Rating

3.4. Competitive Transmission Line Additional Design Requirements

As stated in the Tariff, each Competitive Transmission Line Facility must be designed and constructed to satisfy all relevant federal, state, and local laws, regulations, and codes including the National Electrical Safety Code (NESC); applicable industry standards; and Good Utility Practice. In addition to meeting all of the requirements of the National Electrical Safety Code, all Competitive Transmission Line Facilities shall be designed and constructed to meet or exceed the requirements of the National Electrical Safety Code applicable to Grade B construction.

4. Competitive Substation Facilities

4.1. Request for Proposal Specifications

Listed below are the minimum Request for Proposal specifications for Competitive Substation Facilities which will be included in all Request for Proposals and additional Request for Proposal specifications for Competitive Substation Facilities which may be included in some Request for Proposals depending on specific circumstances.

4.1.1. Minimum Request for Proposal Specifications

The Request for Proposal (RFP) shall always specify the following requirements for each Competitive Substation Facility (unless the Transmission Provider determines a requirement to be inapplicable):

- Bus-branch planning one-line diagram showing all Transmission System Buses, Transmission Circuit terminals, Generation Element terminals, Transmission Transformers, Series Compensation Devices, Shunt Compensation Devices (including Storage As Transmission-Only Asset devices), HVDC Converters, and loads.
- Transmission System Bus voltage characteristics and nominal operating kV.
- Transmission Transformer size, nameplate impedance or impedance range (i.e., positive sequence reactance in percent on ONAN base), and phase shift requirements.
- Series Compensation Device minimum normal and emergency load ratings, impedance range requirements, and bypass requirements.
- Shunt Compensation Device size requirements (e.g., megawatts and megawatt-hours for Storage As Transmission-Only Assets).
- Operating parameters for Storage As Transmission-Only Asset devices as determined in MTEP to resolve the identified Transmission Issue.
- Circuit Breaker Assembly minimum load ratings and circuit breaker interrupting ratings for each acceptable bus configuration alternative specified in the RFP.
- Transmission Physical Bus minimum normal and emergency load ratings for acceptable bus configuration alternatives that contain one or more Transmission Physical Buses.
- Minimum protection system redundancy, speed, and other requirements for protection schemes that do not interface with incumbent Transmission Owners (e.g., bus protection, transformer protection, etc.)
- High level protection system requirements for protection schemes that will interface with incumbent Transmission Owner schemes (e.g., line protection, etc.).
- Breaker failure protection system requirements

4.1.2. Additional Request for Proposal Specifications

A Request for Proposal (RFP) may specify the following additional information for each Competitive Substation Facility when determined appropriate based on specific circumstances:

- List of acceptable bus configurations and/or position assignment constraints for each Transmission System Bus.
- Transmission Transformer no-load and/or load tap changing requirements
- Transmission Transformer winding connection requirements.

4.2. Methods for Determining Minimum Project Requirements of Competitive Substation Facilities

This subsection describes the methods that will be used by MISO staff to determine the minimum load ratings, minimum interrupting ratings, bus configuration requirements, and other minimum project requirements applicable to Competitive Substation Facilities.

4.2.1. Minimum Transmission Physical Bus Load Ratings

Minimum Transmission Physical Bus load ratings are determined for straight buses (if allowable) as well as the main buses in double-bus configurations when Competitive Substation Facilities are included in Competitive Transmission Projects. In no case will MISO require a minimum Transmission Physical Bus load rating above 6,000 A.

4.2.1.1. Straight Buses

For straight buses, the load ratings for Transmission Physical Buses will be based on i) the minimum ratings associated with each Transmission Element and/or Generation Element that connects directly to the Transmission Physical Bus and ii) the total number of elements connected to the bus. Per Section 4.2.6 of this document and Table 3 in Appendix A, the maximum number of connections to a straight bus is four (4) which includes three (3) positions plus a tie breaker. For buses with fewer than four (4) connected elements, the minimum emergency and normal ampere ratings applicable to the Transmission Physical Bus would be equal to the highest minimum emergency and normal ratings associated with each of the elements connecting to the bus since that sets the maximum flow into or out of the bus. For buses with four (4) connected elements, the formulae below will be used to determine the minimum emergency and normal ampere ratings applicable to the Transmission Physical Bus if it is a straight bus:

$$TPBEAR = \sum_{i}\{EAR(i)\} / 2 \tag{22}$$

where

TPBEAR = Transmission Physical Bus Emergency Ampere Rating

i = Index of the four Transmission Elements and/or Generation Elements connecting directly to the Transmission Physical Bus

EAR(i) = Emergency Ampere Rating for Transmission Element or Generation Element i

$$TPBNAR = \sum_{i}\{NAR(i)\} / 2 \qquad (23)$$

where

TPBNAR = Transmission Physical Bus Normal Ampere Rating

NAR(i) = Normal Ampere Rating for Transmission Element or Generation Element i

In the formulae above, the ratings of each of the connecting element are summed and then divided by two to represent the theoretical maximum amount of flow that could pass through the worst-case section of the bus for any possible position assignment. MISO may lower the minimum bus ratings further based on the specific situations when appropriate based on reasoning.

Example. For example, assume a straight bus terminates three 230 kV circuits, each of which have a Summer Emergency Ampere Rating of 1,200 A and a Summer Normal Ampere Rating of 900 A, plus a tie breaker with a rating of 2,000 A. The minimum emergency and normal ampere ratings of the bus would be calculated as follows:

*TPBEAR = (3*1200A + 2000A) / 2 = 2,800 A*

*TPBNAR = (3*900A + 2000A) / 2 = 2,350 A*

In this particular case, it can be further reasoned that the emergency rating need not exceed 2,400 A since it is impossible for the tie breaker and one of the lines to draw more than 2,400 A from the two remaining lines based on the fact each line has an emergency rating of 1,200 A. Similar reasoning could be used to set the minimum normal bus rating at 2,000 A, which would require consistent flow directions into the bus (or out of the bus) for all three lines in order to load up the tie breaker to its continuous rating of 2,000 A.

4.2.1.2. Double Buses

For double bus configurations (i.e., double-bus / breaker-and-a-half, double-bus / double-breaker, or a combination of the two, etc.), the load ratings for Transmission Physical Buses will be based on i) the minimum ratings associated with each Transmission Element and/or Generation Element connected within the bus configuration and ii) an allowance for substation expansion.

The formulae below will be used to determine the minimum emergency and normal ampere ratings applicable to the Transmission Physical Bus if it is one of the two Transmission Physical Buses in a double-bus configuration:

$$\text{TPBEAR} = 1.25 * \sum_{i}\{\text{EAR(i)}\} / 4 \qquad (24)$$

where

TPBEAR = Transmission Physical Bus Emergency Ampere Rating

i = Index of ultimately planned Transmission Elements and/or Generation Elements within the double-bus configuration associated with the Transmission Physical Bus

EAR(i) = Emergency Ampere Rating for Transmission Element or Generation Element i

$$\text{TPBNAR} = 1.25 * \sum_{i}\{\text{NAR(i)}\} / 4 \qquad (25)$$

where

TPBNAR = Transmission Physical Bus Normal Ampere Rating

NAR(i) = Normal Ampere Rating for Transmission Element or Generation Element i

In the formulae above, the ratings of each element are summed and then divided by four (4) to represent the theoretical maximum amount of flow that could pass through the worst-case section of either Transmission Physical Bus assuming a 50/50 split[7] in total flows between the two Transmission Physical Buses. The 125% factor is used to allow for future substation expansion above and beyond the ultimate plan for the substation as well as help account for situations where flow split between Transmission Physical Buses is something other than 50/50.

Example. For example, assume a five position breaker-and-a-half bus terminated four 345 kV circuits, each of which had a Summer Emergency Ampere Rating of 3,000 A and a Summer Normal Ampere Rating of 2500 A, and the 345 kV winding terminal of a Transmission Transformer with a maximum nameplate rating of 700 MVA (1,172A @ 345 kV). The emergency and normal ampere ratings of the bus would be calculated as follows:

*TPBEAR = 1.25 * ((4*3000A) + 1172A) / 4 = 4,117 A*

*TPBNAR = 1.25 * ((4*2500A) + 1172A) / 4 = 3,492 A*

[7] While a 50/50 split in flows is not worst case, it is also not best case for breaker-and-a-half bus configurations since some of the flows through the substation will not go through either Transmission Physical Bus if adjacent positions in a three-break string have flows in opposite directions. Furthermore, it is expected that position assignment constraints will be specified in the RFP to offset any concerns of assuming a 50/50 flow split between Transmission Physical Buses.

4.2.2. Minimum Circuit Breaker Assembly Load Ratings

Minimum Circuit Breaker Assembly load ratings shall apply to all circuit breakers within the ring bus configurations and double-bus configurations as well as bus-tie breakers connecting two or more straight buses. Minimum Circuit Breaker Assembly load ratings do not apply to non-bus-tie breakers connecting Transmission Elements or Generation Elements to straight buses since these circuit breakers would be considered Substation Terminal Equipment for the connecting Transmission Element or Generation Element.

4.2.2.1. Ring Bus Configuration

If a ring bus configuration is included in the Transmission Proposal as an acceptable bus configuration option for a specific Transmission System Bus within a specific Competitive Substation Facility, then the default minimum rating for all Circuit Breaker Assemblies within the ring bus will be set equal to the industry standard Terminal Equipment Rating Class ampere rating (See Table 1) that is closest to, but not less than, the greater of i) the highest minimum emergency rating specified in the RFP for any new Generation Element or Transmission Element connected to the ring bus regardless of whether or not the Circuit Breaker Assembly is adjacent to the element with the highest minimum emergency rating and ii) the highest emergency rating associated with any existing facility being terminated on the new ring bus regardless of whether or not the Circuit Breaker Assembly is adjacent to the element with the highest minimum emergency rating.

Example. For example, if a 345 kV ring bus connects to three Transmission Circuits, each with a RFP specified minimum Summer Emergency Ampere Rating of 1,792 MVA (3,000 A), and one Transmission Transformer winding terminal with an RFP specified maximum nameplate rating of 2,250 MVA (3,766 A at 345 kV), then each Circuit Breaker Assembly within the ring bus must be rated at 4,000 amperes, which is the Terminal Equipment Rating Class just above 3,766 A.

MISO reserves the right, on a case-by-case basis, to provide position assignment constraints and/or higher minimum Circuit Breaker Assembly ratings if analysis performed within the top-down planning process determines such additional constraints are appropriate.

4.2.2.2. Double Bus / Breaker-and-a-Half Bus Configurations

If a double bus / breaker-and-a-half bus configuration is included in the Request for Proposal as an acceptable bus configuration option for a specific Transmission System Bus within a specific Competitive Substation Facility, then the default minimum rating for all Circuit Breaker Assemblies within a single three-breaker string between two main buses must be set equal to the industry standard Terminal Equipment Rating Class ampere rating (See Table 1) that is closest to, but not less than, the greater of i) the highest minimum emergency rating specified in the RFP for a new Generation Element and/or Transmission Element terminating in the breaker string regardless of whether or not the Circuit Breaker Assembly is adjacent to the element with the highest minimum emergency rating or ii) the highest emergency rating associated with any existing facility being terminated in the breaker string regardless of whether or not the Circuit Breaker Assembly is adjacent to the element with the highest minimum emergency rating.

Example. For example, if a three-breaker string in a 500 kV breaker-and-a-half bus terminates a Transmission Circuit with a minimum Summer Emergency Ampere Rating of 2,598 MVA (3,000 A) and a

Generation Element with a nameplate rating of 850 MVA (982 A @ 500 kV), then each Circuit Breaker Assembly within the three-break string must be rated at 3,000 amperes.

MISO reserves the right, on a case-by-case basis, to provide position assignment constraints and/or higher minimum Circuit Breaker Assembly ratings if analysis performed within the top-down planning process determines such additional constraints are appropriate.

4.2.2.3. Double-Bus / Double Breaker Bus Configurations

If a double-bus / double-breaker bus configuration is included in the Request for Proposal as an acceptable bus configuration option for a specific Transmission System Bus within a specific Competitive Substation Facility, then the default minimum rating for the two Circuit Breaker Assemblies that terminate a single Transmission Element or Generation Element must be set equal to the industry standard Terminal Equipment Rating Class ampere rating (See Table 1) that is closest to, but not less than, the minimum emergency rating associated with the Generation Element or Transmission Element being terminated or, in the case where an existing facility is being terminated between the two circuit breakers, the emergency ratings associated with the existing facility. For example, if two Circuit Breaker Assemblies in a 765 kV double-bus / double-breaker bus configuration terminate a Transmission Circuit with a minimum Summer Emergency Ampere Rating of 3,975 MVA (4,000 A), then each Circuit Breaker Assembly terminating the Transmission Circuit must be rated at 4,000 amperes. If that same bus configuration also terminates a Transmission Transformer with a nameplate rating of 2,250 MVA (1,698 A @ 765 kV), then each Circuit Breaker Assembly terminating the Transmission Transformer 765 kV winding terminal must be rated at 3,000 amperes, which is the next highest industry standard Terminal Equipment Rating Class ampere rating.

4.2.3. Minimum Transmission Circuit Substation Terminal Equipment Ampere Ratings

For substation terminals at Competitive Substation Facilities that terminate Transmission Circuits associated with a Competitive Transmission Line Facility, the Request for Proposal will specify minimum Substation Terminal Equipment Ampere Ratings equal to the industry standard Terminal Equipment Rating Class ampere rating (See Table 1) that is closest to, but not less than, the minimum Summer Emergency Ampere Rating specified in the Request for Proposal for the Transmission Circuit associated with the Competitive Transmission Line Facility. For substation terminals at Competitive Substation Facilities that terminate Transmission Circuits associated with existing Transmission Line Facilities (e.g., an existing Transmission Circuit is cut into a Competitive Substation Facility at the midpoint creating two new Transmission Circuits, but no Competitive Transmission Line Facility is specified in the Request for Proposal other than the taps), the Request for Proposal will specify minimum Substation Terminal Equipment Ampere Ratings equal to the industry standard Terminal Equipment Rating Class ampere rating (See Table 1) that is closest to, but not less than, the maximum ampere rating of the existing Transmission Circuit as defined by the incumbent Transmission Owner. For substation terminals at Competitive Substation Facilities that terminate Transmission Circuits that represent a combination of existing Transmission Line Facilities and Competitive Transmission Line Facilities (e.g., a new Transmission Circuit is created by building a 30 mile Competitive Transmission Facility and then installing another 30 miles of conductor on the spare positions of an existing Transmission Line Facility, etc.), the Request for Proposal will specify minimum Substation Terminal Equipment Ampere Ratings equal to the industry standard Terminal Equipment Rating Class ampere rating (See Table 1) that is closest to, but not less than, i) the greater of the maximum ampere rating of the portion of the Transmission Circuit installed as an upgrade to existing transmission facilities as defined by the incumbent Transmission Owner and ii) the minimum Summer Emergency Ampere Rating specified in the Request for Proposal for the Competitive Transmission Line Facility. It is expected that these two ratings will be equivalent. In all cases, MISO will specify the minimum Substation Terminal Equipment Ampere Rating in the Request for Proposal for all Transmission Circuit terminals located at a Competitive Substation Facility.

4.2.4. Minimum Generation Element Substation Terminal Equipment Ampere Ratings

All Substation Terminal Equipment associated with a Generation Element at a Competitive Substation Facility must have an ampere rating greater than or equal to the lesser of the maximum nameplate rating (expressed in amperes at the transmission interconnection voltage level) of all generators associated with the Generation Element or the maximum nameplate rating (expressed in amperes at the transmission interconnection voltage level) of all generator step-up (GSU) transformers.

Example. For example, if a combined cycle generating unit has a total of three 100 MW generators (two gas turbine driven and one steam turbine driven) and each generator has a maximum nameplate MVA of 120 MVA, the total generator MVA would be 360 MVA. If the generators connect to a 345 kV bus via three 112 MVA GSU transformers, then the total GSU MVA would be 336 MVA. The minimum Substation Terminal Equipment Ampere Rating of the substation terminal would be equal to the industry standard Terminal Equipment Rating Class ampere rating (See Table 1) that is closest to, but not less than, the maximum nameplate rating of the 345 kV GSU windings, expressed in amperes. The 345 kV GSU ampere ratings would be calculated as follows:

GSU HS Ampere Rating

$$= (336 \text{ MVA} * 1000) / (345 \text{ kV} * 3^{1/2}) = 562 \text{ A}$$

Therefore, the minimum Substation Terminal Equipment Ampere Rating would be specified as 2,000 A.

4.2.5. Transmission Transformer Size and Impedance Requirements

When a Competitive Substation Facility contains one or more proposed Transmission Transformers, the top-down planning process will determine, on a case-by-case basis the appropriate transformer maximum nameplate MVA rating and targeted impedance range for specification in the Request for Proposal. For substation terminals at Competitive Substation Facilities that terminate Transmission Transformers, the Request for Proposal will specify minimum Substation Terminal Equipment Ampere Ratings equal to the industry standard Terminal Equipment Rating Class ampere rating (See Table 1) that is closest to, but not less than, the specified transformer maximum nameplate rating expressed in amperes at the nominal voltage of the terminated winding.

4.2.6. Bus Configuration and Position Assignment Constraints

MISO may specify bus configuration and/or position assignment constraints in the Request for Proposal to ensure a reliable and robust system that provides operational flexibility. Position assignment constraints will be determined on a case-by-case basis based on the results of the reliability analysis step within the planning process. Table 3A and 3B in Appendix A provide a guideline that will be used in determining acceptable bus configurations for specific Transmission System Buses contained within proposed Competitive Substation Facilities. This guideline is based upon the following guiding principles:

- Straight buses will not be permitted for EHV (i.e., 345 kV and above) voltage levels.
- The maximum number of Transmission Circuits that can be terminated on a single-zone straight bus is two.
- The maximum number of Transmission Circuits that can be terminated on a double-zone straight bus is four, two on each side of the tie-breaker.
- The maximum number of Generation Elements and/or Transmission Elements that can be terminated on a single-zone straight bus is three, of which not more than two can be Transmission Circuits.
- The maximum number of Generation Elements and/or Transmission Elements that can be terminated on a double-zone straight bus is six, three on each side of the tie-breaker, of which not more than four can be Transmission Circuits (a maximum two Transmission Circuits on each side of the tie breaker).
- Ring buses will not be permitted to terminate more than six Generation Elements and Transmission Elements, of which not more than four can be Transmission Circuits
- A breaker-and-a-half bus cannot have fewer than five (5) positions, one of which is a double-breaker position, otherwise it is a ring bus with open positions.

4.2.7. Minimum Short-Circuit Current Design Level for Transmission System Buses

MISO will specify the Minimum Short-circuit Current Design Level for which each Transmission System Bus associated with a Competitive Substation Facility should be designed. The Minimum Short-circuit Current Design Level represents a floor for the maximum available three-phase short-circuit current that should be assumed at a specific Transmission System Bus, and is specified assuming all generation is in service and all transmission facilities are in their normal configuration. The Minimum Short-circuit Current Design Level will be specified in the RFP for each Transmission System Bus for a Competitive Substation Facility. Specifically, the Minimum Short-circuit Current Design Level will apply to:

- Determination of circuit breaker interruption ratings in accordance with Section 4.2.8 of the BPM.
- Determination of momentary and/or short-term current ratings of all switchgear, bus conductors and other series equipment that comprise the Transmission System Bus.
- Determination of short-circuit current for which the ground grid must be designed.
- Three-phase short-circuit current for which facilities comprising the Transmission System Bus must be designed from a structural standpoint, including bus conductors, bus insulators, structural supports and any other equipment and facilities associated with the Transmission System Bus where short-circuit currents impact structural requirements.

Specification of the Minimum Short-circuit Current Design level will be determined as follows:

- Step 1. MISO will calculate the maximum available symmetrical three-phase short-circuit fault current for each Transmission System Bus associated with a Competitive Substation Facility based on positive sequence based power system models which represent conditions at the time the Competitive Substation Facility is studied.

- Step 2. MISO will multiply the calculated maximum available symmetrical three-phase short-circuit fault current determined in Step 1 above by the Fault Level Design Margin to account for potential future system growth in the maximum available fault current and to account for situations where the symmetrical ground fault current level could be higher than the three-phase fault current level.

The Fault Level Design Margin (FLDM) will be determined using a sliding scale as follows:

- For three-phase short-circuit fault currents less than or equal to 25 kA, the Fault Level Design Margin will be set at 125%
- For three-phase short-circuit fault currents greater than or equal to 50 kA, the Fault Level Design Margin will be set at 110%
- For three-phase short-circuit fault currents greater than 25 kA but less than 50 kA, the Fault Level Design Margin will be calculated using the following formula:

$$FLDM = 1.4 - 0.006 * ISC \qquad (25)$$

Where

ISC = Maximum Available Three-phase Short-circuit Current in kA

FLDM = Fault Level Design Margin specified in percent

Upon Selection, and at the appropriate time in the design schedule, the Selected Developer shall complete a fault current study – including, if needed, system stability analysis – with the applicable interconnection Transmission Owner(s) to confirm their proposed design. All types of fault currents (i.e., 3ϕ, ϕϕ, ϕG, ϕϕG) shall be considered in the fault current study. Study analysis shall confirm if independent pole operation capability is needed for any circuit breakers included in the selected proposal along with the required short circuit capability and clearing time requirements. Any design changes to the proposed design contained in the Proposal from the Selected Developer would require coordination between the Selected Developer, MISO, and the interconnection Transmission Owner(s).

4.2.8. Minimum Circuit Breaker Interrupting Ratings

Minimum interrupting ratings for circuit breakers will be determined by MISO during the reliability analysis component of the top-down planning process. MISO will specify minimum interrupting ratings based on the industry standard symmetrical interrupting rating that is closest to, but not less than, the product of the maximum fault exposure for a specific circuit breaker and the Fault Level Design Margin. The industry standard interrupting ratings MISO will use are listed in Table 4 of Appendix A. The Fault Level Design Margin allows for growth of the system (both in terms of new Generation Elements and new Transmission Elements), where such growth could increase the maximum available fault current exposure at the circuit breaker. The maximum fault exposure for a specific circuit breaker will be determined as the greater of the maximum calculated symmetrical three-phase fault current that flows through the circuit breaker given a three-phase short-circuit fault on either of the two terminals of the circuit breaker. Calculation of this fault current assumes all other circuit breakers supplying that protective zone are open. Several examples may help to clarify the type of analysis that MISO will perform to determine minimum circuit breaker interrupting capability requirements.

Example 1. A single 230 kV circuit breaker protects a 230 kV capacitor bank and associated bus work and is supplied by a straight bus. The maximum bus fault current at the circuit breaker terminals is 21,934 A. Because there is only one circuit breaker supplying the capacitor bank, the maximum bus fault current at the circuit breaker terminals represents the maximum fault exposure of the circuit breaker. That is, the capacitor bank contributes no fault current to the short-circuit fault, thus for a fault on the capacitor-side of the circuit breaker, the circuit breaker will be exposed to a fault current magnitude equal to the maximum bus fault current and for a fault on the bus-side of the circuit breaker, the circuit breaker will carry no fault current. The lower bound for the minimum symmetrical interrupting rating of the circuit breaker is the product of the Fault Level Design Margin (125%), and 21,934 A or 27,418 A. Therefore, a circuit breaker with a minimum interrupting rating of 31.5 kA will be specified in the Request for Proposal based on Table 4.

Example 2. A 500 kV circuit breaker is located in a four-position 500 kV ring bus between two Transmission Circuits that terminate on the ring bus designated as Circuit A and Circuit B. The maximum bus fault current at the ring bus is 34,583 A. However, neither of these circuit breakers will ever be exposed to this fault current level regardless of which terminals of the circuit breaker are faulted since there are parallel paths to the fault that do not flow through the circuit breaker. The worst case scenario for a fault on Circuit A is to assume all other circuit breaker supplying Circuit A are open. This includes the other circuit breaker at the substation that connects to Circuit A and all remote circuit breakers that connect to Circuit A. This scenario is representative of a scenario where the circuit breaker in question is slightly slower than the other circuit breakers, the circuit breaker is used to energize a de-energized line (e.g., automatic reclosing, restoration following an outage, etc.), or the other circuit breakers happen to be open for maintenance or other reasons. While the total fault current is reduced for this scenario, the fault current flow through the circuit breaker represents 100% of this reduced fault current and is higher than what it would be with the circuit breakers closed.[8] Assume under this scenario that the fault current through the circuit breaker is equal to 28,345 A (based on the output of a bus/branch short-circuit fault study program where the opposite terminal is opened and the new bus fault current magnitude corresponds to the fault current that would flow through the circuit breaker in question with all other Circuit A circuit breakers open). For a fault current of 28,345 A, the Fault Level Design Margin would be calculated as 123.0%. If the 123.0% factor is applied to this fault current, the tentative lower bound for the minimum required interrupting rating becomes 123.0% of 28,345 A or 34,862 A. This is a tentative lower bound because it is also necessary to check the scenario where the short-circuit fault occurs on the Circuit B terminals of the circuit breaker. Assume the same process is applied for a short-circuit fault on Circuit B and the resulting fault current is simulated to be 29,667 A. For a fault current of 29,667 A, the Fault Level Design Margin would be calculated as 122.2%. The 122.2% factor

[8] The notion that the maximum fault current through a line circuit breaker occurs when the remote terminal is open is a fully accepted principle in the industry and can easily be proven using two-bus equivalent short-circuit models. The same method is used for circuit breakers protecting Transmission Transformer windings.

must be applied to this fault current level (since it is greater than the Circuit A fault current level) to determine the final lower bound for the required minimum interrupting rating. The lower bound for the minimum interrupting rating is determined to be 36,253 A, and thus a minimum interrupting rating of 40 kA is specified in the Request for Proposal.

Example 3. A 345 kV circuit breaker within a six-position 345 kV breaker-and-a-half bus configuration is located between one of the Transmission Physical Buses and one of the Transmission Circuits that terminate at the bus. The maximum bus fault current at the circuit breaker terminals is 35,932 A. It can be reasoned that the worst case fault will be a fault on the bus-side terminals of the circuit breaker with all other circuit breakers supplying the bus in an open position. The reason is because opening the other circuit breakers connected to the bus does not alter the bus/branch topology of the system (all elements are still connected through the other Transmission Physical Bus). Therefore, a bus fault with all other bus breakers open will still result in a fault current magnitude through the circuit breaker equal to the maximum bus fault current, or 35,932 A. It is thus not necessary to investigate a line-side terminal fault on the circuit breaker, as this fault current will be less than the maximum available fault current at the bus, even with all of the other circuit breakers supplying the faulted Transmission Circuit in an open position. For a fault current level of 35,932 A, the fault level design margin is equal to 118.4%. The 118.4% factor is then applied to the maximum bus fault current of 35,932 A to yield a lower bound on the minimum interrupting rating equal to 42,558 A. The resulting minimum interrupting rating for this circuit breaker, and all other circuit breakers at the substation that connect directly to one of the Transmission Physical Buses, is 50 kA.

It is important to note that specification of minimum interrupting ratings for circuit breakers in an RFP is not an indication by MISO that such circuit breakers meet all of the interrupting requirements. MISO is specifying minimum circuit breaker interrupting ratings to aid the RFP Respondent in determining an accurate cost estimate for the project. Should the RFP respondent be named the Selected Developer, the RFP respondent must develop detailed positive, negative, and zero sequence short-circuit models capable of accurately calculating all types of fault currents (i.e., 3ϕ, ϕϕ, ϕG, ϕϕG). The RFP respondent should evaluate the circuit breaker interrupting requirements for the worst fault type. Furthermore, it may be necessary for the RFP Respondent to validate asymmetrical interrupting capability at the circuit breaker contact parting time should the X/R ratios be high enough that analysis of symmetrical fault currents based on the symmetrical interrupting rating is not sufficient. The MISO analysis to determine <u>minimum</u> circuit breaker interrupting ratings is based only on analyzing symmetrical three-phase faults via a positive sequence short-circuit model.

4.2.9. System Protection Requirements

For any Competitive Substation Facility included in the scope of a Competitive Transmission Project, the following minimum system protection, metering, and control requirements apply.

4.2.9.1. System Protection Requirements for Facilities that Interconnect to Existing Incumbent Transmission Owners

For Transmission Circuits and other facilities with protective zones that are shared with existing incumbent Transmission Owners (i.e., facilities that represent ties between existing substations owned by incumbent Transmission Owners and Competitive Substation Facilities, etc.), the incumbent Transmission Owner will determine the design requirements for system protection, metering, and controls that are specific to that facility. Specifically, the incumbent Transmission Owner will specify the following data to be included in the Request for Proposal:

- System protection redundancy requirements (e.g., instrument transformers, protective relays, auxiliary relays and DC trip circuitry, communications, battery systems, etc.)
- Type of system protection scheme(s) to be used (e.g., DCB, DCUB, POTT, PUTT, phase comparison, line differential, etc.)
- Type of communications channel used in protection systems (e.g., power line carrier, fiber optic, microwave, etc.)
- Characteristics of communications signals used in Transmission Circuit protection systems (e.g., type of modulation, frequencies, etc.)
- Characteristics of transfer trip signals used for breaker failure protection
- Type of automatic reclosing system and characteristics (e.g., number of shots, reclosing times, high-speed reclosing capability, conditions for reclosing, etc.)
- Critical infrastructure protection security requirements applicable to the protection scheme, particularly when such requirements exceed industry standards

4.2.9.2. System Protection Requirements for Facilities that do not Interconnect Directly with Existing Substations owned by Incumbent Transmission Owners

For facilities with protective zones that are not shared with incumbent Transmission Owners or Generation Owners (i.e., facilities entirely within a Competitive Substation Facility or facilities that interconnect two Competitive Substation Facilities, etc.), the following minimum design standards for system protection, metering, and control shall apply:

- Substation Buses

  Substation buses include straight buses and each of the buses associated with a double-bus configuration. Buses shall be protected by high speed protective relaying systems (e.g., high speed differential relay schemes, etc.) that will initiate tripping (where "initiate tripping" is defined as the pickup of the last protective relay element that must operate to initiate tripping) within 2 cycles or less for short-circuit faults located within the bus protective zones. Bus protection systems must contain two redundant protection schemes including redundant current transformers, redundant DC sources (a battery and battery charger are not considered a redundant DC source unless separately fused, remotely monitored and alarmed, and the single battery is capable of supplying the station DC load for 12 hours including a complete tripping/reclosing cycle for two circuit breakers), redundant protective relays, redundant auxiliary and/or lockout relays, and redundant DC trip circuitry (including redundant trip coils on each circuit breaker or circuit breaker pole). Bus protection relays should trip lockout (86) relays and shall not allow automatic reclosing on any circuit breaker. Lockout relays should hold trip signals on each circuit breaker protecting the bus and open closing circuits on each circuit breaker protecting the bus. Bus protective relays should initiate breaker failure for all circuit breakers tripped. Bus differential protective relay schemes should be designed to be secure against inadvertent tripping due to unequal current transformer saturation.

- Transmission Transformers

Transmission transformers include autotransformers and multi-winding power transformers (both individual three-phase units and banks of three single-phase units) where at least two terminals connect to transmission level voltages (where transmission level is defined as 100 kV and above). Transmission transformers shall be protected by high speed protective relaying systems (e.g., high speed differential (87) transformer relaying schemes, etc.)[9]. There should be no intentional delay (definite time or inverse time) associated with the differential protective relay elements. Transmission Transformer protection systems must contain two redundant protection schemes including redundant current transformers, redundant DC sources (battery and battery charger are not considered a redundant DC source unless separately fused, remotely monitored and alarmed, and the single battery is capable of supplying the station DC load for 12 hours including a complete tripping/reclosing cycle for two circuit breakers), redundant protective relays, redundant auxiliary and/or lockout relays, and redundant DC trip circuitry (including redundant trip coils on each circuit breaker or circuit breaker pole). RFP Respondents may provide for transformer tripping due to operation of sudden pressure relay elements and/or due to excessive oil temperature and/or winding temperature, and should indicate in their Proposals if such tripping will be incorporated into the protection system. However, such protection schemes should be designed to be secure against inadvertent nuisance tripping and cannot be used to meet the full redundancy requirement for transformer protection. Transmission transformer protective relays should trip lockout (86) relays and shall not allow automatic reclosing on any circuit breaker. The primary relay elements should trip the primary lockout and the secondary relay elements should trip the secondary lockout. It is permissible for all relay elements to trip all lockouts so long as a single point-of-failure is not introduced into the protection system. Lockout relays should hold trip signals on each circuit breaker protecting the transformer and open closing circuits on each circuit breaker protecting the transformer. Transformer protective relays should initiate breaker failure for all circuit breakers tripped.

- Shunt Devices

  Shunt devices (e.g., reactors, capacitors, Storage As Transmission-Only Asset, Static VAR Compensators, etc.) shall be protected by high speed protective relaying systems with no intentional delay. Shunt device protective zones must contain two redundant protection schemes including redundant current transformers, redundant DC sources (battery and battery charger are not considered redundant unless separately fused, remotely monitored and alarmed, and capable of supplying the station DC load for 24 hours including a complete tripping/reclosing cycle for two circuit breakers), redundant protective relays, redundant auxiliary and/or lockout relays, and redundant DC trip circuitry (including redundant trip coils on the circuit breaker). Shunt device protective relays shall trip lockout (86) relays and shall not allow automatic reclosing on the circuit breaker. Lockout relays shall hold the trip signal and open the closing circuit on the circuit breaker or circuit switcher protecting the shunt device.

[9] Each of the two protective relaying schemes should respond to any fault within the entire protective zone. Therefore, while sudden pressure relays (63 relays) may be used for supplemental protection, they cannot be used to meet the redundancy requirement since they will not respond to faults outside the transformer tank between the circuit breakers and transformer.

Shunt device protective relays should initiate breaker failure for the circuit breaker or circuit switcher protecting the shunt device.

- Series Reactors and Capacitors

  Minimum system protection requirements for series reactors and series capacitors shall be determined on a case-by-case basis and included in the applicable Request for Proposal. At a minimum, completely redundant protection systems will be required if these elements are not already in the protective zone of another element (e.g., Transmission Circuit, Transmission Transformer, etc.).

- Phase Angle Regulating and Voltage Regulating Transformers

  Minimum system protection requirements for phase shifting transformers and voltage regulating transformers shall be determined on a case-by-case basis and included in the applicable Request for Proposal. At a minimum, completely redundant protection systems will be required if these elements are not already in the protective zone of another element (e.g., Transmission Circuit, Transmission Transformer, etc.)

- HVDC Transmission Circuits and Converters

  Minimum system protection requirements for HVDC Transmission Circuits and associated converter equipment shall be determined on a case-by-case basis and included in the applicable Request for Proposal. At a minimum, completely redundant protection systems will be required for these elements.

- Breaker Failure Protection

  Each Transmission Circuit breaker must contain a breaker failure relay that will trip all electrically adjacent sources when a trip signal is sent to the circuit breaker and the circuit breaker fails to open and interrupt the fault after a predetermined time. Electrically adjacent sources are defined as electrically adjacent circuit breakers within the substation as well as generators and/or remote terminals if the circuit breaker protects a Generation Element and/or a Transmission Circuit respectively.

  Breaker failure shall be initiated on the circuit breaker if a trip signal to the circuit breaker is sent by a protective relay element, auxiliary relay, lockout relay, or remote transfer trip signal[10]. Breaker failure shall not be initiated for breaker trip signals generated by the breaker control switch (01), from the SCADA system, or from the circuit breaker manual trip switch located on the circuit breaker. When breaker failure is initiated, a breaker failure timer will be started. When the breaker failure timer times out, breaker failure tripping may be initiated depending on conditions described below. The breaker failure timer must be set within the range specified in the Request for Proposal, but in no case greater than 12 cycles or less than 3 cycles.

[10] This document does not require nor prohibit the initiation of breaker failure on a circuit breaker when such circuit breaker receives a trip signal initiated by a breaker failure relay scheme on an adjacent circuit breaker. Should there be special circumstances for a specific project that requires one practice or the other, MISO reserves the right on a case by case basis to require or prohibit this practice in a Request for Proposal.

Breaker failure relays must contain an overcurrent fault detector (50) that measures the current flow through the circuit breaker and the fault detector must be set to detect all bolted short-circuit faults for which the circuit breaker provides primary protection. It is permissible to assume all other circuit breakers (both local and remote) providing primary protection for a specific fault have opened when determining if a breaker failure relay overcurrent fault detector has adequate reach to all remote terminals. Pickup of the overcurrent fault detector shall not be a requirement to initiate breaker failure for terminals with multiple circuit breakers (i.e., ring bus and double bus configurations), but instead will be used to enable breaker failure tripping when appropriate as further described below.

For faults that require a specific circuit breaker to trip in order to clear the fault, breaker failure initiation occurs when a relay element sends a trip signal to the circuit breaker and a timer is started. When the timer expires, if the overcurrent fault detector associated with the breaker failure relay is picked up, then breaker failure tripping shall occur. Breaker failure tripping shall be made via a dedicated breaker failure lockout relay (86) for the circuit breaker in question. The lockout relay will hold a trip signal (which will energize the trip coil when the 52A breaker auxiliary contact is closed) and open the closing circuit on all electrically adjacent circuit breakers at the substation. Depending on the specifications supplied by incumbent Transmission Owners who will be required to trip remote circuit breakers in response to breaker failure tripping for a specific circuit breaker, either the breaker failure lockout relay or the breaker failure relay will be required to send a transfer trip signal to remote terminals that must open and clear the fault and stop carrier transmission to those remote terminals in the case where a directional comparison blocking scheme is used to protect the Transmission Circuit.

For faults in protective zones that include transformers and/or oil-filled reactors (generator protective zones, Transmission Transformer protective zones, shunt reactor zones, etc.), it is permissible to enable breaker failure tripping if either the overcurrent fault detector associated with the breaker failure relay is picked up or a breaker auxiliary contact indicates the circuit breaker is still closed (e.g., 52A contact is closed or 52B contact is open, etc.). This is allowed because it is often not feasible for the breaker failure overcurrent fault detector to detect small fault current magnitudes associated with turn-to-turn internal transformer faults that caused operation of differential or sudden pressure relay elements, thus the overcurrent fault detector could provide false indication that the fault has been cleared. However, this practice shall not be permitted for protective zones that do not include transformers or oil-filled reactors (e.g., Transmission Circuits, Transmission Physical Buses, etc.) since a breaker auxiliary contact only indicates a mechanism position and does not confirm that the fault current has been interrupted.

Finally, it will be necessary for the RFP Respondent to trip (and not initiate automatic reclosing on) appropriate circuit breaker(s) protecting Transmission Circuits or Generation Elements when breaker failure transfer trip signals are received from the remote end.

4.3. Appendix A: Tables

Appendix A contains a number of tables that are used by the procedures, policies, and processes outlined in this document to determine minimum project requirements for Competitive Transmission Facilities associated with Competitive Transmission Projects.

TABLE 1

Industry Standard Terminal Equipment Rating Classes

(Continuous Current)

	1200 A	2000 A	3000 A	4000 A	5000 A
69 kV	X	X	X		
115 kV	X	X	X		
138 kV	X	X	X		
161 kV	X	X	X		
230 kV	X	X	X		
345 kV		X	X	X	X
500 kV		X	X	X	X
765 kV			X	X	X

TABLE 2A
Default Minimum Transmission Circuit Emergency Ampere Ratings

Nominal Operating (kV)	**Emergency Ampere Rating (Amperes)**
765	4,000
500	3,000
345	3,000
230	1,200
100-200	1,200
Below 100	1,200

TABLE 2B
Default Minimum Transmission Circuit Normal Ampere Ratings

Nominal Operating (kV)	**Normal Ampere Rating (Amperes)**
765	2,680
500	2,000
345	2,000
230	800
100-200	800
Below 100	800

TABLE 3A
Bus Configuration Standards – Maximum Number of Total Positions***

Nominal Operating kV	Single-Zone Straight Bus	Double-Zone Straight Bus**	Ring Bus	Double-Bus Breaker-and-a-Half	Double-Bus Double-Breaker
100-199	3	6	6	Unlimited*	Unlimited*
230	3	6	6	Unlimited*	Unlimited*
345	Not Allowed	Not Allowed	6	Unlimited*	Unlimited*
500	Not Allowed	Not Allowed	6	Unlimited*	Unlimited*
765	Not Allowed	Not Allowed	6	Unlimited*	Unlimited*

* NOTE: Limited by breaker duty requirements and/or critical infrastructure limitations.
** NOTE: Tie breaker does not count as a position and each of the two zones associated with a double-zone straight bus must individually meet the requirements for a single-zone straight bus.
***NOTE: Loads, shunt capacitors, and shunt reactors do not count as positions for the purpose of determining the maximum number of total positions.

TABLE 3B
Bus Configuration Standards – Maximum Number of Transmission Circuit Positions

Nominal Operating kV	Single-Zone Straight Bus	Double-Zone Straight Bus**	Ring Bus	Double-Bus Breaker-and-a-Half	Double-Bus Double-Breaker
100-199	2	4	4	Unlimited*	Unlimited*
230	2	4	4	Unlimited*	Unlimited*
345	Not Allowed	Not Allowed	4	Unlimited*	Unlimited*
500	Not Allowed	Not Allowed	4	Unlimited*	Unlimited*
765	Not Allowed	Not Allowed	4	Unlimited*	Unlimited*

* NOTE: Limited by breaker duty requirements and/or critical infrastructure limitations.
** NOTE: Tie breaker does not count as a position and each of the two zones associated with a double-zone straight bus must individually meet the requirements for a single-zone straight bus.

TABLE 4
Industry Standard Circuit Breaker Symmetrical Interrupting Ratings

Nominal Operating (kV)	**Symmetrical Interruption Ratings (kA)**
765	40, 50, 63
500	40, 50, 63
345	40, 50, 63, 80
230	31.5, 40, 50, 63, 80
100-200	31.5, 40, 50, 63, 80
Below 100	31.5, 40, 50, 63

TABLE 5A
Emergency Ampere Adequacy Validation Ratings
Option 1 – Transmission Owner Facility Rating Methodology uses IEEE 738
Required Input Assumptions for IEEE 738 Conductor Rating Methodology

Input Parameter	Value
Maximum Allowable Emergency Operating Temperature	See Note 1
Minimum Ambient Temperature – Summer Ratings	See Note 2
Minimum Ambient Temperature – Winter Ratings	See Note 3
Maximum Wind Speed (Feet Per Second)	0.0
Wind Angle with respect to Conductor Direction (Degrees)	90.0
Conductor Emissivity	See Note 1
Solar Absorptivity	See Note 1
Density of Air (Pounds per Cubic Foot)	See Note 1
Viscosity of Air (Pounds per Hour-Foot)	See Note 1
Thermal Conductivity of Air (Watts per Foot-°C)	See Note 1
Total Solar Radiated Heat Flux (Watts per Square Foot)	See Note 1
Altitude of Sun (Degrees)	See Note 1
Azimuth of Sun (Degrees)	See Note 1
Azimuth of Line (Degrees)	See Note 1
Latitude of Line (Degrees)	See Note 4

Table 5A Notes:

- **Note 1:** The input value should be the same value specified by the Selected Developer's facility rating methodology for the IEEE 738 parameter in question.
- **Note 2:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum summer ambient temperature of 35°C (95°F) should be used. For all other Competitive Transmission Line Facilities, a minimum summer ambient temperature of 40°C (104°F) should be used.
- **Note 3:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum winter ambient temperature of 0°C

(32°F) should be used. For all other Competitive Transmission Line Facilities, a minimum winter ambient temperature of 10°C (50°F) should be used.

- **Note 4:** The latitude of the line should be equal to the average of the latitude of the two interconnecting substations. MISO will supply this value in the RFP.

TABLE 5B
Emergency Ampere Adequacy Validation Ratings
Option 1 – Transmission Owner Facility Rating Methodology does not use IEEE 738
Required Input Assumptions for IEEE 738 Conductor Rating Methodology

Input Parameter	**Value**
Maximum Allowable Emergency Operating Temperature • ACSR (°C) • ACSS (°C) • Other Conductor Types (°C)	100 200 90
Minimum Ambient Temperature – Summer Ratings	See Note 1
Minimum Ambient Temperature – Winter Ratings	See Note 2
Maximum Wind Speed (Feet Per Second)	0.0
Wind Angle with respect to Conductor Direction (Degrees)	90.0
Conductor Emissivity	0.7
Solar Absorptivity	0.9
Density of Air (Pounds per Cubic Foot) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Planning Regions - Winter	0.0716 0.0704 0.0807 0.0779
Viscosity of Air (Pounds per Hour-Foot) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Planning Regions - Winter	0.0456 0.0461 0.0415 0.0427
Thermal Conductivity of Air (Watts per Foot-°C) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Planning Regions - Winter	0.00818 0.00830 0.00739 0.00762
Total Solar Radiated Heat Flux (Watts per Square Foot) • Central and Eastern Planning Regions • Western Planning Region • Southern Planning Region	95.2 94.2

	95.6
Altitude of Sun (Degrees) • Central and Eastern Planning Regions (Summer and Winter) • Western Planning Region (Summer and Winter) • Southern Planning Region (Summer and Winter)	73 68 78
Azimuth of Sun (Degrees)	180
Azimuth of Line (Degrees)	90
Latitude of Line (Degrees)	See Note 3

Table 5B Notes:

- **Note 1:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum summer ambient temperature of 35°C (95°F) should be used. For all other Competitive Transmission Line Facilities, a minimum summer ambient temperature of 40°C (104°F) should be used.
- **Note 2:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum winter ambient temperature of 0°C (32°F) should be used. For all other Competitive Transmission Line Facilities, a minimum winter ambient temperature of 10°C (50°F) should be used.
- **Note 3:** The latitude of the line should be equal to the average of the latitude of the two interconnecting substations. MISO will supply this value in the RFP.

TABLE 5C
Emergency Ampere Adequacy Validation Ratings
Option 2 – Transmission Owner Facility Rating Methodology uses IEEE-738
Required Input Assumptions for IEEE 738 Conductor Rating Methodology

Input Parameter	**Value**
Maximum Allowable Emergency Operating Temperature	See Note 1
Minimum Ambient Temperature – Summer Ratings	See Note 2
Minimum Ambient Temperature – Winter Ratings	See Note 3
Maximum Wind Speed (Feet Per Second)	2.0
Wind Angle with respect to Conductor Direction (Degrees)	90.0
Conductor Emissivity	See Note 1
Solar Absorptivity	See Note 1
Density of Air (Pounds per Cubic Foot)	See Note 1
Viscosity of Air (Pounds per Hour-Foot)	See Note 1
Thermal Conductivity of Air (Watts per Foot-°C)	See Note 1
Total Solar Radiated Heat Flux (Watts per Square Foot)	See Note 1
Altitude of Sun (Degrees)	See Note 1
Azimuth of Sun (Degrees)	See Note 1
Azimuth of Line (Degrees)	See Note 1
Latitude of Line (Degrees)	See Note 4

Table 5C Notes:

- **Note 1:** The input value should be the same value specified by the Selected Developer's facility rating methodology for the IEEE 738 parameter in question.
- **Note 2:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum summer ambient temperature of 35°C (95°F) should be used. For all other Competitive Transmission Line Facilities, a minimum summer ambient temperature of 40°C (104°F) should be used.
- **Note 3:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum winter ambient temperature of 0°C

(32°F) should be used. For all other Competitive Transmission Line Facilities, a minimum winter ambient temperature of 10°C (50°F) should be used.

- **Note 4:** The latitude of the line should be equal to the average of the latitude of the two interconnecting substations. MISO will supply this value in the RFP.

TABLE 5D
Emergency Ampere Adequacy Validation Ratings
Option 2 – Transmission Owner Facility Rating Methodology does not use IEEE 738
Required Input Assumptions for IEEE 738 Conductor Rating Methodology

Input Parameter	**Value**
Maximum Allowable Emergency Operating Temperature • ACSR (°C) • ACSS (°C) • Other Conductor Types (°C)	100 200 90
Minimum Ambient Temperature – Summer Ratings	See Note 1
Minimum Ambient Temperature – Winter Ratings	See Note 2
Maximum Wind Speed (Feet Per Second)	2.0
Wind Angle with respect to Conductor Direction (Degrees)	90.0
Conductor Emissivity	0.7
Solar Absorptivity	0.9
Density of Air (Pounds per Cubic Foot) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Regions – Planning Winter	0.0716 0.0704 0.0807 0.0779
Viscosity of Air (Pounds per Hour-Foot) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Regions – Planning Winter	0.0456 0.0461 0.0415 0.0427
Thermal Conductivity of Air (Watts per Foot-°C) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Regions – Planning Winter	0.00818 0.00830 0.00739 0.00762
Total Solar Radiated Heat Flux (Watts per Square Foot) • Central and Eastern Planning Regions • Western Planning Region • Southern Planning Region	95.2 94.2

	95.6
Altitude of Sun (Degrees) • Central and Eastern Planning Regions (Summer and Winter) • Western Planning Region (Summer and Winter) • Southern Planning Region (Summer and Winter)	73 68 78
Azimuth of Sun (Degrees)	180
Azimuth of Line (Degrees)	90
Latitude of Line (Degrees)	See Note 3

Table 5D Notes:

- **Note 1:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum summer ambient temperature of 35°C (95°F) should be used. For all other Competitive Transmission Line Facilities, a minimum summer ambient temperature of 40°C (104°F) should be used.
- **Note 2:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum winter ambient temperature of 0°C (32°F) should be used. For all other Competitive Transmission Line Facilities, a minimum winter ambient temperature of 10°C (50°F) should be used.
- **Note 3:** The latitude of the line should be equal to the average of the latitude of the two interconnecting substations. MISO will supply this value in the RFP.

TABLE 5E
Normal Ampere Adequacy Validation Ratings
Option 1 – Transmission Owner Facility Rating Methodology uses IEEE 738
Required Input Assumptions for IEEE 738 Conductor Rating Methodology

Input Parameter	**Value**
Maximum Allowable Normal Operating Temperature	See Note 1
Minimum Ambient Temperature – Summer Ratings	See Note 2
Minimum Ambient Temperature – Winter Ratings	See Note 3
Maximum Wind Speed (Feet Per Second)	0.0
Wind Angle with respect to Conductor Direction (Degrees)	90.0
Conductor Emissivity	See Note 1
Solar Absorptivity	See Note 1
Density of Air (Pounds per Cubic Foot)	See Note 1
Viscosity of Air (Pounds per Hour-Hour)	See Note 1
Thermal Conductivity of Air (Watts per Foot-°C)	See Note 1
Total Solar Radiated Heat Flux (Watts per Square Foot)	See Note 1
Altitude of Sun (Degrees)	See Note 1
Azimuth of Sun (Degrees)	See Note 1
Azimuth of Line (Degrees)	See Note 1
Latitude of Line (Degrees)	See Note 4

Table 5E Notes:

- **Note 1:** The input value should be the same value specified by the Selected Developer's facility rating methodology for the IEEE 738 parameter in question.
- **Note 2:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum summer ambient temperature of 35°C (95°F) should be used. For all other Competitive Transmission Line Facilities, a minimum summer ambient temperature of 40°C (104°F) should be used.
- **Note 3:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum winter ambient temperature of 0°C

(32°F) should be used. For all other Competitive Transmission Line Facilities, a minimum winter ambient temperature of 10°C (50°F) should be used.

- **Note 4:** The latitude of the line should be equal to the average of the latitude of the two interconnecting substations. MISO will supply this value in the RFP.

TABLE 5F
Normal Ampere Adequacy Validation Ratings
Option 1 – Transmission Owner Facility Rating Methodology does not use IEEE 738
Required Input Assumptions for IEEE 738 Conductor Rating Methodology

Input Parameter	**Value**
Maximum Allowable Normal Operating Temperature • ACSR (°C) • ACSS (°C) • Other Conductor Types (°C)	75 125 75
Minimum Ambient Temperature – Summer Ratings	See Note 1
Minimum Ambient Temperature – Winter Ratings	See Note 2
Maximum Wind Speed (Feet Per Second)	0.0
Wind Angle with respect to Conductor Direction (Degrees)	90.0
Conductor Emissivity	0.7
Solar Absorptivity	0.9
Density of Air (Pounds per Cubic Foot) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Planning Regions - Winter	0.0716 0.0704 0.0807 0.0779
Viscosity of Air (Pounds per Hour-Foot) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Planning Regions - Winter	0.0456 0.0461 0.0415 0.0427
Thermal Conductivity of Air (Watts per Foot-°C) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Planning Regions - Winter	0.00818 0.00830 0.00739 0.00762
Total Solar Radiated Heat Flux (Watts per Square Foot) • Central and Eastern Planning Regions • Western Planning Region • Southern Planning Region	95.2 94.2

	95.6
Altitude of Sun (Degrees) • Central and Eastern Planning Regions (Summer and Winter) • Western Planning Region (Summer and Winter) • Southern Planning Region (Summer and Winter)	 73 68 78
Azimuth of Sun (Degrees)	180
Azimuth of Line (Degrees)	90
Latitude of Line (Degrees)	See Note 3

Table 5F Notes:

- **Note 1:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum summer ambient temperature of 35°C (95°F) should be used. For all other Competitive Transmission Line Facilities, a minimum summer ambient temperature of 40°C (104°F) should be used.
- **Note 2:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum winter ambient temperature of 0°C (32°F) should be used. For all other Competitive Transmission Line Facilities, a minimum winter ambient temperature of 10°C (50°F) should be used.
- **Note 3:** The latitude of the line should be equal to the average of the latitude of the two interconnecting substations. MISO will supply this value in the RFP.

TABLE 5G
Normal Ampere Adequacy Validation Ratings
Option 2 – Transmission Owner Facility Rating Methodology uses IEEE 738
Required Input Assumptions for IEEE 738 Conductor Rating Methodology

Input Parameter	**Value**
Maximum Allowable Normal Operating Temperature	See Note 1
Minimum Ambient Temperature – Summer Ratings	See Note 2
Minimum Ambient Temperature – Winter Ratings	See Note 3
Maximum Wind Speed (Feet Per Second)	2.0
Wind Angle with respect to Conductor Direction (Degrees)	90.0
Conductor Emissivity	See Note 1
Solar Absorptivity	See Note 1
Density of Air (Pounds per Cubic Foot)	See Note 1
Viscosity of Air (Pounds per Hour-Foot)	See Note 1
Thermal Conductivity of Air (Watts per Foot-°C)	See Note 1
Total Solar Radiated Heat Flux (Watts per Square Foot)	See Note 1
Altitude of Sun (Degrees)	See Note 1
Azimuth of Sun (Degrees)	See Note 1
Azimuth of Line (Degrees)	See Note 1
Latitude of Line (Degrees)	See Note 4

Table 5G Notes:

- **Note 1:** The input value should be the same value specified by the Selected Developer's facility rating methodology for the IEEE 738 parameter in question.
- **Note 2:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum summer ambient temperature of 35°C (95°F) should be used. For all other Competitive Transmission Line Facilities, a minimum summer ambient temperature of 40°C (104°F) should be used.
- **Note 3:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum winter ambient temperature of 0°C

(32°F) should be used. For all other Competitive Transmission Line Facilities, a minimum winter ambient temperature of 10°C (50°F) should be used.

- **Note 4:** The latitude of the line should be equal to the average of the latitude of the two interconnecting substations. MISO will supply this value in the RFP.

TABLE 5H
Normal Ampere Adequacy Validation Ratings
Option 2 – Transmission Owner Facility Rating Methodology does not use IEEE 738
Rating Input Assumptions for IEEE 738 Conductor Rating Methodology

Input Parameter	Value
Maximum Allowable Normal Operating Temperature • ACSR (°C) • ACSS (°C) • Other Conductor Types (°C)	 75 125 75
Minimum Ambient Temperature – Summer Ratings	See Note 1
Minimum Ambient Temperature – Winter Ratings	See Note 2
Maximum Wind Speed (Feet Per Second)	2.0
Wind Angle with respect to Conductor Direction (Degrees)	90.0
Conductor Emissivity	0.7
Solar Absorptivity	0.9
Density of Air (Pounds per Cubic Foot) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Planning Regions - Winter	 0.0716 0.0704 0.0807 0.0779
Viscosity of Air (Pounds per Hour-Foot) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Regions – Winter	 0.0456 0.0461 0.0415 0.0427
Thermal Conductivity of Air (Watts per Foot-°C) • Western Planning Region – Summer • Other Planning Regions – Summer • Western Planning Region – Winter • Other Planning Regions – Winter	0.00818 0.00830 0.00739 0.00762
Total Solar Radiated Heat Flux (Watts per Square Foot) • Central and Eastern Planning Regions	 95.2

• Western Planning Region • Southern Planning Region	94.2 95.6
Altitude of Sun (Degrees) • Central and Eastern Planning Regions (Summer and Winter) • Western Planning Region (Summer and Winter) • Southern Planning Region (Summer and Winter)	73 68 78
Azimuth of Sun (Degrees)	180
Azimuth of Line (Degrees)	90
Latitude of Line (Degrees)	See Note 3

Table 5H Notes:

- **Note 1:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum summer ambient temperature of 35°C (95°F) should be used. For all other Competitive Transmission Line Facilities, a minimum summer ambient temperature of 40°C (104°F) should be used.
- **Note 2:** For Competitive Transmission Line Facilities located entirely within the MISO West Planning Region (i.e., both proposed terminating substations are located within the MISO West Planning Region), a minimum winter ambient temperature of 0°C (32°F) should be used. For all other Competitive Transmission Line Facilities, a minimum winter ambient temperature of 10°C (50°F) should be used.
- **Note 3:** The latitude of the line should be equal to the average of the latitude of the two interconnecting substations. MISO will supply this value in the RFP.