MidAmerican Energy Company 69 kV Facility Ratings Methodology

Version 1.0

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1.0 Scope:

This document provides MidAmerican Energy Company's (MidAmerican's) Transmission Owner methodology used for developing and communicating Facility Ratings (Facility Ratings Methodology) of its solely and jointly owned facilities. This document defines the basis for the calculation of normal and emergency ratings of MidAmerican facilities on the 69 kV system.

1.1 The scope of the facilities addressed in this document includes, but is not limited to line conductors, transformers, relay protective devices, terminal equipment, and series and shunt compensation devices.

1.2 The scope of the ratings addressed in this document includes both Normal and Emergency Ratings.

1.3 The ratings consider design criteria, manufacturer ratings, industry standards, ambient conditions, operating limitations, and other relevant assumptions.

1.4 MidAmerican is prepared to make its facility ratings available to those Reliability Coordinators (RCs), Transmission Operators (TOs), Transmission Planners (TPs), and Planning Authorities (PAs) that have responsibility in which the facilities are located. MidAmerican will provide its 69 kV ratings and methodology documentation upon request.

2.0 Establishment and Communication of Facility Ratings:

MidAmerican establishes 69 kV facility ratings consistent with its Facility Rating Methodology. MidAmerican submits then-current ratings information to the Midwest Reliability Organization (MRO) and Midwest Independent Transmission System Operator (MISO) model building processes on a periodic basis as required by the MOD standards and annual MRO and MISO model building requirements.

MidAmerican will communicate facility ratings information to its Regional Reliability Organization (the MRO), its Reliability Coordinator (MISO) and to other Transmission Owners / Operators upon request.

When MidAmerican has confirmed that updated ratings of its facilities are applicable, it will communicate those new ratings to the MRO, MISO, and MidAmerican System Control via appropriate mechanisms such as by submitting updated ratings to model databases, by electronic mail, by web-based tools, or, in the event of real-time system loading issues, by telephone. MidAmerican will maintain records of updated facility ratings submittals for documentation.

3.0 Facilities Rating Methodology:

3.1 Definition

This section defines the basis for the calculation of seasonal normal and emergency ratings of MidAmerican facilities rated 69 kV.

3.2 Determination of Most Limiting Element

All series elements that together make up a line section, or substation transformer circuit are reviewed to determine which element has the most limiting rating. The most limiting element will determine the normal and emergency ratings of the facility.

If information is received suggesting that a more limiting element exists on a line section or substation transformer circuit, MidAmerican will take steps to verify the information, which may include field inspections. Once review and field verification, if applicable, is complete, MidAmerican will take steps to mitigate any differences identified for either the facility normal rating or the facility emergency rating. Mitigation may include replacing or upgrading the limiting element(s) or updating the normal and/or emergency rating to reflect the latest available information.

3.3 Jointly-Owned Facility Ratings

3.3.1 In cases where a 69 kV facility is owned in segments (such as a line terminal being owned by one party and the line conductor by another party), MidAmerican takes into account rating data provided the owner(s) of the other segment(s) of the line and applies the most limiting rating as the rating of the facility.

3.3.2 In cases where a facility is jointly owned (such as two owners each owning an undivided 50% ownership interest in a facility), the operator of the facility determines the facility rating and shares this rating information with the other joint owners.

3.4 Procedures for Ring Buses and Breaker-and-a-Half Configurations

In the event that a line section or transformer terminates on a substation configured as a ring bus or a breaker-and-half, the facility rating for long-range planning models will be determined assuming a closed ring bus or closed breaker-and-a-half. The most limiting facility rating of the entire ring bus or the most limiting facility rating of the breaker positions adjacent to the line section or transformer in a breaker-and-a-half scheme are considered in determining the rating of the line section or transformer. In order to account for the flow split when entering a closed ring or closed breaker-and-a-half, a multiplier is used to adjust the ratings of the ring bus or breaker-and-a-half facilities. The multiplier assumes a split of 75%-25%, meaning that 75% of the line section flow or bulk transformer flow is assumed to be transferred onto one leg of the ring bus or breaker-and-a-half. This results in the ring bus limit or breaker-and-a-half limit being adjusted by 133% (100/75%) to account for the flow split of a closed ring or a closed breaker-and-a-half. The most limiting series element facility rating, and where applicable, 133% of the most limiting ring bus facility rating, or 133% of the most limiting facility rating of the adjacent breaker positions in a breaker-and-a-half is then used in the MRO/MISO model data submittal and in operations of the MidAmerican system.

During near-term operations, the status of the ring bus or breaker-and-a-half breakers is monitored. In the event the ring bus or breaker-and-a-half scheme is open, the multiplier accounting for flow split described in the previous paragraph is not applied, and the most limiting facility rating of the ring bus or the most limiting facility rating of the breaker positions adjacent to the line section or transformer in a breaker-and-a-half scheme are considered in determining the rating of the line section or transformer for real-time operations.

3.5 Assumptions

MidAmerican will consider certain assumptions as necessary including control actions, short-term ratings, and supplemental protection systems.

3.5.1 Ambient temperatures will be assumed at 100 Deg F for summer season ratings and 32 degrees F for winter season ratings unless otherwise specified. Additional ambient assumptions used in calculating line conductor ratings are included in section 3.7.1. For other equipment, manufacturer or industry standard ambient conditions are used unless otherwise specified.

3.5.2 Equipment ratings will be set considering manufacturer ratings and recommendations.

3.5.3 Equipment ratings will be set considering industry standards.

3.5.4 Equipment ratings will be set considering other operational limitations as applicable and necessary.

3.6 Substation Transformers and Auto-Transformers with a 69 kV low side winding, including 161-69 kV transformers

3.6.1. Normal Rating

The normal rating shall be the top nameplate rating of the transformer or that of the most limiting series device (e.g., a disconnect switch) in the transformer circuit, whichever is less.

3.6.2 Emergency Rating

The emergency rating shall be the emergency rating of the transformer, or that of the most limiting series device (e.g., a disconnect switch) in the transformer circuit, whichever is less.

For emergency rating purposes, it is assumed the transformer is loaded to its first forced cooled rating for eight hours, followed by one hour (or, for some transformers, two hours) of loading at the “one-hour” (or “two-hour”) emergency rating, then seven hours (or ten hours) of loading at the “seven-hour” (or “ten-hour”) emergency rating, followed by eight hours (or twelve hours) of loading at its first forced cooled rating.

If emergency ratings are not available from the manufacturer, they may be calculated using IEEE Standard 756 and ANSI/IEEE Standard C57.92-(latest revision) using the same emergency loading cycle specified above. However, the manufacturer is to review capability of transformer internals including internal leads plus ratings of transformer auxiliaries. If there are detrimental circumstances, such as indication of deteriorating conditions, the emergency rating of the transformer shall be the top nameplate of the transformer. In situations where an emergency rating was not originally specified with the transformer purchase and an emergency rating is either calculated or obtained via a subsequent manufacturer review, the proposed emergency rating shall be reviewed with the Substation Operations group, and if the Substation Operations group is aware of detrimental circumstances, such as indication of deteriorating conditions, the emergency rating of the transformer shall be the top nameplate of the transformer. If the emergency rating cannot be obtained from the manufacturer or calculated, the emergency rating will be assumed to be the top nameplate rating of the transformer.

3.6.3 Operating limitations.

Emergency ratings will be based on the transformer loading profile and assumed ambient temperature profile for each transformer, and the top oil or hot-spot temperatures as defined in the transformer purchasing specifications. Emergency ratings will consider transformer internal equipment limitations by obtaining a transformer manufacturer’s assessment when possible.

3.7 Line Conductors

3.7.1 Ambient Assumptions

The normal and emergency bare overhead conductor rating shall be calculated under the following assumed atmospheric conditions:

3.7.1.1 Ambient air temperature of 100 degrees F for summer season ratings and 32 degrees F for winter season ratings

3.7.1.2 A wind velocity of 7 ft/sec

3.7.1.3 An incident wind angle of 20 degrees

3.7.1.4 The following solar factors:

3.7.1.4.1 Latitude of 41 degrees north and longitude of 95 degrees west (these are the approximate values for Des Moines)

3.7.1.4.2 Time of day of 2:00 p.m. on July 15th for summer season ratings and 2:00 p.m. on January 15th for winter ratings

3.7.1.4.3 Elevation of 900 feet above sea level

3.7.1.4.4 East-west line orientation

3.7.1.4.5 Clear Skies

3.7.1.5 Conductor absorptivity and emissivity coefficients of 0.5

3.7.2 Sag Limit

The rating calculation for the line conductor also considers the maximum operating temperature of the line conductor, which may be sag limited based on minimum clearances specified in the National Electrical Safety Code. The maximum operating temperature is based on best available data for the line construction and the topography within the line corridor, which may be based on either line design plan and profiles, as-built drawings, field measurements, or LiDAR surveys. MidAmerican typical practice is to include a two (2) foot margin above the minimum clearances specified in the National Electric Safety Code.

In the event that field measurements or surveys identify deviations in either the assumed data for the line construction or the topography within the line corridor, which would result in a reduced maximum operating temperature in order to maintain clearances specified in the National Electric Safety Code, mitigation steps will be taken to achieve acceptable clearances. Such mitigations steps may include reducing the line conductor maximum operating temperature (and thus the line conductor rating), performing grading under affected spans, modifying underlying electric line crossings or underbuilt lines, replacing existing line structures, and/or installing mid span structures. Upon completion of the mitigation, an updated rating will be prepared.

3.7.3 Normal Conductor Operating Temperature

If clearances are not a factor, the normal conductor ratings are based on 100 degrees C conductor operating temperature for ACSR, 93.3 degrees C for AAC and ACAR, 180 degrees C for ACSS conductor, and 75 degrees C for copper conductor.

3.7.4 Emergency Conductor Operating Temperature

For AAC and ACAR conductors, if conductor clearances are not an issue, the emergency conductor rating may be calculated at a 100 degrees C conductor operating temperature at the above atmospheric conditions. A 1-hour duration shall be used for the application of the emergency conductor rating for AAC or ACAR conductors.

For copper conductors, if conductor clearances are not an issue, the emergency conductor rating may be calculated at a 100 deg C conductor operating temperature at the above atmospheric conditions. A 4-hour duration shall be used for application of the emergency conductor rating for copper conductors.

3.7.5 Line Rating Review Process

MidAmerican continues an ongoing system-wide line rating review that began in late 2001. MidAmerican initiated this review to better determine line conductor operating temperature capabilities. The process involves an aerial survey of each span of a particular line providing estimates of the conductor temperature at which violations of clearances can occur when analysis from the aerial survey is completed.

The order of aerial surveying and analysis of MidAmerican's lines is based upon targeting first those lines that were known to be constraints to the system, and those that were near their existing rating. Logistics of aerial surveying are also taken into account such that if certain lines in an area are targeted to be surveyed, additional segments not necessarily having a high priority are also flown due to the efficiency of getting that information while the aerial surveying helicopter was in the area.

MidAmerican's 345 kV lines and 161 kV lines have gone through the line rating review process resulting in revised ratings, as appropriate. MidAmerican's 69 kV lines are going through the same review process resulting in revised ratings, as appropriate. MidAmerican's line conductor ratings are subject to change as new information becomes available.

3.7.6 Bare Overhead Line Conductor Ampacity Calculation Methodology

Prior to 2003, MidAmerican utilized the DYNAMP bare overhead conductor methodology. In 2003, MidAmerican began utilizing the IEEE Standard 738-1993 methodology, and presently uses the updated methodology in IEEE Standard 738-2006.

Since MidAmerican is in the process of aerial surveying its lines and that process can result in lower line conductor ratings in some cases and since the IEEE conductor rating methodology typically results in a conductor rating in excess of the rating calculated by DYNAMP, MidAmerican uses the IEEE-based conductor rating for new line construction and in cases where a line has been aerial surveyed. This practice prevents the likelihood of conductor ratings increasing by applying the IEEE methodology and then decreasing based on aerial survey data.

3.7.7 Reasons for Adoption of Conductor Rating Assumptions

3.7.7.1 There were only three instances in the 10-year period from 1983 through 1992 in Des Moines, Sioux City or Davenport when the temperature was at or above 100 degrees F and the wind speed was below 7 feet/second, in accordance with information from the Midwest Climate Center in Champaign, Illinois.

3.7.7.2 An assumed wind incident angle of 20 degrees will likely be smaller than the actual angle approximately 7/9, or 78%, of the time, if random wind direction and line orientation are assumed. Also, IEEE calculations are performed with an assumed east-west line orientation, which is a worst-case assumption.

3.7.7.4 The only temperature limitations for ACSS are those which may cause damage to the protective coatings of steel wires or which may cause some loss of strength in the steel. These limitations, as advised by steel manufacturers, are 245 degrees C for Class A galvanized and 260 degrees C for aluminum clad. It is important to note however that there is significant uncertainty regarding the long-term effects of operating ACSS conductor at temperatures above 180 Deg C. MidAmerican will assume a maximum operating temperature of 180 Deg C for ACSS lines based on this uncertainty. However, a specific line with ACSS conductor could be limited to something less than 180 Deg C due to sag limits or other equipment limits.

3.7.8 Ambient Temperature Adjusted Conductor Ratings Excluding Seasonal Ratings

Ambient temperature adjusted conductor ratings are made available for use in the near-term operation of the system when appropriate. The rating of the bare overhead conductor is calculated at ambient temperatures in 10 degrees F increments from 100 degrees F down to 0 degrees F. In the determination of the ambient temperature adjusted rating of the bare overhead conductor, only the ambient temperature assumption is modified; the other atmospheric conditions are not changed, nor is the maximum operating temperature of the conductor. In the determination of the overall line ambient temperature adjusted rating for use in periods where the near-term operation of the system is conducted, other facility limits such as terminal equipment limits are observed.

The ambient temperature adjusted rating is determined only for the time-frame of the near-term operating condition; typically only an hour at a time. As the ambient temperature changes with time, the ambient temperature adjusted rating is adjusted to reflect the current ambient temperature. Ambient temperature adjusted ratings are not utilized in planning models.

3.8 Series and Shunt Capacitors and Reactors

3.8.1 Normal Rating

The normal rating shall be the lesser of the top nameplate rating of the capacitor, reactor, or that of the most limiting device (e.g., a disconnect switch) in the series circuit for series compensation or in the shunt circuit for shunt compensation.

3.8.2 Emergency Rating

The emergency rating shall be the lesser of the top nameplate rating of the capacitor, reactor, or that of the most limiting device (e.g., a disconnect switch) in the series circuit for series compensation or in the shunt circuit for shunt compensation.

3.9 Terminal Equipment

Terminal equipment includes all other series equipment that must be considered in rating and completing an electrical circuit including, breakers, cables, circuit switchers/linebackers, current transformers, jumpers, switches, tubular bus, wavetraps, fuses, and potential devices.

3.9.1 Breakers

3.9.1.1 Normal Rating

The normal rating shall be the top nameplate rating provided by the manufacturer in accordance with ANSI Standard C37.04 and C37.010.

3.9.1.2 Emergency Rating

The emergency rating shall be the top nameplate rating provided by the manufacturer in accordance with ANSI Standard C37.04 and C37.010

3.9.2 Cables

3.9.2.1 Normal Rating

The normal rating shall be the rating supplied by the cable manufacturer in accordance with IEEE Standard 835.

3.9.2.2 Emergency Rating

The emergency rating shall be the rating supplied by the cable manufacturer in accordance with IEEE Standard 835.

3.9.3 Circuit Switchers and Line Backers

3.9.3.1 Normal Rating

The summer normal rating shall be the nameplate rating of the circuit switcher or line backer. The winter normal rating shall be based on manufacturer-supplied information.

3.9.3.2 Emergency Rating

The emergency rating shall be based on manufacturer-supplied information.

3.9.4 Current Transformers

3.9.4.1 Normal Rating

The normal rating shall be the nameplate rating of the current transformer (CT). Continuous overload thermal rating factors will be applied to tapped windings per manufacturer's data and recommendations.

Also based on manufacturer data, CTs with distributed windings not set on the highest available tap, will have a rating equal to the square root of the product of the tap setting currently in use and the highest available tap setting, provided that the resultant rating does not exceed two times the tap winding value, the maximum CT rating increased by the continuous thermal rating factor, or the circuit breaker rating (in cases where the CT is associated with a circuit breaker). An example of this rating follows: if a multi-ratio current transformer with distributed windings is set on a 1200 Amp tap and the highest available tap setting is 2000 Amps, the CT rating would be the square root of (1200 x 2000), or 1549 Amps.

In situations where the CT is associated with a circuit breaker and the circuit breaker rating is less than the highest available tap setting of a multi-ratio CT, the CT rating will be equal to the square root of the product of the tap setting currently in use and the circuit breaker rating, provided that the resultant rating does not exceed two times the tap winding value, the maximum CT rating increased by the continuous thermal rating factor, or the circuit breaker rating. An example of this rating follows: if a multi-ratio current transformer with distributed windings is set on a 1200 Amp tap and the highest available tap setting is 2000 Amps, but the circuit breaker rating is 1600 Amps the CT rating would be the square root of (1200 x 1600), or 1385 Amps.

3.9.4.2 Emergency Rating

Based on manufacturer data, the emergency rating shall be 110% of the normal rating/continuous overload rating as long as the circuit breaker rating (if the CT is associated with a circuit breaker) is not exceeded.

3.9.5 Jumpers

3.9.5.1 Normal Rating

The normal rating is calculated utilizing the IEEE Standard 738 methodology, assuming the ambient conditions listed in section 3.7.1. A maximum operating temperature of 70 degrees Celsius is used for jumpers which connect to condenser bushings, and the maximum operating temperature for all other jumpers is 90 degrees Celsius. The normal rating is calculated utilizing the IEEE Standard 738 methodology, and the ambient conditions listed in section 3.7.1.

3.9.5.2 Emergency Rating

The emergency rating of substation equipment jumpers is equal to the normal rating.

3.9.6 Switches

3.9.6.1 Normal Rating

For switches manufactured under the ANSI standards, the normal rating shall be the nameplate rating of the switch. For some switches manufactured under the NEMA standards (a predecessor to the ANSI standards), a higher rating may be assigned based on the recommended method provided in ANSI Standard C37.37.

The formula given in the ANSI standard which relate the NEMA rating to the ANSI rating is:

$$(I1/I2)^{1.8} = T1/T2$$

where:

I1 = NEMA continuous rating
I2 = ANSI continuous rating
T1 = NEMA temperature rise in ° C
T2 = ANSI temperature rise in ° C

Information from the switch manufacturer is used to determine the temperature rise of the switch manufactured under NEMA standards. The ANSI temperature rise is based on the allowable temperature rise in ANSI C37.37 for the specific switch contact material utilized in the switch (e.g., copper/copper alloy or aluminum).

3.9.6.2 Emergency Rating

The emergency rating shall be in accordance with ANSI Standard C37.37. Emergency ratings are applicable to switches for which the rating has been converted from a NEMA rating to an ANSI rating. In such cases, the full emergency rating percentage is applicable to the ANSI rating of such switches.

3.9.7 Tubular Bus

3.9.7.1 Normal

The normal rating shall be calculated utilizing the IEEE Standard 738 methodology, assuming and the ambient conditions listed in section 3.7.1. and a maximum operating temperature of 90 degrees Celsius

3.9.7.2 Emergency

The emergency rating of tubular bus is equal to the normal rating.

3.9.8 Wavetraps

3.9.8.1 Normal Rating

The normal rating shall be the rating supplied by the manufacturer in accordance with ANSI Standard C93.3.

3.9.8.2 Emergency Rating

The emergency rating shall be in accordance with ANSI Standard C93.3.

3.9.9 Fuses

MidAmerican bases the normal and emergency rating upon information provided by the equipment manufacturer and applicable industry standards.

3.9.10 Potential Devices

MidAmerican bases the normal and emergency rating upon information provided by the equipment manufacturer and applicable industry standards.

3.10 Relay Protective Devices

Protective relay settings are considered in establishing facility normal and emergency ratings. In instances where the relay settings are identified to limit the normal and/or emergency rating of a facility, MidAmerican will take steps to mitigate. Mitigation may include adjusting protective relay settings (such that they do not limit the rating), replacing or upgrading the protective relay(s), or updating the normal and/or emergency rating to reflect the associated relay load limit.

3.11 Assumptions for Underbuild Lines for Line Re-Rates

In situations where the subject line has underbuild the following procedures will be practiced during the line re-rating process.

3.11.1 The desired maximum operating temperature for the line in question is determined according to the process described in section 3.12 assuming a 100 degree F ambient temperature and the other standard assumptions for ambient conditions listed in Section 3.7.1.

3.11.2 While maintaining the line in question at its maximum conductor operating temperature, the ambient temperature used to sag the underbuild line(s) is reduced in 10 degree F increments (starting at 100 degrees F) until the first clearance violation appears between the line conductor in question and the underbuild line(s) (unless there are no under-build violations at an ambient temperature of 0 degrees F).

3.11.3 At a minimum, clearance violations between the subject line and the underbuild line(s) occurring at the desired maximum conductor operating temperature of the subject line assuming a 100 degree F ambient sag on the under-build sections are addressed, according to the process described in section 3.7.2.

3.11.4 Ambient temperature adjusted ratings are calculated down to a value at which there are no sag violations to the under-build. For example, if the first sag violation to the under-build appears at an ambient temperature of 40 degrees F, then ambient adjusted ratings are calculated only down to 50 degrees F.

A brief description of the general steps in the line re-rating process practiced at MidAmerican is provided below and a discussion as to why the criteria above are necessary.

3.12 Line Re-rate Process

Power flow cases, including n-1 and n-2 contingencies, are reviewed to determine the maximum expected flow on the line in question. The desired maximum conductor operating temperature is then calculated assuming the maximum expected flow (plus adders based on engineering judgment) occurs at an ambient temperature of 100 degrees F, with the other standard assumptions for ambient conditions listed in Section 3.7.1.

3.12.1 Clearance violations are addressed according to the process described in section 3.7.2 in order to allow the line to be operated at the desired maximum conductor operating temperature.

3.12.2 Once the line remediation work is complete, the new maximum operating temperature is used to calculate the conductor MVA rating and to set alarms and warning levels. It is also used to calculate ambient adjusted conductor ratings for use in periods where the near-term operation of the system is conducted The principle behind ambient adjusted ratings is that for a given maximum conductor operating temperature, a lower ambient temperature allows additional current capacity on the line before reaching that maximum operating temperature.

3.12.3 The maximum expected line flow is intended to be the bound of the possible flow on the line, and therefore the maximum conductor operating temperature should only be reached during the maximum ambient conditions (100 degrees F). However, many unplanned scenarios can occur in the daily operation of the system (maintenance outages, generator outages, abnormal switching of the system, etc), and under these abnormal conditions it is possible that a conductor could reach its maximum operating temperature while the ambient temperature is less than 100 degrees F. At lower ambient temperatures the under-build would sag less than the 100 degrees F sag; therefore, the procedures described in Section 3.11 are implemented with respect to lines having under-build.

4.0 References (use latest revision for industry standards):

[1] General Cable Technologies Corporation, "TransPower ACSS – A Proven Concept for a Composite Aluminum-Steel Conductor for Overhead Transmission Lines", (2001): p. 6.

[2] House & Tuttle, "Current-Carrying capacity of ACSR", AIEE Transactions, Vol. 77, (1958): pp. 1169-1177.

[3] J. R. Harvey, "Effect of Elevated Temperature Operation on the Strength of Aluminum Conductors", IEEE-PAS Vol. 91 (1972): pp. 1769-1772.

[4] L. M. Olmsted, "Safe Ratings for Overhead Line Conductors", AIEE Transactions, Vol. 62 (1943): pp. 845-853.

[5] ANSI/IEEE Standard Power Cable Ampacity Tables, 835.

[6] ANSI/IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current, C37.04

[7] IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current, C37.010

[8] ANSI Standard Requirements for Power-Line Carrier Line Traps, C93.3

[9] ANSI/IEEE Standard loading Guide for AC High Voltage Air Switches (in excess of 1000v), C37.37

[10] ANSI Standard for Electric Connectors – for Use Between Aluminum to Aluminum or Aluminum to Copper Bare Overhead Conductors, C119.4

[11] IEEE Standard 738 Standard for Calculating the Current-Temperature of Bare Overhead Conductors.

Revision History:

1. Version 1.0 issued on 8/29/2012.