ROCHESTER PUBLIC UTILITIES

FACILITY RATINGS METHODOLOGY FOR TRANSMISSION, SUBSTATION, & GENERATION EQUIPMENT

The document describes the current methodology used for developing facility ratings of Rochester Public Utilities' (RPU) transmission, substation, and generation facilities. This document has been prepared to comply with the North American Electric Reliability Corporation (NERC) Facilities Ratings Methodology requirements of standard FAC-008-5.

REQUIREMENTS

R1 GENERATION FACILITY RATINGS

RPU solely owns all of its generator facilities, including the generator step up transformers. RPU does not have any jointly owned generation. RPU manages the facility ratings of its generator facilities up to the high side terminals of RPU-owned main step up transformers. A facility is considered a system of equipment and major components that must be integrated and operated together. A generation facility's rating reflects one or more of the following factors:

- Design or construction information such as design criteria, equipment drawings and/or specifications,
- Ratings provided by equipment manufacturers
- Industry standards applicable to the equipment or major component
- Operating practices verified through engineering analysis or performance history.

Ultimately, the facility rating shall equal the most limiting applicable equipment rating of the individual equipment or major components that comprise that facility.

R2 GENERATION FACILITY RATINGS METHODOLOGY

RPU maintains a methodology for determining the facility ratings of its solely owned generator facilities encompassing the equipment mentioned in R1 of this document as well as the equipment up to and including the point of interconnection to the bulk electric system. All facilities are considered a system of equipment and major components that must be integrated and operated together. The methodology for determining a facility's rating is based on one or more of the following factors:

- Ratings provided by equipment manufacturers
- Industry standards applicable to the equipment or major component
- Operating practices verify through engineering analysis or performance history.

It is the responsibility of the project engineer to examine and apply these factors during the design and implementation of the facility construction or upgrade project. It is the responsibility of the Sr. Electrical Engineer to record the resulting facility rating in the RPU System Data Book.

R2.1 GENERATOR FACILITY RATINGS METHODOLOGY SCOPE

In general, a facility is considered a system of equipment and major components that must be integrated and operated together. A facility's rating reflects one or more of the following factors:

- Ratings provided by equipment manufacturers
- Industry standards applicable to the equipment or major component, such as IEEE, ANSI, and NEMA.
- Operating practices verified through engineering analysis or performance history.

R2.2 ASSUMPTIONS, CRITERIA, AND METHODS

The scope and method by which the rating of major electric generation equipment is based on the criteria and factors shown in section R2 of NERC Standard FAC-008-5. The resulting ratings for RPU's solely owned facilities are collected and reported in the RPU System Data Book, as required in section R6 of NERC Standard FAC-008-5.

R2.2.1 EQUIPMENT RATING STANDARDS

Equipment ratings criteria shall follow applicable industry rating practices, including recommendations and guidelines from manufacturer's literature, IEEE, ANSI, NEMA, and ASTM standards in effect at the date of manufacture. These standards are not listed in this document for brevity. It is the project engineer's responsibility to research the appropriate and current version applicable to the equipment or major component. Normal and emergency ratings are addressed for applicable equipment.

R2.2.2 MANUFACTURER'S EQUIPMENT RATINGS

Ratings listed per equipment such as generators and transformers, shall be provided by the manufacturer. Where possible, these ratings shall appear on the equipment nameplate.

Ratings listed per major component such as generator terminal lead conductors, bus, and related accessories, shall be provided by the manufacturer or shall be calculated by accepted industry practices or applicable standards.

R2.2.3 AMBIENT CONDITIONS

A. Ambient Conditions – Generation Equipment.

   Ratings of all equipment shall be selected to meet the anticipated indoor and outdoor environmental conditions. Factors shall include:

1. Elevation

Elevation Range (Mean Sea Level)	Less than 1500 Feet

2. Temperature and Humidity – Substation Equipment

Outdoor Conditions	Ambient Temperature, °F	Relative Humidity, %
Summer Design Condition – 50 yr	104°F	100%
Summer Design Condition – Typical	95°F	95%
Winter Design Condition – 50 yr	-40°F	---
Winter Design Condition – Typical	-20°F	---

Indoor Conditions	Ambient Temperature, °F	Relative Humidity, %
Summer Design Condition – 50 yr	105°F	100%
Summer Design Condition – Typical	80°F	95%
Winter Design Condition – 50 yr	50°F	---
Winter Design Condition – Typical	70°F	---

3. Seismic

   Earthquake loads and seismic provisions are not required in accordance with Minnesota Building Code Sections 1305.0011 Subpart 4.

4. Other factors as applicable to specific project circumstances

R2.2.4 OPERATING LIMITATIONS

All facilities shall be planned so the resulting rating shall meet or exceed the operating forecasts of the intended facility across the planned life of the facility. Normal and emergency ratings are addressed for applicable equipment.

Operating limits of a facility shall reflect the lowest rating of the set of equipment and major components that make up the facility. Conductor temperature, sag limits, relay settings and CT secondary circuit limits shall be part of this consideration.

Operating limits of a facility shall also reflect temporary de-ratings of impaired equipment in accordance with good utility practices or in accordance with external input from interconnected utilities and reliability coordinators, i.e. operating guides, loading relief measures, etc.

R2.3 ULTIMATE FACILITY RATINGS

As defined in the NERC glossary, a facility is "a set of electrical equipment that operates as a single Bulk Electric System Element (e.g., a line, a generator, a shunt compensator, transformer, etc.)." Ultimately, the facility rating shall equal the most limiting applicable equipment rating of the individual equipment or major components that comprise that facility.

R2.4 GENERATION FACILITY RATINGS PROCESS AND SCOPE

Equipment addressed by this standard covers all generation and interconnecting substation equipment and lines, including conductors, transformers, relay protective devices, terminal equipment, and series and shunt compensation devices.

Normal and emergency ratings are addressed for applicable equipment.

The project engineer or project manager conducting a project to install or upgrade equipment is responsible for verifying that methodologies to determine facilities ratings as directed by this document are consistent with industry best practices and evolving standards. The project engineer or project manager is also responsible for determining the facilities rating as directed by this document.

For generator facilities, the following apply:

A. Ratings listed per generator shall be based on manufacturer's ratings as provided by the manufacturer. Where possible, these ratings shall appear on the equipment nameplate, design document, or machine capability graph or table.

B. For generating units where hydrogen is used as the generator coolant, the manufacturer's maximum nameplate MVA rating is given for a hydrogen pressure of 30.0 PSI gauge. The manufacturer's minimum nameplate MVA rating is given for a hydrogen pressure of 0.5 PSI gauge.

C. The generator Maximum MW and MVAR output and Maximum MVAR intake ratings shall be based on the manufacturer's published limits of the machine.

D. Generator ratings may be modified based on the results of URGE testing.

E. Ratings of bus duct and other series components shall be based on manufacturer's ratings as provided by the manufacturer. Where possible, these ratings shall appear on the equipment nameplate or design document.

R3 TRANSMISSION FACILITY RATINGS METHODOLOGY

At this time, RPU solely owns all of its transmission facilities, with the exception of transmission interties solely owned by Southern Minnesota Municipal Power Agency (SMMPA) or Dairyland Power Cooperative (DPC). RPU does not currently have any jointly owned transmission facilities. Two new transmission interties are planned and will be commissioned in 2013 and 2014 respectively. RPU maintains a methodology for determining the facility ratings of its solely owned transmission facilities (except for those generating unit facilities addressed in R1 and R2) as well as the equipment up to and including the point of interconnection to the bulk electric system.

The methodology for determining a facility's rating is based on one or more of the following factors:

- Ratings provided by equipment manufacturers
- Industry standards applicable to the equipment or major component
- Operating practices verify through engineering analysis or performance history.

It is the responsibility of the project engineer to examine and apply these factors during the design and implementation of the facility construction or upgrade project. It is the responsibility of the Sr. Electrical Engineer to record the resulting facility rating in the RPU System Data Book.

R3.1 TRANSMISSION FACILITY RATINGS METHODOLOGY SCOPE

In general, a facility is considered a system of equipment and major components that must be integrated and operated together. A facility's rating reflects one or more of the following factors:

- Ratings provided by equipment manufacturers
- Industry standards applicable to the equipment or major component such as IEEE, ANSI, and NEMA.

- Operating practices verified through engineering analysis or performance history.

R3.2 ASSUMPTIONS, CRITERIA, AND METHODS

The scope and method by which the rating of major bulk electric system equipment is based on the criteria and factors shown in section R3.2 of NERC Standard FAC-008-5. The resulting ratings for RPU's solely and jointly owned facilities are collected and reported in the RPU System Data Book, as required in section R6 of NERC Standard FAC-008-5.

R3.2.1 EQUIPMENT RATING STANDARDS

Equipment ratings criteria shall follow applicable industry rating practices, including recommendations and guidelines from manufacturer's literature, IEEE, ANSI, NEMA, and ASTM standards in effect at the date of manufacture. These standards are not listed in this document for brevity. It is the project engineer's responsibility to research the appropriate and current version applicable to the equipment or major component. Normal and emergency ratings are addressed for applicable equipment.

R3.2.2 MANUFACTURER'S EQUIPMENT RATINGS

Ratings listed per equipment such as circuit breakers, disconnect switches, and transformers, shall be provided by the manufacturer. Where possible, these ratings shall appear on the equipment nameplate.

Ratings listed per major component such as line conductors, bus, and related accessories, shall be provided by the manufacturer or shall be calculated by accepted industry practices or applicable standards.

R3.2.3 AMBIENT CONDITIONS

A. Ambient Conditions – Substation Equipment.

Ratings of all equipment shall be selected to meet the anticipated indoor and outdoor environmental conditions. Factors shall include:

1. Elevation

Elevation Range (Mean Sea Level)	Less than 1500 Feet

2. Temperature and Humidity – Substation Equipment

Outdoor Conditions	Ambient Temperature, ^{o}F	Relative Humidity, %
Summer Design Condition – 50 yr	104^{o}F	100%
Summer Design Condition – Typical	95^{o}F	95%
Winter Design Condition – 50 yr	-40^{o}F	---
Winter Design Condition – Typical	-20^{o}F	---

Indoor Conditions	Ambient Temperature, ^{o}F	Relative Humidity, %
Summer Design Condition – 50 yr	95^{o}F	100%
Summer Design Condition – Typical	80^{o}F	95%
Winter Design Condition – 50 yr	50^{o}F	---
Winter Design Condition – Typical	70^{o}F	---

3. Precipitation

Rainfall

100 year	24 hour storm	6.2 inches
25 year	24 hour storm	4.8 inches
10 year	24 hour storm	4.3 inches
2 year	24 hour storm	3.0 inches

Flood Elevation (100 years): site specific

Design Ground Snow Load: 50 Lbs/Ft^2

Frost Depth: 42 Inches

4. Wind

   Basic Wind Speed: 90 mph

5. Seismic

   Earthquake loads and seismic provisions are not required in accordance with Minnesota Building Code Sections 1305.0011 Subpart 4.

6. Other factors as applicable to specific project circumstances

B. Ambient Conditions – Transmission Lines.

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

1. Ambient air temperature of 80 degrees F for summer season rating and 32 degrees F for winter season ratings.

2. Wind velocity of 2 ft./sec.

3. Incident wind angle of 90 degrees to the conductor

4. Solar factors of:
   - Latitude 44 degrees north and longitude 92 degrees west (approximate for Rochester, MN)
   - Elevation of 1100 ft. above mean sea level
   - East-West line orientation
   - Absorptivity and emissivity coefficients of 0.5.

R3.2.4 OPERATING LIMITATIONS

All facilities shall be planned so the resulting rating shall meet or exceed the operating forecasts of the intended facility across the planned life of the facility. Normal and emergency ratings are addressed for applicable equipment.

Operating limits of a facility shall reflect the lowest rating of the set of equipment and major components that make up the facility. Conductor temperature, sag limits, relay settings and CT secondary circuit limits shall be part of this consideration.

Operating limits of a facility shall also reflect temporary de-ratings of impaired equipment in accordance with good utility practices or in accordance with external input

from interconnected utilities and reliability coordinators, i.e. operating guides, loading relief measures, etc.

R3.3 ULTIMATE FACILITY RATINGS

As defined in the NERC glossary, a facility is "a set of electrical equipment that operates as a single Bulk Electric System Element (e.g., a line, a generator, a shunt compensator, transformer, etc.)." Ultimately, the facility rating shall equal the most limiting applicable equipment rating of the individual equipment or major components that comprise that facility.

R3.4 TRANSMISSION FACILITY RATINGS PROCESS AND SCOPE

Equipment addressed by this standard covers all 161 kV substation equipment and lines, including transmission conductors, transformers, relay protective devices, terminal equipment, and series and shunt compensation devices.

Normal and emergency ratings are addressed for applicable equipment.

The project engineer or project manager conducting a project to install or upgrade equipment is responsible for verifying that methodologies to determine facilities ratings as directed by this document are consistent with industry best practices and evolving standards. The project engineer or project manager is also responsible for determining the facilities rating as directed by this document.

For Transmission and Substation Facilities, the following apply:

A. Circuit Breakers The summer and winter normal and emergency ratings of the equipment shall be the nameplate rating of the equipment.

B. Circuit Switchers The summer and winter normal and emergency ratings of the equipment shall be the nameplate rating of the equipment.

C. Disconnect Switches The summer and winter normal and emergency ratings of the equipment shall be the nameplate rating of the equipment. Where facility ratings require higher operating ratings, overload factors are permitted as defined in IEEE Std. C37.37 Loading Guide for AC High-Voltage Air Switches in Excess of 1000 V. These factors are dependent on ambient temperature, duration, and materials that make up the electric circuit through the switch. Overload factors must be evaluated for each switch model and type on a case by case basis.

D. Wave Traps The summer and winter normal and emergency ratings of the equipment shall be the nameplate rating of the equipment.

E. Power Transformers The summer and winter normal and emergency ratings of the equipment shall be the nameplate rating of the equipment. Power transformers are sized based on the ability to support four distribution feeders each loaded at 50% of summer emergency rating plus one feeder loaded at 100% of summer emergency rating. The resulting total load when allowed for a maximum of three hours and must not exceed 0.1% loss of transformer life in accordance with ANSI/IEEE standards.

F. Current Transformers The summer and winter normal ratings of the equipment shall be the nameplate rating and applied continuous overload rating of the equipment. Continuous overload thermal rating factors will be applied to tapped windings per manufacturer's data and recommendations as well as in accordance with ANSI/IEEE Standard C37.110. The summer and winter emergency ratings of the equipment shall be 110% of the normal rating and applied continuous overload rating as long as the circuit breaker rating (if the CT is associated with a circuit breaker) is not exceeded.

G. Tubular Bus The summer and winter normal ratings of the equipment shall be the calculated rating determined in accordance with NEMA Standard CC1.

H. Line Conductors The summer and winter normal ratings of the equipment shall be based on not exceeding the maximum allowable design temperature of the conductor.

1. Under no circumstances shall the normal or emergency operating temperature of a line exceed the sag limit based on minimum clearances specified in the National Electrical Safety Code.

2. Bare overhead conductor transmission line conductor ratings are based on the maximum operating temperature for the line at which minimum clearances are in accordance with the National Electrical Safety Code. If clearances are not a factor, the ratings are based on 167 degrees F or 212 degrees F maximum conductor temperature for ACSR, depending on the line.

3. Emergency ratings are 10% over normal ratings.

4. Line ratings may be adjusted for certain short-term operating conditions, such as during operating conditions in which a transmission line may load above its seasonal rating. For such situations, the rating of the bare overhead conductor is calculated at ambient conditions in 10 degree F increments from -20 degrees F to 110 degrees F. In the determination of the adjusted ratings, only the ambient temperature is modified. All other atmospheric conditions remain unchanged. In the determination of the

overall transmission line adjusted rating, other facility limits such as terminal equipment ratings are observed.

I. Jumpers & Connectors The summer and winter normal ratings of the equipment shall be based on not exceeding the maximum allowable operating temperature of the substation equipment to which it is connected. For equipment without oil-filled condenser bushings, the maximum temperature is 90 degrees C. For equipment with oil-filled condenser bushings, the maximum temperature is 70 degrees C. Standard ratings of conductors are based on data published by Southwire Company with conductor temperature of 75 degrees C, ambient temperature 25 degrees C, emissivity 0.5, wind 2 ft./sec., in sun light. Adjustment of the published ratings is allowed using Southwire Company's SWRATE software program or similar software or direct calculations based on ANSI/IEEE standards. Maximum jumper ratings are allowed under the following conditions: conductor temperature of 90 degrees C, ambient temperature 40 degrees C, emissivity 0.5, solar absorptivity 0.5, wind 2 ft./sec., wind to conductor angle 90 degrees, industrial atmosphere, 1100 ft. above sea level, 44 degrees N latitude. Ratings for all connectors are based on the conductor size as allowed by ANSI/IEEE Standard C119.4 for line applications and NEMA Standard CC1 for substation applications.

J. Protective Relays Protective relays must be examined to assure their AC secondary current input ratings, in conjunction with the current transformer rating and ratio, do not limit the primary current of the facility. The rating of the relay equipment shall be the nameplate rating and applied continuous overload rating. Relay settings and adjustments shall be within the range allowed by the manufacture and shall be coordinated with the protection requirements of the facility according to industry best practices.

K. Series and Shunt Compensation Devices There are no series or shunt compensation devices present on the RPU system at this time.

R4 RESERVED

R5 RESERVED

R6 FACILITY RATINGS RECORD

Facility ratings for transmission and generator facilities as developed by the ratings methodology of this document are recorded in the RPU System Data Book, and are updated periodically. Updates will generally occur following major system changes or

after an accumulation of new or upgraded equipment has occurred. The RPU System Data Book is the record.

R7 RESERVED

R8 FACILITY RATINGS SUPPORTING INFORMATION REQUESTS

RPU shall provide requested supporting information as specified below for its solely and jointly owned facilities that are existing facilities, new facilities, modifications to existing facilities, and re-ratings of existing facilities to its associated Reliability Coordinator(s), Planning Coordinator(s), Transmission Planner(s), Transmission Owner(s) and Transmission Operator(s):

R8.1 As scheduled by the requesting entity:

R8.1.1 Facility ratings

R8.1.2 Identity of the most limiting equipment of the facilities

R8.2 Within 30 calendar days of request or later as specified by the requesting entity, information for any requested facility with a thermal rating that limits the use of facilities under the requester's authority by causing any of the following: 1) an Interconnection Reliability Operating Limit, 2) a limitation of Total Transfer Capability, 3) an impediment to generator deliverability, or 4) an impediment to service to a major load center:

R8.2.1 Identity of the existing next most limiting equipment of the facility

R8.2.2 The thermal rating for the next most limiting equipment identified in this section.

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Version Control:

Version	Date	Author	Change Description
1	July, 2009	N. Stiller	Compiled from empirical sources, Conformed to NERC standard FAC-008-1
2	October, 2009	N. Stiller	Improvements and updates as requested. Added distribution and review section to conform to NERC standard FAC-009-1
3	December, 2012	N. Stiller	Conform ratings for disconnect switches and jumper conductors to updated ANSI & IEEE standards. Conformed document to NERC standard FAC-008-3.
4	November, 2013	N. Stiller	Requirements R4 and R5 retired by NERC. Sections struck.

5	July 30, 2021	R. Anderton	Updated document to reflect FAC-008-5