NEBRASKA PUBLIC POWER DISTRICT

Facility Ratings Methodology

Nebraska Public Power District
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Regulatory, Planning & Contracts Department

Revision History

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6.0	Coordination of Joint Owned Facilities		10/19/07
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Document Control List

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1.0 Introduction

This document was developed to comply with NERC Standard FAC-008-1 *Facility Ratings Methodology*. NPPD uses these standards and assumptions to rate our transmission line and substation equipment.

2.0 Methodologies to Determine Transmission Facility Ratings

NPPD's facility rating policies and procedures for transmission related equipment are as follows:

2.1 Transmission Lines

Standards/Practices

"Instruction Manual for Conductor Temperature Program – Transmission Line CDTEMP" developed July 2, 1985. These instructions are now used with the program RATETEMP, an IEEE conductor temperature and thermal rating program.

This program was developed from IEEE Std 738-1991, "IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors."

This standard presents a simplified method of calculating the current-temperature relationship of bare overhead lines, given the weather conditions. Along with a mathematical method, sources of the values to be used in the calculations are given in the standard.

NPPD utilizes the output of the program using the referenced IEEE Standard to determine its normal conductor rating limits.

NPPD utilizes summer thermal limits to rate its transmission system MVA capacity throughout the year. The Nebraska region experiences wide temperature variations throughout the year and unseasonably warm temperatures during the winter season are not abnormal. NPPD recognizes winter ampacity limits, but operates the transmission system so not to exceed the summer thermal ampacity limits during system intact and contingency conditions.

NPPD allows emergency loading of conductors up to 110% of the normal rating for time periods less than 30 minutes.

Assumptions

Input variables for the program include:

1. Wind and ambient Temperature
2. Air density, viscosity and conductivity
3. Emissivity and absorbtivity
4. Solar heat gain

Assumptions made by NPPD for the above input variables:

1. 5 ft/sec wind speed and maximum ambient temperature of 40°C (104°F)
2. Tables and equations from IEEE Std 738 using ambient temperature and elevation
3. Coefficient of emissivity & absorbtivity are assumed to be a value of 0.5
4. Tables and equations from IEEE Std 738 (NPPD uses solar altitude of 90°)

Assumptions based on the study "NPPD Conductor Design Temperature Study" prepared April 1979. The purpose of this study was to determine the maximum expected conductor design temperature so that transmission lines could be designed with adequate clearances in accordance with the NESC.

Other factors used in the program which are specific to the transmission line location include:

1. Type of conductor
2. Line elevation above sea level
3. Line latitude
4. Time of day
5. Line direction and atmosphere conditions

2.2 Transformers

Standards/Practices

NPPD utilizes the transformer manufacturer's nameplate ratings for normal rating limits.

For transformers operated near or above nameplate ratings, NPPD utilizes EPRI's Power Transformer Loading Program (PTLOAD) for calculating transformer temperatures, thermal ratings, insulation loss-of-life and gas bubble formation based on user-specified physical parameter for the transformer and user-specified load and air temperature data.

The calculation methods are based on the Institute for Electrical and Electronics Engineers (IEEE) C57.91-1995, "Guide for Loading Mineral-Oil-Immersed Transformers" as well as the International Electrotechnical Commission (IEC) Standard 354, "Loading Guide for Oil-Immersed Power Transformers."

NPPD allows emergency loading of transformers up to 125% of the normal rating for time periods less than 30 minutes.

Assumptions

The physical, electrical and temperature characteristics of each transformer required to determine the loadability calculations include:

1. Top-oil temperature rise over ambient temperature at rated load
2. Bottom-oil temperature rise over ambient temperature at rated load
3. Average conductor temperature rise over ambient temperature at rated load

4. Winding hottest-spot temperature rise over ambient temperature at rated load
5. Load loss at rated load
6. No-load (core) loss
7. Total loss at rated load
8. Confirmation of oil flow design
9. Weight of core and coil assembly
10. Weight of tank and fittings
11. Volume of oil in the tank and cooling equipment

The load losses at the base nameplate MVA rating as indicated on the certified test report are converted to the losses at the maximum nameplate MVA rating before being used in this program.

The probable ambient temperature at a particular transformer location for the duration of the load cycle is approximated from climatological data received from seven Nebraska National Weather Service Stations.

Other factors which are considered when determining the load capability of a transformer are the ratings of ancillary components such as CT's, transformer leads, bushings, tap changers, capacity of windings, cooling system, oil expansion, pressure in sealed units, stray flux heating. The thermal capability of associated equipment such as cables, reactors, circuit breakers and disconnecting switches are also considered. Manufacturers are consulted for advice on limitations associated with ancillary components.

2.3 Series and Shunt Reactive Elements

Standards/Practices

Manufacturer's recommendations for normal and emergency rating limits.

NPPD allows emergency loading of series and shunt reactive elements up to 110% of the normal rating for time periods less than 30 minutes.

2.4 Terminal Equipment (including switches, circuit breakers, current transformers, wave traps, bus conductor and risers)

Standards/Practices

Manufacturer's recommendations for normal and emergency rating limits.

NPPD allows emergency loading of terminal equipment up to 110% of the normal rating for time periods less than 30 minutes.

2.5 Terminal Equipment (including protection and control settings)

Standards/Practices

NPPD adheres to the following Guide for Transmission System Relay Load Limits from the MAPP Reliability Handbook. (The latest revision is available on the MAPP Member Website located at http://www.mapp.org/content/reliabilityhandbook.shtml.)

To place each MAPP company on an equivalent basis for relay tripping values on transmission systems it is recommended that:

1. *For overcurrent type relays the relay load limit (RLL) with nominal voltage shall be*
   RLL = .8 X Minimum pickup value (MVA)

2. *For distance type relays the relay load limit (RLL) with nominal voltage shall be*
   RLL = .9 X Minimum pickup value (MVA) at 90% power factor

3. *This value (RLL) will be added to the MAPP Transmission Line Capacity Data.*

The above guidelines for relay load limits under steady state conditions at nominal rated voltage are based on the premises that:

4. *More leeway is required in the setting of overcurrent type relays (induction overcurrent and instantaneous overcurrent) because of the large number of time curve characteristics available and the electromagnetic design used in the relay.*

5. *Transmission line relays, both electromechanical and solid state types of mho, reactance and impedance along with their timers are inherently more accurate insofar as the repeatability of the operate level is concerned.*

6. *These limits will establish uniform interpretation of relay settings in the MAPP area.*

7. *Operating within these limits will provide an acceptable, safe margin between load and the relay operating point.*

2.6 Electrical Energy Storage Devices (e.g., superconducting magnetic energy storage (SMES) system)

NPPD does not own or operate any electrical energy storage devices.

Any future installations of electrical energy storage devices will be rated consistent with the manufacturer's recommendations for normal and emergency rating limits.

2.7 VAR Compensators

VAR Compensators and associated equipment will be rated consistent with the manufacturer's recommendations for normal and emergency rating limits.

2.8 High Voltage Direct Current Converters

High Voltage Direct Current Converters and associated equipment will be rated consistent with the manufacturer's recommendations for normal and emergency rating limits.

3.0 Seasonal Ratings Procedure

NPPD does not utilize seasonal ratings for transmission lines, transformers, series and shunt reactive elements, terminal equipment. NPPD utilizes summer thermal limits to rate its transmission system MVA capacity throughout the year. The Nebraska region experiences wide temperature variations throughout the year and unseasonably warm temperatures during the winter season are not abnormal. NPPD recognizes winter ampacity limits, but operates the transmission system so not to exceed the summer thermal ampacity limits during system intact and contingency conditions.

4.0 Transmission Circuit Rating Procedure

The rating of a transmission circuit shall not exceed the rating(s) of the most limiting element(s) in the circuit, including terminal connections and associated equipment. In cases where protection systems and control settings constitute a loading limit on a facility, this limit shall become the rating for that facility.

5.0 Generation Facility Ratings

NPPD's facility rating methodologies for generation facilities and related equipment are as follows:

5.1 Turbine / Generator Ratings

NPPD generators are rated according to their manufacturer's capability curves for real and reactive power output at their specified voltage, power factor and hydrogen pressure.

NPPD is a member of the MAPP Generation Reserve Sharing Pool (GRSP) which has established the Uniform Rating of Generating Equipment (URGE). The net generating capability rating (MW) of generators included in a GRSP Member's Accredited Capability is based on the URGE criteria documented in the *MAPP Generation Reserve Sharing Pool Handbook*.

As a member of the MAPP Regional Transmission Committee (MAPP RTC), the generation levels can also be limited by the MAPP Design Review Subcommittee (MAPP DRS) approved generation accredited levels based on generation accreditation studies.

Based on the lower of the URGE rating or DRS approved accredited level (MW) of a particular generator, the continuous reactive power output capability of a synchronous generator is calculated based on the reactive capability curves which are limited by three considerations: armature current limit, field current limit, and end region heating limit. The reactive capability of a synchronous generator may also be limited by the excitation system control and protective functions such as the maximum excitation limiter, minimum excitation limiter, steady-state stability limiter or the loss-of-excitation limiter.

Turbine / Generator ratings are Continuous ratings only. There are no Emergency ratings.

5.2 Medium Voltage Bus

The required ratings of medium-voltage bus are identified when the equipment specifications are prepared. The continuous current rating specified is based on the requirements of the connected generator(s).

The Normal and Emergency Ratings for medium voltage bus are rated according to the manufacturer's recommendations.

5.3 Generator Breakers and Associated Equipment

The required ratings of generator circuit breakers are identified when the equipment specifications are prepared. The current rating specified is based on the requirements of the connected generator(s). Current transformers and breaker disconnect switches are reviewed when the ratings are specified. The rating for the circuit breaker will be the lowest of the ratings for the breaker, current transformers and disconnect switches.

The Normal and Emergency Ratings for generator circuit breakers are rated according to the manufacturer's recommendations.

5.4 Generator Step-up Transformers

The required ratings of generator step-up transformers are identified when the equipment specifications are prepared. The rating specified is based on the requirements of the connected generator(s).

The Normal and Emergency Ratings for generator step-up transformers are rated according to the manufacturer's recommendations.

5.5 Generation Facility Rating Procedure

The rating of the most limiting element between the turbine and the point of interconnection with the transmission system shall determine the Generation Facility rating.

6.0 Coordination of Joint Owned Facilities

The rating of jointly owned transmission and generation facilities is coordinated though joint planning studies with owners of the facility. Joint planning meetings are held on an annual basis. NPPD's Regulatory, Planning and Contracts Department submits new or modified transmission and generation facility ratings on an annual basis through the Midwest Reliability Organization (MRO) Model Building Process. Transmission and generation facility ratings are also coordinated with other Transmission Planners and Planning Authorities through the MRO Model Building Process.