APPENDIX 1

Bulk Electric System

Facility Ratings Methodology

Revision History			
Version	Date	Author	Brief Description of Change/Review
1	March 6, 2008	Robin Smyrski	Initial version of this document
2	March 15, 2008	Bruce Link	Merged with generation information
3	June 5, 2009	Ron Mazur	Annual 2009 updates
4	August 12, 2010	Ron Mazur	Annual 2010 updates

Approval			
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1 Purpose and Scope

The purpose of this document is to ensure that Manitoba Hydro (MH) facility ratings methodologies for its solely and jointly owned facilities are documented to the satisfaction of NERC standard FAC-008-1.

MH facility ratings are equal to the most limiting applicable equipment rating of the individual equipment that comprises that facility including protection (NERC Standard FAC-008 R1.1).

Manitoba Hydro currently does not have any jointly owned transmission or generation facilities. For tie line interconnection facilities to neighbouring utilities, MH coordinates with all applicable neighbouring Transmission Owner(s) to evaluate their component ratings and ensure the most limiting applicable equipment rating for the facility is applied.

The scope of equipment detailed in this document is any capital equipment requisite to the reliable operation of Manitoba Hydro's bulk electric system. This includes but is not limited to generators, transmission conductors, transformers, relay protective equipment, terminal equipment and series and shunt compensation devices (NERC Standard FAC-008 R1.2.1).

The scope of the facility ratings includes both normal and emergency ratings (NERC Standard FAC-008 R1.2.2).

In developing the facility rating methodology for MH's facilities, the following were considered (FAC-008 R1.3):

- Ratings provided by equipment manufacturers
- Design criteria such as industry standards, nameplate ratings, IEEE, ANSI and other standards
- Ambient conditions
- Operating limitations
- Other assumptions

2 Dissemination

The facility ratings for all solely and jointly owned facilities that are new facilities, modifications to existing facilities and re-ratings of existing facility shall be provided to the associated reliability coordinators, planning authorities, transmission planners and transmission operators (FAC-009-1 R.2).

The facility ratings methodology shall be made available within 15 days upon request for inspection and technical review by any reliability coordinator, transmission operators, transmission planner, and planning authorities that have responsibility for the area in which the associated facilities are located. (FAC-008-1 R.2)

If written comments are provided by any reliability coordinator, transmission operator, transmission planner, or planning authority upon technical review of a facility ratings methodology, then a written response shall be provided to that entity within 45 calendar days to the commenting entity. (FAC-008-1 R.3)

3 Generator Facility Rating Methodology

MH considers generation facility nominal ratings to be equal to that of its emergency ratings.

MH's hydraulic generation facilities are not de-rated at any time due to ambient temperatures. Hydraulic generation facilities are limited only by available water reservoir levels. MH designs these generator nameplates to match rated head.

The ratings for each individual generator are documented in testing and commissioning documents which fulfill the requirement of NERC FAC-009-1.

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3.1 Turbines

Turbine capacity will be established using the lesser of the turbine manufacturer's nameplate or the turbine limit established from field tests. Field tests will consist of performance tests (Index, Ott meter, or manufacturer's acceptance tests).

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3.2 Generators [1]

Generators which operate on the MH interconnected power system are designed by their respective manufacturers to operate continuously at a specified rated power as per Institute of Electrical and Electronics Engineers, Inc. (IEEE) standard C50.12-2005 (Previously American National Standards Institute (ANSI) C50.12-1982) and ANSI C50.14-1977.

The generator rating process begins with the unit's design capability as supplied by the manufacturer via a unit real and reactive power capability curve or D-Curve. Any emergency ratings of a generator are equal to that of the nominal ratings.

[1] This section does not apply to the synchronous condensers associated with Bipole I and Bipole II. The rating methodology for these synchronous condensers can be found in the High Voltage DC Facilities section.

The reactive power or MVAr rating is the available amount of reactive power supply and absorption capability. The MVAr rating is limited by a combination of the armature current limit, the exciter field current limit and the requirement for the generator to maintain synchronism with the system in the under excited region. The generator active power or MW rating is limited by the available prime mover energy source.

If there have been no changes to the original design rating of the generator, the rating can be determined by applying the overload capability (if applicable) of the machine to the nameplate data for MVA, at rated voltage, frequency, and power factor.

In the event of a change to major components of a generator due to either degradation or upgrades, the above process is repeated to determine the new effective ratings. The changes are recorded according to company policy and the corresponding FAC-009 document is updated.

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3.3 Generator Step-up Transformers

Generator step-up transformer ratings are based on temperature rise and cooling methods as defined by Canadian Standards Association (CSA) standard CAN/CSA-C88-M90, the maximum continuous rating is for all cooling in service. Generator step-up transformers are matched to, or exceed the sum of the power output of the generation unit(s) that they service. As such, generator step-up transformers with 55° C thermal rise built with 65° C rise insulation (i.e. 55/65° C) are rated at nameplate load (NERC FAC-008-1 R1.2).

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3.4 Isolated Phase Bus

The continuous rating of an isolated phase bus is based on the IEEE C37.23 standard. Conductors are chosen to exceed the current rating of the associated generator at the specified power factor and minimum rated voltage. The nominal rating for an isolated phase bus is shown on its nameplate. MH considers emergency ratings for isolated phase bus conductors to be equal to that of the normal ratings.

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3.5 Terminal Equipment

3.5.1 Instrument Transformers

Instrument transformers are rated according to CSA standard CAN3-C13-M83, and IEEE standard C57.13. The normal rating of any particular device is the manufacturer's nameplate value. Required ratings are developed to meet or exceed that of the generator, and are not the limiting factor in the generation station.

3.5.2 Circuit Breakers

Circuit breakers are rating according to IEEE standards C37.013, C37.013a, and their referenced documents. The normal load current carrying capability of a device is determined from manufacturer's nameplate, and specifications for the application required. Required ratings are developed in co-ordination with generator capability and transmission system interconnection requirement.

3.5.3 Disconnect Switches

The load current carrying capabilities are determined from manufacturer's specifications and the maximum ambient temperature and maximum temperature rise of the current carrying parts of disconnect switches. The maximum temperature rise is specified for different parts of disconnect switch in ANSI/IEEE standard C37.40.

3.5.4 Protective Device Settings

Protective device are configured relative to the nameplate value of the generation system(s) serviced by the device. Protective devices are configured to trip outside of full load parameters for the system under protection, this includes both over current protection and low impedance protection, and as such are not the limiting factor in the generation station.

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4 Transmission Facility Rating Methodology

Ratings fall into two general categories: normal or emergency.

The normal or continuous rating in this document refers to the NERC normal rating. This is the rating of the equipment at which the equipment can transfer current continuously without causing any loss of equipment life or violation of allowable transmission line sag, jeopardizing public safety.

The emergency or short-term overload rating in this document refers to the NERC emergency rating. It applies during a transition period immediately following a system disturbance and for a finite period of time during which control action is allowed to restore the system to steady state operation. In this application the emergency period is 30 minutes.

Both of these rating categories (normal and emergency) can be expressed in one of two ways. They can be defined simply as a constant value for a season or as a variable dependant on ambient temperature as detailed below:

1) Seasonal ratings - summer and winter ratings based on 'worst case' seasonal ambient assumptions.

- Summer - assumes 40° C ambient and typically applicable from May 1 to Oct. 31
- Winter - assumes 0° C ambient and typically applicable from Nov. 1 to April 30

2) Ambient based ratings - rating based on specific ambient temperature

There can be instances where ratings from standards aren't achievable due to equipment design flaws.

4.1 Power Transformers

Power transformer normal ratings are based on temperature rise and cooling methods as defined by Canadian Standards Association (CSA) standard CAN/CSA-C88-M90. The maximum continuous rating is for all cooling in service. MH will load a transformer based on the criteria contained in CAN/CSA-C88-M90.

For Planning purposes, summer loadings are based on an average daily ambient not exceeding 30° C with a maximum temperature of 40° C. Winter loadings are based on an average daily ambient temperature of 0° C or colder.

Power transformer emergency ratings are generally equal to the normal rating. Exceptions are assessed on a case by case basis.

Also, on a case by case basis MH will load a transformer based on the System Planning Department report SPD 2006/01 [1]. This report defines the transformer winding rating which must (at a minimum) be met by the bushing and station equipment associated with any transformer to be loaded based on the report.

There are some instances where a transformer rating is not as specified above due to a known manufacturing deficiency.

For a detailed explanation on the specific normal (or continuous) and emergency rating procedure and rating factor calculation used in the equipment ratings database across the ambient temperature range from -50° C to 50° C, please see the section on power transformers in the Rating Procedures document as well as the SPD 2006-01 report.

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4.2 Underground Conductors

MH uses Version 5.12 of the Cable Ampacity Program (CAP) developed by CYME International Inc. to calculate the normal and emergency ratings of most underground conductors in Manitoba. The CYME CAP follows procedures outlined in "Calculation of the Continuous Current Ratings of Cables (100% Load Factor)", International Electrotechnical Commission (IEC) Publication 287 as well as methods defined by J.H. Neher and M.H. McGrath in "The Calculation of the Temperature Rise and Load Capability of Cable Systems", American Institute of Electrical Engineers (AIEE) Transaction Oct. 1957 pp.752-772.

The CYME CAP requires a substantial amount of manufacturer-supplied data to calculate an underground conductor rating. For each underground conductor, the required manufacturer-supplied data includes:

- Underground conductor type, material, diameter, construction and skin and proximity loss factors.
- Insulation material, diameter, dielectric loss factor and constant of insulation.
- Type and thickness of conductor screen, insulation screen, tape over insulation, sheath, oversheath, armour and jacket.
- Skid wire and concentric neutral materials, amounts and diameters.
- Sheath bonding method.
- Installation method (directly buried in the ground or placed in appropriate sized ductbank or pipe) and backfill material.

The CYME CAP requires information regarding the thermal resistivity of various backfill materials. This data is derived from common industry-accepted assumptions.

Finally, the CYME CAP requires information regarding the daily load factor of underground conductors and the ambient earth temperature. In addition, MH assumes a daily load factor of 75%. MH assumes a 20° C ambient earth temperature in the summer and a 0° C ambient earth temperature in the winter.

When calculating the normal and emergency rating of underground conductors using the CYME CAP, MH assumes all low-pressure oil-filled (LPOF) and high-pressure dielectric-fluid-filled

(HPPT) underground conductors can continuously withstand temperatures less than or equal to 85° C and can withstand temperatures up to 95° C under emergency conditions. MH assumes all W4 paper insulated lead sheathed (PILC) underground conductors can continuously withstand temperatures less than or equal to 60° C and can withstand temperatures up to 70° C under emergency conditions. MH also assumes all cross-linked polyethylene (XLPE) underground conductors can continuously withstand temperatures less than or equal to 90° C and can withstand temperatures up to 105° C under emergency conditions. These temperatures reflect published, industry-accepted values.

MH uses the manufacturers' ratings of the underground conductors of the Long Spruce to Henday transmission lines L46H, L47H and L48H and the Long Spruce to Radisson transmission lines L41R, L42R and L43R based on the thermal limits of the conductors, as specified by the manufacturer. The calculations assume the Long Spruce SF_6 (sulfur hexafluoride) building basement indoor ambient air temperature does not exceed 23° C. The calculations also assume very conservative ambient earth temperature values (35° C ambient earth temperature when the outdoor ambient air temperature exceeds 0° C (summer) and 25° C ambient earth temperature when the outdoor ambient air temperature is less than or equal to 0° C (winter)).

The underground conductors of the Long Spruce to Henday and Long Spruce to Radisson transmission lines have normal ratings equal to 976 A during winter and 881 A during summer. These underground conductors have restrictive emergency ratings equal to 1103 A during winter and 1020 A during summer. The restrictive emergency ratings are in effect for 10 minutes following a system disturbance and may only be applied for a total duration of 300 hours per year. Less restrictive emergency ratings (1142 A during winter and 1062 A during summer) may be applied for 10 minutes following a system disturbance provided these emergency ratings are applied for a total duration that does not exceed 100 hours per year.

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4.3 Overhead Conductors

The normal rating of an overhead conductor is the current the conductor can continuously transfer without causing any loss of conductor life or violation of allowable transmission line clearance to ground.

MH's Aluminum Conductor Steel Reinforced (ACSR) overhead conductors can continuously withstand temperatures less than or equal to 100° C and MH's Aluminum Conductor Steel Supported (ACSS) overhead conductors can continuously withstand temperatures less than or equal to 200° C (manufacturers' ratings).

Under normal and emergency conditions all overhead conductors are rated to maintain minimum acceptable vertical conductor clearance to ground as defined in CSA standard CAN/CSA 22.3

No. 1-06 (Overhead Systems). This is achieved by defining the maximum allowable conductor temperature, and hence conductor sag. All newer ACSR conductor transmission lines are designed to allow for 60° C conductor temperature rise above the greatest maximum ambient temperature (conservatively assumed to be 40° C). This gives a maximum conductor temperature of 100° C and is consistent with the CSA standard. Some newer ACSS conductor transmission lines are designed to allow for 200 ° C maximum conductor temperature. However, the Transmission Design Department has elected to design for a 150° C maximum conductor temperature. For older transmission lines, the Transmission Design Department determines an appropriate maximum allowable conductor temperature. This is done through a detailed survey of each older transmission line or is assumed to be 75° C, in accordance with past design practice.

The ampacity ratings of overhead conductors under normal and emergency conditions are calculated based on the IEEE standard 738-2006 equations, CSA standard CAN/CSA 22.3 No. 1-06 (Overhead Systems), overhead conductor data (includes overhead conductor stranding, layers, damping, diameter, component weight and resistance based on temperature as well as the maximum overhead conductor temperature) and the following assumptions:

- Overhead conductor emissivity equal to 0.5
- Solar absorption equal to 0.5.
- Solar altitude based on conditions occurring on June 21 at high noon (if the ambient temperature is greater than 0° C) or April 30 at high noon (if the ambient temperature is less than or equal to 0° C)
- Smog factor equal to 0 to reflect a clear non-industrial atmosphere
- Wind speed equal to 2.2 km/hr
- Wind angle equal to 90° to reflect wind perpendicular to overhead conductor
- 40° C ambient temperature in summer and 0° C ambient temperature in winter

In 2010 a methodology was developed and is being implemented to allow for some overhead line conductor ratings under normal conditions to vary with ambient temperature, as is the case for station equipment. At a given wind speed, the ambient temperature has more significant impact on the ratings for conductors with lower design temperatures especially at higher ambient temperatures. The ambient adjusted rating methodology provides technical justification for ampacity increase at lower ambient temperature conditions for overhead transmission lines with maximum design temperature up to 75° C.

The ambient adjusted ampacity ratings of overhead conductors under normal conditions are calculated based on the IEEE standard 738-2006 equations, CSA standard CAN/CSA 22.3 No. 1-06 (Overhead Systems), overhead conductor data (includes overhead conductor stranding, layers, damping, diameter, component weight and resistance based on temperature as well as the maximum overhead conductor temperature) and the following conservative assumptions:

- Overhead conductor emissivity equal to 0.5
- Solar absorption
    - 0.5 (Day time)
    - 0.0 (Night time)

- Solar altitude based on conditions occurring on June 21 at high noon (if the ambient temperature is greater than 0° C) or April 30 at high noon (if the ambient temperature is less than or equal to 0° C)
- Smog factor equal to 0 to reflect a clear non-industrial atmosphere
- Wind speed
    - 0.5 m/s or 1.8 km/hr for ambient temperature between 32° C and 40° C (Day time)
    - 0.4 m/s or 1.44 km/hr for ambient temperature below 32° C (Day time)
    - Zero wind speed (Night time)
- Wind angle equal to 90° to reflect wind perpendicular to overhead conductor

The selection of parameters for the ambient adjusted ratings is based on the "Guide for Selection of Weather Parameters for Bare Overhead Conductor Ratings" by IEEE/CIGRE Joint Task Force – August 2006. Day time is the time from sunrise to sunset. Night time is the time from sunset to sunrise.

G37C - Dynamic or real time line ratings are calculated for the overhead conductors of transmission line G37C. The dynamic ratings calculation is done via a proprietary transmission line tension monitoring system (Valley Group CAT-1 System). Manitoba Hydro Transmission Operators use the calculated dynamic ratings as a guide. When the dynamic rating varies from the normal seasonal static rating, Transmission Operators can manually select either limit to be enforced.

The emergency rating of an overhead conductor applies during a transition period immediately following a system disturbance and for a finite period of time during which control action is allowed to restore the system to steady state operation. Overhead conductor emergency ratings are generally equal to the normal rating. The 30 minute emergency ratings can be identified on a case by case basis.

COMMON TOWER - Following a common tower disturbance an overhead conductor emergency rating of up to 115% of the conductors' normal rating can apply. This higher rating reflects the time required for conductor temperature rise. The higher rating is calculated to ensure the conductor does not exceed its' sag limit within 30 minutes following a system disturbance.

G8P, L20D, and Y51L - The overhead conductors of transmission lines G8P, L20D, and Y51L have summer emergency ratings equal to 110% of the normal summer ratings. Winter emergency ratings are 110% of the normal winter ratings for G8P and L20D and 108% of the normal winter ratings for Y51L. These emergency ratings are in effect for 30 minutes following a system disturbance. The emergency ratings for these lines have been chosen to respect the CSA minimum ground clearance standard rather than the more stringent MH transmission design standard.

G9F and F27P - The overhead conductors of transmission lines G9F and F27P have summer emergency ratings equal to 148% and 125% of their normal ratings, respectively. These lines, with 60º and 65º C thermal ratings, respectively, have no high risk spans for operating temperatures up to 100 º C. A conservative 75 º C thermal rating is applied to calculate the emergency rating.

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4.4 Risers and Bus Conductors

MH's risers and bus conductors can withstand maximum temperatures less than or equal to 100° C (manufacturers' rating). The applied temperature rating is chosen to ensure adjacent connected equipment, in some cases limited to 70° C maximum temperature, are not overheated.

The ampacity ratings for risers and bus conductors under normal and emergency conditions are calculated at 5° C increments from -50° C to 50° C ambient. The calculations are based on the IEEE standard 738-2006 equations, CSA standard CAN/CSA 22.3 No. 1-06 (Overhead Systems), riser and bus conductor data (includes riser and bus conductor stranding, layers, damping, diameter, component weight and resistance based on temperature as well as the maximum riser and bus conductor temperature) and the following assumptions:

- Riser and bus conductor emissivity equal to 0.5.
- Solar absorption equal to 0.5.
- Solar altitude based on conditions occurring on June 21 at high noon (if the ambient temperature is greater than 0° C) or April 30 at high noon (if the ambient temperature is less than or equal to 0° C).
- Smog factor equal to 0 to reflect a clear non-industrial atmosphere.
- Wind speed equal to 2.2 km/hr.
- Wind angle equal to 90° to reflect wind perpendicular to risers and bus conductors.

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4.5 Wavetraps

The normal current ratings of wavetraps are as specified in ANSI/IEEE Standard C93.3.

The emergency current ratings of older wavetraps are limited to their normal current ratings (the manufacturer's nameplate ratings) due to the unavailability of data needed to confirm any overload capability.

MH generally assumes no emergency (30 minute) overload capability except for Dorsey line D602F wavetraps where 110% of the continuous rating is applied.

For a detailed explanation on the specific continuous and emergency rating procedure and rating factor calculation used in the equipment ratings database across the ambient temperature range from -50° C to 50° C, please see the section on wavetraps in the Rating Procedures document.

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4.6 High Voltage DC Facilities

MH's High Voltage DC (HVDC) transmission facilities consist of two bipolar transmission systems called Bipole I and Bipole II. Each pole is comprised of two conductor cables which, in bundles 4 cm in diameter, are supported by the steel transmission towers.

While each piece of series equipment in Bipole I and Bipole II has its own rating, the overall Bipole I and Bipole II ratings are a result of a coordination of these individual ratings. When the HVDC facilities are in operation as two separate transmission systems, the HVDC valve groups limit the overall Bipole I and Bipole II ratings. When one bipole is out-of-service, it is possible to operate both bipoles on the bipole that remains in-service. This is referred to as parallel operation of Bipole I and Bipole II. During parallel operation, the DC transmission conductors limit the overall Bipole I and Bipole II ratings.

Bipole I and Bipole II were custom designed by manufacturers to design rating specifications. As such, the Bipole I and Bipole II ratings are generally as they were originally specified and as provided by the manufacturers. The manufacturers' nameplate ratings for the bipoles are specified at the mid-point of the DC transmission conductors. However, MH specifies the Bipole I and Bipole II ratings at the rectifier, in accordance with the International Council on Large Electric Systems (CIGRE) 14-97 (WG04-21) rating protocol.

Bipole I has a manufacturers' specified normal rating of 1800 A at ±463.5 kV (1669 MW) for ambient temperatures less than 40° C. After consulting with the manufacturer, and completing equipment tests, it was determined that the normal rating could be increased to 2000 A at ±463.5 kV (1854 MW) for ambient temperatures less than 26° C. There is no emergency rating.

Bipole II originally had a manufacturers' specified normal rating of 1800 A at ±500 kV (1800 MW) for ambient temperatures less than 40° C. After consulting with the manufacturer, and completing equipment tests, it was determined that adding additional cooling would allow this rating to be increased. The specified additional cooling was added in 2000, allowing the normal rating to be increased to 2000 A at ±500 kV (2000 MW) for ambient temperatures less than 40° C. There is no emergency rating.

The manufacturers' specified power ratings of the bipoles during monopolar operation are half of the power ratings during bipolar operation. Bipole I monopolar operation is limited by the ground electrode design to 2000 A for 23 consecutive days. Bipole II monopolar operation is limited by the ground electrode design to 2000 A for 123 consecutive days. When both Bipole I and Bipole II operate as monopoles, this operation is limited by the ground electrode design to 2000 A for 31 consecutive days.

During parallel operation, each bipole has a manufacturers' specified normal rating of 1800 A at ±463.5 kV (1669 MW), limited by the DC transmission conductors. The DC transmission conductors can operate at a maximum of 110° C. This corresponds to a maximum operating current of 1800 A assuming an ambient temperature of 40° C, with 0.61 m/s wind speed, 0.5 emissivity and 0.5 solar absorption. There is no emergency rating.

There are ten AC filter banks associated with the Bipole I inverter. These filter banks have a total nameplate rating of 356 MVAr (normal rating). There are nine AC filter banks at the Bipole I rectifier which have a total nameplate rating of 277 MVAr (normal rating). There is no emergency rating.

There are five AC filter banks associated with the Bipole II inverter. These filter banks have a total nameplate rating of 400 MVAr (normal rating). There are three AC filter banks at the Bipole II rectifier which have a total nameplate rating of 600 MVAr (normal rating). There is no emergency rating.

There are six synchronous condensers associated with Bipole I. Each of these condensers has a nameplate rating of 160 MVAr capacitive and 80 MVAr inductive (normal ratings). Each synchronous condenser associated with Pole 1 of Bipole I has negligible emergency rating. Each synchronous condenser associated with Pole 2 of Bipole I has a 4 second emergency nameplate rating of 240 MVAr capacitive and 80 MVAr inductive.

There are three synchronous condensers associated with Bipole II. Each of these condensers has a general nameplate rating of 300 MVAr capacitive and 165 MVAr inductive (normal ratings). For ambient temperatures less than 20^{o}C, the nameplate ratings increase to 360 MVAr capacitive and 150 MVAr inductive (normal rating). Each of these condensers has a 15 second emergency nameplate rating of 500 MVAr capacitive and 165 MVAr inductive.

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4.7 Static VAr Compensators

A Static VAr Compensator (SVC) refers to a static VAr generator whose reactive power output is varied, during standard operation, in an attempt to regulate the transmission system voltage at the SVC interconnection point. A SVC is made up of many pieces of equipment, including a power transformer, shunt reactors, shunt capacitors and various pieces of auxiliary equipment. Each piece of equipment in a SVC will have its' individual ratings. The manufacturer coordinates these individual equipment ratings such that the SVC rating meets the requirements in the Manitoba Hydro SVC specification.

All SVCs operating in MH's transmission system were custom designed by manufacturers to design rating specifications. Consequently, the ratings applied to all SVCs are as they were originally specified and as provided by the manufacturers.

All SVCs are designed for continuous operation up to a specified voltage, within a specified reactive power or MVAr range and within a specified frequency range (normal ratings). In addition, all SVCs may be designed for temporary operation (e.g. for a specified time period like 10 seconds) up to a higher specified VAr output and within a larger specified frequency range (emergency ratings).

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4.8 Current Transformers

The continuous rating (normal rating) of a current transformer is based on the transformers' tap ratio setting and the transformers' thermal rating factor. In accordance with CSA standard CAN3-C13-M83, MH specifies a thermal rating factor of 1.0 for free standing post-type current transformers and 2.0 for bushing current transformers at an ambient temperature of 30° C. Ambient temperatures above or below 30° C alter the thermal rating factor (refer to Figure 7 in CSA standard CAN3-C13-M83).

Short term or emergency ratings are provided by manufacturers; however MH does not apply short term ratings.

Manitoba Hydro applies temperature dependent ratings for current transformers. For a detailed explanation on the specific rating procedure and rating factor calculation used in the equipment ratings database across the ambient temperature range from -50° C to 50° C, please see the section on current transformers in the Rating Procedures document.

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4.9 Capacitors

Any series connected capacitor banks have normal and emergency ratings that meet IEEE Standard 824 for Series Capacitor Banks in Power Systems (from 2004).

All shunt connected capacitor banks have normal and emergency ratings that meet the CSA capacitor standards CAN/CSA-C60871-1 and CAN/CSA-C60871-2.

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4.10 Reactors

All series reactors have normal and emergency ratings that meet IEEE Standard C57.16 (from 1996).

All shunt reactors connected in grounded wye configurations have normal and emergency ratings that meet IEEE Standard 32 (from 1972). Any shunt reactors connected in non-grounded wye configurations have normal and emergency ratings that meet IEEE Standard C57.21 (from 1990).

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4.11 Circuit Breakers

The load current carrying capabilities are related to manufacturer's specifications and the maximum ambient temperature and maximum temperature rise of the current carrying parts of circuit breakers. The maximum temperature rise is specified for different parts of circuit breakers in ANSI/IEEE standard C37.04.

In general, MH purchases circuit breakers with continuous current ratings (normal ratings) that exceed system requirements. Minimum-oil and SF_6 gas-filled circuit breakers purchased over the last fifteen years have typically been rated at 2500 or 3150 Amps.

Short term overload or emergency ratings may be specified by the manufacturer and Tables 5(a), 5(b) and 5(c) in ANSI/IEEE standard C37.919; however MH does not apply short term overload ratings.

Manitoba Hydro calculates ambient temperature based ratings for circuit breakers. For a detailed explanation on the specific rating procedure and rating factor calculation used in the equipment ratings database across the ambient temperature range from -50° C to 50° C, please see the section on circuit breakers in the Rating Procedures document.

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4.12 Disconnect Switches

The load current carrying capabilities are related to manufacturer's specifications and the maximum ambient temperature and maximum temperature rise of the current carrying parts of disconnect switches. The maximum temperature rise is specified for different parts of the disconnect switch in ANSI/IEEE standard C37.30.

Short term overload or emergency ratings may be specified by the manufacturer and Figures 3, 4, 5 and 6 in ANSI/IEEE standard C37.37; however MH does not apply short term overload ratings.

For a detailed explanation on the specific rating procedure and rating factor calculation used in the equipment ratings database across the ambient temperature range from -50° C to 50° C, please see the section on switches in the Rating Procedures document.

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4.13 Protective Devices

Protective devices generally operated at voltages of 230 kV or higher:

MH's current practice is to design, purchase and set protective relaying devices such that they do not limit the normal or emergency ratings of any facility. In situations where historical practice has differed from the current practice, the limiting protective relaying devices are presently being adjusted or modified to remove the limitation. An exception is out-of-step tripping protection installed on interconnection tie line facilities, which are considered and can be a limiting rating.

Protective devices generally operated at voltages equal to or higher than 100 kV and less than 230 kV:

Protection settings (relays) which might impact steady state operating limits are considered for rating determination. Specifically, the four types of protection considered are:

- overcurrent
- forward reach distance protection (furthest reach installed, zone 2 or 3)
- special limit due to PRC-023 Standard Technical Exceptions

While protection is generally not a limiting factor for determination of line ratings, there are exceptions. This is particularly true for zone 2 or 3 forward reach distance protection. If the limits imposed by this protection impede system operation, System Performance Protection staff will review the settings to determine whether they can be relaxed.

In the past few years, MH has gone through the relay loadability review process based on NERC requirements which eventually became NERC Standard PRC-023. MH is currently compliant to this standard with some accepted technical exceptions. Those technical exceptions are valid provided a special loading limit (calculated using the NERC formula) is imposed on those lines. In the current version of the Equipment Rating database application, these limits are documented distinctly from the other protection, using the "Miscellaneous" category.

Where the protection is directional and would not operate when power flow is in the normal direction to serve load (versus fault), it is excluded from rating consideration.

To provide a margin between the maximum operating point (applied rating) and the relay trip setting, a rating is chosen below the trip setting based on a percentage of the trip setting.

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System Performance

4.14 Bushings

Bushings are generally selected to match the current ratings (normal and emergency) of the associated series equipment. MH uses CSA standard CAN/CSA C88.1 to establish the maximum temperature that a bushing connector should achieve during full load conditions. That temperature is 70° C.

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4.15 Operating Limitations

The metering equipment used in Operations to monitor and alarm power system operation has limited range based on the equipment in the metering chain including CT's, PT's and transducers. While the major equipment could carry more power, if power flow exceeds the metering saturation point Control System Operators would be effectively "flying blind" and would not see the actual power flow. Therefore, an operating limit called the "Reasonability Limit" is used to limit operation below that level.

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References

[1] Manitoba Hydro System Planning Report on Transformer Loading Criteria SPD 2006/01, April 24, 2007.