NLSO STANDARD

Transmission Facilities Rating Guide

Doc # **TP-S-001**

Date: 2017/11/01

newfoundland labrador hydro
a nalcor energy company

Table of Contents

1 Purpose

The purpose of this Transmission Facilities Rating Guide is to present the methodology used in the development and communication of transmission system equipment ratings within the NLSO jurisdiction. This document has also been developed to align with the North American Electric Reliability Corporation (NERC) facilities ratings methodology requirements found in the reliability standard FAC-008.

2 Terms, Abbreviations and Acronyms

The NERC glossary of terms utilized in the development of reliability standards can be found on the NERC website at www.nerc.com under the "Standards" tab. In addition, the NPCC glossary of terms can be found on the NPCC website at www.npcc.org. This guide utilizes the NERC and NPCC definitions where appropriate. A summary of the key terms, abbreviations and acronyms used in this guide have been compiled below for reference.

Bulk Electric System or **NERC BES**: Unless modified by the lists shown below, all **Transmission Elements** operated at 100 kV or higher and **Real Rower** and **Reactive Power** resources connected at 100 kV or higher. This does not include facilities used in the local distribution of electric energy. (This definition includes five inclusion clauses and four exclusion clauses.) (As per the NERC Glossary of Terms)

Bulk-Power System or **NERC BPS**: Bulk-Power System:

(A) facilities and control systems necessary for operating an interconnected electric energy transmission network or any portion thereof); and

(B) electric energy from generation facilities needed to maintain transmission system reliability. The term does not include facilities used in the local distribution of electric energy. (Note that the terms "Bulk- Power System" or Bulk Power System" shall have the same meaning.) (As per NPCC Glossary of Terms)

Bulk Power System or **NPCC BPS**: The interconnected electrical systems within northeastern North America comprised of system **elements** on which **faults** or **disturbances** can have a **significant adverse impact** outside the **local area**. (As per NPCC Glossary of Terms) Note that for NPCC **BPS elements** are determined through application of NPCC Document A-10 "Classification of Bulk Power System Elements".

For greater clarity, the term **BPS** or **Bulk Power System** (with upper case letters) when used by the **NLSO** is in reference to the **NPCC** definition. The term **bulk power system** (all lower case) is in reference to the **NERC** definition.

Cascading: The uncontrolled successive loss of **System Elements** triggered by an incident at any location. **Cascading** results in widespread electric service interruption that cannot be restrained from sequentially spreading beyond an area predetermined by studies. (As per NERC Glossary of Terms)

Disturbance: Severe oscillations or severe step changes of current, voltage and/or frequency usually caused by **faults**. (As per NPCC Glossary of Terms)

ECC: The **NLSO** Energy Control Centre.

Element: Any electrical device with terminals that may be connected to other electrical devices such as generator, transformer, circuit breaker, bus section or transmission line. An **element** may be comprised of one or more components. (As per NERC Glossary of Terms)

Extra High Voltage (EHV) Transmission: Transmission system with a nominal operating voltage greater than 300 kV.

Facility: A set of electrical equipment that operates as a single **Bulk Electric System Element** (e.g., a line, a generator, a shunt compensator, transformers, etc.) (As per NERC Glossary of Terms)

Facility Rating: The maximum or minimum voltage, current, frequency or real or reactive power flow through a **facility** that does not violate the applicable equipment rating of any equipment comprising the **facility**. (As per NERC Glossary of Terms)

Fault: An electrical **short circuit**. (AS per NPCC Glossary of Terms)

High Voltage (HV) Transmission: Transmission system with a nominal operating voltage up to 300 kV.

Hydro: Newfoundland and Labrador Hydro.

HVdc: High Voltage direct current.

Interconnected Reliability Operating Limit (IROL) is a **System Operating Limit**, that if violated, could lead to instability, uncontrolled separation, or **Cascading** outages that adversely impact the reliability of the **Bulk Electric System**.

Load: An end-use device or customer that receives power from the electric system. (As per NERC Glossary of Terms)

Local Area: An electrically confined or radial portion of the system. The geographic size and number of system elements contained will vary based on system characteristics. A local area may be relatively large geographically with relatively few buses in a sparse system, or be relatively small geographically with a relatively large number of buses in a densely networked system. (As per NPCC Glossary of Terms)

Newfoundland and Labrador Interconnected System: The interconnected transmission systems in both Newfoundland and Labrador with a rated voltage of 46 kV and above including the Labrador – Island HVdc Link.

Newfoundland and Labrador System Operator (NLSO): **Newfoundland and Labrador Hydro** operating in its role as the system operator. This is synonymous with the role of Hydro's Energy Control Centre (**ECC**) and corresponding support staff.

NL: Newfoundland and Labrador

NL Subtransmission System: Those transmission facilities located in **NL**, operating at a voltage level above 66 kV but below 230 kV. This is a term used in commercial agreements.

NL Transmission District: The **NL Transmission District** is comprised of the Labrador – Island HVdc Link and the bulk 230 kV AC portion of the Island Interconnected System, including all equipment and radial lines rated at 230 kV and above used to connect the bulk system to NL generating plants or to equipment rated at lower voltage levels to supply NL Native Load. The NL Transmission District also includes all reactive devices whether static or synchronous, including associated dedicated transformers connected directly to the 230 kV or higher voltage equipment. It does not include generator step-up transformers or transformers stepping down to voltages below 230 kV. This is a term used in commercial agreements for determination of losses.

NL Transmission System: The transmission facilities located in **NL**, primarily operating at a voltage level of 230 kV or higher, including, without limitation, the Labrador-Island Link, the Labrador Transmission Assets and Island Interconnected System but excluding the high voltage direct current portion of the Maritime Link transmission line owned by NSP Maritime Line Incorporated. This is a term used in commercial agreements.

North American Electric Reliability Corporation (NERC): A not-for-profit international regulatory authority whose mission is to assure the reliability and security of the **bulk power system** in North America. **NERC** develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the **bulk power system** through system awareness; and educates, trains, and certifies industry personnel. **NERC**'s area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico.

Northeast Power Coordinating Council (NPCC): A not-for-profit corporation in the state of New York responsible for promoting and enhancing the reliability of the international, interconnected **bulk power system** in Northeastern North America.

OLTC: on load tap changer. This is a device that adjusts the tap ratio of a power transformer to maintain a predefined bus voltage while the transformer is under load.

Primary Transmission System or **PTS**: Given that **Hydro** is not a registered entity within **NERC** and/or **NPCC**, it would be inappropriate to describe **elements** within the **Newfoundland and Labrador Interconnected System** as **BES** or **BPS**. As a result the term **Primary Transmission System** is used to define the bulk transmission facilities within the **NLSO** jurisdiction to which the **NLSO** transmission planning criteria will be applied to ensure reliable operation of the **bulk power system**. The **PTS elements** form the basis of the **NSLO's** future **BES**.

PUB: The Board of Commissioners of Public Utilities – Newfoundland and Labrador

Reactive Power: The portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment. Reactive Power must be supplied to most types of magnetic equipment, such as motors and transformers. It also must supply the reactive losses on transmission facilities. Reactive Power is provided by generators, synchronous condensers, or electrostatic equipment such as capacitors and directly influences electric system voltage. It is usually expressed in kilovars (kvar) or megavars (Mvar). (As per NERC Glossary of Terms)

Real Power: The portion of electricity that supplies energy to the **Load**. (As per NERC Glossary of Terms)

Significant Adverse Impact: With due regard for the maximum operating capability of the affected systems, one or more of the following conditions arising from **faults** or **disturbances**, shall be deemed as having **significant adverse impact**:

a. instability;

- any instability that cannot be demonstrably contained to a well-defined **local area**.
- any loss of synchronism of generators that cannot be demonstrably contained to a well-defined **local area**

b. unacceptable system dynamic response;

- an oscillatory response to a **contingency** that is not demonstrated to be clearly positively damped within 30 seconds of the initiating event.

c. unacceptable equipment tripping

- tripping of an un-faulted **bulk power system element** (**element** that has already been classified as **bulk power system**) under planned system configuration due to operation of a **protection system** in response to a stable **power swing**
- operation of a Type I or Type II **Special Protection System** in response to a condition for which its operation is not required

d. voltage levels in violation of applicable **emergency** limits;

e. loadings on transmission facilities in violation of applicable **emergency** limits.

(As per NPCC Glossary of Terms)

System Operating Limit (SOL) is the value (such as MW, MVAR, amperes, frequency or volts) that satisfies the most limiting of prescribed operating criteria for a specified system configuration to ensure operation within acceptable reliability criteria. System Operating Limits are based upon certain operating criteria. These included, but are not limited to:

- Facility Ratings (applicable pre- and post-Contingency Equipment Ratings or Facility Ratings)
- transient stability ratings (applicable pre- and post-Contingency stability limits)
- voltage stability ratings (applicable pre- and post-Contingency voltage stability)
- system voltage limits (applicable pre- and post-Contingency voltage limits)

Transmission: An interconnected group of lines and associated equipment for the movement or transfer of electric energy between points of supply and points at which it is transformed for delivery to customers or is delivered to other electric systems. (As per NERC Glossary of Terms)

3 Introduction

In order to effectively plan and operate the transmission system, the NLSO must understand the ratings of the electrical facilities. The ratings of system elements and facilities permit the determination of acceptable electrical loading and voltage levels on equipment prior to, during and immediately following system contingencies. The ratings are used to calculate power transmission limits when planning and operating the transmission system. This document outlines the methodology utilized by the NLSO when determining/calculating the facility ratings of equipment for both planning and operating purposes.

The NLSO Transmission Planning Department will ensure that the facility ratings within its jurisdiction align with the adopted NERC standards pertaining to facility ratings including FAC-008 Facility Ratings Methodology.

Within NERC these standards apply to all NERC defined **BES elements**. At the present time, the NLSO has not registered with NERC or NPCC. Consequently, the standards are taken to apply to the NLSO definition of **Primary Transmission System**, or **PTS**.

4 TYPES OF RATINGS

The Province of Newfoundland and Labrador is geographically quite large and consequently at any one point in time there can be very different meteorological conditions impacting the power system **elements** and ultimately **facility ratings**. Similarly, there is a very wide range in ambient conditions when one considers the seasonal basis. To this end it is practical to have **facility ratings** in Labrador based upon different assumptions than those on the Island. Further, there is a requirement to have different ratings for summer and winter due to the variation in ambient conditions. Finally, experience has shown that a spring/fall or intermediate rating is required on transmission lines in particular due to the system load shape and limited thermal capacities of older lines at that time of year.

Facility ratings are calculated for all ac transmission equipment rated 315 kV, 230 kV, 138 kV, 69 kV, 66 kV and 46 kV, as well as HVdc equipment, under the NLSO control.

4.1 Summer Rating

The MVA loading up to the summer rating limit can be carried continuously by the transmission system under summer conditions. For planning purposes this limit is referred to as the “summer rating” and cannot be exceeded under all elements in service conditions (i.e. pre-contingency) or under post-contingency conditions (for all applicable design contingencies).

4.2 Spring/Fall Rating

The MVA loading up to the spring/fall rating limit can be carried continuously by the transmission system under spring/fall conditions. For planning purposes this limit is referred to as the “intermediate rating” and cannot be exceeded under all elements in service conditions (i.e. pre-contingency) or under post-contingency conditions (for all applicable design contingencies).

4.3 Winter Rating

The MVA loading up to the winter rating limit can be carried continuously by the transmission system under winter conditions. For planning purposes this limit is referred to as the “winter rating” and cannot be exceeded under all elements in service conditions (i.e. pre-contingency) or under post-contingency conditions (for all applicable design contingencies).

4.4 Assumptions

The seasonal equipment ratings are based on the following assumptions:

- Island of Newfoundland
  - Summer Conditions – Ambient temperature of 30 °C, 2.19 km/h[1] wind speed
  - Spring/Fall - Ambient temperature of 15 °C, 2.19 km/h wind speed
  - Winter - Ambient temperature of 0 °C, 2.19 km/h wind speed
- Labrador
  - Summer Conditions – Ambient temperature of 30 °C, 2.19 km/h wind speed
  - Spring/Fall - Ambient temperature of 15 °C, 2.19 km/h wind speed
  - Winter - Ambient temperature of -15 °C, 2.19 km/h wind speed

4.5 Warnings/Alarms

For operational purposes the NLSO utilizes warning and alarm ratings within its Energy Management System (EMS) to assist operators in identifying situations that require continuous monitoring and the potential for action to be taken in the short term. The warning and alarm ratings for transmission equipment are set lower than the rating limits provided in this document. The operational warning/alarm limits as set as per the NLSO document "SCADA Database and Display Standard" ADM-S-002.

[1] 2.19 km/h equals 2 ft/sec wind.

5 Transmission Line Ratings

The seasonal rating limits for transmission lines are set equal to the most restrictive rating of all equipment associated with the transmission line from one end to the other including the line conductor, the circuit breakers, disconnect switches and bus conductors/jumpers at each line termination.

Transformer ratings for planning and operational purposes will be as outlined below unless more restrictive ratings are required due to angular instability, voltage instability or system voltage limits as indicated in power system studies.

5.1 Transmission Line Conductors

Transmission lines must be operated such that the overhead conductor does not sag below the minimum ground clearance. Consequently overhead conductors are tensioned to provide safe ground clearances under a variety of conditions. Two important sag conditions within the NLSO jurisdiction and transmission line ratings are the maximum sag under hot conductor and maximum sag under maximum ice load.

Initial line designs within the NLSO jurisdiction utilized a maximum conductor temperature of 50 °C for minimum ground clearance. Consequently, the seasonal transmission line ratings have been set to the current in amps required to yield a 50 °C conductor temperature for each seasonal ambient temperature.

There are a number of regions within the jurisdiction where the resultant conductor sag due to radial ice load exceeds a 50 °C conductor hot curve. In these areas an equivalent hot conductor temperature is calculated using the transmission designer's sag-tension program to provide a conductor temperature which provides the same sag as the ice load sag. The equivalent hot conductor temperature is used to determine the conductor current in amps for each seasonal ambient temperature.

Ratings for overhead transmission line conductors are calculated based upon the IEEE Standard 738 "IEEE Standard for Calculation of Bare Overhead Conductor Temperature and Ampacity Under Steady-State Conditions".

5.2 Power Cables

The seasonal rating limits for power cables will be set according to the manufacturer's ratings.

5.3 Open Wire Bus Conductor and Jumpers

The seasonal rating limits for open wire bus conductors and jumpers are calculated based upon the IEEE Standard 738 "IEEE Standard for Calculation of Bare Overhead Conductor Temperature and Ampacity Under Steady-State Conditions". The maximum conductor temperature for aluminum conductors (ASC, AASC, ACSR) is set at 90 °C. The maximum conductor temperature for copper conductors is set at 70 °C given the onset of excessive oxidation rates above 80 °C.

5.4 Rigid Tubular Bus

The seasonal rating limits for rigid (tubular) bus conductor are calculated based upon the method presented in chapter 13 of the book "Aluminum Electrical Conductors Handbook" by the Aluminum Association. The maximum conductor temperature for aluminum is set at 90 °C. The maximum conductor temperature for copper is set at 70 °C given the onset of excessive oxidation rates above 80 °C.

5.5 Disconnect Switches

Disconnect switch ratings are based upon an ambient temperature of 40 °C. Given the ambient temperature variation for seasonal ratings, adjustment to the nameplate rating of outdoor air disconnect switches is required. The rating limits are calculated as follows:

- The summer rating limit = 115% * manufacturer's nameplate rating
- The spring/fall rating limit = 125% * manufacturer's nameplate rating
- The winter rating limit = 130% at 0 °C, 135% at -15 °C * manufacturer's nameplate rating.

5.6 Circuit Breakers

Circuit breaker ratings are based upon an ambient temperature of 40 °C. Given the ambient temperature variation for seasonal ratings, adjustment to the nameplate rating of outdoor power circuit breakers is required. The rating limits are calculated as follows:

- The summer rating limit = 105% * manufacturer's nameplate rating
- The spring/fall rating limit = 112% * manufacturer's nameplate rating
- The winter rating limit = 119% at 0 °C, 125% at -15 °C * manufacturer's nameplate rating.

5.7 Current Transformers

Current transformer ratings are based upon a design having a 55 °C temperature rise over an ambient temperature of 30 °C. Given the ambient temperature variation for seasonal ratings, adjustment to the nameplate rating of outdoor current transformers are required. The rating limits are calculated as follows:

- The summer rating limit = 100% * manufacturer's nameplate rating
- The spring/fall rating limit = 113% * manufacturer's nameplate rating
- The winter rating limit = 125% * manufacturer's nameplate rating.

5.8 Shunt Reactive Devices

Shunt reactive devices (i.e. capacitors and reactors) are applied to the bulk system to assist with voltage control. These devices are specified, designed and manufactured for the full range of system voltage conditions that they will be subject to during normal and contingency operation. The reactive power loading of these shunt devices is the result of the voltage applied to the terminals of the device. Therefore, overloading of the device is not applicable. The seasonal rating limits of the shunt reactive devices are as per the manufacturer's nameplate.

5.9 Series Reactive Devices

There are no series reactive devices (capacitors or reactors) installed on the transmission system within the NLSO jurisdiction.

6 Transformer Ratings

Transformer ratings for planning and operational purposes will be as outlined below unless more restrictive ratings are required due to angular instability, voltage instability or system voltage limits as indicated in power system studies.

6.1 Power Transformers and Autotransformers

The transformer rating limit corresponds to the manufacturer's maximum nameplate rating at a 65 °C Temperature Rise (55 °C rise for older designs as appropriate) based upon the oil cooling methods applied to the specific unit. For example, a transformer rated 75/100/125 MVA (ONAN/ONAF/ONAF) will have a maximum summer rating of 125 MVA.

It is understood that for transformers manufactured to CAN/CSA-C88-M90 "Power Transformers and Reactors", the transformer rating will be increased from the manufacturer's maximum nameplate rating at a 65 °C Temperature Rise as outlined in Clause 3.5 Low-Ambient Temperature Load Capability. Clause 3.5 states:

> *Transformers, except for generator step-up units (see Clause 3.4.1), shall be capable of an increase in loading for each degree Celsius that the daily average ambient temperature is lower than 25 °C, down to a minimum average ambient temperature of 0°C. Self-cooled and water cooled units shall have an increase of 1.0% for each degree Celsius below 25 °C and forced-air-cooled and forced-air-/forced-liquid-cooled units shall have an increase of 0.75% for each degree Celsius below 25°C.*

As a result, The spring/fall or intermediate rating limit could correspond to the manufacturer's maximum nameplate rating at a 65 °C Temperature Rise times 1.075 for transformers manufactured to CSA C88-M90 and identified as such on the manufacturer's nameplate. For example, a transformer rated 75/100/125 MVA (ONAN/ONAF/ONAF) and the nameplate indicates that it has been built to CAN/CSA/C88-M90 shall have a maximum spring/fall or intermediate rating of 134.3 MVA (i.e. 125 x 1.075)

Further, the winter rating limit could correspond to the manufacturer's maximum nameplate rating at a 65 °C Temperature Rise times 1.1875 for transformers manufactured to CSA C88-M90 and identified as such on the manufacturer's nameplate. For example, a transformer rated 40/53.3/66.6 MVA (ONAN/ONAF/ONAF) and the nameplate indicates that it has been built to CAN/CSA-C88-M90 shall have a maximum winter rating of 79 MVA (i.e. 66.6 x 1.1875).

For transmission planning purposes the summer, spring/fall and winter rating limits of all power transformers and autotransformers will be equal to the nameplate rating at 25 °C ambient as provided by the manufacturer. Given the time requirements for the procurement of a new transformer(s) once installed unit(s) reach nameplate rating, the increase in transformer rating limit associated with lower ambient air temperatures at time of system peak (i.e. spring/fall and winter) available from transformers designed to CAN/CSA-C88-M90 is allocated as operational margin to avoid loss of transformer life due to excessive loading in the period between transformer reaching 100% of nameplate rating and installation of additional transformer capacity following transformer failure in multiple transformer installations.

The emergency rating limit for transformers will be in accordance with NLSO operating instruction TOP-P-057.

6.2 Generator and Synchronous Condenser Step-up Transformers

Clause 3.4.1 of CAN/CSA C88-M90 Generator Step-up Transformer Loading Capability states:

> *As the requirement for loading capability of a generator step-up transformer is related directly to the output capacity of the generator to which it is connected, the transformer loading capability, including low temperature capability, shall be specified by the purchaser. The purchaser is advised to refer to ANSI/IEEE Guide C57.116 for transformers directly connected to generators.*

Consequently, the summer, spring/fall and winter rating limits of a generator step-up transformer will correspond to the manufacturer's maximum nameplate rating at a 65 °C Temperature Rise (55 °C rise for older designs as appropriate) unless otherwise specified on the transformer nameplate.

6.3 Transformer Tap Deratings

For transformers equipped with either de-energized tap changers or on load tap changers a reduced MVA rating may be warranted based upon the current rating of the transformer for the actual tap position or tap range. For example, a 230/66 kV transformer rated 75/100/125 MVA with de-energized tap changer having five positions ±5% in 2.5% steps on the high voltage winding may be rated as follows:

Tap 1: 241,500 V and 299 A
Tap 2: 235,750 V and 306 A
Tap 3: 230,000 V and 314 A
Tap 4: 224,250 V and 322 A
Tap 5: 218,500 V and 322 A

If the transformer is operating in tap position 5 the winding current is limited to 322 A then the maximum summer rating limit would equal 121.86 MVA. The spring/fall and winter rating limits would

depend upon whether or not the transformer was built to CAN/CSA-C88-M90 with the appropriate multiplication factor applied for the ambient temperature.

7 Voltage Limits

Voltage limits for equipment on the transmission system are the same regardless of the seasonal time frame. Voltage limits will be as outlined below unless more restrictive ratings are required due to angular instability, voltage instability or system voltage limits as indicated in power system studies.

Pre-contingency Limit:

95% to 105% of nominal at all buses

Post-contingency Limit:

90% to 110% of nominal at all buses

Minimum bus voltage of 212 kV at Come By Chance 230kV

All system voltages should be within the “Pre-Contingency Limit” with all equipment in service and within the “post-contingency Limit” for all design contingencies.

8 Communication of Facilities Ratings

The NLSO shall communicate **facility ratings** information to the PUB upon request.

The NLSO Transmission Planning Department will notify the NLSO System Operations Department whenever there is a new **facility rating**, or change to an existing **facility rating**. The System Operations Department will ensure that the change is implemented for use in the ECC. When a **facility** is made up of multiple elements, the most limiting element will be identified.

The NLSO System Operations Department will notify the NLSO Transmission Planning Department whenever there is an equipment rating change due to operational requirements.

The NLSO shall provide **facility ratings**, including the identity of the most limiting **element** to associated entities when requested. These entities would include Nova Scotia Power, New Brunswick Power (as the reliability coordinator for the Maritime Area) and Hydro Québec.

The NLSO shall provide **facility ratings** to requesting entities including the identity of the limiting **element** and next most limiting **element** that limits the use of the **facility** by causing any of the following:

- An Interconnection Reliability Operating Limit
- A limitation of Total Transfer Capability
- An impediment to generator deliverability
- An impediment to service a major load center.

The NLSO shall endeavor to provide this information within 30 calendar days of the request.

The NLSO will maintain records of updated **facility ratings** for documentation purposes and will retain such records for a period of three years.

9 SOL and IROL Determination

All **facilities** will have seasonal ratings calculated as per the methodology described in this document. By default, for any **PTS facility**, the associated seasonal rating will be considered a SOL. Anytime a **facility rating** is updated, the update will be communicated to the NLSO System Operations Department as per section 8.0 of this document.

Whenever a planning study identifies that a violation of a **SOL** could expose a widespread area of the defined **PTS** to instability, cascading outages or uncontrolled separation, the **SOL** will be considered an **IROL**. When the NLSO Transmission Planning Department identifies a new **IROL**, it will be communicated to the NLSO System Operations Department and added to their **IROL** documentation. In addition, the new **IROL** will be provided to neighbouring jurisdictions as appropriate.

10 Reference Documents

1. CAN/CSA-C88-M90 Power Transformers and Reactors
2. Aluminum Electrical Conductor Handbook by the Aluminum Association
3. IEEE Standard 738 “IEEE Standard for Calculation of Bare Overhead Conductor Temperature and Ampacity Under Steady-State Conditions”
4. ANSI/IEEE C37.37-1979 Loading Guide for AC High Voltage Air Switches (in excess of 1000 volts)
5. ANSI/IEEE C37.010-1979 Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Basis
6. Standard FAC-008-3 Facility Ratings, North American Electric Reliability Corporation
7. IEEE C57.13-2008 “IEEE Standard Requirements for Instrument Transformers”