**Table of Contents**

[APPENDIX A - GENERAL RATING PARAMETERS FOR SEASONAL AND STUDY CASE RATINGS 3](#_Toc182984507)

[APPENDIX B – BARE STRANDED CONDUCTORS 1](#_Toc182984508)

[APPENDIX C - UNDERGROUND CABLES 1](#_Toc182984509)

[APPENDIX D - POWER TRANSFORMERS 1](#_Toc182984510)

[APPENDIX E - SERIES AND SHUNT REACTIVE ELEMENTS 1](#_Toc182984511)

[APPENDIX F - CIRCUIT BREAKERS 1](#_Toc182984512)

[APPENDIX G - DISCONNECT SWITCHES 1](#_Toc182984513)

[APPENDIX H - CURRENT TRANSFORMERS 1](#_Toc182984514)

[APPENDIX I - LINE TRAPS 1](#_Toc182984515)

[APPENDIX J - SUBSTATION BUSES 10](#_Toc182984516)

[APPENDIX K - CURRENT TRANSFORMER SECONDARY CIRCUIT COMPONENTS 1](#_Toc182984517)

[APPENDIX L - VAR COMPENSATORS 1](#_Toc182984518)

[APPENDIX M - HVDC SYSTEMS 1](#_Toc182984519)

[APPENDIX N – Ambient Adjusted Ratings (AAR) 1](#_Toc182984520)

# APPENDIX A - GENERAL RATING PARAMETERS FOR SEASONAL AND STUDY CASE RATINGS

##### INTRODUCTION

This Appendix A describes the general parameters that shall be used in calculating Seasonal and Study Case ratings for equipment that is required to have a rating per OP-16

Such parameters for underground cables are described in Appendix C, Underground Cables.

Seasonal ratings shall be defined as 12 separate rating periods that represent each month of the year. In addition to these 12 rating periods, two additional Study Case ratings sets are required. The Study Case 1 and Study Case 2 rating sets will be used for transmission planning and operational studies and are not required seasons pursuant to FERC Order 881.

##### AMBIENT TEMPERATURES AND WIND VELOCITIES

###### AMBIENT TEMPERATURES

Table A1 shall be used for determining Normal Emergency (LTE, STE, and DAL) transmission facility ratings. The ambient temperatures were developed from Hartford, Connecticut area temperature statistics for the years 2007 to 2022 and reaffirmed following analysis of similar data from eight locations throughout New England for the same time period. This data is summarized in Table A2 (Hartford Area) and Table A3 (New England). Sections 2.1.1-2.1.3 below explain the rationale behind the chosen temperatures.

**Table A 1**

**Ambient Temperature for Determining Equipment Ratings[[1]](#footnote-2) [[2]](#footnote-3)**

A table with numbers and symbols

Description automatically generated

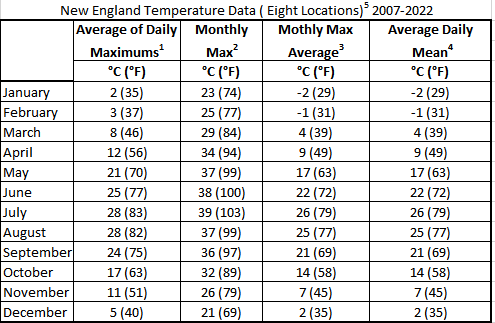
**Table A 2**

**Hartford, CT Area Temperature Data 2007-2022**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Daily Monthly Average** | | **Monthly Max** | | **Average Max** | | **Average Daily Mean** | |
| **°F** | **°C** | **°F** | **°C** | **°F** | **°C** | **°F** | **°C** |
| **January** | 36 | 2 | 72 | 22 | 55 | 13 | 30 | -1 |
| **February** | 39 | 4 | 77 | 25 | 58 | 14 | 32 | 0 |
| **March** | 48 | 9 | 83 | 28 | 69 | 20 | 41 | 5 |
| **April** | 61 | 16 | 94 | 34 | 81 | 27 | 53 | 12 |
| **May** | 73 | 23 | 99 | 37 | 89 | 32 | 65 | 18 |
| **June** | 80 | 27 | 99 | 37 | 93 | 34 | 73 | 23 |
| **July** | 86 | 30 | 103 | 39 | 96 | 36 | 80 | 27 |
| **August** | 84 | 29 | 99 | 37 | 94 | 34 | 78 | 25 |
| **September** | 77 | 25 | 96 | 36 | 90 | 32 | 70 | 21 |
| **October** | 64 | 18 | 89 | 32 | 79 | 26 | 58 | 15 |
| **November** | 52 | 11 | 79 | 26 | 69 | 20 | 45 | 7 |
| **December** | 41 | 5 | 69 | 21 | 58 | 15 | 35 | 2 |

**Table A 3**

**New England Temperature Data (Eight Locations) 2007-2022**



1 This is the average of the daily maximum temperatures for each month over the timeframe of 2007-2022.

2 Monthly max temperature over the timeframe of 2007-2022.

3 This is the average of the monthly maximum temperature over the timeframe of 2007-2022.

4 This is the average of the daily maximum and minimum temperatures over the month over the timeframe of 2007-2022.

5 Based on eight New England locations of Hartford/Windsor Locks and Bridgeport in CT, Boston and Worcester in MA, Burlington VT, Providence RI, Concord NH and Portland ME.

The ambient temperature recommendations of Table A1 are based upon the following:

###### Overhead Conductors (Bare Stranded Conductors)

Overhead Conductor ambient temperature assumptions are provided in in Section 2.1 and wind velocities are discussed in Section 2.2. The ambient temperatures selected in Section 2.1 are based on historic data for each month. The Seasonal Normal and Emergency ambient temperature were derived from the monthly maximum temperature for each season, rounded to the nearest 5F.

###### Power and Current Transformers

IEEE Standard C57.91-2011, “Guide for Loading Mineral-Oil-Immersed Transformers” (IEEE C57.91-2011) [Reference 3] recommends using average daily temperatures for the month involved in

determining Normal ratings and average of maximum daily temperatures for the month involved for Emergency ratings. IEEE C57.91-2011 also recommends the use of a 5C adder to the Daily Mean ambient temperature. The ambient temperatures indicated in Table A1 are consistent with the recommendations for determining ambient temperatures set forth in IEEEC57.91-2011, including the recommended 5C adder as based on the data of Table A2. The Normal ambient temperatures that are shown in Table A1 were derived from the Daily Mean temperatures of Table A2; and Emergency ambient temperatures were derived from the Average of the Daily Maximum temperatures of Table A2. Both Normal and Emergency temperatures shown in table A1 were derived by applying the 5C adder applied and then rounding to the nearest 5F.

The criteria to be used for developing ambient temperature for current transformers is the same as power transformers.

###### Terminal and Other Equipment

Seasonal Normal and Emergency ambient temperatures for terminal equipment other than transformers and current transformers are based on the averages of daily maximum temperatures for each season and rounded up to the nearest 5F.

###### OTHER AMBIENT CONDITIONS

Wind velocity and angle; emissivity and solar absorptivity; and other environmental conditions not specifically address in this procedure shall be determined by the Market Participant. In determining these values, applicable standards and guidance documents such as IEEE 738-2023 and CIGRE Technical Brochure 299 should be consulted.

##### EQUIPMENT TEMPERATURE

Equipment temperatures for Normal loadings shall be in accordance with industry standards or loading guides where applicable. In cases where no industry approved guides exist for Emergency loading, total equipment temperatures higher than design values may be allowed for Emergency

operation, at the discretion of the individual companies.

##### ASSUMED LOADING CONDITIONS

Where time-temperature relationships for annealing characteristics have been applied, the following estimated hours of operation at allowable equipment temperatures have been assumed, over a 30-year equipment life:

Normal Rating 13,200 hours

Long-Time Emergency (4 hour) Rating 500 hours Short-Time Emergency (15 minute) Rating 20 hours Drastic Action Limit Not Applicable

These estimates are based on the fact that annealing and loss of strength occur only when a device is operating at or near its rated temperature limit. For most locations on the transmission system, ambient temperature variations together with daily and seasonal cycling of load current will result in conditions where the equipment typically operates at temperatures considerably lower than rated values.

The total duration of operation at Emergency temperatures, with the exception of Drastic Action Limits, reflects a conservative estimate for post-contingency operation.

It should be recognized that at locations where the load cycle is more severe, such as in proximity to a base load generator, the hours of operation at rated temperature would be expected to increase under Normal operation. With more annealing taking place under Normal loading, Emergency ratings should be assigned with care.

##### REFERENCES

* 1. IEEE C57.91-1995 (R2004), “IEEE Guide for Loading Mineral-Oil-Immersed Transformers”
  2. IEEE 738-2023, “IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors”
  3. CIGRE Technical Brochure 299, “Guide for Selection of Weather parameters for Bare Overhead Conductor Ratings”

###### Document History

Rev. 0 App.: SDTF – 3/22/05; RC – 6/14/05; NPC – 8/5/05; ISO-NE – 8/31/05

Rev. 1 4/11/06 Introduction corrected; editorial and format changes Rev. 2 RC – 8/10/10

# APPENDIX B – BARE STRANDED CONDUCTORS

##### INTRODUCTION

The following shall be used by Market Participant for determining Normal and Emergency load-current carrying capabilities of overhead conductors installed on the New England transmission system at 69kV or higher for equipment that is required to have a rating per OP-16.

##### STANDARDS

Overhead conductors are to be rated in accordance with the Market Participant’s methodology. Such methodology should consider IEEE Standard 738-20062023, “IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors”.

##### APPLICATION GUIDE

Overhead conductor ratings shall be calculated as described below at a rated power frequency of 60 Hertz and nominal voltage, e.g. 69 kV, 115 kV, 230 kV or 345 kV.

###### Clearances

Clearance requirements are established by the National Electrical Safety Code and applicable state codes. These codes also specify that ground clearances are to be calculated using the maximum conductor operating temperatures. The reduced ground clearances due to final[[3]](#footnote-4) sag conditions must be considered in choosing a maximum allowable temperature.

###### Recommended Maximum Allowable Conductor Temperature

The determination of maximum allowable conductor temperatures is left to the discretion of each Market Participant, with due consideration for the conductor material; however, such temperatures must not be less than 100C for any Emergency rating.

###### OVERHEAD CONDUCTOR RATING METHODOLOGY

Since the thermal time constant of a conductor is generally greater than 15 minutes, a steady-state calculation is to be applied in determining Normal and Long-Time Emergency ratings. A transient calculation is applied in determining Short-Time Emergency ratings and Drastic Action Limits. In all cases, adequate clearances must be maintained with conductor loadings at the rated values.

###### OVERHEAD CONDUCTOR RATING PARAMETERS

Overhead conductor rating calculations are based largely on the conductor resistance and maximum allowable temperature along with certain environmental factors including ambient temperature and wind speed. The following physical characteristics and environmental conditions may also influence the calculation of conductor ratings and may vary with the conductor or with location:

* Conductor Diameter & Material (ACCC, AAC, ACAR, ACSR, ACSS, etc)
  + Impacts thermal capacity and resistance
* Latitude
* Elevation
* Atmosphere (Clear/Industrial)
* Line Direction (North – South, East-West, etc.)
* and the appropriate parameters are left to the discretion of the Market Participants.

Other parameters can be uniformly applied throughout New England:

* Solar Heat Gain Assumptions: Based on the most conservative day during the appropriate season with sun at its peak in the sky. This will be the day in the appropriate season that is closest to the Summer Solstice. Hour angle assumed to be solar noon (when the sun is at its peak in the sky (actual local clock time will differ).

###### CONNECTORS AND SPLICES

The loadability of connectors and splices must meet or exceed the loadability of the conductors for which they are sized. The individual owners are to confirm, with the manufacturers involved, that the connectors and splices, when installed in accordance with the actual methods used in each installation, may be loaded safely to the proposed line ratings, without exceeding the maximum allowable temperature limits of the connectors or splices.

##### REFERENCES

1. National Electrical Safety Code
2. IEEE 738-2023, “IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors”

###### Document History

Rev. 0 App.: SDTF – 2/22/06; RC – 3/14/06; NPC – 4/7/06; ISO-NE – 4/10/06 Rev. 1 RC – 8/10/10

# APPENDIX C - UNDERGROUND CABLES

##### INTRODUCTION

The following methodology applies to underground and submarine transmission lines, and covers the following type of cables and their accessories:

* + 1. Impregnated paper or laminated paper - polypropylene insulated cables and accessories.
       - High Pressure Fluid Filled Pipe Type Cable (HPFF)
       - Low & Medium Pressure Self-contained Liquid Filled Cable (LPOF)
       - High Pressure Gas Filled Cables (HPGF)
    2. Extruded Solid dielectric cross linked polyethylene (XLPE) or Ethylene-Propylene-Rubber (EPR) insulated cables

##### INPUT ASSUMPTIONS

Inputs to underground ratings are as follows:

**CABLE SYSTEM ENVIRONMENT**

1. Earth Ambient Temperature: This is the temperature of the soil surrounding the cable. This temperature varies either cyclically through the year, with the maximum earth

ambient temperature generally lagging one or two months behind the corresponding air temperature or remains constant depending upon the burial depth of the conductor. Earth ambient temperatures can often be obtained either from local soil conservation services or by the use of thermal probes.

1. Soil, Concrete and Backfill Thermal Resistivity: The thermal resistivity of the backfill material(s) is a function of several variables, including the intrinsic value of the material itself (or mixture of materials), the moisture content, and the degree of compaction around the cables. A backfill having low thermal resistivity will generally have the following characteristics:
   * High Moisture Content
   * Highly compacted
   * Uniform sizing of components (well-graded)

Typical cable system backfill materials include thermal sand, stone screenings, weak concrete and/or fluidized thermal backfill. Representative thermal resistivity of these materials, with 5% - 0% moisture, range from 30 - 100 C°-cm/watt, as shown in Reference 3, Table 5-11 on Page

236. Typical design values are 60 for weak concrete or fluidized thermal backfill and 90 –100 for thermal sand and stone screenings.

The cable system environment typically consists of a combination of backfill material around the cable and native soils having higher thermal resistivities.

**LOAD FACTOR**

The load factor of each underground line should be determined. It generally should not be less than 75% for typical transmission lines and should be 100% for dedicated generator leads.

**ADJACENT HEAT SOURCES**

Adjacent heat sources (i.e.: adjacent heat pipes, distribution lines, or transmission lines) are to be taken into account. Hot Spots should be identified throughout the cable system.

**BONDING SCHEMES**

Bonding schemes, such as multipoint/single point/cross bonding etc., shall be considered for the rating of the cable.

**CABLE AND DUCT/PIPE CHARACTERISTICS**

The cable's characteristics (conductor size, type and stranding, insulation type and thickness, metallic shield type and thickness and/or size and number of wires, etc., jacket type and thickness) shall be considered. If the installation is in conduit or pipe, include the dimensions and type of conduit or pipe (if used), pipe or conduit filling medium (typically air, or dielectric fluid as in the case of high pressure dielectric fluid filled pipe type cable).

**INSTALLATION CHARACTERISTICS**

The cross Section of the Cable Environment, depth of burial, spacing and configuration (vertical and/or horizontal spaced, close triangular etc) of adjacent phases, number of circuits, spacing and configuration of adjacent circuits and/or external heat sources, type of installation (direct burial or in conduit of pipe), type and dimensions of backfill material, type of native soil etc. shall be considered when rating the cable.

##### CABLE RATINGS

The ratings of underground cables are largely influenced by the ambient earth temperature and properties of the surrounding soil and the way the cable is installed and operated.

**NORMAL RATING**

The Normal rating is that in which a cable operates continuously with negligible loss of life. This is the current that the cable system is expected to carry through its normal load cycle for an indefinite period of time without exceeding its Normal operating temperature.

**EMERGENCY RATINGS**

###### Long Time Emergency Rating (LTE)

Long Time Emergency Ratings (LTE) are defined in OP-19. Conductor temperatures for paper and Solid Dielectric Cables are not to exceed 105°C for 300 Hrs./5Years.

###### Short Time Emergency Rating (STE)

Short Time Emergency Ratings (STE) are defined in OP-19. Consistent with OP-19, the 15-minute conductor rating shall not reach temperature limits as specified in LTE above.

###### Drastic Action Limit (DAL)

Drastic Action Limits (DAL) are defined in OP-19. Consistent with OP-19, the 5-minute conductor rating shall not reach temperature limits as specified in LTE above.

##### REFERENCES

None.

###### Document History

Rev. 0 App.: SDTF – 3/22/05; RC – 6/14/05; NPC – 8/5/05; ISO-NE – 8/31/05

Rev. 1 4/11/06 Add Section 7, References; editorial changes Rev. 2 RC – 8/10/10

# APPENDIX D - POWER TRANSFORMERS

##### INTRODUCTION

The following methodology applies to power transformers with at least one winding connected at a voltage of 69 kV or higher for equipment that is required to have a rating per OP-16

##### STANDARDS

Ratings for power transformers shall be determined by Market Participants considering IEEE Standard C57.91-2011, “IEEE Guide for Loading Mineral-Oil-Immersed Transformers.”

##### APPLICATION GUIDE

**3.1 Pool Transmission Facility (PTF) TRANSFORMERS**

The rating of an autotransformer shall be calculated at the fixed tap that will be utilized when the autotransformer is in service, and with any forced cooling (fans and/or pumps) in operation. If the autotransformer has a load tap changer the rating shall be calculated at the tap that gives the most conservative rating.

The rating of the autotransformer shall be calculated at 60 Hertz and nominal voltage.

##### LOAD SERVING TRANSFORMERS

Load serving transformer ratings shall be determined by the Market Participant and the duration associated with LTE, STE and DAL limits may vary from the durations in OP-19.

##### PHASE SHIFTING TRANSFORMERS

Phase-shifting transformers ratings shall be determined by the Market Participant.

##### GENERATOR STEP-UP TRANSFORMERS

Generator step-up transformers shall be given a normal load carrying rating.

##### Ambient Adjusted Rating Methodology

If a Market Participant determines a transformer is required to have an AAR, AARs are discussed in Appendix N.

##### REFERENCES

None

###### Document History

Rev. 0 App.: SDTF – 2/22/06; RC – 3/14/06; NPC – 4/7/06; ISO-NE – 4/10/06 Rev. 1 RC – 8/10/10

# APPENDIX E - SERIES AND SHUNT REACTIVE ELEMENTS

##### INTRODUCTION

The following methodology applies to series capacitors, shunt capacitors, series reactors and shunt reactors connected at voltages 69 kV or above.

##### STANDARDS

Ratings for series capacitors shall be determined by the Market Participant. In determining these values, applicable standards and guidance documents such as IEEE Standard 824-2004, “IEEE Standard for Series Capacitors in Power Systems”.

Ratings for shunt capacitors shall be determined by the Market Participant. In determining these values, applicable standards and guidance documents such as IEEE Standard 18-2012, “IEEE Standard for Shunt Power Capacitors”.

Ratings for series reactors shall be determined by the Market Participant. In determining these values, applicable standards and guidance documents such as IEEE Standard C57.16-1996, “IEEE Standard Requirements, Terminology, and Test Code for Dry-Type Air-Core Series- Connected Reactors”.

Ratings for shunt reactors shall be determined by the Market Participant. In determining these values, applicable standards and guidance documents such as IEEE Standard C57.21-2021 “IEEE Standard Requirements, Terminology, and Test Code for Shunt Reactors Rated Over 500 kVA”.

##### APPLICATION GUIDE

**SERIES CAPACITORS**

The impedance, Normal rating, LTE, STE, DAL, and short circuit current withstand rating of a series capacitor bank shall be the values provided by the manufacturer or calculated by the owner at 60 Hertz and nominal system voltage e.g. 69 kV, 115 kV, 230 kV or 345 kV.

**SHUNT CAPACITORS**

The rating of a shunt capacitor bank shall be the rating provided by the manufacturer or calculated by the owner at 60 Hertz and nominal system voltage e.g. 69 kV, 115 kV, 230 kV or 345 kV.

**SERIES REACTORS**

The impedance, losses, Normal rating, LTE, STE, DAL, and short circuit current withstand rating of a series reactor bank shall be the values provided by the manufacturer or calculated by the owner at 60 Hertz and nominal system voltage e.g. 69 kV, 115 kV, 230 kV or 345 kV.

**SHUNT REACTORS**

The rating, losses and impedance of a shunt reactor shall be the values provided by the manufacturer or calculated by the owner at 60 Hertz and nominal system voltage e.g. 69 kV, 115 kV, 230 kV or 345 kV. The impedance of the shunt reactor shall be measured at full voltage.

##### REFERENCES

None.

###### Document History

Rev. 0 App.: SDTF – 9/9/05; RC – 10/4/05; NPC – 11/4/05; ISO-NE – 11/30/05

Rev. 1 4/11/06 Editorial changes Rev. 2 RC – 8/10/10

# 

# APPENDIX F - CIRCUIT BREAKERS

##### INTRODUCTION

These procedures shall be used by Market Participants for determining Normal and Emergency load-current carrying capabilities of circuit breakers installed on the New England transmission system, 69kV and above.

##### STANDARDS

Circuit breakers ratings are to be determined by the Market Participant. In determining these values, applicable standards and guidance documents such as IEEE Standard C37.010-2016, “IEEE Application Guide for AC High-Voltage Circuit Breakers > 1000V ac Rated on a Symmetrical Current Basis”

##### APPLICATION GUIDE

Circuit Breaker load current ratings shall be calculated at a rated power frequency of 60 Hertz and nominal voltage, e.g. 69 kV, 115 kV, 230 kV or 345 kV. Current transformers that are part of the circuit breaker installation are normally selected so they will not limit the circuit breaker continuous or emergency ratings. Refer to Appendix H for current transformer rating procedures.

###### Document History

Rev. 0 App.: SDTF – 9/9/05; RC – 10/4/05; NPC – 11/4/05; ISO-NE – 11/30/05

Rev. 1 4/11/06 Editorial changes Rev. 2 RC – 8/10/10

# APPENDIX G - DISCONNECT SWITCHES

##### INTRODUCTION

These procedures shall be used by Market Participants for determining normal and emergency load-current carrying capabilities of disconnect switches installed on the New England transmission system, 69 kV and above.

##### STANDARDS

Disconnect switches are to be determined by the Market Participant. In determining these values, applicable standards and guidance documents such as IEEE Standard C37.30.1-2022, “IEEE Standard Requirements for High-Voltage Switches.”

##### APPLICATION GUIDE

Disconnect switch load current ratings shall be calculated at a rated power frequency of 60 Hertz and nominal voltage, e.g. 69 kV, 115 kV, 230 kV or 345 kV.

##### References

None

###### Document History

Rev. 0 App.: SDTF – 2/22/06; RC – 3/14/06; NPC –4/ 7/06; ISO-NE – 4/10/06 Rev. 2 RC – 8/10/10

# APPENDIX H - CURRENT TRANSFORMERS

##### INTRODUCTION

These procedures shall be used by Market Participants for determining Normal and Emergency load-current carrying capabilities of current transformers installed on the New England transmission system, 69 kV and above.

##### STANDARDS

Current transformers are to be determined by the Market Participant. In determining these values, applicable standards and guidance documents such as ANSI/IEEE Standard C57.13-2016, “IEEE Standard Requirements for Instrument Transformers”.

##### APPLICATION GUIDE

Current transformer ratings shall be calculated at a rated power frequency of 60 Hertz and nominal voltage, e.g. 69 kV, 115 kV, 230 kV or 345 kV.

##### REFERENCES

None.

###### Document History

Rev. 0 App.: SDTF – 10/18/05; RC – 11/1/05; NPC – 12/2/05; ISO-NE – 12/30/05 Rev. 1 RC – 8/10/10 RC – 8/10/10

# APPENDIX I - LINE TRAPS

##### INTRODUCTION

These procedures shall be used by Market Participants for determining normal and emergency load-current carrying capabilities of Line Traps installed on the New England transmission system, at 69 kV and above.

##### STANDARDS

Line traps are to be determined by the Market Participant. In determining these values, applicable standards and guidance documents such as IEEE Standard C93.3-2017, “Requirements for Power-Line Carrier Line Traps (30 kHz to 500 kHz).”

##### APPLICATION GUIDE

Line trap ratings shall be calculated at a rated power frequency of 60 Hertz and nominal voltage, e.g. 69 kV, 115 kV, 230 kV or 345 kV. Line Traps have limited overload capacity; therefore the continuous current rating should be selected to be above the four-hour emergency rating of the circuit in which it is installed. Furthermore, Line Traps must have a higher short-circuit capability and a continuous current rating greater than other any of the other components in the circuit (i.e. circuit breakers, disconnect switches, etc).

##### REFERENCES

None

###### Document History

Rev. 0 App.: SDTF – 10/18/05; RC – 11/1/05; NPC – 12/2/05; ISO-NE – 12/30/05

Rev. 1 4/11/06 Editorial and format changes Rev. 2 RC – 8/10/10

# APPENDIX J - SUBSTATION BUSES

*.*

##### INTRODUCTION

These procedures shall be used by Market Participants for determining Normal and Emergency load-current capabilities of buses on the New England transmission system, 69 kV and above.

##### Substation Buses

Bare, outdoor, non-enclosed buses and cables of circular cross section will be rated by the Market Participant. In determining these values, applicable standards and guidance documents such as the following:

1. IEEE Standard 605-2024, “Guide for Design of Substation Rigid Bus Structures” is a primary reference for ampacity ratings for tubular bus and bare circular wire cables /conductors used in substations.
2. IEEE Standard 738-2023, “Guide for Calculating the Current-Temperature relationship of Bare Overhead Conductors”.
3. Methods outlined in Sections 6-2 through 6-9 of the “*Alcoa Conductor Engineering Handbook*, 1957.”

##### APPLICATION GUIDE

* 1. **RIGID SUBSTATION BUSES**

The ampacity rating calculations of rigid, Aluminum or Copper, outdoor, exposed non-enclosed buses and conductors involves parameters such as ambient temperature, maximum conductor temperature limitations, wind speed, wind direction, solar gain, emissivity, and absorptivity. The maximum temperature at which the bus can operate is limited by loss of strength (loss of life) due to temperature cycles and mechanical movement due to expansion.

###### Ambient Temperature

Ratings should be based on the ambient conditions as defined in Appendix A to this procedure.

###### Maximum Allowable Temperature

The maximum temperature limit at which the rigid bus is permitted to operate should be determined with consideration of the following:

* + - * Loss of life over a period of rigid bus life
      * Maximum allowable movement due to expansion and contraction.
      * Unbalanced loading effects due to paralleling of buses

The maximum temperature at which the bus can operate varies with the rigid bus material (e.g. copper, aluminum and its alloys) and is best determined by consulting manufacturer recommendations.

###### Wind Speed and Wind Direction

Wind velocity and angle and other environmental conditions not specifically addressed in this Procedure shall be determined by the Market Participant. In determining these values, applicable standards and guidance documents such as IEEE Standard 605-2023 should be consulted.

* 1. **FLEXIBLE SUBSTATION BUSES**

Flexible substation bus ratings shall be assigned in accordance with Appendix B of this procedure.

##### REFERENCES

1. IEEE 738-2023, “IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors”
2. IEEE Standard 605-2024, “Guide for Design of Substation Rigid Bus Structures

###### Document History

Rev. 0 App.: SDTF – 4/3/06; RC – 4/4/06; ISO-NE – 5/8/06 Rev. 1 RC – 8/10/10

# APPENDIX K - CURRENT TRANSFORMER SECONDARY CIRCUIT COMPONENTS

##### INTRODUCTION

These procedures shall be used by Market Participants for determining Normal and Emergency load-current carrying capabilities of current transformer (CT) secondary circuit components, including relay protective devices, installed on the New England transmission system, at 69 kV and above.

##### APPLICATION GUIDE

CT circuit component ratings shall be determined by the Market Participant at a rated power frequency of 60 Hertz.

##### REFERENCES

None.

###### Document History

Rev. 0 App.: SDTF – 4/3/06; RC – 4/4/06; ISO-NE – 5/8/06 Rev. 1 RC – 8/10/10

# APPENDIX L - VAR COMPENSATORS

##### INTRODUCTION

The following methodology applies to VAR compensators such as Static Synchronous Compensator (Statcoms), Static Var Compensators (SVCs), Dynamic Volt-Ampere Reactive (D-VAR), and synchronous condensers connected at voltages 69 kV or above.

##### APPLICATION GUIDE

The rating of a VAR compensator shall be determined by the Market Participant calculated at 60 Hertz and nominal system voltage.

##### REFERENCES

None.

###### Document History

Rev. 0 App.: SDTF – 10/18/05; RC – 11/1/05; NPC – 12/2/05; ISO-NE – 12/30/05 Rev. 1 RC – 8/10/10

# APPENDIX M - HVDC SYSTEMS

##### INTRODUCTION

The following methodology applies to HVDC converters and associated transmission systems connected to the New England transmission system at 69 kV or above.

##### APPLICATION GUIDE

The rating of an HVDC system (which includes converters, converter transformers, conductors and associated equipment such as filters, switches and busses) is one aspect of its performance protocol, being determined by the facility’s specifications, design and operation. Accordingly, ratings shall be determined by the Market Participant based on information provided by the manufacturer.

The rating to be assigned is the Maximum Continuous Capacity, which is the maximum capacity (MW), excluding the added capacity available through means of redundant equipment, for which continuous operation under normal conditions is possible. Since power flows through an HVDC system are continuously controlled, the LTE, STE and DAL ratings are the same as the Maximum Continuous Capacity.

##### REFERENCES

None.

###### Document History

Rev. 0 App.: SDTF – 3/21/06; RC – 4/4/06; ISO-NE – 5/8/06 Rev. 1 RC – 8/10/10

# APPENDIX N – Ambient Adjusted Ratings (AAR)

**PRACTICES FOR CALCULATION OF AAR**

##### Introduction

This appendix describes the general assumptions and methods that should be used when calculating the ambient-adjusted ratings (AAR) as required in Attachment Q of the ISO New England Open Access Transmission Tariff (Attachment Q).

Ratings methodologies (including but not limited to wind speed and direction) for AARs shall be determined by the Market Participant. It is the Market Participant’s responsibility to determine whether equipment is affected by ambient temperature and therefore is required to have AARs calculated under Attachment Q.

In the event that an Market Participant determines, consistent with Good Utility Practice, that a transmission line rating is not affected by ambient air temperature or solar heating, the Market Participant may except that transmission line from AARs and provide transmission line ratings based upon the limiting condition as further defined in Attachment Q and this Procedure. As it is the individual Market Participant’s responsibility to determine to what extent ambient air temperature and solar heating affect a transmission line rating, this Procedure does not define which equipment may or may not be excepted from AARs. Any exceptions to AARs shall be documented, as required in Attachment Q, electronically in the ISO New England rating software.

##### Wind Speed and Angle

Wind velocity and angle; emissivity and solar absorptivity; and other environmental conditions not specifically address in this procedure shall be determined by the Market Participant. In determining these values, applicable standards and guidance documents such as IEEE 738-2023 and CIGRE Technical Brochure 299 should be consulted.

##### Forecast temperature

Each Market Participant is responsible for acquiring forecast or real-time weather data, including temperature, as required to perform AAR calculations that are representative of the equipment for which the calculation is being performed. AARs must be calculated using a forecast temperature at which there is sufficient confidence that the actual temperature will not be greater than that temperature; therefore, the temperature utilized to determine an AAR value should be equal to the forecast temperature plus an appropriate forecast margin. Because each Market Participant may use a different weather vendor and have different safety margins, it is up to each individual Market Participant to determine the appropriate forecast margin for its AAR calculations.

##### Solar Heating

AARs shall reflect solar heating during the daytime hours and lack of solar heating during nighttime hours consistent with Attachment Q of the Tariff.

##### Special considerations for Power Transformers

It is the Market Participant’s responsibility to determine whether they are required to provide an AAR for each transformer. In general, autotransformers that directly connect to a transmission line by a single isolation device may be required to provide AARs, that shall be determined by the Market Participant.

1. **Local Transmission Ratings**

ISO shall receive and post to the electronic transparency database Local Transmission Service Ratings as required under Attachment Q and Attachment M to Schedule 21 of the ISO New England Open Access Transmission Tariff (Attachment M). It is the sole responsibility of the Transmission Owner to calculate and provide these ratings. Nothing in this PP7 requires that Local Transmission Service transmission line ratings required to be calculated and provided to ISO under Attachment M adhere to these PP7 ratings procedures.

1. **REFERENCES**
   1. FERC Order 881
   2. Attachment Q of the ISO New England Open Access Transmission Tariff
   3. Attachment M to Schedule 21 Attachment M to Schedule 21

###### Document History

Rev.

1. Study Case 1 shall use 20F as a study assumption with all other assumptions utilizing the month of March input assumptions [↑](#footnote-ref-2)
2. Study Case 2 shall be the maximum rating (either AAR or seasonal for excepted equipment) the Market Participant could provide for a transmission facility [↑](#footnote-ref-3)
3. Final Sag can cause permanent increased conductor sag and is defined as the non-elastic deformation or flow of material, which occurs with time under its installed tension (creep) and advanced by application of additional wind or ice load (load). [↑](#footnote-ref-4)