CAPACITY RATING PROCEDURES

BY THE

SYSTEM DESIGN TASK FORCE

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PREFACE

The data procedures contained herein are assembled for the convenience of the members of the New England Power Pool in providing them with methods to serve as a guide for the uniform rating of the designated electrical equipment. No warranty, expressed or implied, is made by the contributors or their sponsors.

1.0 INTRODUCTION

1.1 Ratings to be Assigned

Transmission Line Terminal Equipment is to be assigned ratings for each condition listed below. The capacity of either the line conductor or the terminal equipment, or both, limits these ratings.

Winter Normal

Winter Emergency – 15 Minutes

Winter Emergency – 4 Hours

Winter Drastic Action Limit

Summer Normal

Summer Emergency – 15 Minutes

Summer Emergency – 12 Hours

Summer Drastic Action Limit

The Winter Period is defined as November 1 to March 31. The Summer Period is defined as April 1 to October 31.

Normal Rating is defined as the rating, adjusted for ambient conditions, which will allow maximum equipment loading without incurring loss of life above design criteria.

Emergency Ratings, which exceed normal ratings, involve loss of life or loss of tensile strength in excess of design criteria, and are not to be scheduled.

Drastic Action Limits, unlike normal and emergency loading ratings, are limits at which immediate action will be taken to prevent damage to equipment.

1.2 Ambient Temperatures and Wind Velocities

The following table of ambient temperatures should be used for determining equipment normal and emergency ratings:

Table 1

	Power and Current Transformers		All Other Line Terminal Equipment[1]	
	Normal	Emergency	Normal	Emergency
Winter (November 1 To March 31)	5°C	10°C	10°C	10°C
Summer (April 1 to October 31)	25°C	32°C	28°C	28°C

The above ambient temperatures were developed from Hartford, Connecticut area temperature statistics for the years 1905 to 1970. A comparison of ambient temperature statistics of several other New England locations indicates that Hartford area statistics are representative of New England. A summary of Hartford area data is attached as Table 2 on page 10 of this report.

The ambient temperature recommendations are based upon the following:

1.2.1 Power and Current Transformers

The ANSI Guide for Loading Oil Immersed Distribution and Power Transformers (C57.92) recommends the use of "average maximum daily temperatures" for the month involved in determining normal and emergency ratings. The Guide also recommends the use of a 5°C adder to be conservative. The ambient temperatures indicated in the preceding table are based on the recommendations for determining ambient temperatures set forth in the ANSI Guide including the recommended 5°C adder. Weighted averages of temperatures were used for the periods involved instead of monthly temperatures as suggested by the Guide. Normal and emergency ambient temperatures were derived from Column 3 and 1 respectively on the attached temperature data. The criteria to be used for developing ambient temperature for current transformers will be the same as power transformers.

1.2.2 All Equipment Except Transformers

Conservative weighted averages of daily maximum ambient temperatures (Column 1 of the attached temperature data) should be used for determining ratings of all other line terminal equipment. Therefore, the average of August daily maximums should be used for summer ratings and the average of November daily maximums should be used for winter ratings.

1.3 Temporary Ratings

The intent of these procedures is to provide a uniform method of rating line terminal equipment. Equipment owners may provide temporary ratings when deemed necessary which recognize local ambient temperatures or weather conditions.

1.4 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.

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[1] Wind velocity of 3 fps during the Winter period and 3 fps during the Summer should be assumed where applicable

The equipment owners are cautioned that operation at total temperatures above design values may violate manufacturers' warranties and/or may result in undesirable changes in operating characteristics.

1.5 Temperature Measurements

The temperature of line terminal equipment which experience maximum rated loads are to be measured with infrared equipment or other appropriate devices during these maximum rated loads. Ratings based on reliable infrared observations, or any other reliable temperature measurements, obtained under operating conditions, take precedence over all other ratings.

1.6 Nonconforming Equipment

Equipment not designed, not manufactured, not installed, or not maintained in accordance with the express or implied requirements of these Procedures is to be assigned ratings by its owners, in accordance with the express or implied requirements of these Procedures is to be assigned ratings by its owners, in accordance with the manufacturer's recommendations.

1.7 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
Emergency (4-12 hour) Rating	500 hours

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 operates at temperatures considerable lower than rated values, most of the time.

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

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 will be expected to increase under normal operation. With more annealing taking place under normal loading, emergency ratings should be assigned with care. In fact, it is recommended that base loaded equipment, which is rated on the basis of loss of strength due to annealing, be assigned emergency ratings equal to normal ratings.

1.8 Calculation of Drastic Action Limits

For purposes of calculation, the Drastic Action Limit is defined as the current flow, which would cause the circuit component to reach its 15-minute emergency thermal limit, if allowed to flow for five minutes, the following conditions having been assumed:

1) The guidelines as to summer and winter ambient conditions being as described in paragraph 1.2.

2) Pre-disturbance loading of the circuit assumed to be 75 percent of the normal terminal equipment rating or 75 percent of the conductor sag limitation; whichever is less, for the appropriate season.

The prescribed “drastic action” is to be whatever immediate action is required to return the circuit loading to the long term emergency rating for the appropriate season, including, but not limited to, tripping of the circuit. The use of five minutes in computing the Drastic Action Limit does not indicate that five minutes, or any other time increment, exists for which current of the calculated magnitude may safely be allowed to flow.

Table 2
Hartford Area Temperature Data
(1905-1970)

	Average of the Daily Maximums[2]		Average of the Monthly Maximum[3]		Daily Mean[4]	
	°F	ºC	°F	ºC	°F	ºC
January	35.1	1.7	54.0	12.2	27.2	-2.7
February	36.1	2.3	53.0	11.7	27.7	-2.4
March	45.5	7.5	66.1	18.9	36.9	2.7
April	58.0	14.4	79.0	26.1	48.0	9.0
May	69.6	20.9	86.9	30.5	58.6	14.8
June	78.3	24.6	92.0	33.3	67.8	19.9
July	83.2	28.4	94.0	34.4	70.8	21.6
August	82.5	28.1	91.0	32.8	70.8	21.6
September	77.1	25.1	87.0	30.6	62.2	16.8
October	63.9	17.7	81.0	27.2	51.1	10.6
November	50.5	10.3	66.0	18.9	42.0	5.5
December	38.0	3.3	57.0	13.9	30.4	-0.9

2 This is the average of the daily maximum temperatures for each month.
3 This is the average of the monthly maximum temperature over 65 years.
4 This is the average of the daily maximum and minimum temperatures over the month.

2.0 CIRCUIT BREAKERS

2.1 Standards

Circuit breakers are to be rated in accordance with the latest edition of ANSI/IEEE Standard C37.010, "Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis" and any supplements to the standard as issued. Non-conforming circuit breakers are to be rated in accordance with Section 1.6, of these procedures. Section 1.4, of these procedures considers the use of equipment temperatures higher than design values for emergency operations of non-standard equipment.

ANSI/IEEE Standard C37.010 and supplements does allow operation at total circuit breaker temperatures higher than the normal design values during limited duration emergencies. The following equations may be used to determine the relationship between load current and time, while not exceeding a maximum acceptable temperature of the applicable breaker parts:

2.1.1 <u>Use For Extended Period Emergencies</u>

$$\mathrm{I_s} = \mathrm{I_r}\left(\frac{q\ \max(1) - qa}{qr}\right)^{\frac{1}{1.8}} \qquad (1)$$

2.1.2 <u>Use For Short Time Emergencies</u>

$$\mathrm{I_s} = \mathrm{I_r}\left[\frac{q\ \max(1) - \mathrm{Y}e\frac{-t_s}{t} - q_a}{(q\ \max - 40)\left(1 - e\frac{-t_s}{t}\right)}\right]^{\frac{1}{1.8}} \qquad (2)$$

$$t_s = \tau \left[-1n \left(1 - \frac{q\ \max(1) - Y - qa}{Y\left[\left(\frac{I_s}{I_i}\right)^{1.8} - 1\right]} \right) \right] \qquad (3)$$

Equations (1) and (3) as well as the terms appearing in equations (1), (2) and (3), with one exception, are displayed and defined in Section 4.4.3.2 and 4.4.3.3.2 of ANSI/IEEE Standard C37.010. The one exception is $q\ \max(1)$ which is here defined as the maximum allowable hottest spot temperature of the applicable breaker component; the following relationship is used to define it:

$q\ \max(1)$ = $q\ \max$ + degrees C above normal maximum as allowed during and emergency period. Use 15°C for 0-4 hours time period and 10°C for 4-12 hours time period.

Copies of ANSI/IEEE Standard C37.010 and supplements may be purchased from the American National Standards Institute or from the Institute of Electrical and Electronics Engineers.

2.2 Example (Loadability Multipliers)

The following Table 3 has been prepared using the methods outlined in C37.101 and supplements as elaborated on in Section 2.1 and as shown in Section 2.3. It should be recognized that these loadability multipliers are applicable only for the conditions assumed below.

Assumed Conditions

1. The typical breaker may be an oil or oilless type with silver to silver contacts, ANSI Standard bushings, and Class A insulated current transformers. It is designed and rated for operation in a 40° ambient. The thermal time constant (τ) is 0.5 hour. Copper to copper contacts can be used since 65°C rating of bushings and CT's are limiting.

2. Use 10°C for winter ambient.

   Use 28° for summer ambient.

3. During a designated emergency overloading period the breaker owner will allow a 10°C or 15°C increase above the normal q max for the hottest spot temperature of the applicable breaker component.

4. All components of the breaker subject to these thermal limitations shall be well maintained and in essentially new condition.

5. The allowable emergency loadings follow 4 hours or more, during which the loading does not exceed 75 percent of the normal rating at the designated winter or summer ambients.

Table 3

	Loadability Multipliers To be Applied to Nameplate Rating	
Ratings	**Winter**	**Summer**
Normal	1.23	1.10
Emergency – 15 Minutes	1.83	1.67
Emergency – 4 hours	1.34	-
Emergency – 12 hours	-	1.18
Drastic Action Limit	2.00	2.00

NOTE: ANSI Standard C37.010 limits the loadability multiplier to a maximum value of 2.00.

2.3 Sample Calculations – Loadability Multipliers

Data Used:

$q\,\max(1)$	=	105°C, θr = 65°C
$q\,\text{mas}(1)$	=	105°C + 15°C = 120°C[5]

(Use 10°C for 4-12 hour time period)

qa	=	10°C Winter and 28°C Summer
ts	=	15 Minutes = 0.25 hour
τ	=	30 minutes = 0.5 hour
e	=	2.7183

1. Normal (continuous rating) – I_s

$$I_s = I_r \left(\frac{q\,\max - q\text{a}}{qr} \right)^{\frac{1}{1.8}}$$

Per C37.010 and supplements part 4.4.3.2

Winter

$$I_s = I_r \left(\frac{105 - 10}{65} \right)^{\frac{1}{1.8}} = 1.23\, I_r$$

Summer

$$I_s = I_r \left(\frac{105 - 28}{65} \right)^{\frac{1}{1.8}} = 1.10\, I_r$$

2. Extended period emergency rating - I_s

Use equation (1), where $q\,\max(1) = q\,\max + 15°C = 120°C$

Use 10°C for 4-12 hour time period

Winter 4 hours

$$I_s = I_r \left(\frac{120-10}{65}\right)^{\frac{1}{1.8}} = 1.34\, I_r$$

Summer 12 Hours

$$I_s = I_r \left(\frac{115-28}{65}\right)^{\frac{1}{1.8}} = 1.18\, I_r$$

3. Short time emergency rating - I_s

Use equation (2), where q max(1) = q max + 15° = 120°C

And Y = (q max - 40) $\left(\frac{I_i}{I_r}\right)^{1.8}$

Winter 15 minute emergency

Where $I_i = (0.75 \times 1.23\ I_r) = 0.9225\ I_r$

$$I_s = I_r \left(\frac{120-(105-40)(\frac{0.9225 I_r}{I_r})^{1.8}(e)^{\frac{-15}{30}} - 10}{(105-40)(1-e^{\frac{-15}{30}})}\right)^{\frac{1}{1.8}}$$

$$I_s = I_r \left[\frac{120-34.09-10}{25.58}\right]^{\frac{1}{1.8}} = 1.83\, I_r$$

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[5] Applies under emergency conditions only: otherwise $q\max(1) = q\max$

Summer 15 minute emergency

Where $I_i = (0.75 \text{ x } 1.10_r) = 8.25 \; I_r$

$$I_s = I_r \left(\frac{120-(105-40)(\frac{0.825\,I_r}{I_r})^{1.8}(e)^{-\frac{15}{30}}-28}{25.58} \right)^{\frac{1}{1.8}}$$

$$I_s = I_r \left[\frac{120-27.88-28}{25.58} \right]^{\frac{1}{1.8}} = 1.67\, I_r$$

4. Drastic Action Limit

Use equation (2) as above

Winter Limit

Where $I_i = (0.75 \text{ x } 1.23 \; I_r) = 0.9225 \; I_r$

$$I_s = I_r \left[\frac{120-(105-40)\left(\frac{0.9225\,I_r}{I_r}\right)^{1.8} e^{-\frac{5}{30}}-10}{(105-40)(1-e^{-\frac{5}{30}})} \right]^{\frac{1}{1.8}}$$

$$= I_r \left[\frac{120-47.58-10}{9.98} \right]^{\frac{1}{1.8}}$$

$= 2.77\, I_r$, so use $2.0\, I_r$

Summer Limit

Where $I_i = (0.75 \times 1.10\ I_r) = 0.825\ I_r$

$$I_s = I_r \left[\frac{120 - (105 - 40)\left(\frac{0.825 I_r}{I_r}\right)^{1.8}}{9.98} e^{\frac{-5}{30}} - 28 \right]^{\frac{1}{1.8}}$$

$$I_s = I_r \left[\frac{120 - 38.92 - 28}{9.98} \right]^{\frac{1}{1.8}}$$

$= 2.53\ I_r$, so use $2.0\ I_r$

3.0 TRANSFORMERS

3.1 Standards

The ratings described in this section apply only to transformers with nameplate ratings of below 100 MVA, since the existing loading guides apply only to transformers of less than 100 MVA nameplate rating.

Permissible loadings for transformers with nameplate ratings above 100 MVA should be developed with the manufacturer on an individual basis. Loading guides for transformers with nameplate ratings greater than 100 MVA are presently being developed. (Project number 756 of the IEEE Transformers Committee has developed “Trial Use Guide for Loading of Mineral Oil Insulated Power Transformers Rated in Excess of 100 MVA”).

Transformers are to be rated in accordance with the following listed standards and exceptions to these standards.

1. Transformers are to be rated by computer using the computer programs listed in Section 3.2, or other computer programs which provide equivalent results, except that transformers which are not ANSI Standard transformers are to be assigned ratings by their individual owners, in accordance with the manufacturer's recommendations. Many transformers manufactured prior to 1948, and a few modern transformers, are not ANSI Standard transformers.

2. Transformers are not to be loaded beyond the limits of Table 4, below, taken from ANSI Standard Appendix: C57.92 – 1981, "Guide for Loading Oil-Immersed Distribution and Power Transformers" for transformers with 55ºC and 65ºC average winding rise.

Table 4

	C RISE TRANSFORMER	**C RISE TRANSFORMER**
Max Hottest Spot Temperature	150 C	180 C
Max Top Oil Temperature	100 C	110 C
Max Load on Transformer	Twice Nameplate	Twice Nameplate

3. Winter Normal and Summer Normal ratings are to be based on the normal daily load cycle and on the maximum twenty-four hour average ambient temperatures of Section 1.2 of these Procedures, and are to impose no loss of life on the transformer.

4. Winter Emergency – 15 Minutes, and Summer Emergency – 15 Minutes ratings are to be at twice nameplate. No loss of life is considered for 15 minute emergencies.

5. Winter Drastic Action Limit, and Summer Drastic Action Limit are to be any loading greater than twice nameplate. No loss of life is considered for Drastic Action Limit Operation.

6. Winter Emergency – 4 Hours, and Summer Emergency – 12 Hours ratings are to be based on the normal daily load cycle with the emergency load added to the peak period, on the maximum twenty-four hour average ambient temperatures of Section 1.2 of these Procedures, and on imposing 1 percent loss of life on the transformer for each daily load cycle during which such an emergency occurs, except as follows:

   a. No loss of life is to be imposed on any transformer which does not have a replacement readily available.

   b. Individual owners may elect to impose greater loss of life on their own transformers.

   c. The amount of loss of life to be imposed on any transformer which is not and ANSI Standard transformer is to be determined by the individual owners, in accordance with the manufacturer's recommendations.

d. When the accumulated loss of life of a transformer exceeds 5 percent, any additional loss of life to be tolerated will be determined by the individual owners.

3.2 Computer Programs

NOTE: this section has been withdrawn and will be replaced. Contact the Chairman of the System Design Task force for the current status of the replacement: csedlacek@iso-ne.com

The computer programs listed below are part of these Procedures, and copies of these computer programs are appended to this Section of these Procedures.

Appendix A - Rating of Two-Winding Transformers Manufactured Prior to 1940

Appendix E - Rating of Two-Winding 55ºC Rise Transformers manufactured after 1940

Appendix C - Rating of Two-Winding 65ºC Rise Transformers

Appendix D - Rating of Three-Winding Transformers

These computer programs are written in Fortran for the IBM 1130 Computer with a single disc and 8k core. They can be adapted to other computers which have a Fortran compiler.

4.0 PHASE SHIFTERS, REGULATORS, SERIES CAPACITORS, AND SERIES REACTORS

4.1 Standards

Phase shifters, regulators, series capacitors, and series reactors are to be assigned ratings by their individual owners, in accordance with the manufacturer's recommendations.

5.0 CURRENT TRANSFORMERS

5.1 Standards

Current transformers are to be rated in accordance with the "Guide for Loading Current Transformers" by the System Design Task Force, New England Planning Committee. A copy of this Guide is appended to this Section 5.3 of these Procedures.

5.2 Example

The Loadability multipliers of Table 6 have been prepared using the methods presented in the Guide.

5.2.1 Assumptions

1. The current transformer is an independent, oil filled, current transformer, with thermal rating factor of 1.5.

2. Ambient temperatures:

Table 5

	Normal	Emergency
Winter	5ºC	10ºC
Summer	25ºC	32ºC

3. Accuracy and thermal capability of the secondary circuit and the secondary devices is satisfactory at the ratings in the table.

4. The loss of life associated with the emergency ratings in the table is acceptable.

Table 6

Ratings	Loadability Multipliers To Be Applied To Nameplate Rating	
	Winter	Summer
Normal	1.8	1.6
Emergency – 15 Minutes	3.0	2.5
Emergency – 4 Hours	2.5	----
Emergency – 12 Hours	----	2.1
Drastic Action Limit	3.2	2.6

5.3 Guide For Loading Current Transformers

By System Design Task Force - New England Planning Committee

5.3.1 Independent Current Transformers

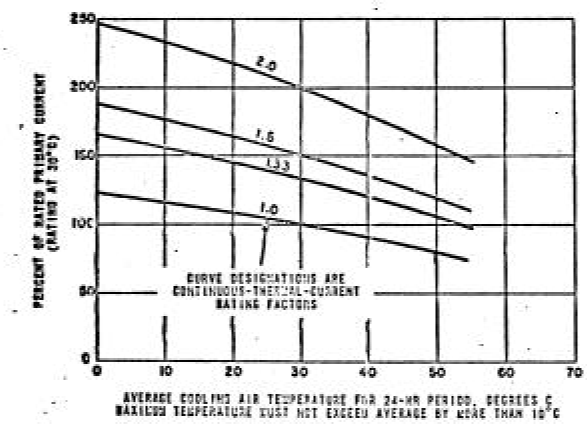
These are current transformers, which are purchased and installed as independent units.

5.3.1.1 Normal Continuous Capability

The normal continuous capability of a current transformer depends on its thermal rating factor and the average cooling air temperature. It can be found by entering Curve I, which is a reproduction of Figure 6 of USA Standard C57.13-1968, with the Thermal rating factor, which is catalog information, and average ambient temperature for the location and season, and the reading percent of rated current at the left of the curve.

Design temperature limits will not be exceeded if this loading procedure is followed.

CURVE I



55°C Rise Current Transformer
Basic Loading Characteristics

5.3.2 Emergency loading with Moderate Loss of Life

If emergency conditions require temporary loading beyond normal continuous capability, the multiplying factors in Table 7 on page 24 can be applied. Before this is done, revised values should be calculated for normal capability, based on emergency ambient temperatures a specified in Section 1.2, and the procedure outlined in Section 5.3.1.1 of this Guide. The factors in Table 7 then are applied to the revised normal values for the time durations specified.

Table 7 was prepared from a major manufacturer's curve of allowable overload following rated load to produce not more than a 1 percent loss of life for an oil-filled current transformer. Values for butyl-molded and compound filled transformers were extrapolated on the basis of correspondingly shorter thermal time constants than for oil-filled units.

Table 7
Multiplying Factors

Duration of Emergency	Transformer Type		
	Oil-Filled	Butyl-Molded	Compound
0-1 ½ Hr.	1.7	1.6	1.4
2-3 ½ Hr.	1.5	1.4	1.3
4-24 Hr.	1.4	1.3	1.2

5.4 Internal Bushing Current Transformers

These are current transformers which use the current-carrying parts of major equipment as their primary windings and are usually purchased as integral parts of such equipment. On a multi-ratio transformer, the secondary winding is tapped.

5.4.1 Normal Continuous Capability

Most manufacturers state that internal bushing current transformers furnished with a piece of equipment have thermal capabilities which equal the capability of the equipment.

1) For a single-ratio or multi-ratio internal bushing current transformer operating at a nominal primary current rating equal to the nameplate rating of the equipment with which it is used, the current transformer should be considered to have the same thermal capability as the equipment.

2) For a single-ratio internal bushing current transformer with a rating less than that of the equipment in which it is installed, the calculated equipment capability should be reduced by the factor

$$\sqrt{I_{ct}/I_e}$$

Where I_{ct} is the current transformer nameplate primary current rating and I_e is the equipment nameplate current rating.

3) For a multi-ratio internal bushing current transformer with a maximum rating equal to the nameplate rating of the equipment in which it is installed, but which is operating on a reduced tap, the calculated equipment capability should be reduced by the factor

$$\sqrt{I_t/I_n}$$

Where I_t is the reduced tap current rating, and I_n is the maximum current rating of the current transformer.

If information is not readily available on the continuous thermal rating factor of a bushing current transformer, the manufacturer should be consulted.

5.4.2 Emergency Loading

Calculate the emergency capability of the equipment in which the bushing current transformer is installed. With this value as a base, apply the principle outlined in Section 5.4.1, paragraph 1, 2 and 3 (whichever is applicable) to determine how the emergency capability should be modified, because of the current transformer.

5.5 External Bushing Current Transformers

These are current transformers, which use the current-carrying parts of major equipment as their primary windings, and are not usually purchased as integral parts of such equipment. These current transformers are to be assigned ratings by their individual owners, in accordance with the manufacturer's recommendations.

5.6 Loading of Secondary Devices

In all cases where current transformer secondaries may be loaded in excess of 5 amperes, a careful check should be made of the effect this will have on the devices connected in the secondary circuit, with respect to both accuracy and thermal capability.

6.0 DISCONNECT SWITCHES

6.1 Standards

Disconnect switches are to be rated in accordance with A.N.S.I. Standard C37.37-1979 entitled "Loading Guide for AC High Voltage Air Switches, Part I – Allowable Continuous Current." This guide will be utilized for all normal continuous ratings.

Emergency and short time ratings are to be determined in accordance with the "Guide for Emergency Loading of Disconnect Switches" by the System Design Task Force, New England Planning Committee. A copy of this guide is Section 6.4 on page 29 of these Procedures. The emergency rating is to be limited to 180 percent of the normal rating where the normal rating is the rated continuous current adjusted for specific temperature rise and ambient temperature.

Loading prior to the emergency period is assumed to be 100 percent of the normal rating at that ambient temperature.

6.2 Example

The following table has been prepared using the methods presented in the Guides.

Assumptions:

1. Non-conforming switches are to be rated in accordance with Section 1.6, of these procedures.

2. With reference to Section 1.2 of these procedures the emergency ratings have been determined utilizing a 20°C increased allowable maximum equipment temperature during these emergency periods of operation as described in Section 1.7 of these procedures.

3. The example is calculated for an ITE Co. type TTR-6 or and H.K. Porter, Inc. type MK40A disconnect switch which has an Allowable Continuous Current Class (ACCC) of DO6. Consult A.N.S.I. Standard C37-1979, for other switches with different material designations and ACCC designation. The switch is assumed to have a nameplate rating of 1200A. or greater with a ½ hour time constant for 15 minute emergency ratings.

4. The winter ambient temperature is 10°C and the summer ambient is 28°C.

Table 8

Ratings	Loadability Factor Multipliers to be Applied to Nameplate Rating	
	Winter	Summer
Normal	1.34	1.20
Emergency – 15 minutes	1.66	1.62
Emergency – 4 hours	1.47	
Emergency – 12 hours		1.38
Drastic Action Limit	2.41	2.16

6.3 Correction of Rated Continuous Current

When the switch test temperature rise is less than guaranteed, all ratings may be adjusted as follows for each material class:

$$I = Ir \left(\frac{q_r}{q}\right)^{0.5}$$

I = Adjusted rated current

Ir = Rated current from Section 6.4 on starting on page 29

θ = Test observable temperature rise at nameplate rated continuous current

θr = Limit of observable temperature rise at nameplate rated continuous current per Section 6.4 on starting on page 29

6.4 Guide for Emergency Loading of Disconnect Switches

6.4.1 Scope

This loading guide supplements A.N.S.I. Standard C37.37-1979 and is to be utilized for the determination of emergency ratings of disconnect switches. Reference must be made to the tables in the Standard for switch material classes and temperature limits.

Reference: Barker, Beran, Hendrix, Hill, Kolarik, Massey, "Determination of Disconnect Switch Ratings for the Pennsylvania – New Jersey – Maryland Interconnection", IEEE Trans., Vol. PAS-91, No. 2, Page 404, March/April 1972.

6.4.2 Method of Calculation

1. Calculation of 4 hour and 12 hour emergency rating

   Winter and summer emergency ratings can be determined as follows:

$$I_e = I\left(\frac{q\max_e - q_a}{q_r}\right)^{0.5}$$

I_e	=	Emergency rating, 4 hour or 12 hour
I	=	Rated Nameplate current
$q\max_e$	=	Emergency allowable maximum temperature (20°C higher than normal allowable maximum temperature used in example, see Section 1.4
θ_a	=	Ambient temperature

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θ_r	=	Limit of observable temperature rise at rated continuous current from tables in A.N.S.I. Std. C37.37-1979

2. Calculation of 15 minute emergency rating

Winter and summer 15 minute emergency ratings can be determined as follows:

$$I_{e15} = I \left[\frac{1}{q_r} \left(\frac{q \max_e - q \max_n}{1 - e^{-15/T}} + q \max_n - q_a \right) \right]^{0.5}$$

I_{e15}	=	15 minute emergency rating
$q \max_n$	=	Normal allowable maximum temperature
T	-	Thermal time constant of switch in minutes. This may be conservatively assumed to be 30 minutes for switches rated 1200 A or greater. Contact the manufacturer for switches rated less than 1200 amperes.

6.4.3 Sample Calculation

1. Sample calculation of 4 hour winter and 12 hour summer rating using same switch as in the example of Section 6.2.

Summer $I_e = I \left(\frac{110 - 28}{43} \right)^{0.5} = I \times 1.38$

Winter $I_e = I \left(\frac{125 - 10}{53} \right)^{0.5} = I \times 1.47$

2. Sample calculation of 15 minute winter and summer rating using same switch as in the example of Section 6.2.

Summer $$I_{e15} = I\left[\frac{1}{43}\left(\frac{110-90}{1-e^{-0.5}}+90-28\right)\right]^{0.5} = I \times 1.62$$

Winter $$I_{e15} = I\left[\frac{1}{53}\left(\frac{125-105}{1-e^{-0.5}}+105-10\right)\right]^{0.5} = I \times 1.66$$

3. Sample calculations of drastic action limit using same switch as in example Section 6.2

<u>Summer Limit</u>

Initial $I_i = 0.75\ (1.20I) = 0.90\ I$

Calculate initial max. temperature q max I

$$I_i = I\left(\frac{q\ \max i_{-} - q_a}{q_r}\right)^{0.5}$$

$$\frac{I_i}{I} = 0.90 = \left(\frac{q\ \max i - 28}{43}\right)^{0.5}$$

$$0.81 = \frac{q\ \max i - 28}{43}$$

$$q\ \max i = 63^{?}C$$

$$I_{e5} = I\left[\frac{1}{43}\left(\frac{110-63}{1-e^{-0.167}}+63-28\right)\right]^{0.5}$$

= 2.81 I, so use 1.8 (1.20 I) = 2.16 I

<u>Winter Limit</u>

Initial $I_i = 0.75\ (1.34)\ I = 1.00\ I$

Corrected October 2004

$$\frac{I_i}{I} = 1.00 = \left(\frac{q \max i - 10}{53}\right)^{0.5}$$

$$q \max i = 63^{?} C$$

$$I_{e5} = I\left[\frac{1}{53}\left(\frac{125-63}{1-e^{-0.167}} + 63 - 10\right)\right]^{0.5}$$

= 2.93I, so use 1.8(1.34 I) = 2.41 I

7.0 LINE TRAPS

7.1 Standards

Line traps are to be rated in accordance with the current version of ANSI Standard C93.3, "Requirements for Power Line Carrier Line Traps." Appended to, but not part of the standard is a conservative guide for emergency current overload capability of line traps. The resulting loading factors are somewhat more conservative than those produced from the guide developed by the SDTF and contained herein. The SDTF application guide is based on information provided by leading manufacturers of line traps and is documented in the Report of the Ad Hoc Line Trap Rating Procedure Working Group of the System Design Task Force, dated June 1990. The resulting line trap emergency overload rating factors are accepted based on very infrequent operation above rated continuous current.

7.2 Application Guide

7.2.1 Normal Capabilities

Based on the premise that hottest spot temperature rise is proportional to I^2R losses, the following equation can be used to find a normal capability at any ambient temperature without exceeding the hottest spot design limit:

$$I_A = I_D \sqrt{\frac{T_D - T_A}{T_H - T_D}}$$

Where, I_A = capability at ambient T_A (amperes)

I_D = nominal rating of trap, rated continuous current (amperes)

T_H = maximum hottest spot design temperature (hottest spot temperature rise from ANSI Standard C93.3 Table 6, plus 40°C design ambient, if manufactured to ANSI standards)

T_H = actual ambient temperature (°C)

T_D = design ambient temperature (40°C, if manufactured to ANSI standards)

7.2.2 Emergency Capabilities

Normal capabilities (not rated continuous current), found by applying Paragraph 7.2.1, can be multiplied by the following factors to determine emergency capabilities, depending on the duration:

Duration of Emergency	Multiplying Factor
4-48 Hours	1.15
15 Minutes	1.50
D.A.L.	1.65

7.2.3 Example

The following table has been prepared using the methods introduced in Paragraph 7.2.

Assumptions

1. The line traps meet the requirements of ANSI Standard C93.3.
2. The maximum winter ambient is 10°C, and the maximum summer ambient is 28°C.
3. (Taken from ANSI Standard C93.3, Table 6) The trap is designed for a hottest spot temperature rise of 110°C over a 40°C ambient. (Insulation Temperature Index of 130)

Table 9

Ratings	Loadability Multipliers to be Applied to Nameplate rating Winter	Summer
Normal	1.13	1.05
Emergency – 12 Hours	-	1.21
Emergency – 4 Hours	1.30	-
Emergency – 15 Minutes	1.69	1.58
D.A.L.	1.86	1.73

8.0 INTERCONNECTING BUSSES AND CABLES

8.1 Standards

Bare, outdoor, non-enclosed busses and cables of circular cross section will be rated in accordance with the following requirements:

1. Methods outlined in Sections 6-2 through 6-9 of the "Alcoa Conductor Engineering Handbook" will be followed.
2. The maximum allowable bus or cable temperature will be 10°C less than the maximum allowable temperature of any connected equipment.
3. No rating may result in excessive expansion or sag.
4. Ratings are to be based on the ambient conditions and loading criteria of Sections 1.2 and 1.7 respectively.
5. Normal and Long Time Emergency ratings may be calculated using the computer program "Current Carrying Capacity of Overhead Conductors".
6. Drastic Action and Short Time Emergency ratings may be found using the computer program "Transient Overhead Conductor Temperature Calculations". 75 percent of normal circuit rating will be assumed as the pre-disturbance loading.

Busses and cables which do not have a circular cross section, or which are forced cooled, enclosed, indoors, or insulation covered are to be assigned ratings by their owners, in accordance with manufacturer'’ recommendations.

8.2 Example

The following sample ratings have been prepared using the methods presented in the Alcoa handbook sections, and the computer programs.

8.2.1 Assumptions

1. The bus of interest is 4” SPS weathered aluminum tube, with an emissivity factor of .75, located in New England.
2. Solar heat gains are 2.41 Watts/ft/in dia winter, and 5.59 watts/ft/in diameter summer.
3. Maximum ambient temperatures are 10°C winter, and 28°C summer.
4. Wind velocity is 3 ft/sec in summer and 2 ft/sec in winter.
5. Maximum allowable bus conductor temperatures are 80°C normal, and 100°C emergency.
6. Load cycles, emergency loads, ambient temperatures, and wind velocities will not produce more than 10 percent loss of tensile strength in 30 years.

8.2.2 Results:

4” SPS Aluminum Tube

Table 10

		Amperes	
		Winter	Summer
1.	Ratings		
	Normal	4274	3311
	Emergency – 15 Minutes	5717	4826
	Emergency – 4 Hours	4851	--
	Emergency – 12 Hours	--	4084
2.	Drastic Action Limit	7905	6638

8.3 Bibliography

1. Computer Program PG-108, "Transient Overhead Conductor Temperature Calculations", dated January 1979, New England Electric System

2. Computer Program PG-92 – "Current Carrying Capacity of Overhead Conductors", dated April 1972, New England Electric System

3. "Alcoa Conductor Engineering Handbook", Sections 6-2 through 6-9.

9.0 CONNECTORS AND SPLICES

9.1 Standards

The loadability of connectors and splices does not necessarily equal 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 methods actually used in each case, may be loaded safely to the proposed line terminal ratings, without exceeding the maximum allowable temperature limits of the conductors.

10.0 CURRENT TRANSFORMER CIRCUITS

10.1 Standards

The current limits for the output of current transformers are to be determined by the connected equipment in accordance with the Guide “Thermal Capabilities of Components in the Current Circuit Starting at the CT Terminals” by the Relay Working Group of the System Design Task Force, New England Planning Committee. A copy of this Guide is appended to this Section of these Procedures.

10.2 Exclusion

There is no intent to indicate whether any protective relay will or will not operate for the currents tabulated. The current limit due to relay settings is given elsewhere.

10.3 Example

The following table has been prepared for a transmission line using the data presented in the Guide.

10.3.1 ASSUMPTIONS

1) Ambient Temperatures

Table 11

Outdoor	Normal	Emergency
Winter (Nov. 1 – Mar. 31)	5C	10C
Summer (Apr. 1 – Oct. 31)	25C	32C

Inside Control House

Winter	15C	20C
Summer	35C	42C

2) The equipment is less than 20 years old.

3) The voltage supply (either ac or de) is at or below rated.

4) The short-time (non-continuous) currents will be followed by at least 24 hours at rated current (5 amperes or less) before equipment is again subjected to the values shown.

5) All of the equipment listed in the following table is supplied by one set of CT's connected in wye.

Table 12
Example - Ratings In Secondary Amperes

	Winter			Summer				
		Emergency			Emergency			
Relay Type	Normal	15 Min.	4 Hrs.	Normal	15 Min.	12 Hrs.	DAL	Notes
CEB52	8.5	8.5	8.5	8.5	8.5	8.5	15.0	
CEY52	8.0	8.0	8.0	8.0	8.0	8.0	13.5	
GCXG51	8.0	8.0	8.0	8.0	8.0	8.0	14.5	
KC-4	8.0	8.0	8.0	8.0	8.0	8.0	13.0	
Instruments								
Ammeters AB30	10.0	10.0	10.0	10.0	10.0	10.0	14.0	
Wattmeters AB30	7.5	7.5	7.5	7.5	7.5	7.5	11.0	
Shunts GC-8	7.5	7.5	7.5	7.5	7.5	7.5	12.0	

10.4 DRASTIC ACTION LIMIT (DAL)

The drastic action limit has been established by assuming that the current versus time thermal capability of a relay or instrument coil can be defined by a straight-line characteristic when plotted on logarithmic paper between the limits of time = 1 second and time = 1000 seconds.

The data for the one-second point has been obtained from manufacturers' published information. The data for the 1000 – second point has been obtained by assuming the 1000 – second current rating to be equal to the normal (continuous) rating as published in these tables.

The drastic action (five-minutes) limit has then been extracted from the straight-line characteristic connecting these two defined points. This method is not necessarily endorsed by either General Electric or Westinghouse. Neither manufacturer professed to be able to furnish this type of data or an analytical method for obtaining it.

10.5 Thermal Capabilities Of Components in the Current Circuit Starting at the Ct Terminals

10.5.1 Protective Relays

A. The thermal capabilities of relay current coils in amperes used on transmission line terminal equipment is tabulated on the following pages. The relays are not expected to operate at these currents (or more) to trip a circuit breaker and thus protect themselves from overheating. The list does not include all possible or available relays. For further information consult the manufacturer.

10.5.1.1 General Electric Relays

Comments by the manufacturer:

1) Relays as designed by Power Systems Management Business Dept. have a conservative design life of 20 years.

2) Relays 20 years old or older should be considered as having no overload capability.

3) The design standard is ANSI C37.90 (IEEE 313) 1971, which defines Class A insulated relays as having a total coil temperature of 105C (55C ambient plus 50C rise).

4) If the 55C ambient temperature is exceeded then the values listed are not applicable.

5) It is assumed that those relays having potential circuits (either ac or dc) are being operated at or below rated voltage.

6) Overload capability calculations were based on "Insulating Materials for Design and Engineering Practice" by Franie M. Clark. John Wiley Publishers. Library of Congress #62-17460.

7) Those relays having the same rating for ½ hour[6] and continuous are limited by components other than the insulation system. These components may be resistors, capacitors, rheostats, etc. and these limitations are considered confidential information.

[6] The General Electric list of relays covered four time periods: Continuous, 10Hrs., 2 Hrs. and 0.5 Hr. These have been converted to the following time periods.

8) The 10, 2 or 0.5 hour6 values assume at least 24 hours at rated current (or less) will exist before the relays are again subjected to the values shown.

9) Where a relay has more than one current tap, the value listed is for a particular tap such as 5 amp. The current at other taps ($T_{N)}$ may be calculated from the formula:

$(I_5)^2\ T_N = (I_N)^2\ T_5$ Where I_5 is listed current at 5 amp. Tap. I_N is desired current. T_5 is The listed tap, in this example is 5.

Table 13
Relay Type Table

Relay Type	Winter			Summer			DAL	Notes
	Normal	Emergency		Normal	Emergency			
		15 Min.	4 Hrs.		15 Min.	12 Hrs.		
Static Equipment								
MOD11	7.5	7.5	7.5	7.5	7.5	7.5	14.0	
MOD111	10.0	10.0	10.0	10.0	10.0	10.0	15.0	7

Table 14

Relay Type	Winter			Summer			DAL	Notes
	Normal	Emergency		Normal	Emergency			
		15 Min.	4 Hrs.		15 Min.	12 Hrs.		
Electromechanical Equipment								
BDD	10.0	18.5	17.0	10.0	18.5	16.0	25.0	
CAP15A	10.0	18.5	17.0	10.0	18.5	16.0	25.0	
CAP15B	10.0	13.8	12.0	10.0	13.8	12.0	17.0	
CEB12B	8.0	8.0	8.0	8.0	8.0	8.0	13.0	8
CEB12B	10.0	10.0	10.0	10.0	10.0	10.0	15.5	9, 8

[7] Suffix “50” series
[8] Thermal limits are independent of the relay setting
[9] Short reach relays

Relay Type	Winter Normal	Winter Emergency 15 Min.	Winter Emergency 4 Hrs.	Summer Normal	Summer Emergency 15 Min.	Summer Emergency 12 Hrs.	DAL	Notes
Electromechanical Equipment								
CEB13	7.5	7.5	7.5	7.5	7.5	7.5	13.0	10, 8
CEB16	7.5	7.5	7.5	7.5	7.5	7.5	14.0	10, 8
CEB17A	7.5	7.5	7.5	7.5	7.5	7.5	14.5	8
CEB51	7.5	7.5	7.5	7.5	7.5	7.5	14.0	10
CEB52A	8.5	8.5	8.5	8.5	8.5	8.5	15.0	8
CEB52A	10.0	10.0	10.0	10.0	10.0	10.0	17.0	9, 8
CEX17E	6.5	6.5	6.5	6.5	6.5	6.5	11.5	8
CEX17E	7.5	7.5	7.5	7.5	7.5	7.5	14.0	9, 8
CEX19A1	7.5	7.5	7.5	7.5	7.5	7.5	10.5	8
CEX19A2	8.5	8.5	8.5	8.5	8.5	8.5	11.0	9, 8
CEX20	5.0	5.0	5.0	5.0	5.0	5.0	10.0	10, 11
CEX57	5.0	5.0	5.0	5.0	5.0	5.0	10.0	10, 11
CEXG20	5.0	5.0	5.0	5.0	5.0	5.0	8.0	10, 12
CEXG20	5.0	5.0	5.0	5.0	5.0	5.0	9.5	9, 10, 12
CEY12	5.0	5.0	5.0	5.0	5.0	5.0	10.0	10, 11
CEY14	7.5	7.5	7.5	7.5	7.5	7.5	13.0	10, 8
CEY14	10.0	10.0	10.0	10.0	10.0	10.0	16.5	9, 10, 8
CEY15A	7.5	7.5	7.5	7.5	7.5	7.5	14.5	8
CEY15A	10.0	10.0	10.0	10.0	10.0	10.0	18.0	9, 8
CEY15B3	7.5	7.5	7.5	7.5	7.5	7.5	10.5	8
CEY15B	10.0	10.0	10.0	10.0	10.0	10.0	18.0	9, 8
CEY16G	7.5	7.5	7.5	7.5	7.5	7.5	9.0	8
CEY16G	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9, 8
CEY20	5.0	5.0	5.0	5.0	5.0	5.0	10.0	10, 11
CET51	8.0	8.0	8.0	8.0	8.0	8.0	14.5	8
CEY52	8.0	8.0	8.0	8.0	8.0	8.0	13.5	8
CEY52	10.0	10.0	10.0	10.0	10.0	10.0	17.0	9, 8
CEYB12	6.5	6.5	6.5	6.5	6.5	6.5	10.0	8
CEYB13	7.5	7.5	7.5	7.5	7.5	7.5	11.5	9, 8

[10] NC = Not Calculated
[11] Continuous rating from instruction book one second rating assumed
[12] Continuous rating and one sec rating from instruction book

Relay Type	Winter			Summer			DAL	Notes
	Normal	Emergency		Normal	Emergency			
		15 Min.	4 Hrs.		15 Min.	12 Hrs.		
Electromechanical Equipment								
CEYB52	5.0	5.0	5.0	5.0	5.0	5.0	10.0	10, 11
CEY51	8.5	8.5	8.5	8.5	8.5	8.5	15.0	10, 8
CEYG53	5.0	5.0	5.0	5.0	5.0	5.0	8.5	10, 12
CFW11E	6.0	14.0	12.5	6.0	14.0	12.0	15.0	
CFZ	5.5	NC	NC	5.5	NC	NC	5.5	10
CHC11	4.0	9.2	8.5	4.0	9.2	8.0	11.5	13
CJC15	5.0	NC	NC	5.0	NC	NC	9.0	10, 12, 14
CPD11	8.0	NC	NC	8.0	NC	14.5		10
GCX17A	6.5	6.5	6.5	6.5	6.5	6.5	11.0	8
GCX17A	7.5	7.5	7.5	7.5	7.5	7.5	12.5	9, 8
GCX17B	6.5	6.5	6.5	6.5	6.5	6.5	11.0	10, 15, 8
GCX17B	7.5	7.5	7.5	7.5	7.5	7.5	12.5	9, 10, 15, 8
GCX17G	6.5	6.5	6.5	6.5	6.5	6.5	11.0	8
GCX17G	7.5	7.5	7.5	7.5	7.5	7.5	14.0	9, 8
GCX17M	6.5	6.5	6.5	6.5	6.5	6.5	10.5	10, 15, 8
GCX17M	7.5	7.5	7.5	7.5	7.5	7.5	11.5	9, 10, 15, 8
GCX17N	6.5	6.5	6.5	6.5	6.5	6.5	10.5	10, 15, 8
GCX17N	7.5	7.5	7.5	7.5	7.5	7.5	11.5	9, 10, 15, 8
GCX51	7.5	7.5	7.5	7.5	7.5	7.5	14.0	8
GCX51	8.5	8.5	8.5	8.5	8.5	8.5	15.0	9
GCXG51	8.0	8.0	8.0	8.0	8.0	8.0	14.5	8
GCXG51	9.5	9.5	9.5	9.5	9.5	9.5	16.5	9, 8
GCXY51	7.5	7.5	7.5	7.5	7.5	7.5	14.0	10, 8
GCXY51	8.5	8.5	8.5	8.5	8.5	8.5	15.0	9, 10, 8
GCY12	7.5	7.5	7.5	7.5	7.5	7.5	10.5	8
GCY51	8.0	8.0	8.0	8.0	8.0	8.0	14.5	8
GCY51	10.0	10.0	10.0	10.0	10.0	10.0	17.0	9, 8
GYC	8.0	8.0	8.0	8.0	8.0	8.0	14.5	10, 8
GYC	10.0	10.0	10.0	10.0	10.0	10.0	17.0	9, 10, 8
IC51	10.0	19.0	17.0	10.0	19.0	16.0	25.0	16
IC53	10.0	19.0	17.0	10.0	19.0	16.0	25.0	16

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13 1-4 Amp unit
14 1-4, 2-8, 4-16 Ranges
15 Relay must not be operated continuously picked up
16 4-16 Amp range. Limit is same on all taps

Relay Type	Winter			Summer			DAL	Notes
	Normal	Emergency		Normal	Emergency			
		15 Min.	4 Hrs.		15 Min.	12 Hrs.		
Electromechanical Equipment								
IAC60B	10.0	19.0	17.0	10.0	19.0	16.0	25.0	16
JBC51E-L	10.0	19.0	17.0	10.0	19.0	16.0	25.0	16
JBC51M	6.0	11.0	9.0	6.0	11.0	6.0	10.5	17
JBC53E-L	10.0	19.0	17.0	10.0	19.0	16.0	25.0	16
JBC53M	6.0	11.0	9.0	6.0	11.0	6.0	10.5	17
JBC77E-L	10.0	19.0	17.0	10.0	19.0	16.0	25.0	16
JBC77M	6.0	11.0	9.0	6.0	11.0	6.0	10.5	17
NHC11	8.0	9.0	9.0	8.0	9.0	9.0	15.0	18
PJC31	12.0	22.0	20.0	12.0	22.0	19.0	25.0	15, 16
SBC	10.0	NC	NC	10.0	NC	NC	17.5	10
SBD	10.0	NC	NC	10.0	NC	NC	16.0	10
SFC	12.0	NC	NC	12.0	NC	NC	21.0	10
SGC	6.5	NC	NC	6.5	NC	NC	10.0	10
SLC20	10.0	NC	NC	10.0	NC	NC	18.0	10
SLC51	10.0	NC	NC	10.0	NC	NC	18.0	10
SLCG	5.0	NC	NC	5.0	NC	NC	9.5	10
SLCN51	10.0	NC	NC	10.0	NC	NC	18.0	10
SLD	5.0	NC	NC	5.0	NC	NC	9.5	10
SLL	5.0	NC	NC	5.0	NC	NC	10.0	10
SLPG	5.0	NC	NC	5.0	NC	NC	10.0	10
SLX	5.0	NC	NC	5.0	NC	NC	9.5	10
SLXG	5.0	NC	NC	5.0	NC	NC	9.5	10
SLY	5.0	NC	NC	5.0	NC	NC	10.0	10
SLYG	5.0	NC	NC	5.0	NC	NC	10.0	10
SLYG81	10.0	NC	NC	10.0	NC	NC	18.0	10
SLYL	5.0	NC	NC	5.0	NC	NC	10.0	10
SLNP	10.0	NC	NC	10.0	NC	NC	18.0	10
STD	5.0	NC	NC	5.0	NC	NC	9.5	10

[17] Directional Unit has 6 Amp continuous rating
[18] 1 Amp unit

10.5.1.2 Westinghouse Relays

Comments by the manufacturer:

1) The attached data gives the continuous and one (1) second current ratings[19] of the relays. No information is available for the time period of 15 minutes, 4 hours, etc. Any current applied to the relay in excess of one (1) second should be within the continuous current rating of the relay.

2) The current ratings given do not reflect any difference based on the 50F winter ambient and 100F summer ambient. The 100F (37C) summer ambient is within the 40C (104F) average specified in ANSI 37.90 Std. and IEEE 313 Std.

3) Both electromechanical and solid state phase distance relays have continuous current ratings based on a maximum torque angle of less than nominal. For example, the nominal maximum torque angle of the 0.75 – 20 ohm range KD-4 is 75° for both the three phase and phase-to-phase units. If the relay is applied using a max torque angle setting for less than 75° than the currents given in the table apply. Where there is a limit of less than 10 amps, the 10 amp rating may be obtained by using a maximum torque angle equal to or greater than nominal. If the reduced angle is necessary, the 10 amp rating may be obtained by either reducing

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[19] The (1) second current ratings are not reproduced here.

or increasing the setting ohms, since the setting effects the thermal capability.

Table 15

	Winter			Summer				
		Emergency			Emergency			
Relay Type	Normal	15 Min.	4 Hrs.	Normal	15 Min.	12 Hrs.	DAL	Notes
CO-5 (0.5/2.5)	2.7	2.7	2.7	2.7	2.7	2.7	5.0	0.5A Tap
	3.1	3.1	3.1	3.1	3.1	3.1	5.5	0.6A Tap
	3.7	3.7	3.7	3.7	3.7	3.7	6.5	0.8A Tap
	4.1	4.1	4.1	4.1	4.1	4.1	7.0	1.0A Tap
	5.7	5.7	5.7	5.7	5.7	5.7	9.0	1.5A Tap
	6.8	6.8	6.8	6.8	6.8	6.8	10.5	2.0A Tap
	7.7	7.7	7.7	7.7	7.7	7.7	11.5	2.5A Tap
(2/6)	9.7	9.7	9.7	9.7	9.7	9.7	16.5	3.0A Tap
	10.4	10.4	10.4	10.4	10.4	10.4	17.5	3.5A Tap
	11.2	11.2	11.2	11.2	11.2	11.2	19.0	4.0A Tap
	12.5	12.5	12.5	12.5	12.5	12.5	21.0	5.0A Tap
	13.7	13.7	13.7	13.7	13.7	13.7	22.5	6.0A Tap
(4/12)	16.0	16.0	16.0	16.0	16.0	16.0	28.0	4.0A Tap
CO-6	Same as CO-5							
C0-7	Same as CO-5							
CO-8	Same as CO-5							
CO-9	Same as CO-5							
CO-11 (0/5/2.5)	1.7	1.7	1.7	1.7	1.7	1.7	3.1	0.5A Tap
	1.9	1.9	1.9	1.9	1.9	1.9	3.4	0.6A Tap
	2.2	2.2	2.2	2.2	2.2	2.2	3.8	0.8A Tap
	2.5	2.5	2.5	2.5	2.5	2.5	4.3	1.0A Tap
	3.0	3.0	3.0	3.0	3.0	3.0	5.0	1.5A Tap
	3.5	3.5	3.5	3.5	3.5	3.5	5.6	2.0A Tap
	3.8	3.8	3.8	3.8	3.8	3.8	6.0	2.5A Tap
(2/6)	8.3	8.3	8.3	8.3	8.3	8.3	15.0	3.0A Tap
	9.0	9.0	9.0	9.0	9.0	9.0	16.0	3.5A Tap
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	4.0A Tap
	11.0	11.0	11.0	11.0	11.0	11.0	19.0	5.0A Tap
	12.0	12.0	12.0	12.0	12.0	12.0	21.0	6.0A Tap
(4/12)	14.0	14.0	14.0	14.0	14.0	14.0	25.0	4.0A Tap
Co Hi Lo	Same as CO							
CKO	Same as CO							
COD	Same as CO							
COM	Same as CO							
COV	Same as CO							
CR	Same as CO							

Relay Type	Winter			Summer			DAL	Notes
		Emergency			Emergency			
	Normal	15 Min.	4 Hrs.	Normal	15 Min.	12 Hrs.		
CRN-1	5.0	8.0	5.0	5.0	8.0	5.0	9.0	
H-3	5.0	5.0	5.0	5.0	5.0	5.0	9.8	
HCB	10.0	10.0	10.0	10.0	10.0	10.0	17.0	
HCB-1	10.0	10.0	10.0	10.0	10.0	10.0	17.0	
HU	10.0	10.0	10.0	10.0	10.0	10.0	18.0	
HU-1	10.0	10.0	10.0	10.0	10.0	10.0	18.0	
HV-3	5.0	5.0	5.0	5.0	5.0	5.0	9.8	
IRV	Tap ratings same as CO							
IRV								
0.5-2	10.0	10.0	10.0	10.0	10.0	10.0	17.0	Dir Unit
2-6	10.0	10.0	10.0	10.0	10.0	10.0	17.0	Dir Unit
4-12	12.0	12.0	12.0	12.0	12.0	12.0	20.5	Dir Unit
0.5-2	5.0	5.0	5.0	5.0	5.0	5.0	8.0	Inst Unit
1-4	8.0	8.0	8.0	8.0	8.0	8.0	13.0	Inst Unit
2-8	8.0	8.0	8.0	8.0	8.0	8.0	13.0	Inst Unit
4-16	10.0	10.0	10.0	10.0	10.0	10.0	17.0	Inst. Unit
ITH	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.25-0.5A
	1.0	1.0	1.0	1.0	1.0	1.0	1.6	0.5-1.0A
	2.0	2.0	2.0	2.0	2.0	2.0	3.2	1-2A
	4.0	4.0	4.0	4.0	4.0	4.0	6.5	2-4A
	8.0	8.0	8.0	8.0	8.0	8.0	13.0	2-8A
	12.0	12.0	12.0	12.0	12.0	12.0	19.0	6-12A
KC-2	5.0	5.0	5.0	5.0	5.0	5.0	8.5	0.5-2A
	8.0	8.0	8.0	8.0	8.0	8.0	13.0	1-4A
	8.0	8.0	8.0	8.0	8.0	8.0	13.0	2-8A
	10.0	10.0	10.0	10.0	10.0	10.0	17.0	4-16A
KC-4	Same as KC-2							
KC-3	10.0	10.10	10.0	10.0	10.0	10.0	17.5	0.759-2.612ZC all ZA
	8.0	8.0	8.0	8.0	8.0	8.0	14.5	2.609-3.529ZC all ZA
	6.0	6.0	6.0	6.0	6.0	6.0	11.5	3.652-4.942ZC all ZA
	5.0	5.0	5.0	5.0	5.0	5.0	10.0	5.043-6.824ZC all ZA
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	7.059-9.882ZC all ZA
	8.5	8.5	8.5	8.5	8.5	8.5	15.0	10.09-13.65ZC all ZA
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	13.85-14.82ZC all ZA
	8.5	8.5	8.5	8.5	8.5	8.5	15.0	15.13-20.47ZC all ZA
KD-4 (0.2-4.35)	15.0	15.0	15.0	15.0	15.0	15.0	24.0	0.23-0.59 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	0.6-1.447 Ω
	15.0	15.0	15.0	15.0	15.0	15.0	24.0	1.47-2.09 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	2.14-2.89 Ω

Relay Type	Winter Normal	Winter Emergency 15 Min.	Winter Emergency 4 Hrs.	Summer Normal	Summer Emergency 15 Min.	Summer Emergency 12 Hrs.	DAL	Notes
	15.0	15.0	15.0	15.0	15.0	15.0	24.0	3.03-3.140Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	3.21-4.34 Ω
KD-4 (0.75-20)	10.0	10.0	10.0	10.0	10.0	10.0	17.5	0.737-2.39 Ω
	8.0	8.0	8.0	8.0	8.0	8.0	14.5	2.46-3.41 Ω
	6.0	6.0	6.0	6.0	6.0	6.0	11.5	3.44-4.78 Ω
	5.0	5.0	5.0	5.0	5.0	5.0	10.0	4.92-7.07 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	7.26-9.55 Ω
	8.5	8.5	8.5	8.5	8.5	8.5	15.0	9.83-14.14 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	14.8 Ω
	9.5	9.5	9.5	9.5	9.5	9.5	17.0	14.7-21.2 Ω
KD-4 (1.1-30)	10.0	10.0	10.0	10.0	10.0	10.0	17.5	1.1-3.59 Ω
	8.0	8.0	8.0	8.0	8.0	8.0	14.5	3.69-5.12 Ω
	6.0	6.0	6.0	6.0	6.0	6.0	11.5	5.16-7.17 Ω
	5.0	5.0	5.0	5.0	5.0	5.0	10.0	7.38-10.61 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	10.89-14.33 Ω
	8.5	8.5	8.5	8.5	8.5	8.5	15.0	14.75-21.21 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	22.2 Ω
	9.5	9.5	9.5	9.5	9.5	9.5	17.0	22.1-31.8 Ω
KD-5 (0.2-4.35)	Same as KD-4 0.2-4.35							
KD-5 (0.75-20)	Same as KD-4 0.75-20							
KD-5 (1.1-30)	Same as KD-4 1.1-30							
KD-10	10.0	10.0	10.0	10.0	10.0	10.0	17.0	0.2-4.5 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.0	0.75-21.2 Ω
KD-10 (1.27-36.7)	10.0	10.0	10.0	10.0	10.0	10.0	17.0	1.27-5.90 Ω
	7.0	7.0	7.0	7.0	7.0	7.0	13.0	5.94-8.25 Ω
	6.0	6.0	6.0	6.0	6.0	6.0	11.5	8.5-12.2 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.0	12.5-16.5 Ω
	8.0	8.0	8.0	8.0	8.0	8.0	14.5	17.0-24.4 Ω
	9.0	9.0	9.0	9.0	9.0	9.0	16.0	25.5-36-7 Ω
KD-11	Same as KD-10							
KD-41	Same as KD-4							
KDTG	10.0	10.0	10.0	10.0	10.0	10.0	17.5	
KDXG	10.0	10.0	10.0	10.0	10.0	10.0	16.0	
KH-1	5.0	5.0	5.0	5.0	5.0	5.0	9.0	
KO-3	5.0	5.0	5.0	5.0	5.0	5.0	8.5	0.5-2
	8.0	8.0	8.0	8.0	8.0	8.0	13.0	1-4, 2-8A
	10.0	10.0	10.0	10.0	10.0	10.0	16.5	
KRV	5.0	5.0	5.0	5.0	5.0	5.0	8.5	0.5-2A
	8.0	8.0	8.0	8.0	8.0	8.0	13.0	1-4, 2-8A
	10.0	10.0	10.0	10.0	10.0	10.0	17.0	4-16, 10-40A
KS (0.75-20)	10.0	10.0	10.0	10.0	10.0	10.0	17.5	0.87-3 Tap

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Relay Type	Winter Normal	Winter Emergency 15 Min.	Winter Emergency 4 Hrs.	Summer Normal	Summer Emergency 15 Min.	Summer Emergency 12 Hrs.	DAL	Notes
	7.0	7.0	7.0	7.0	7.0	7.0	13.0	4.2 Tap
	5.0	5.0	5.0	5.0	5.0	5.0	10.0	5.8 Tap
KS (0.51-30)	10.0	10.0	10.0	10.0	10.0	10.0	17.5	0.6-3.68 Tap
	7.0	7.0	7.0	7.0	7.0	7.0	13.0	5.5 Tap
	5.0	5.0	5.0	5.0	5.0	5.0	10.0	8.2 Tap
KST (0.75-20)	10.0	10.0	10.0	10.0	10.0	10.0	17.0	0.757-3.54 Ω
	7.0	7.0	7.0	7.0	7.07.0	7.0	12.5	3.65-4.96 Ω
	5.0	5.0	5.0	5.0	5.0	5.0	9.5	5.04-6.84 Ω
	7.0	7.0	7.0	7.0	7.0	7.0	12.5	7.30-9.91 Ω
	5.0	5.0	5.0	5.0	5.0	5.0	9.5	10.1-13.7 Ω
	7.0	7.0	7.0	7.0	7.0	7.0	12.5	14.86 Ω
	5.0	5.0	5.0	5.0	5.0	5.0	9.5	15.13-20.5 Ω
POQ	5.0	5.0	5.0	5.0	5.0	5.0	8.5	
SA-1	20.0	20.0	20.0	20.0	20.0	20.0	32.0	
SBF	8.0	8.0	8.0	8.0	8.0	8.0	15.5	0.5-2 A
	10.0	10.0	10.0	10.0	10.0	10.0	19.0	1-4A
SBFU	Same as SBF							
SC	1.5	1.5	1.5	1.5	1.5	1.5	3.2	0.5-2A
	3.0	3.0	3.0	3.0	3.0	3.0	5.5	1-4A
	6.0	6.0	6.0	6.0	6.0	6.0	10.0	2-8A
	12.0	12.0	12.0	12.0	12.0	12.0	17.5	4-16A
SC-1	Same as SC							
SCO (0.5-12)	1.6	1.6	1.6	1.6	1.6	1.6	2.8	0.5 Tap
	3.3	3.3	3.3	3.3	3.3	3.3	5.2	1.0 Tap
	4.9	4.9	4.9	4.9	4.9	4.9	9.2	1.5 Tap
	6.5	6.5	6.5	6.5	6.5	6.5	11.5	2.0 Tap
	8.1	8.1	8.1	8.1	8.1	8.1	13.5	2.5 Tap
	9.8	9.8	9.8	9.8	9.8	9.8	16.5	3.0 Tap
	11.4	11.4	11.4	11.4	11.4	11.4	18.5	3.5 Tap
	13.0	13.0	13.0	13.0	13.0	13.0	20.0	4.0 Tap
	16.3	16.3	16.3	16.3	16.3	16.3	29.0	5.0 Tap
SD-2	5.0	5.0	5.0	5.0	5.0	5.0	9.0	T=6.4, 12.8
	10.0	10.0	10.0	10.0	10.0	10.0	16.0	T=0.8, 1.6,3.2
SDB	10.0	10.0	10.1	10.1	10.1	10.1	17.5	1.51-3.5 Tap
	8.0	8.0	8.0	8.0	8.0	8.0	14.5	5.0 Tap
	6.0	6.0	6.0	6.0	6.0	6.0	11.5	7.1 Tap
	5.0	5.0	5.0	5.0	5.0	5.0	9.7	10.0 Tap
SDBU-2	Same as SDB							
SDG	10.0	10.0	10.0	10.0	10.0	10.0	17.5	
SDGU	10.0	10.0	10.0	10.0	10.0	10.	17.5	
SDU-1	10.0	10.0	10.0	10.0	10.0	10.0	17.5	
SI	6.0	6.0	6.0	6.0	6.0	6.0	13.5	0.25-1A
	8.0	8.0	8.0	8.0	8.0	8.0	15.5	0.5-2A

Relay Type	Winter			Summer			DAL	Notes
	Normal	Emergency		Normal	Emergency			
		15 Min.	4 Hrs.		15 Min.	12 Hrs.		
	10.0	10.0	10.0	10.0	10.0	10.	19.0	1-4A
	12.0	12.0	12.0	12.0	12.0	12.0	22.0	2-8A
	15.0	15.0	15.0	15.0	15.0	15.0	26.5	4-16A
SI-1	Same as SI							
SI-T (0.5-16)	7.0	7.0	7.0	7.0	7.0	7.0	12.5	0.5-2A
	15.0	15.0	15.0	15.0	15.0	15.0	23.0	2-8A
SIU	Same as SI							
SIU	3.5	3.5	3.5	3.5	3.5	3.5	6.2	0.25-1A
Compensated	7.0	7.0	7.0	7.0	7.0	7.0	12.5	0.5-2A
SKB	10.0	10.0	10.0	10.0	10.0	10.0	17.0	
SKB-1	Same as SKB							
SKBU	Same as SKB							
SKBU-1	Same as SKB							
SKBU-2	Same as SKB							
SKBU-2A	Same as SKB							
SKBU-11	7.0	7.0	7.0	7.0	7.0	7.0	12.0	
SKBU-21	Same as SKBU-11							
SKD (0.2-4.35)	10.0	10.0	10.0	10.0	10.0	10.0	17.5	0.195-0.571 Ω
	8.0	8.0	8.0	8.0	8.0	8.0	14.5	0.585-0.758 Ω
	6.0	6.0	6.0	6.0	6.0	6.0	11.5	0.78-1.01 Ω
	5.0	5.0	5.0	5.0	5.0	5.0	10.0	1.04-1.50 Ω
	10.0	10.0	10.0	10.0	10.0	10.	17.5	1.56-2.02 Ω
	8.5	8.5	8.5	8.5	8.5	8.5	15.0	2.08-3.0 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	3.03 Ω
	9.5	9.5	9.5	9.5	9.5	9.5	17.0	3.13-4.5 Ω
SKD (0.73-21.0)	10.0	10.0	10.0	10.0	10.0	10.0	17.5	0.737-2.39 Ω
	8.0	8.0	8.0	8.0	8.0	8.0	14.5	2.46-3.41 Ω
	6.0	6.0	6.0	6.0	6.0	6.0	11.5	3.44-4.77 Ω
	5.0	5.0	5.0	5.0	5.0	5.0	10.0	4.92-7.08 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	7.26-9.55 Ω
	8.5	8.5	8.5	8.5	8.5	8.5	15.0	9.85-14.1 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	14.3 Ω
	9.5	9.5	9.5	9.5	9.5	9.5	17.0	14.7-21.3 Ω
SKD (1.1-31.8)	10.0	10.0	10.0	10.0	10.0	10.0	17.5	1.11-3.59 Ω
	8.0	8.0	8.0	8.0	8.0	8.0	14.5	3.68-5.11 Ω
	6.0	6.0	6.0	6.0	6.0	6.0	11.5	5.16-7.17 Ω
	5.0	5.0	5.0	5.0	5.0	5.0	10.0	7.37-10.6 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	10.9-14.3 Ω
	8.5	8.5	8.5	8.5	8.5	8.5	15.0	14.71-21.2 Ω
	10.0	10.0	10.0	10.0	10.0	10.0	17.5	21.5 Ω
	9.5	9.5	9.5	9.5	9.5	9.5	17.0	22.1-31.8 Ω
SKD-IT	Sam as SKD							
SKD-T	Sam as SKD							
SKDU	Sam as SKD							

Relay Type	Winter Normal	Winter Emergency 15 Min.	Winter Emergency 4 Hrs.	Summer Normal	Summer Emergency 15 Min.	Summer Emergency 12 Hrs.	DAL	Notes
SKDU-1	Sam as SKD							
SKDU-3								
(1.4-40)								1.39-6.57 Ω
(1.74-50)								1.74-8.16 Ω
Combined	10.0	10.0	10.0	10.0	10.0	10.0	17.5	
(1.4-40)								6.72-13.3 Ω
(1.74-50)								8.4-16.1 Ω
Combined	5.0	5.0	5.0	5.0	5.0	5.0	10.0	
(1.4-40)								13.8-40.0 Ω
(1.74-50)								16.8-8.50 Ω
Combined	8.5	8.5	8.5	8.5	8.5	8.5	15.0	
(1.4-40)								1.39-6.57* Ω
(1.74-50)								1.74-8.16* Ω
Combined	10.0	10.0	10.0	10.0	10.0	10.0	17.5	* S=2 setting
(1.4-40)								1.39-6.57* Ω
(1.74-50)								1.74-8.16* Ω
Combined	10.0	10.0	10.0	10.0	10.0	10.0	17.5	**S=3 setting
SKDU-32	Same as SKDU-3							
SKSU								
LR								1.11-3.59 Ω
SR								0.87-2.03 Ω
Combined	10.0	10.0	10.0	10.0	10.0	10.0	17.5	
LR								3.68-5.11 Ω
SR								2.9 Ω
Combined	8.0	8.0	8.0	8.0	8.0	8.0	14.5	
LR								5.16-7.17 Ω
SR								4.06 Ω
Combined	6.0	6.0	6.0	6.0	6.0	6.0	11.5	
LR								7.37-10.6 Ω
SR								5.8 Ω
Combined	5.0	5.0	5.0	5.0	5.0	5.0	10.0	
LR								10.9-14.3 Ω
SR								4.06 Ω
Combined	10.0	10.0	10.0	10.0	10.0	10.0	17.5	
LR								14.71-21.2Ω
SR								5.8 Ω
Combined	8.5	8.5	8.5	8.5	8.5	8.5	15.0	
LR								21.5 Ω
SR								4.06 Ω
Combined	10.0	10.0	10.0	10.0	10.0	10.0	17.5	
LR								22.1-31.8 Ω
SR								5.8 Ω
Combined	9.5	9.5	9.5	9.5	9.5	9.5	17.0	
SLB	5.0	5.0	5.0	5.0	5.0	5.0	8.5	

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Relay Type	Winter			Summer			DAL	Notes
	Normal	Emergency		Normal	Emergency			
		15 Min.	4 Hrs.		15 Min.	12 Hrs.		
SP	Same as SKD							
SP-1	Same as SKD							
SPCU	10.0	10.0	10.0	10.0	10.0	10.0	18.0	
SPCU-1	Same as SPCU							

10.5.2 Instruments

10.5.2.1 Westinghouse

Comments by the manufacturer.

1) Instantaneous Overload

The term is used incorrectly when “momentary overload” is intended.

Generally the term “instantaneous” connotes absence of a deliberate or measured time-an extremely short period of time.

Instantaneous voltages can puncture insulation but instantaneous currents are considered to be of too short duration to cause mechanical or thermal damage.

ANSI C39.1-1964 Standards do not recognize the terms.

2) Momentary Overload

Generally, this is a load applied for a measured period of time less than one second.

Momentary overload ratings are an indication of the mechanical limits of the instrument. They are usually well within thermal limits.

3) Short-time Overload

This is always a stated value of current for a stated duration. Short-time overload ratings are an indication of thermal capability.

ANSI C39.1-1964 does not specify short-time overload capability for any but rectifier and rf instruments but this is a most vital consideration in the application of other instruments, particularly ammeters and watt meters.

4) Sustained Overload

ANSI 39.1-1964 required that an instrument be capable of withstanding a 120 percent of rated load for six hours with a permanent error of less than one-half of rated accuracy. All Westinghouse instruments meet this standard. The continuous current values listed are on a longer time base (24 hours) and are limited by the threshold of thermal damage. The permanent error will be within the one-half of the rated accuracy limits.

5) Transducers

These are all able to withstand two times rating continuously, 5 times rating for 5 sec. And 10 times rating for 1 sec. The ambient temperature range is 120C to 65C.

ANSI Standard C39.1-1964, in part:

"6.2.10.1 Instruments shall be capable of indicating freely but not necessarily within their accuracy ratings when operated continuously at any temperature from -20°C to 50°C.

6.2.10.1 Alternating-current and direct-current instruments having

current circuits shall be capable of withstanding the series of momentary overloads given below.

For Panel and Switchboard instruments, an overload current of 10 times end-scale value shall be applied ten times for a duration of ½ second, with a 1 minute interval between each successive application. If the instruments are provided with a voltage circuit, normal voltage shall be applied to the instruments for the whole period.

In addition, the current circuits of ac switchboard instruments rated from 1 through 10 amps shall be capable of withstanding 40 times rated current rms applied for 2 seconds without open-circuiting. Instruments are not, however, required to be in operating condition after this test.

6.2.10.2 All circuits of instruments shall be capable of

withstanding an applied load of 20 percent greater than rated capability for a period of 6 hours. Where a maximum rating is given, this value shall be applied rather than 20 percent greater than rated capacity."

Table 16
Amperes

	Winter			Summer				
		Emergency			Emergency			
Relay Type	**Normal**	**15 Min.**	**4 Hrs.**	**Normal**	**15 Min.**	**12 Hrs.**	**DAL**	**Notes**
Instrument								
Ammeters - Panel Type - 5 Amp. Coils								
A20/20 Type								
GA331	10	10	10	10	10	10	10	
GA352	10	10	10	10	10	10	10	
GA372	10	10	10	10	10	10	10	
GA382	10	10	10	10	10	10	10	
NA351	24	24	24	24	24	24	24	
NA371	24	24	24	24	24	24	24	
RA351	24	24	24	24	24	24	24	
RA371	24	24	24	24	24	24	24	
Ammeters - Switchboard Type - 5 Amp. Coils								
EA251	20	20	20	20	20	20	20	
HC252	11	11	11	11	11	11	11	
KA221	20	20	20	20	20	20	20	
KA231	27	27	27	27	27	27	27	
KA241	27	27	27	27	27	27	27	
KA251	20	20	20	20	20	20	20	
UA251	20	20	20	20	20	20	20	
VC252	11	11	11	11	11	11	11	
Wattmeters - Varmeters - PF Meters - Panel Type - 5 Amp. Coils								
GX352	10	10	10	10	10	10	10	
GX372	10	10	10	10	10	10	10	
GX382	10	10	10	10	10	10	10	
Wattmeters - Varmeters - PF Meters - Switchboard Typ - 5 Amp. Coils								

Relay Type	Winter			Summer			DAL	Notes
	Normal	Emergency		Normal	Emergency			
		15 Min.	4 Hrs.		15 Min.	12 Hrs.		
HX252	10	10	10	10	10	10	10	
K125	8	8	8	8	8	8	8	
KP231	16	16	16	16	16	16	16	
KP241	16	16	16	16	16	16	16	
KV231	16	16	16	16	16	16	16	
KV241	16	16	16	16	16	16	16	
KX231	10	10	10	10	10	10	10	
KX241	10	10	10	10	10	10	10	
KY25	15	10	10	15	10	10	10	
KY221	15	10	10	15	10	10	10	
UI25	8	10	8	8	10	8	10	
UV25	10	15	10	10	15	10	10	
UY25	10	15	10	10	15	10	10	
VX252	10	10	10	10	10	10	10	
Transducers - V2 Type								
V12-841	10	10	10	10	10	10	14	
VF2-841	10	10	10	10	10	10	14	
VP2-840	10	10	10	10	10	10	14	
VV2-840	10	10	10	10	10	10	14	
V14-841	10	10	10	10	10	10	15	
VP4-846	10	10	10	10	10	10	17	
VVR-846	10	10	10	10	10	10	17	

10.5.2.2 General Electric

Comments by the manufacturer

1) All meters are designed to, and will meet, specifications in Standard ANSI C-39.1 (1964)

2) Panel Type instrument overload ability.

Ammeters

Momentary: 10 times rated current for 10 consecutive intervals of ½ second with a 1 minute interval between successive applications.

Sustained: 20 percent for 8 hours.

3) Switchboard type instrument overload ability,

(a) Ammeters

Two times rated current continuously,

100 times for 1 sec.

(b) Current coils, other than ammeters

1.5 times rated current continuously

4) Transducer overload ability

(a) Current

Two times current continuously

15 times rated current for 10 sec

60 times rated current for 1 sec.

Ambient temperature –28C to 72C

(b) Watt or Var

Two times rated current continuously

15 Times rated current for 10 sec applied

not more than once per hour.

Ambient temperature –20C to 70

(c) Power Factor

Two times rated current continuously

10 times rated current momentarily

Ambient temperature –20C to 60C

Table 17
Amperes

Relay Type	Winter			Summer			DAL	Notes
		Emergency			Emergency			
	Normal	15 Min.	4 Hrs.	Normal	15 Min.	12 Hrs.		
Instrument								
Ammeters - Panel Type - 5 Amp. Coils								
Type 250	6	6	6	6	6	6	8.5	
Type 251	6	6	6	6	6	6	8.5	
Type AW91	6	6	6	6	6	6	8.5	
Type AO91	6	6	6	6	6	6	8.5	
Type AO92	6	6	6	6	6	6	8.5	
Type 157	6	6	6	6	6	6	8.5	
Type 167	6	6	6	6	6	6	8.5	
Type 178	6	6	6	6	6	6	8.5	
Type 180	6	6	6	6	6	6	8.5	
Ammeters - Switchboard Type - 5 Amp. Coils								
Type AB16	10	10	10	10	10	10	14	
Type AB30	10	10	10	10	10	10	14	
Type AB40	10	10	10	10	10	10	14	
Type AD6	10	10	10	10	10	10	14	
Type AD7	10	10	10	10	10	10	14	
Wattmeters - Varmeters - PF Meters - Switchboard Type - 5 Amp. Coils								
Type AB16	7.5	7.5	7.5	7.5	7.5	7.5	11	
Type AB30	7.5	7.5	7.5	7.5	7.5	7.5	11	
Type AB40	7.5	7.5	7.5	7.5	7.5	7.5	11	
Type AD6	7.5	7.5	7.5	7.5	7.5	7.5	11	
Type AD7	7.5	7.5	7.5	7.5	7.5	7.5	11	
Transducers								
Type 4701	10	10	10	10	10	10	17	
Type 472	10	10	10	10	10	10	18	

<u>Transducers</u>

There are no ANSI standards on electrical transducers yet. However, as these transducers are used generally as accessories for electrical measuring instruments, the standard ANSI C39.1-1964 is used insofar as is practical.

Table 18
Amperes

Relay Type	Winter			Summer			DAL	Notes
	Normal	Emergency		Normal	Emergency			
		15 Min.	4 Hrs.		15 Min.	12 Hrs.		
Instrument								
C								
S. C.	(See Below)							
WT3	10	10	10	10	10	10	17	Watt Transducer
VT3	10	10	10	10	10	10	17	Var. Transducer
CT-51	10	10	10	10	10	10	17	Current Transducer
XL-A2	15	15	15	15	15	15	21	
XLV-A2	15	15	15	15	15	15	21	
XLWV-A2	15	15	15	15	15	15	21	
D								
RIS								
PCH, PCA	15.	15	15	15	15	15	23	Watt Transducer
VCH, VCA	15.	15	15	15	15	15	23	Var. Transducer
CC	20	20	20	20	20	20	30	Current Transducer
WV Series	20	20	20	20	20	20	28	
E								
TRANS								
10CS	10	10	10	10	10	10	17	Current Transducer
20WS, 25WS	10	10	10	10	10	10	15	Watt Transducer
30WS	10	10	10	10	10	10	17	Watt Transducer
20PS, 30PS	10	10	10	10	10	10	17	Var. Transducer
10e, 20E, 25E)	10	10	10	10	10	10	18	
30E, Series)								
F								
FW BELL								
PS-2000	10	10	10	10	10	10		Watt Transducer

Corrected October 2004

Relay Type	Winter			Summer			DAL	Notes
	Normal	Emergency		Normal	Emergency			
		15 Min.	4 Hrs.		15 Min.	12 Hrs.		
QS-2000	10	10	10	10	10	10		Var. Transducer
JS-2100	10	10	10	10	10	10		Current Transducer

Table 19
Manufacturers Of Transducers

S.C.	Scientific Columbus, Division of Esterline Corporation Columbus, Ohio
RIS	Rochester Instrument Systems, Inc. Rochester, New York
TRANS	Transdata, Inc. Columbus, Ohio
F. W. BELL	F. W. Bell, Inc. Columbus, Ohio

10.5.3 Oscillograph Shunts and Sensors

10.5.3.1 Hathaway Instruments

Comments by the manufacturer

The 5 Amp shunt used in the GC-8 Galvanometer Control Unit has been tested at 7.5 Amps continuously.

GC-8 shunts are available for 10 amps.

An existing standard 5 Amp GC-8 shunt assembly may be changed in the field to 10 amps by installing a replacement assembly.

New GC-1 units are now available with a 10 amp shunt.

The RIC-5 does have a 10 Amp tap although this connection may not have been brought out. Field change can be accomplished by reference to the manual.

Table 20
Amperes

Relay Type	Winter			Summer			DAL	Notes
	Normal	Emergency 15 Min.	Emergency 4 Hrs.	Normal	Emergency 15 Min.	Emergency 12 Hrs.		
Sensors								
GC-1 5A shunt	7.5	7.5	7.5	7.5	7.5	7.5	16	50A one Min
CC-1 10A shunt	10.0	10.0	10.0	10.0	10.0	10.0	12*[20]	
CC-8 5A shunt	7.5	7.5	7.5	7.5	7.5	7.5	16	50A one Min
CC-8 10A shunt	10.0	10.0	10.0	10.0	10.0	10.0	12*	
OC Sensor								
P/N7031600	10.0	10.0	10.0	10.0	10.0	10.0	12*	Any Tap
63939	10.0	10.0	10.0	10.0	10.0	10.0	12*	5 Amp rating
RIC5 Relay	10.0	10.0	10.0	10.0	10.0	10.0	12*	5A Tap
SC-8 Control	5.0	5.0	5.0	5.0	5.0	5.0	8*	5A Tap
Unit Shunt								

10.5.4 Switchboard Wire

From the National Electric Code – 1978, articles 310-1 through 310-17, there are three types of switchboard wire, all having a maximum operating temperature of 90°C (194°F).

Type letter: TA Trade name: Thermoplastic and Asbestos

Type letter: TBS Trade name: Thermoplastic and Fibrous Outer Braid

Type letter: SIS Trade name: Synthetic Heat-Resistant

The ratings are given with a 30°C ambient (60° rise to the 90° conductor), with correction factors for other ambient temperatures. The example of Section 10.3 indicates assumed ambients of 35°C and 42°C.

---

[20] Conservative Estimate

Single Copper conductor in free air rating

#14AWG	30 amps	30°C ambient
	27	31-40°C
	25	41-50°C
#12AWG	40 amps	30°C ambient
	36	31-40°C
	33	41-50°C

No ratings have been standardized for currents having a short duration of time, these are continuous ratings. Switchboard wiring should not be smaller than #14 if stranded or #13 if solid. The precise manner in which an ambient temperature is to be measured is not given in the available standards.

Normal loading limits of insulated cables are based on extensive testing backed by many years of practical experience. The rate of deterioration due to heat is expected to develop a useful life of 20 to 30 years. The life of cable insulation is about halved for each 10°C increase in operating temperature.

Under short circuit conditions, with a duration of 15 sec or less, the conductor temperature may be allowed to rise to approximately 150C. It is important to note that the abnormal temperature persists much longer than the duration of the fault current flow. Furthermore the maximum temperature may depend upon the reclosing sequence where there is a permanent fault. On the basis that all the energy produced during a fault current flow is effective in raising the conductor temperature (since the time period is very short this is a valid assumption for engineering purposes), the conductor heating is governed by the following equation for copper:

$$\log_{10}\left(\frac{T2+234}{T1+234}\right)=\frac{t}{0.0297}\left(\frac{I}{A}\right)^2$$

where: I = Short circuit current in amperes

A = Conductor area in circular mils

t = Time of short circuit in sec

T_1 = Initial conductor temperature in C

T_2 = Final conductor temperature in C

For example: A current of 100 amps in #14 wire for 3 sec will raise the conductor from 90°C to 138°C.

For the DAL rating this formula was used assuming a previous current at the Emergency – Summer value, an existing conductor temperature of 90°C and a time of 5 min. to reach 150°C.

Table 21
Ratings In Secondary Amperes

Relay Type	Winter			Summer			DAL	Notes
	Normal	Emergency		Normal	Emergency			
		15 Min.	4 Hrs.		15 Min.	12 Hrs.		
Wire								
#14	30	30	30	27	25	25	28	TA, TBS, SIS
#12	40	40	40	36	33	33	38	TA, TBS, SIS

10.5.5 Auxiliary Current Transformers

10.5.5.1 Continuous Thermal Current Rating Factor

From ANSI – C57.13-1978, the Continue Thermal Current Rating Factor, the specified factor by which the primary of a current transformer can be multiplied to obtain the maximum primary current that can be carried continuously without exceeding the limiting temperature rise from 30°C ambient temperature.

10.5.5.2 Basis of ratings

The stated nameplate winding current is listed under the note column. The basis for the current value listed for each column is summarized for a particular type of auxiliary current transformer at the end of the columns.

10.5.5.3 General Electric Auxiliary Current Transformer

Comments by the manufacturer:

Applicable Standards cover only the continuous thermal rating and the one-second thermal rating, and do not cover intermediate times. Such coverage presumably would include coverage of ambient temperatures, preceding duty cycles, thermal time constants, and acceptance of some reduction in life. There have been some suggestions that such work be undertaken.

In the absence of Standards coverage, we are providing some guidelines for JAR-O applications. These guidelines are not based on a thorough investigation by include sufficient conservatism to be appropriate for practical purposes.

Figure 1 of C57.13-1978 shows current transformer basic loading characteristics for "55°C rise" designs such as the JAR-O, on the assumptions that quoted RF is met without margin and that the ultimate rise is proportional to the square of the current. This figure is based on no loss of life compared to rated continuous duty. Standard JAR-O's are rated for 1.5 RF at 30°C ambient, but an RF of 1.8 would be more accurate. Another curve could be marked on Figure 1 for RF of 1.8, crossing the 30° line at 180 percent, the 0°C line at 223.8 percent and the 60°C line at 121.3. Such a curve would indicate that normal[21] life would be expected for continuous operation as follows:

Table 22

Ambient, Degrees C	percent of Rated Current
0	223.8
10	210.2
20	195.7
30	180.7
40	162.8
50	143.6
60	121.3

This provides a conservative approach to the 4 hour overload question, in that this tabulation is based on continuous operation and normal life.

[21] Life based on RF of 1.8 is expected to be entirely satisfactory and thus "Normal" – life based on an RF of 1.5 would be greater, but this is probably academic.

The temperature achieved during 4 hours operation for the condition described, can be estimated as follows:

1) Assumed conditions are 20°C ambient, 210 percent of rated current for 4 hours.

2) Estimated temperature rise = $\left[\frac{210}{180}\right]^2$ X 55 = 74.9ºC.

3) Total temperature[22] = 20+75 = 95ºC.

4) "Normal" total temperature = 30+55 = 85ºC.

5) Excess over normal total temperature = 10ºC.

If we arbitrarily accept a rule-of-thumb that thermal aging is accelerated by 2:1 for each 10ºC increase in temperature, then 4 hours at 95ºC total temperature would correspond to 8 hours at 85ºC total temperature.

The above approach is a practical approximation for use up to total temperatures of 125ºC.

We do not have the detailed data required for accurate estimation of the 15 minute capability. We have made some approximation indicating that occasional 15 minute operations at 300 percent of rated current would not result in substantial decrease in product life, if conditions at the start of the 15 minute duty did not exceed conditions appropriate for continuous operation.

Out intent here is to provide some practical assistance without implying that a comprehensive study has been made. We expect the information provided here will indicate the JAR-O can be subjected to many of the actual overloads in question.

---

[22] "Total temperature" is used here as the average operating temperat ure of the hottest winding, as established by resistance changes.

Table 23
Winter Emergency

Relay Type	Winter			Summer			DAL	Notes
		Emergency			Emergency			
	Normal	15 Min.	4 Hrs.	Normal	15 Min.	12 Hrs.		
Instrument								
General Electric Company Type JAR-O								
Auxiliary Current Transformer								
Basis for Table								
Normal = 1.5 x nameplate current								
15 Min. = 3.0 x nameplate current								
4 Hrs. = 1.8 x nameplate current								
DAL = 3.0 x nameplate current								
	.15	.3	.18	.15	.2	.18	.3	.1a Winding
	.3	.6	.36	.3	.4	.36	.6	.2
	.38	.75	.45	.38	.5	.45	.75	.25
	.75	1.5	.9	.75	1.0	.9	1.5	.5
	.94	1.9	1.13	.94	1.25	1.13	1.9	.625
	1.38	2.8	1.66	1.38	1.85	1.66	2.8	.923
	1.5	3.0	1.8	1.5	2.0	1.8	3.0	1.0
	1.9	3.75	2.25	1.9	2.5	2.25	3.75	1.25
	2.5	5.0	3.0	2.5	3.33	3.0	5.0	1.667
	3.0	6.0	3.6	3.0	4.0	3.6	6.0	2.0
	3.6	7.2	6.46	3.6	4.8	6.46	7.2	2.395
	3.75	7.5	4.5	3.75	5.0	4.5	7.5	2.5
	4.33	8.7	5.2	4.33	5.78	5.2	8.7	2.89
	4.5	9.0	5.4	4.5	6.0	5.4	9.0	3.0
	5.0	10.0	6.0	5.0	6.66	6.0	10.0	3.33
	5.63	11.3	6.75	5.63	7.5	6.75	11.3	3.75
	6.0	12.0	7.2	6.0	8.0	7.2	12.0	4.0
	7.5	15.0	9.0	7.5	10.0	9.0	15.0	5.0
	8.0	16.0	9.6	8.0	10.6	9.6	16.0	5.33
	9.38	18.8	11.3	9.38	12.5	11.3	18.8	6.25
	11.3	22.5	13.5	11.3	15.0	13.5	22.5	7.5
	12.0	24.0	14.4	12.0	16.0	14.4	24.0	8.0
	15	30.0	18	15	20	18	30.0	10.0
	18.8	37.5	22.5	18.8	25	22.5	37.5	12.5
	22.5	45.0	27.0	22.5	30	27.0	45.0	15.0

10.5.5.4 Westinghouse Electric Corporation

Comments by the manufacturer:

Assuming average ambient of 30ºC, the continuous thermal rating of auxiliary current transformers, as shown in PB44-132, and the maximum continuous current shown in PB44-128 for type A autotransformer can be multiplied by a factor of 2.0 for 15 minute emergency operation and 1.12 for 4 hour emergency operation without exceeding 0.1 percent loss of life.

10.5.6 Winter Emergency

Table 24

	Winter			Summer				
		Emergency			Emergency			
Relay Type	**Normal**	**15 Min.**	**4 Hrs.**	**Normal**	**15 Min.**	**12 Hrs.**	**DAL**	**Notes**
Normal								
Westinghouse Corporation								
Auxiliary Current Transformer								
Basis for Table								
Normal = Rating Factor x Normal								
15 Min. = 2.0 x Normal								
4 Hrs. = 1.12 x Normal								
DAL = 2.0 x Normal								Multi-Ratio
	1	2	1.12	1	2	1.12	2	.5a Winding
	2	4	2.2	2	4	2.2	4	1.0
	4	8	4.5	4	8	4.5	8	2.0
	6	12	6.7	6	12	6.7	12	3.0
	7	14	7.8	7	14	7.8	14	4.0
	8	16	9.0	8	16	9.0	16	4.62
	8.4	16.8	9.4	8.4	16.8	9.4	16.8	4.8
	7.5	15	8.4	7.5	15	8.4	15	5.0
	9.32	18.6	10.4	9.32	18.6	10.4	18.6	5.33
	12	24	13.4	12	24	13.4	24	6.0
	9.6	19.2	10.8	9.6	19.2	10.8	19.2	6.4
	9.37	18.7	10.5	9.37	18.7	10.5	18.7	7.5
	14	28	15.9	14	28	15.9	28	8.0

Relay Type	Winter			Summer			DAL	Notes
		Emergency			Emergency			
	Normal	15 Min.	4 Hrs.	Normal	15 Min.	12 Hrs.		
	15	30	16.8	15	30	16.8	30	10.0
	13.3	26.6	14.9	13.3	26.6	14.9	26.6	10.66
	20.0	40	22.4	20	40	22.4	.40	16.0
	25	50	28.0	25	50	28	50	20.0
	40	80	44.8	40	80	44.8	80	32.0
								Single Ratio
	6.65	13.3	7.5	6.65	13.3	7.5	13.3	5a Winding
	13.3	26.6	14.9	13.3	26.6	14.9	26.6	10
	20.0	40	22.4	20	40	22.4	40	15
						Current Balancing Autotransformer 600VA		
	3.57	7.14	4.0	3.57	7.14	4.0	7.14	3.57a Winding
	5.8	11.6	6.5	5.8	11.6	6.5	11.6	5.8
	5.0	10.0	5.6	5.0	10.0	5.6	10.0	5.0
	10.8	21.6	12.1	10.8	21.6	12.1	21.6	10.8
								100kVA
	5	10	5.6	5	10	5.6	10	5a Winding
	10.8	21.6	12.1	10.8	21.6	12.1	21.6	10.8

11.0 OVERHEAD CONDUCTOR RATING PROCEDURES

The System Design Task Force Of the New England Planning Committee

11.1 Foreword

The capacity rating calculation procedures set forth for Overhead Conductors are recommendations by the System Design Task Force for use by each New England company. They are designed to achieve uniformity in approach and it is hoped that all companies will decide to use them as presented. In the case of intercompany tie lines, the companies involved shall adopt a single set of ratings.

In applying any rating procedure, care must be used in deciding on parameters such a ambient air temperature and wind velocity. The Task Force recommends the use of wind and ambient temperature as follows:

Summer – April 1 to October 31 - 100°F 3 ft. per second

Winter – November 1 to March 31 - 50°F 3 ft. per second

These recommended values are discussed in SDTF-20 "Analysis of Wind Temperature Data and Their Effect on Current Carrying Capacity of Overhead Conductors."

It must be recognized that at any given moment temperature and wind conditions will almost certainly be different from the above; therefore, the use of rating based on the above must be clearly defined. It is the Task Force's understanding that ratings arrived at by application of these procedures and parameters will be used as alarm points in the system dispatch computers. It is further understood that on receiving and alarm for a particular line, the satellite dispatcher may either contact the operating company or companies involved and ask for a revised rating based on atmospheric conditions existing at the time of the required emergency loading or consult data supplied to him by the operating companies.

If a company chooses to apply probability calculations and use different atmospheric parameters, it is likely that the alarm point ratings will be the actual ratings to be used to limit line loadings irrespective of ambient conditions at the time.

11.2 Recommendations

Bearing in mind that the recommendations are guidelines, the following proposals are presented:

1. Normal and Long-Time Emergency conductor ratings should be obtained by use of New England Electric System Computer Program PG92 titled "Current Carrying Capacity of Overhead Conductors."

2. Drastic Action Limit and Short-Time Emergency rating (15 minute) may be found using the NEES Computer Program PG108, "Transient Overhead Conductor Temperature Calculations." Seventy-five percent of the clearance limited circuit rating will be assumed as the pre-disturbance loading for the calculation of the Drastic Action Limit.

3. Input parameters for conductor diameter, wind velocity, emissivity factor, ambient temperature, and conductor resistance should be as specified or obtained by methods specified herein.

4. Equation constants used in the rating program should be as specified herein.

5. Input parameters for conductor temperatures are left to the discretion of each company using this procedure, but the final conductor temperature must not be less than 100°C for any rating except for certain older existing circuits.

6. Conductor ratings to be developed by individual companies should include:
    a. Summer normal
    b. Summer 12-hour emergency
    c. Summer 15-minute emergency
    d. Summer Drastic Action Limit

e. Winter normal

f. Winter 4-hour emergency

g. Winter 15-minute emergency

h. Winter Drastic Action Limit

The basic method of ampacity calculation employed by New England Electric System PG92 and PG108 is outlined in a 1958 AIEE paper titled "Current Carrying Capacity of ACSR" by H. E. House and P D. Tuttle and in the "ALOCA Conductor Engineering Handbook." Section 6.

The following values for equation parameters are recommended by the System Design Task Force:

Table 25

Parameter	Parameter Name	Recommended Value
D	Conductor Diameter	NA
E	Emissivity Factor	0.75
R_{25}	Conductor Resistance	NA
T_a	Ambient Temperature	100°F Summer 50°F Winter
T_c	Conductor Temperature	NA
V	Wind Velocity	3.0 fps

Internal program parameters such as solar effect constants are described in the Section 11.5.

11.3 Example

Given the following parameters for a 795 kcmil ACSR transmission line:

R_{25} = 0.119 ohms/mile = 0.0000225 ohms/foot

D = 1.093 inches

e = 0.75

For the purpose of this rating, the following meteorological conditions are used:

V = 2 feet/second

T_a = 100°F (summer ambient)

Because of a sag limitation, we will assume that the conductor has a maximum temperature of 140°C = T_c.

Calculation of Solar Heating Effect

Summer equation

Q_s = 5.59 D

= 5.59 (1.093) = 6.12 watts/foot

Calculation of Heat Dissipated by Radiation

$W_r = 13.81 \times 10^{-10} \times D \times e \times (T_C^4 - T_A^4)$

T_c = 140°C + 273 = 413°K

T_a = 100°F = 310.78°K

$W_r = (13.81 \times 10^{-10})\,(1.093)(0.75)(413^4 - 310.78^4) = 22.32$ watts/foot

Calculation of Heat Dissipated by Convection

$$W_c = 0.2688\ (1.093)^{.6}\ (2)^{.6}\ (102.22) = 43.94 \text{ watts/foot}$$

$$t_r = T_c - T_a \text{ in °C} - 140 - 37.78 = 102.22$$

$$W_c = 0.2688\ (1.093)^{.6}\ (2)^{.6}\ (102.22) = 43.94 \text{ watts/foot}$$

Resistance

$$R_o = \frac{(T_c + 228)\ R_{25}}{(253)} = \frac{(140 + 228)\ (.0000225)}{253}$$

$$= 0.000033 \text{ ohms/foot}$$

Current Carrying Capacity

$$I = \sqrt{\frac{W_c + W_r - Q_s}{R_o}}$$

$$= \sqrt{\frac{43.94 + 22.32 - 6.12}{0.000033}} = 1350 \text{ amperes}$$

11.4 Rating Limitations

Conductor ratings are limited by two main factors. These are sag and loss of life. In any particular line, one of these two factors will be dominant in limiting the conductor rating.

In the case where sag is the limiting factor, the effects of reduced ground clearances due to increased sag and/or creep at the higher temperatures have to be considered. Creep can cause permanent increased conductor sags and is defined as the non-elastic deformation or flow of material, which occurs with time under load, and after the initial deformation, which results from application of load. The rate of creep at any instance of time depends upon the tension and temperature at the particular instance in time. A more extensive study on creep should be considered. The determination of these limitations and final conductor temperatures should be made by each individual company. After the final conductor temperature (Tc) is determined, this temperature can then be used in the computer program PG92 to determine the line's ampacity rating. In the sag-limited case, variation of the ambient conditions can provide multiple ratings.

When loss of life or loss of strength is the limiting factor in line rating, the establishment of a particular conductor rating becomes somewhat more difficult. Loss of strength is directly related to annealing and the rate of annealing depends on conductor temperature and time. A line loading probability method may be refined and more widely utilized in New England to compute annealing after more meteorological data on temperature and wind are obtained and then a more extensive study should fie considered. In rating a conductor on the basis of loss of strength, the objective should be to produce a certain maximum allowable 1oss of strength over the chronological life of the conductor. Multiple ratings could be obtained because of varying ambient conditions and/or by varying loss of ultimate strength at normal and emergency conditions. Each individual company should decide, based on its own policies, what the maximum strength losses should be.

11.5 Conductor Rating Parameters

* Wind velocity: 3 fps (for both summer and winter)

	Summer	Winter
* Ambient temperature	100ºF	50ºF
* Conductor ratings:	Normal	Normal

STE (15 min)	STE (15 min)
LTE (12 hr)	LTE (4 hr)
DAL (5 min)	DAL (5 min)

* Conductor temperature

Table 26

	69 kV	115 kV	345 kV
Norm.	80ºC	80ºC	100ºC
LTE	100ºC	100ºC	120ºC
STE & DAL	120ºC	120ºC	140ºC

* Other associated parameters:

Conductor Diameter	-	
Conductor Resistance	-	
Solar Effect	2.41 (Win.)	5.50 (Sum.)
Emissivity Factor	0.75	