ANSI/IEEE C37.24-1986
(Revision of ANSI/IEEE C37.24-1971)

IEEE Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear

Sponsor
Switchgear Committee
of the
IEEE Power Engineering Society

Approved September 18, 1986
Reaffirmed December 5, 1991

IEEE Standards Board

Approved October 21, 1988
Reaffirmed May 20, 1992

American National Standards Institute

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Foreword

(This Foreword is not a part of Draft ANSI/IEEE C37.24-1986, IEEE Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear.)

This guide originated as a technical paper at the AIEE Winter general meeting in New York, NY, Jan 18–22, 1954. In October 1955, it was issued by AIEE Standards Committee as Publication 955. Subsequent document revision in 1962 included a 3000 A ratings and updating of the temperature data from the National Oceanic and Atmospheric Administration.

This revision of the guide reflects the references to the new standards, ANSI/IEEE C37.20.1-1987, C37.20.2-1987, and C37.20.3-1987 as well as the most recent monthly normal maximum temperatures of the United States; and Canada (1951–1980). A new section, 7, has been written that discusses color and finish of the metal-enclosed switchgear and their impact on temperature due to solar radiation.

The revision on this document was prepared by a working group within the Switchgear Assemblies Subcommittee of the Switchgear Committee of the Power Engineering Society of IEEE.

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IEEE Guide for Evaluating the Effect of Solar Radiation on Outdoor Metal-Enclosed Switchgear

1. Introduction and References

1.1 Introduction

Outdoor metal-enclosed low-voltage power circuit breaker switchgear, outdoor metal-clad switchgear, and outdoor metal-enclosed interrupter switchgear have reached a position of widespread application comparable to that of indoor switchgear. Outdoor switchgear has had a satisfactory operating record for many years in cold, temperate, and hot climates that has contributed to this increased usage. However, there are conditions affecting its application that are different from those for indoor switchgear and warrant special consideration.

This was realized and a study of the situation for metal-enclosed switchgear was undertaken by the Switchgear Assemblies Subcommittee. It was first determined that temperature data were not available on fully loaded units in the field. Outdoor laboratory and field testing was then tried, and it became evident, due to uncontrollable conditions, that accurate and complete data suitable for establishing the current-carrying capability of outdoor metal-enclosed switchgear could not be obtained. Next, indoor testing simulating outdoor conditions was resorted to. Further valuable data were accumulated, but there was still no absolute relationship between results obtained indoors and conditions existing outdoors. However, based on these investigations, sufficient data are now available for the preparation of a guide for using outdoor metal-enclosed switchgear in various climates.

1.2 References

The following publications shall be used in conjunction with this standard:

[1] ANSI/IEEE C37.20.1-1987, IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.[1]

[2] ANSI/IEEE C37.20.2-1987, IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear.

[3] ANSI/IEEE C37.20.3-1987, IEEE Standard for Metal-Enclosed Interrupter Switchgear.

[1]ANSI/IEEE publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, or from the Service Center, Institute of Electrical and Electronics Engineers, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331.

2. Scope

The general information in this guide is applicable to all forms of outdoor metal-enclosed switchgear. Specific data are given in Fig 2 for outdoor metal-enclosed low-voltage power circuit breaker switchgear, outdoor metal-clad switchgear, and outdoor metal-enclosed interrupter switchgear.

3. Purpose

Switchgear will perform satisfactorily and have a reasonable life when operated within the temperature limits established in ANSI/IEEE C37.20.1-1987 [1],[2] C37.20.2-1987 [2], and C37.20.3-1987 [3]. In outdoor applications, the limiting temperatures result from the net effect of internal losses and external influences, principally the sun, wind, and local ambient temperatures. All of these must be considered in determining the current-carrying capacity of outdoor metal-enclosed switchgear.

ANSI/IEEE C37.20.1-1987 [1], C37.20.2-1987 [2], and C37.20.3-1987 [3] specify the temperature rise above a standard ambient temperature of 40 °C. This is satisfactory for indoor applications where the temperature rise is due entirely to heat release. However, when the gear is located outdoors, several additional factors require consideration. The effect of sun, wind, ventilation, ambient temperature, etc, on internal temperatures will be considered in this guide.

The magnitude of these factors will vary geographically and from season to season. The time relationship of maximum circuit loads with respect to maximum ambient temperature is important. It is not practical to design switchgear on the basis that all adverse factors reach their maxima coincident with maximum loads. If this does not occur, full current ratings may be realized. Recommendations will be made to point out the cumulative effect of these various influences.

4. Operating Limitations

Temperature limitations for metal-enclosed switchgear are established at a value that will ensure satisfactory life of the insulation. Operation at higher temperatures than permitted by the appropriate standard will result in shortened life, but if the temperature of the insulation goes above normal for a few hours during a few days of the year, the effect on total life is hardly measurable. This is very different from the establishment of higher short-duration ratings that might be repetitive on a day-to-day basis. The hazard of immediate breakdown is not increased unless extreme temperatures are reached.

Outdoor metal-enclosed switchgear is usually designed with more restricted ventilation than indoor switchgear with the object of excluding wind-blown dust and dirt. The effect of this is a tendency toward somewhat increased internal temperatures of outdoor switchgear compared to indoor installations with equivalent circuit breakers and buses. These conditions have been recognized in designs. With this restricted ventilation, the effect of solar radiation on an enclosure will cause the air immediately under the roof to be relatively warm. Electrical parts, therefore, located near the roof will be operated in air considerably warmer than that surrounding equipment in the center or lower portion of the switchgear units. Cable insulation of certain types cannot be operated in as high air temperatures as others. If cables are located in the upper part of housings, insulation with appropriate thermal characteristics should be selected. ANSI/IEEE C37.20.1-1987 [1], C37.20.2-1987 [2], and C37.20.3-1987 [3] state in effect that the temperature of the air surrounding outgoing insulated cables in any compartment shall not exceed 65 °C with a maximum average ambient temperature of 40 °C outside the structure based on the use of 90 °C insulated power cables. Use of lower temperature rated cables requires special consideration. In many cases the effect of solar radiation alone will raise the

[2]The numbers in square brackets correspond to those of the references listed in 1.2 of this standard; when preceded by a “B,” they correspond to those documents listed in Section 11., Bibliography.

inside temperature above that permitted by the appropriate standard. The insulation and size of conductors in this location should be carefully considered by both manufacturers and users.

End units, particularly those exposed to the sun during periods of heavy load, should be considered on a different basis from the others in determining loading, conductor sizes, and cable insulation.

In addition to the effect on insulation, high internal air temperatures will increase the total temperature of the conducting parts. If circuit breakers are properly maintained, no adverse effects will result if their temperatures exceed allowable limits by a few degrees for short intervals during a few days of the year. All primary connections in metal-enclosed switchgear are silver surfaced, or the equivalent, and no trouble should be experienced with them if rated temperatures are exceeded under similar conditions. Here again it is important to realize the difference between increased temperatures due to outside influences that occur infrequently as compared to higher short-duration ratings that might be repetitive on a daily basis.

Caution must be used, however, in the application of temperature sensitive devices, such as devices with solid-state components, in outdoor metal-enclosed switchgear. Accelerated component aging and device failure can result from increased temperatures that occur infrequently. Maximum temperature limitations for temperature-sensitive devices should be determined, and those temperature limitations should be considered during equipment design.

5. External Influences on Internal Operating Temperatures

5.1 Ambient Temperatures

The ambient temperature surrounding switchgear is the base to which the temperature rise of insulation and electric parts is added. At rated current, the conducting parts have an established temperature rise above the outside air. If the temperature of this air is lower, the total temperature of the electric parts will be correspondingly reduced. In all test work, measurements are made with the ambient temperatures determined by the methods established in ANSI/IEEE C37.20.1-1987 [1], C37.20.2-1987 [2], and C37.20.3-1987 [3], and the thermal performance of the equipment is based on the temperature rise above these ambient temperatures. Outdoor ambient temperatures vary widely in most localities over a 24 h period and provide a varying influence on the internal temperatures of switchgear. Under the more stable conditions affecting indoor applications, it is possible to establish a reasonably accurate relationship between ambient temperatures and the temperature rise of electrical equipment. However, with the changing conditions that exist outdoors, it was found that it was impossible to get test data sufficiently accurate and consistent for use in establishing the current-carrying capability of switchgear. The establishment of ambient temperatures over a considerable period of time, as would be necessary to fix a value to be used for determining the loading of switchgear, is a rather lengthy procedure. Readings of ambient temperature should be taken in standard US Weather Bureau enclosures. The construction of these can be obtained from any US Weather Bureau Station. The housing for the thermometer should be located in a position that will expose it to air of about the same temperature as that around the switchgear. In outdoor locations there is no significant variation with respect to the top, middle, or bottom of the structure. However, the thermometer should not be affected by heat reflection from the ground.

The US Weather Bureau, in [B16] , covers data taken or adjusted to a standard time period of 30 years from 1951 to 1980, inclusive. These data were obtained from Weather Bureau Stations in the United States, Hawaii, Alaska, the West Indies, and Pacific Islands and are believed to be the best information available for determining reference temperatures for the purpose of this guide (see Table 3). The monthly normal maximum temperatures are given for each month of the year. The monthly normal maximum temperature for the month of July, for example, is computed by adding the maximum temperature for each day in July in a particular year and dividing the sum by the number of days. This provides the monthly normal maximum temperature for July of that year. The yearly temperatures for that month are averaged to provide the figure shown in the tabulation. It is recognized that an average obtained in this way may be lower than an average based on some particular shorter period of time. Table 4 provides monthly normal maximum temperatures for Canada.

The absolute maximum temperature for a particular month (available in other US Weather Bureau records), is the maximum temperature that has ever been reached in a particular locality. Ordinarily such extremes of temperature would occur for only a few hours on one day over a period of several years. It does not seem feasible to design and apply switchgear on this basis and, therefore, the monthly normal maximum temperatures are recommended for determining the continuous current-carrying capacity of outdoor metal-enclosed switchgear in the locality where it is to be installed and operated. An examination of this tabulation will show that in the hot months of the year the 40 °C (104 °F) standard ambient temperature was exceeded only in Arizona, California, and Nevada. In most localities the monthly normal maximum temperature is considerably below 40 °C (104 °F), leaving a margin that should help to offset some of the adverse factors caused by higher temperature and that should provide longer than normal insulation life.

There are many Weather Bureau Stations where long-time records of those monthly normal maximum temperatures are available in addition to those listed in this guide. Where such additional local Weather Bureau data can be obtained, a check should be made to be sure that the temperature data used for determining current-carrying capacity are representative of the conditions where the outdoor metal-enclosed switchgear will be installed and operated.

5.2 Solar Radiation

The most important source of heat in outdoor metal-enclosed switchgear, aside from electrical losses within the gear itself, is the effect of solar radiation. The intensity (flux density) of solar radiation on a surface normal to the sun's rays, beyond the earth's atmosphere, and at the mean earth-sun distance is termed the *solar constant*. Its value approximates 124 W/ft^2 (1334 W/m^2). In passing through the earth's atmosphere, the sun's radiation is scattered and absorbed by dust, gas molecules, ozone, and water vapor. The extent of this depletion at any given time depends upon the composition of the atmosphere and the length of the path through the atmosphere that the sun's rays must travel. Thus, the irradiance at a given point on the earth's surface depends on this depletion as well as on the deviation from the mean earth-sun distance, the declination of the earth's axis, the time of year, the time of day, and the latitude of the given point.

For example, records at Santa Fe, New Mexico, and Mt Whitney, California, representative of high and dry locations where depletion should be minimal, show magnitudes of 106 and 111 W/ft^2, respectively. Tests made during the last two weeks of June at State College, Pennsylvania, and at Columbus, Ohio, indicate that a maximum of approximately 97 W/ft^2 is reached at these two locations. The value varies from zero at sunrise approximately sinusoidally to a maximum at noon (solar time), and diminishes to zero at sunset. Figure 1 shows the measured maximum, irradiation at these two locations and also a curve indicating what this irradiation would be if the increase and decrease during the day were exactly sinusoidal. The average irradiation at both locations was considerably below the maximum values shown in Fig 1. However, in other localities, particularly in the West, full values of irradiation may be an almost daily occurrence in the summer.

A value of 97 W/ft^2 was chosen as a practical value representative of areas in which the majority of outdoor metal-enclosed switchgear will be installed. Indoor tests were made with this value of irradiation simulated by banks of infrared lamps. These lamps were selected from a practical standpoint, but they are not entirely satisfactory since their emission does not contain the entire spectrum of solar radiation. The indoor tests did take into account the additional horizontal component of irradiation on a southern-exposed vertical surface, which approximated 29 W/ft^2 at 40 ° north latitude at the time of the field measurements.

On the basis of field measurements, indoor tests, and calculated data that were accumulated during this study on outdoor metal-enclosed switchgear, it was established that the maximum temperature rise of the conducting parts due to solar radiation alone is about 15 °C (27 °F).

5.3 Wind Influence

It is estimated that a 10 mi/h (4.5 m/s) wind would totally offset the heating effect of the noonday sun. However, switchgear structures vary so much in shape and relative amount of exposed surface that no accurate figure can be given. The effect of air movement as low as 3 mi/h (1.3 m/s) would be significant, and values in this range are recognized as having a cooling effect on transmission line conductors. However, since there may be localities where the wind velocity is very low and no accurate data are available, it is recommended that no consideration be given to the effect of wind in cooling switchgear.

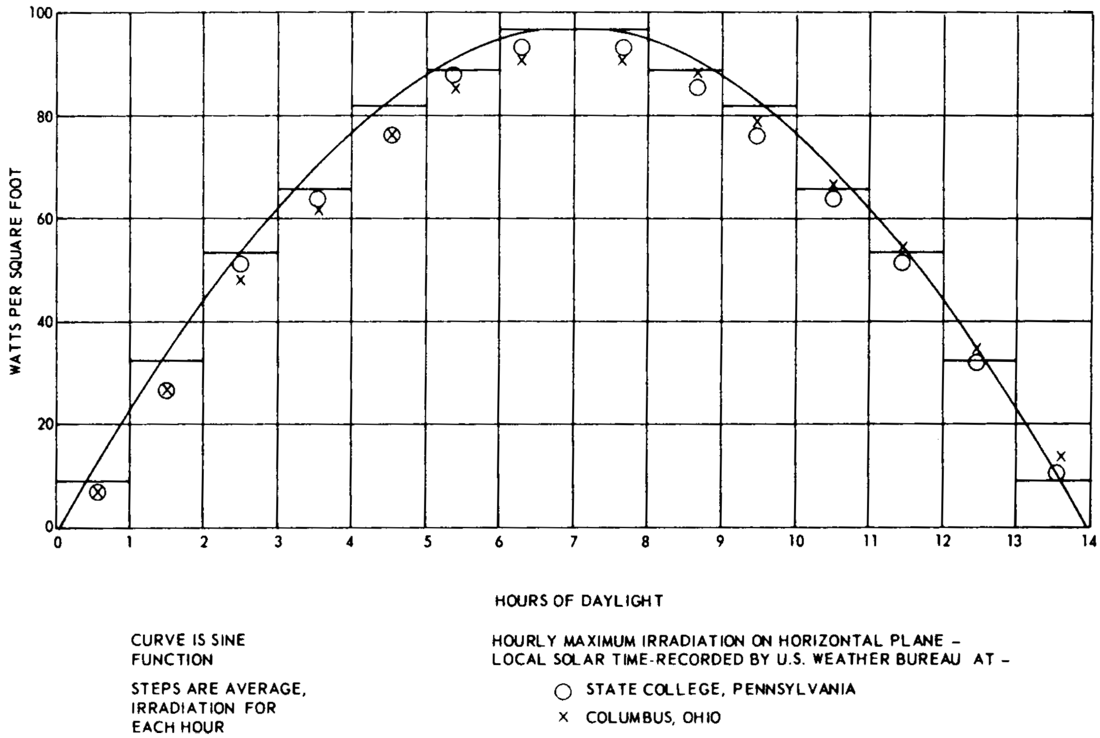

Figure 1— Relation Between Recorded Data for Solar Irradiation on a Horizontal Surface and a Sine Function Curve

6. Ventilation and Condensation Control

Ventilation of outdoor switchgear is usually more restricted than that for indoor switchgear because it is desirable to provide filters to exclude airborne dust and dirt. It is not desirable to seal switchgear units tightly because moisture condensation may occur on the electrical parts and insulation. Some form of heat is also necessary to keep the internal air above the dew point. Electrical losses when appreciable loads are being carried on the circuits would usually be adequate, but the automatic means required to recognize this source of heat and turn off the heaters have not been used consistently. A large percentage of outdoor switchgear units are equipped with heaters under manual control. However, thermostats, humidistats, and differential thermostats have all been used. Theoretically, the use of the latter is one of the better approaches to the problem, but differential thermostats operating on the small heat differential provided by the usual heater installation may not be entirely satisfactory or reliable. If heaters are used in the hotter parts of the country in the months when maximum temperatures are reached and the application requires that switchgear be operated very near to full load, it may be desirable to use current-responsive relays to turn them off. This would result in a 2–3 °C decrease in internal air temperature.

7. Enclosure Color and Finish Considerations

The exterior color and finish of outdoor switchgear enclosures can have a significant impact on the heating effect of solar radiation. Since light-colored paints absorb and radiate heat from low temperature (below 200 °C) sources, as well as do dark-colored paints, the interior and exterior enclosure color has little impact on the thermal performance of the enclosure for heat generated by the electrical equipment within. Light-colored paints will radiate heat generated from internal equipment loading as effectively as will dark-colored paints. However, since light-colored paints absorb heat from high temperature (above 1500 °C, which includes solar radiation) sources at a lower rate than dark-colored paints, the exterior enclosure color has a significant impact on interior temperature rise due to solar radiation. Light-colored paints will absorb less solar radiation than will dark-colored paints, and the resulting maximum internal temperature rise due to solar radiation will be reduced.

Metallic and reflecting paints and finishes absorb and radiate heat generated from both low-temperature and high-temperature sources at a low rate. They will usually not materially reduce internal temperatures because, while they keep radiated energy out, they also keep heat from internal losses in. These effects largely cancel each other when the switchgear is fully loaded.

Table 1 lists several representative colors and their approximate solar radiation absorption coefficients. Since the heating effect due to solar radiation for different colors varies directly as the ratio of their solar radiation absorption coefficients, the maximum temperature rise of conducting parts due to solar radiation alone also varies directly as a ratio of their coefficients. Black and dark colors have the highest absorption coefficients, and enclosures painted those colors exhibit the maximum temperature rise of 15 °C (27 °F). With the coefficient for black of 0.97, and the coefficient for white of 0.14, the corresponding maximum temperature rise for a white-painted enclosure would be:

$$\frac{0.14}{0.97} \cdot 15°\text{C} = 2.2°\text{C}\ (4°\text{F})$$

The associated derating temperature threshold for a white-painted enclosure would be:

40 °C – 2.2 °C = 37.8 °C (100 °F)

compared to 25 °C (77 °F) for a black or dark-painted enclosure.

Table 1— Approximate Solar Radiation Absorption Coefficients (According to Paint Color)

Paint Color	Approximate Solar Radiation Absorption Coefficient
White	0.14
Cream	0.25
Yellow	0.30
Light Grey, Blue, Green	0.50
Medium Grey, Blue, Green	0.75
Dark Grey, Blue, Green	0.95
Black	0.97

Paint color, however, is not the only factor to consider when establishing a temperature rise due to solar radiation. An accurate solar radiation coefficient must be determined for the paint color used because there can be a wide variation in coefficients, even when the colors appear visually identical. Table 1 lists approximate values only. Paint color durability and paint adherence must be considered. For certain applications, surface accumulation of dust and soot may be as important a factor in the resulting temperature rise as enclosure color. The solar radiation absorption coefficient for acetylene soot is 0.99 and sufficient regular accumulations would negate any advantage gained from the application of light-colored paint. It is recommended that consideration be given to the effect of exterior color in reducing the 15 °C (27 °F) maximum temperature rise due to solar radiation only if all the above factors are addressed throughout the service life of the equipment.

8. Current-Carrying Capabilities of Switchgear

8.1 Metal-Clad Switchgear

The continuous current rating of metal-clad switchgear is based on a temperature rise above a 40 °C ambient temperature. The sum of the temperature rise and the 40 °C ambient temperature must not exceed the maximum total temperature limits as established by ANSI/IEEE C37.20.2-1987. When the ambient temperature exceeds 40 °C, it is necessary to decrease the continuous current loading in order to stay within the established maximum total temperature limits. Since the test and calculated data previously mentioned has established that solar radiation contributes a temperature rise of 15 °C to the conducting parts, a correction factor for the continuous current capability is required whenever the ambient temperature exceeds 25 °C. The curve in Fig 2 takes this into account. The values given on the horizontal scale are not temperatures that can be measured at any particular time, but are the 30-year monthly normal maximum temperatures. The values given on the vertical scale provide the continuous current capacity factor that should be multiplied by the rated continuous current for the metal-clad switchgear equipment to derive the allowable current-carrying capacity of the equipment.

For example, a 1200 A metal-clad switchgear equipment, operating outdoors and exposed to the effect of a typical solar cycle of 97 W/ft^2 maximum amplitude and in a 40 °C (104 °F) monthly normal maximum temperature, should not be loaded continuously above 1200 A · 0.84 = 1008 A. Likewise under the same conditions, a 2000 A metal-clad switchgear equipment should not be loaded above 2000 A · 0.84 = 1680 A, and a 3000 A equipment should not be loaded above 3000 A · 0.84 = 2520 A. However, at 25 °C (77 °F) all of these equipments can be loaded to their continuous current raings. This is further illustrated in the following examples in Table 2, which show monthly normal maximum temperatures of 25 °C (77 °F) and 40 °C (104 °F) as approximately the midsummer conditions encountered at Duluth, Minnesota, and Phoenix, Arizona, respectively.

Based on the Weather Bureau data, there are very few localities where the monthly normal maximum temperature is above 90 °F and a reference to the curve in Fig 2 indicates a relatively small reduction in the current-carrying capacity of the switchgear.

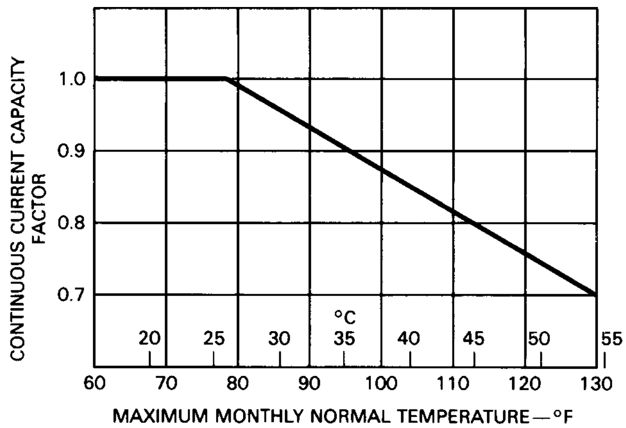

Figure 2— Current-Temperature Relationship for Outdoor Metal-Enclosed Switchgear (including the effect on a typical solar cycle of 97 W/ft^2 maximum amplitude, as shown in Fig 1 on standard switchgear units)

Table 2— Sample Calculations

	Duluth		Phoenix	
	°C	°F	°C	°F
Maximum limit of observed temperature (ANSI/IEEE C37.20.2-1987 [2])	105	221	105	221
Less the monthly normal maximum temperature	25	77	40	104
Less the temperature rise due to solar radiation	15	27	15	27
Allowable temperature rise of buses and connections due to switchgear losses	65	117	50	90

	Amperes	
Continuous current capacity of metal-clad switchgear under above conditions	1200	1008
	2000	1680
	3000	2520

8.2 Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

Outdoor enclosures for metal-enclosed low-voltage power circuit breaker switchgear are similar in size, shape, etc, to metal-clad switchgear. Therefore, the effects of solar radiation will, on an average basis, be similar. Figure 2 is based on a maximum temperature rise of 15 °C (27 °C) of the conducting parts due to solar radiation alone. The continuous current capacity factor from Fig 2 should be multiplied times the allowable cumulative loads for indoor equipment. The preferred values for allowable cumulative loads are stated in Table 11 of ANSI/IEEE C37.20.1-1987 [1]. For example, in Phoenix with a maximum monthly normal temperature of 40 °C (104 °F), the allowable cumulative loading for 4–1600 circuit breakers in a vertical section is 4500 A · 0.84 = 3780 A.

8.3 Metal-Enclosed Interrupter Switchgear

Outdoor enclosures for metal-enclosed interrupter switchgear are similar in size, shape, etc, to metal-clad switchgear. Therefore, the effects of solar radiation will, on an average basis, be similar. The continuous current capacity factor from Fig 2 should be multiplied by the rated continuous current of the metal-enclosed interrupter switchgear equipment to derive the allowable current-carrying capability of the switchgear equipment. For example, in Phoenix with a maximum monthly normal temperature of 40 °C (104 °C), the allowable cumulative loading for a 1200 A metal-enclosed switchgear equipment would be 1200 A · 0.84 = 1008 A.

9. Suggested Modifications of Standard Designs

Where the full current rating must be realized on outdoor metal-enclosed switchgear units, various methods can be used to reduce internal temperatures. Modifications that can be made vary with the designs of different manufacturers and therefore should be discussed with them.

Properly applied shading can be reasonably effective in reducing the air temperature in the top of the enclosure. The need for such construction is influenced by the relative location of the conductors. It should be realized that standard designs having conductors near the roof recognize these temperature conditions.

Shading the sides of units with southern exposures, such as the use of double walls with free air circulation between the sheets, will be helpful in controlling the internal temperatures. Shading should be considered only under the most adverse combination of high current and external heat. An increase of approximately 5% in current-carrying capability can be expected from this arrangement. This, of course, will vary with different designs of housings and should be checked with manufacturers.

Various types of thermal insulation are rather ineffective for the reason that they keep heat in as well as out.

Forced ventilation may also be used to keep the electrical parts within the allowable temperature limits of ANSI/IEEE C37.20.1-1987 [1], C37.20.2-1987 [2], and C37.20.3-1987 [3].

However, if a ventilation duct system is required, the installation of a suitable one may be expensive. Isolation between compartments should not be sacrificed. The ventilating equipment will require maintenance. Forced ventilation can also be helpful in unusual conditions where the standard breaker ratings may be less than the actual load current. Circulation of air within a cubicle may be effective in reducing the temperature near the top in some switchgear designs.

Specifying load and service conditions is the responsibility of the user/specifier, with the final equipment installation arrangement agreed to jointly between the user/specifier and the manufacturer to ensure a proper application throughout the service life of the equipment.

10. Conclusion

It has been pointed out that a maximum temperature rise of about 15 °C (27 °F) may be expected on the conducting parts in metal-enclosed switchgear due to solar radiation alone. Furthermore, where the switchgear is operated in a monthly normal maximum temperature above 25 °C (77 °F), as shown in Fig 2, its full rating may not be realized.

However, there are relatively few installations where full current ratings at maximum temperature are required. Where these conditions exist, remedial measures are suggested. The various problems associated with high temperatures and high currents have been pointed out. Satisfactory performance of outdoor metal-enclosed switchgear should be realized if it is applied and used as recommended in this guide.

Table 3— 30-Year Monthly Normal Maximum Temperature in Degrees Fahrenheit, United States

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Alabama												
Birmingham	52.7	57.3	65.2	75.2	81.6	87.9	90.3	89.7	84.6	74.8	63.7	55.9
Huntsville	49.4	53.9	61.9	73.0	79.9	86.8	89.4	89.2	83.5	73.4	61.6	53.0
Mobile	60.6	63.9	70.3	78.3	84.9	90.2	91.2	90.7	87.0	79.4	69.3	63.1
Montgomery	57.0	60.9	68.1	77.0	83.6	89.8	91.5	91.2	86.9	77.5	67.0	59.8
Alaska												
Anchorage	20.0	25.5	31.7	42.6	54.2	61.8	65.1	63.2	55.2	40.8	27.9	20.4
Barrow	–8.0	–13.8	–9.7	5.4	23.6	37.4	44.6	42.4	33.8	18.9	4.6	–7.0
Fairbanks	–3.9	7.3	21.7	40.8	59.2	70.1	71.8	66.5	54.4	32.6	12.4	–1.7
Nome	13.4	11.8	15.7	25.8	42.1	52.0	56.6	55.7	48.5	33.8	22.7	12.0
Arizona												
Flagstaff	41.7	44.5	48.6	57.1	66.7	77.6	81.9	78.9	74.1	63.7	51.0	43.6
Nogales	64.0	66.6	70.2	77.5	85.O	93.9	92.7	90.2	89.1	81.8	71.7	65.0
Pheonix	65.2	69.7	74.5	83.1	92.4	102.3	105.0	102.3	98.2	87.7	74.3	66.4
Prescott	50.3	54.1	57.7	65.4	74.0	84.7	88.7	85.2	81.5	71.9	59.5	51.8
Tombstone	61.2	64.0	68.4	76.7	85.1	94.5	93.4	90.5	88.4	80.3	68.9	61.4
Tuscon	64.1	67.4	71.8	80.1	88.8	98.5	98.5	95.9	93.5	84.1	72.2	65.0
Winslow	45.0	53.2	60.7	70.0	79.9	91.0	94.5	91.1	85.2	73.1	57.9	46.0
Yuma	68.6	73.9	78.5	85.7	93.6	102.9	106.8	105.3	101.4	90.9	77.4	69.1
Arkansas												
Fort Smith	48.4	53.8	62.5	73.7	81.0	88.5	93.6	92.9	85.7	75.9	61.9	52.1
Jonesboro	46.5	50.9	60.2	72.4	80.8	88.7	92.1	90.7	84.1	74.5	60.5	50.0
Little Rock	49.8	54.5	63.2	73.8	81.7	89.5	92.7	92.3	85.6	75.8	62.4	53.2
Pine Bluff	52.8	57.8	65.8	76.4	83.1	89.9	93.6	92.8	86.6	77.1	64.5	56.0
Texarkana	53.5	58.6	66.0	75.2	82.3	89.1	93.0	92.7	86.6	77.4	65.1	56.9
California												
Bakersfield	57.4	63.7	68.6	75.1	83.9	92.2	98.8	96.4	90.8	81.0	67.4	57.6
Bishop	52.9	58.2	63.4	70.9	80.2	90.4	97.5	95.2	88.2	77.1	63.5	55.1
Blue Canyon	43.5	44.9	45.3	51.3	60.3	69.2	77.7	76.5	72.4	62.8	51.4	46.3

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Blythe	67.6	73.4	78.7	86.5	94.8	104.0	108.7	106.5	102.2	90.7	76.5	67.8
Eureka	53.4	54.6	54.0	54.7	57.0	59.1	60.3	61.3	62.2	60.3	57.5	54.5
Fresno	54.2	61.2	66.5	73.7	82.7	91.1	97.9	95.5	90.3	79.9	65.2	54.4
Long Beach	66.0	67.3	68.0	70.9	73.4	77.4	83.0	83.8	82.5	78.4	72.7	67.4
Los Angeles	64.6	65.5	65.1	66.7	69.1	72.0	75.3	76.5	76.4	74.0	70.3	66.1
Mount Shasta	42.1	47.3	50.9	57.9	67.0	75.4	85.1	83.3	77.5	65.4	50.9	43.9
Oakland	54.5	58.3	60.1	62.6	65.2	68.5	70.6	71.1	72.8	69.4	61.8	55.4
Red Bluff	53.9	60.0	64.0	71.2	81.2	90.3	98.2	95.7	90.4	78.8	63.6	55.2
Sacramento	52.6	59.4	64.1	71.0	79.7	87.4	93.3	91.7	87.6	77.7	63.2	53.2
San Diego	65.2	66.4	65.9	67.8	68.6	71.3	75.6	77.6	76.8	74.6	69.9	66.1
San Francisco	55.5	59.0	60.6	63.0	66.3	69.6	71.0	71.8	73.4	70.0	62.7	56.3
Stockton	52.8	59.9	65.3	72.4	81.1	89.0	95.0	93.1	88.7	78.6	64.1	53.5
Colorado												
Alamosa	34.2	40.1	48.0	57.8	67.7	78.1	82.0	79.3	73.6	62.9	47.1	36.1
Colorado Springs	41.4	45.3	49.3	59.5	68.9	79.9	84.9	82.3	74.9	64.6	50.4	43.9
Cortez	40.3	45.7	52.5	62.4	72.4	83.5	88.9	86.0	79.1	67.7	52.2	42.1
Denver	43.1	46.9	51.2	61.0	70.7	81.6	88.0	85.8	77.5	66.8	52.4	46.1
Fort Collins	40.6	45.1	50.2	60.1	69.5	80.0	85.8	83.3	75.4	64.9	50.4	43.7
Grand Junction	35.7	44.5	54.1	65.2	76.2	87.9	94.0	90.3	81.9	68.7	51.0	38.7
Pueblo	45.2	50.7	55.9	66.5	76.0	87.3	92.2	89.5	81.6	70.7	55.7	48.3
Connecticut												
Bridgeport	36.5	37.9	45.5	57.2	67.1	76.4	82.1	81.1	74.5	64.5	52.8	41.0
Hartford	33.6	36.3	45.5	60.0	71.4	80.1	84.8	82.6	74.8	63.9	50.6	37.3
Delaware												
Dover	43.1	46.1	54.5	66.1	75.7	83.7	87.5	86.1	80.4	69.6	58.0	47.2
Lewes	43.1	45.0	52.5	63.4	71.8	80.1	84.2	83.2	77.5	67.3	57.5	47.4
Wilmington	39.2	41.8	50.9	63.0	72.7	81.2	85.6	84.1	77.8	66.7	54.8	43.6
Florida												
Apalachicola	60.5	62.4	68.0	75.1	81.7	86.6	88.0	88.0	85.3	78.2	69.2	63.0
Daytona Beach	68.4	69.3	74.6	80.0	84.8	87.8	89.6	89.0	86.9	81.2	74.8	69.8
Fort Myers	74.3	75.1	79.8	84.5	88.7	90.1	91.0	91.2	89.6	85.2	80.0	75.6

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Jacksonville	64.6	66.8	73.3	79.7	85.2	88.9	90.7	90.2	86.9	79.7	72.4	66.3
Key West	71.8	74.8	78.6	82.0	84.9	87.7	88.9	88.9	86.5	84.4	79.6	75.2
Lakeland	71.5	73.3	78.6	83.9	88.6	91.1	92.2	92.0	90.1	84.3	77.8	72.7
Miami	75.0	75.8	79.3	82.4	85.1	87.3	88.7	89.2	87.8	84.2	79.8	76.2
Orlando	71.7	72.9	78.3	83.6	88.3	90.6	91.7	91.6	89.7	84.4	78.2	73.1
Pensacola	60.6	63.6	69.2	76.7	83.7	89.0	90.1	89.6	86.6	79.7	69.4	63.2
Tallahassee	63.4	65.9	72.7	80.0	86.0	90.1	90.9	90.6	87.8	80.4	71.5	65.3
Tamoa	70.0	71.0	76.2	81.9	87.1	89.5	90.0	90.3	88.9	83.7	76.9	71.6
West Palm Beach	74.5	75.3	79.3	82.5	85.7	88.1	89.7	90.1	88.4	84.4	79.6	75.7
Georgia												
Athens	52.2	55.9	63.6	73.6	80.7	86.8	89.3	88.8	82.9	73.6	63.3	54.7
Atlanta	51.3	55.3	63.2	71.1	79.8	85.6	87.9	87.6	82.3	72.9	62.6	54.1
Augusta	56.7	60.1	67.6	76.8	83.7	89.1	91.4	90.9	85.6	76.9	67.9	59.2
Brunswick	64.1	66.3	72.5	79.1	85.2	89.1	91.6	91.0	87.3	79.9	72.4	65.6
Columbus	59.9	60.6	68.0	77.4	83.8	89.4	91.1	90.8	86.0	77.0	67.0	59.5
Macon	57.6	61.1	68.6	78.2	85.0	90.4	92.2	91.9	86.8	78.0	68.1	60.2
Savannah	60.3	63.1	69.9	77.8	84.2	88.6	90.8	90.1	85.6	77.8	69.5	62.5
Hawaii												
Hilo	79.5	79.0	79.0	79.7	81.0	82.5	82.8	83.3	83.6	83.0	80.9	70.5
Honolulu	79.9	80.4	81.4	82.7	84.8	86.2	87.1	88.3	88.2	86.7	83.9	81.4
Kahului	79.5	79.7	81.1	82.2	84.5	85.9	86.5	87.4	87.6	86.4	83.5	81.0
Kanoehe	77.1	76.8	77.1	78.2	79.7	81.3	81.9	82.6	83.0	82.1	79.6	78.0
Lihue	77.8	78.0	78.1	79.2	81.2	83.0	83.8	84.6	84.7	83.2	80.8	78.8
Idaho												
Boise	37.1	44.3	51.8	60.8	70.8	79.8	90.6	87.3	77.6	64.6	49.0	39.3
Idaho Falls	27.0	33.6	42.6	55.8	66.9	75.9	86.4	83.8	73.6	60.5	42.8	30.8
Lewiston	38.6	46.3	52.7	61.6	70.7	79.0	89.5	87.3	77.6	63.1	47.6	41.5
Pocatello	32.4	38.6	45.8	56.8	67.7	77.6	88.6	86.0	75.7	62.8	45.6	35.3
Illinois												
Cairo	41.9	46.8	56.4	69.2	78.5	87.0	89.8	87.9	81.4	70.9	56.6	46.3
Chicago	29.2	33.9	44.3	58.8	70.0	79.4	83.3	82.1	75.5	64.1	48.2	35.0

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Danville	34.4	39.5	50.2	64.8	75.2	84.1	86.9	85.0	79.6	67.7	51.9	39.6
Moline	28.0	33.7	44.8	61.1	72.5	82.1	85.4	83.6	76.2	64.8	48.0	34.3
Peoria	29.7	35.2	46.5	61.9	72.5	62.1	89.5	83.4	76.7	64.8	48.5	35.4
Rockford	26.6	31.8	42.5	58.5	70.6	80.1	83.7	81.9	74.6	63.0	46.3	32.6
Springfield	32.8	38.0	48.9	64.0	74.6	84.1	87.1	84.7	79.3	67.5	51.2	38.4
Waukegan	28.3	32.7	41.9	55.7	67.4	77.1	81.4	80.1	73.3	62.3	47.2	34.1
Indiana												
Evansville	39.3	44.2	54.5	67.6	76.8	85.9	88.8	87.3	81.4	70.0	55.1	44.0
Fort Wayne	30.8	34.5	45.2	59.7	70.9	80.5	84.1	82.3	76.0	63.9	48.2	36.0
Gary	30.6	34.9	44.4	58.4	69.8	80.0	83.7	82.0	75.9	64.1	48.8	36.1
Indianapolis	34.2	38.5	49.3	63.1	73.4	82.3	85.2	83.7	77.9	66.1	50.8	39.2
Richmond	34.4	38.1	48.9	62.2	72.5	81.1	84.3	82.9	76.5	64.7	50.1	39.0
South Bend	30.4	34.1	44.3	58.6	69.9	79.5	82.7	81.0	74.6	63.1	47.8	35.7
Terre Haute	35.0	39.6	49.7	63.7	74.1	83.2	86.8	85.0	79.5	68.0	52.4	40.4
Iowa												
Davenport	28.6	34.2	44.5	60.3	72.1	81.5	85.0	83.2	75.8	64.7	47.9	34.7
Des Moines	27.0	33.2	44.2	61.0	72.6	81.8	86.2	84.0	75.7	65.0	47.6	33.7
Dubuque	23.7	29.6	40.6	57.3	69.0	78.1	82.0	80.0	72.1	61.1	44.2	30.2
Sioux City	26.0	33.0	43.5	61.5	73.1	82.0	86.5	84.2	75.4	64.9	46.9	32.7
Waterloo	23.2	29.5	40.5	58.2	70.5	80.1	83.4	81.6	73.4	62.3	44.7	30.1
Kansas												
Concordia	35.0	41.7	51.3	64.8	74.8	85.2	90.9	89.2	79.8	69.1	52.0	40.8
Dodge City	41.1	47.2	55.0	67.4	76.2	87.2	92.5	90.8	81.5	71.0	54.5	45.3
Goodland	40.6	45.6	51.1	63.2	72.8	84.4	90.6	88.2	79.2	68.0	51.6	43.4
Salina	37.8	44.6 1	53.8	66.5	76.1	87.0	92.7	91.3	81.4	70.6	53.9	43.0
Topeka	36.3	43.0	53.2	66.5	76.0	84.6	89.6	88.5	80.7	69.9	53.8	41.9
Wichita	39.8	46.1	55.8	68.1	77.1	87.4	92.9	91.5	82.0	71.2	55.1	44.6
Kentucky												
Bowling Green	43.1	47.6	57.1	69.3	78.2	86.0	89.2	88.3	82.3	70.8	56.9	47.6
Covington	37.3	41.2	51.5	64.5	74.2	82.3	85.8	84.8	78.7	66.7	52.6	41.9

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Lexington	39.8	43.7	53.7	65.8	74.9	82.6	85.9	85.0	79.3	67.6	54.1	44.4
Louisville	40.8	45.0	54.9	67.5	76.2	84.0	87.6	86.7	80.6	69.2	55.5	45.4
Owensboro	42.0	46.8	56.9	69.5	78.4	86.8	89.8	88.9	83.3	72.3	57.5	46.5
Louisiana												
Alexandria	59.1	63.0	70.2	78.1	84.7	90.8	92.9	92.8	88.3	80.4	69.6	62.2
Baton Rouge	61.1	64.5	71.6	79.2	85.2	90.6	91.4	90.8	87.4	80.1	70.1	63.8
Lake Charles	60.8	64.0	70.5	77.8	84.1	89.4	91.0	90.8	87.5	80.8	70.5	64.0
Monroe	54.9	59.8	67.3	76.6	83.9	90.7	92.7	92.0	87.0	78.7	66.5	58.5
New Orleans	61.8	64.6	71.2	78.6	84.5	89.5	90.7	90.2	86.8	79.4	70.1	64.4
Shreveport	55.8	60.6	68.1	76.7	83.5	90.1	93.3	93.2	87.7	78.9	66.8	59.2
Maine												
Bangor	27.1	29.1	38.1	50.7	63.4	72.8	77.9	76.4	67.8	56.6	44.2	31.0
Caribou	19.9	22.9	33.5	45.8	60.7	71.0	75.7	73.1	63.9	51.7	38.0	23.9
Houlton	22.9	26.0	36.2	48.4	63.4	72.9	77.8	75.2	66.1	54.2	40.2	26.6
Portland	31.0	33.1	40.5	52.5	63.4	72.8	78.9	77.5	69.6	59.0	47.1	34.9
Maryland												
Baltimore	41.0	43.7	53.1	65.1	74.2	82.9	87.1	85.5	79.1	67.7	55.9	45.1
Hagerstown	38.7	41.8	52.2	65.0	75.0	82.8	86.8	85.2	78.6	66.7	53.4	42.3
Massachusetts												
Blue Hill	33.5	35.3	43.1	55.7	66.7	75.2	80.7	78.7	70.9	60.9	49.2	37.4
Boston	36.4	37.7	45.0	56.6	67.0	76.6	81.8	79.8	72.3	62.5	51.6	40.3
Nantucket	38.2	37.8	43.0	51.0	59.9	68.5	74.9	74.9	69.5	61.2	52.1	42.9
New Bedford	38.3	39.4	46.2	56.4	66.2	75.2	80.8	80.0	73.2	63.9	53.0	42.3
Springfield	35.0	37.3	46.5	60.3	71.4	79.8	84.6	82.9	75.0	64.5	51.4	38.3
Worcester	30.9	32.9	41.1	54.5	65.9	74.4	79.0	77.0	69.4	59.3	46.9	34.7
Michigan												
Alpena	26.2	28.1	36.9	51.1	64.4	74.2	79.0	76.8	68.1	57.5	42.8	30.9
Benton Harbor	31.4	34.6	44.1	57.9	69.0	78.7	82.1	80.6	74.6	63.4	48.8	36.6
Detroit	30.6	33.5	43.4	57.7	69.4	79.0	83.1	81.5	74.4	62.5	47.6	35.4
Escanaba	23.7	26.5	34.5	46.6	58.5	68.7	75.0	73.2	64.8	54.4	41.0	29.3

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Grand Rapids	29.0	31.7	41.6	56.9	69.4	78.9	83.0	81.1	73.4	61.4	46.0	33.8
Houghton Lake	25.2	28.0	37.3	52.6	65.8	74.8	78.9	76.5	68.0	56.7	41.8	29.9
Lansing	29.0	31.7	41.7	56.8	69.1	78.5	82.6	80.9	73.2	61.3	46.3	34.0
Marquette	23.5	26.1	34.2	47.3	59.6	69.4	75.2	73.7	65.0	55.3	40.1	28.8
Muskegon	28.9	30.9	40.4	54.6	66.6	76.1	80.3	78.7	71.2	59.7	45.6	34.0
Saginaw	27.1	29.5	39.3	55.0	67.5	77.4	81.7	79.5	71.5	60.0	45.1	32.3
Sault Ste Marie	21.2.	23.1	32.3	47.1	61.0	70.1	75.1	73.4	64.2	53.6	39.0	26.6
Traverse City	26.3	28.1	37.4	52.9	66.0	76.2	80.7	78.5	69.7	58.5	43.6	31.6
Minnesota												
Duluth	15.5	21.7	31.9	47.6	61.3	70.5	76.4	73.6	63.6	53.0	35.2	21.8
International Falls	11.1	19.5	32.0	49.1	63.9	73.3	78.5	75.4	64.1	52.8	32.9	17.8
Minneapolis-St. Paul	19.9	26.4	37.5	56.0	69.4	78.5	83.4	80.9	71.0	59.7	41.1	26.7
Rochester	19.7	26.2	36.7	54.9	68.2	77.6	81.4	79.4	70.3	59.2	41.1	26.3
St. Cloud	17.4	24.5	35.8	54.1	68.3	76.9	81.8	79.2	69.0	58.0	38.8	24.2
Mississippi												
Biloxi City	60.6	63.3	69.1	76.5	83.1	88.6	90.2	89.9	86.7	79.6	69.8	63.6
Columbus	53.2	57.9	65.9	76.2	83.1	89.8	92.7	92.5	87.2	77.4	65.9	57.2
Greenville	53.1	58.6	66.5	76.6	83.9	90.4	92.7	91.8	86.8	78.1	65.6	57.1
Jackson	56.5	60.9	68.4	77.3	84.1	90.5	92.5	92.1	87.6	78.6	67.5	60.0
Meridian	56.7	61.1	68.6	77.7	84.2	90.4	92.5	92.1	87.2	77.8	67.3	60.0
Missouri												
Columbia	36.3	41.6	51.6	65.4	74.5	83.3	88.6	87.2	79.7	68.4	53.1	41.3
Jefferson City	40.9	46.4	56.4	69.9	77.9	85.8	90.9	89.8	82.7	71.6	56.7	45.4
Joplin	41.9	47.3	56.4	69.0	76.7	89.0	90.3	89.1	81.5	71.2	56.4	46.6
Kansas City	34.5	41.1	51.3	65.1	74.6	83.3	88.5	86.8	78.6	67.9	52.1	40.1
St. Louis	37.6	43.1	53.4	67.1	76.4	85.2	89.0	87.4	80.7	69.1	54.0	42.6
Springfield	42.2	47.1	56.1	68.3	76.5	84.9	89.8	89.3	81.6	70.8	56.2	46.4
Montana												
Billings	29.9	37.9	44.0	55.9	66.4	76.3	86.6	84.3	72.3	61.0	44.4	36.0
Butte	27.1	33.2	38.0	49.2	60.2	69.2	80.1	77.9	67.0	55.5	39.3	31.0
Glasgow	17.7	25.5	36.6	54.2	67.0	75.8	84.1	82.7	70.5	58.7	39.5	26.4

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Great Falls	28.2	36.5	41.7	54.0	65.3	74.3	84.2	82.0	70.5	59.5	43.5	34.7
Hayre	21.5	30.3	39.8	55.3	67.8	76.4	85.4	83.6	71.6	60.0	41.5	29.6
Helena	28.1	36.2	42.5	54.7	64.9	73.1	83.6	81.3	70.3	58.6	42.3	33.3
Miles City	24.3	35.6	42.6	57.1	69.2	79.2	88.9	86.6	73.8	61.3	42.7	31.5
Missoula	28.8	32.6	44.4	56.5	65.8	74.0	84.8	82.7	71.3	57.0	40.4	31.8
Nebraska												
Falls City	34.8	41.5	51.9	66.7	76.2	84.7	89.2	87.4	79.4	69.4	53.1	40.9
Grand Island	31.2	38.1	47.1	62.3	73.0	83.6	88.8	86.9	77.1	66.7	49.4	37.3
Lincoln	31.0	37.7	47.3	62.9	73.8	83.6	88.6	86.6	77.5	67.0	50.1	37.5
McCook	39.5	45.8	52.9	66.3	75.6	85.9	91.8	89.8	81.5	70.6	53.4	43.6
Norfolk	27.8	34.2	43.8	60.5	72.2	82.4	87.4	85.0	75.5	64.7	47.1	34.1
North Platte	34.2	40.5	47.8	61.5	71.5	81.6	87.8	86.4	77.3	66.7	49.4	39.3
Omaha	30.2	37.3	47.7	64.0	74.7	84.2	88.5	86.2	77.5	67.0	50.3	36.9
Scottbluff	37.2	43.4	48.8	60.3	70.8	81.7	89.2	86.7	77.5	66.0	49.8	40.8
Valentine	31.6	36.9	44.2	59.0	70.6	81.3	88.7	86.7	76.4	64.7	47.3	36.5
Nevada												
Elko	36.6	42.6	48.9	58.2	68.5	79.2	90.4	87.8	78.8	66.3	49.4	38.3
Ely	39.0	42.6	47.3	56.2	66.5	77.5	86.8	84.2	76.0	64.0	49.2	40.9
Las Vegas	56.0	62.4	68.3	77.2	87.4	98.6	104.5	101.9	94.7	81.5	66.0	57.1
Reno	44.8	51.1	55.8	63.3	72.3	81.8	91.3	88.7	81.4	70.0	55.6	46.2
Winnemucca	42.3	48.7	53.6	61.8	72.0	81.8	92.7	89.7	80.8	68.5	53.2	43.9
New Hampshire												
Concord	30.8	33.2	41.9	56.5	68.9	77.7	82.6	80.1	71.9	61.0	47.2	34.4
Durham	33.8	36.4	44.5	57.5	68.9	78.0	83.3	81.3	73.7	62.9	49.4	35.9
Keene	32.3	35.4	44.0	58.3	70.6	78.9	83.5	81.3	73.3	62.5	48.3	35.4
Lebanon	28.5	31.7	40.7	54.5	67.6	76.5	81.1	78.7	70.2	59.0	45.0	32.1
Mt. Washington	13.4	13.1	19.1	28.9	40.7	50.7	54.4	52.7	46.3	36.5	26.9	17.0
New Jersey												
Atlantic City	40.6	42.4	50.3	61.6	71.0	79.6	84.0	82.5	76.7	66.1	55.4	45.0
Newark	38.2	40.3	49.1	61.3	71.6	80.6	85.6	84.0	76.9	66.0	54.0	42.3
Trenton	38.3	40.5	49.1	61.7	71.5	80.5	84.9	83.2	76.1	65.2	53.6	42.4

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
New Mexico												
Albuquerque	47.2	52.9	60.7	70.6	79.9	90.6	92.8	89.4	83.0	71.7	57.2	48.0
Carlsbad	57.1	61.9	69.4	79.1	87.4	95.5	95.6	93.6	86.9	77.5	64.8	58.3
Clayton	47.4	50.6	56.3	65.9	74.5	84.4	87.8	85.6	78.4	69.2	55.8	49.6
Las Cruces	58.4	62.9	69.3	77.8	85.7	94.6	94.6	92.1	87.1	78.5	66.4	58.6
Roswell	55.4	60.4	67.7	76.9	85.0	93.1	93.7	91.3	84.9	75.8	63.1	56.7
New York												
Albany	30.2	32.7	42.5	57.6	69.5	78.3	83.2	80.7	72.8	61.5	47.8	34.6
Binghamton	28.0	29.6	38.7	53.5	64.9	73.9	78.4	76.4	68.9	57.6	44.4	32.4
Buffalo	30.0	31.4	40.4	54.4	65.9	75.6	80.2	78.2	71.4	60.2	47.0	35.0
Massena	24.4	26.7	37.1	52.7	67.0	76.0	80.6	78.0	69.6	58.0	43.4	28.9
New York	37.4	39.2	47.3	59.6	69.7	78.7	83.9	82.3	75.2	64.5	52.9	41.5
Patchogue	38.3	39.6	47.1	57.8	67.6	76.5	82.1	81.3	74.7	64.8	53.6	42.8
Rochester	30.8	32.2	41.2	56.0	67.7	77.7	82.3	80.1	72.8	61.5	48.0	35.5
Syracuse	30.6	32.2	41.4	56.2	67.9	77.2	81.6	79.6	72.3	60.9	47.9	35.3
Watertown	27.7	29.4	39.3	53.2	65.1	74.7	79.9	77.9	70.3	58.7	46.1	32.6
North Carolina												
Asheville	47.5	50.6	58.4	68.6	75.6	81.4	84.0	83.5	77.9	68.7	58.6	50.3
Cape Hatteras	52.6	53.5	58.8	67.2	74.1	80.5	84.4	84.4	80.5	71.7	63.6	56.4
Charlotte	50.3	53.6	61.6	72.1	79.1	85.2	88.3	87.6	81.7	71.7	61.7	52.6
Elizabeth City	50.5	52.6	59.8	69.9	76.8	83.6	87.3	86.4	81.2	71.4	62.6	53.9
Greensboro	47.6	50.8	59.3	70.7	77.9	84.2	87.4	86.2	80.4	70.1	59.9	50.4
Raleigh Durham	50.1	52.8	61.0	72.3	79.0	85.2	88.0	87.1	81.6	71.6	61.8	52.7
Wilmington	55.9	58.1	64.8	74.3	80.9	86.1	89.3	88.6	83.9	75.2	66.8	59.1
North Dakota												
Bismark	17.5	25.2	36.4	54.2	67.7	76.8	84.4	83.3	71.4	59.3	39.4	25.9
Dickinson	20.9	27.7	37.2	53.0	66.0	74.8	83.4	82.4	70.1	58.6	39.7	28.3
Fargo	13.7	20.5	33.2	52.5	68.1	76.9	82.7	81.1	69.8	57.7	37.0	21.3
Grand Forks	11.6	19.1	31.4	50.6	67.2	76.2	81.6	80.1	68.4	56.0	34.8	19.7
Minot	14.9	22.4	33.1	51.3	65.3	74.5	81.7	80.1	67.7	56.1	36.2	23.1
Williston	17.5	25.6	36.3	54.0	67.5	76.5	84.0	82.5	70.2	58.2	38.1	25.5

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Ohio												
Akron—Canton	32.9	32.6	45.8	59.2	69.8	78.7	82.3	80.9	74.3	62.6	48.9	37.5
Cincinnati	38.0	42.0	52.3	65.2	75.0	82.9	86.3	85.7	79.4	67.4	52.8	42.2
Cleveland	32.5	34.8	44.8	57.9	68.5	78.0	81.7	80.3	74.2	62.7	49.3	37.5
Columbus	34.7	38.1	49.3	62.3	72.6	81.3	84.4	83.0	76.9	65.0	50.7	39.4
Dayton	34.5	38.0	48.6	62.0	72.4	81.6	84.9	83.4	77.1	65.1	50.5	39.3
Mansfield	32.2	35.0	45.4	58.8	69.3	78.4	82.1	80.7	74.4	62.8	48.5	36.8
Sandusky	32.7	34.8	44.0	57.5	68.6	78.6	82.7	81.3	74.8	63.1	49.5	37.8
Toledo	30.7	34.0	44.6	59.1	70.5	79.9	83.4	81.8	75.1	63.3	47.9	35.5
Youngstown	31.4	33.8	44.0	57.9	68.6	77.5	81.2	79.8	73.2	61.4	47.7	36.0
Oklahoma												
Enid	45.9	52.1	61.4	72.4	80.6	90.3	95.6	94.4	85.7	75.3	59.3	49.7
Lawton	51.2	56.8	65.5	75.5	82.7	90.9	96.4	95.9	87.9	77.5	63.5	54.7
Muskogee	48.0	53.9	62.6	73.7	80.4	87.9	94.1	93.3	85.6	75.2	61.0	51.9
Oklahoma City	46.6	52.2	61.0	71.7	79.0	87.6	93.5	92.8	84.7	74.3	59.9	50.7
Tulsa	45.6	51.9	60.8	72.4	79.7	87.9	93.9	93.0	85.0	74.9	60.2	50.3
Oregon												
Astoria	46.8	50.6	51.9	55.5	60.2	63.9	67.9	68.6	67.8	61.4	53.5	48.8
Burns	37.3	44.0	47.1	55.9	65.2	74.0	84.4	81.9	74.2	62.1	46.6	36.8
Eugene	46.3	51.4	55.0	60.5	67.2	74.2	82.6	81.3	76.4	64.6	52.8	47.3
Medford	45.0	52.9	57.1	63.8	72.2	81.0	90.7	88.8	82.8	68.7	52.6	44.2
Ontario	36.7	45.2	55.7	66.1	76.4	85.8	96.4	93.2	92.8	67.6	49.8	38.8
Pendleton	39.4	46.9	53.4	61.4	70.6	79.6	88.9	85.9	77.1	63.7	48.7	42.5
Portland	44.3	50.4	54.5	60.2	66.9	72.7	79.5	78.6	74.2	63.9	52.3	46.4
Salem	45.7	51.1	54.6	60.3	67.3	73.9	82.2	81.2	76.2	64.5	52.6	47.0
Sexton Summit	39.9	43.0	44.4	51.0	59.3	66.9	75.8	74.3	69.6	58.6	46.8	41.6
Pennsylvania												
Allentown	34.9	37.8	47.6	61.0	71.1	80.1	84.6	82.4	75.3	64.2	51.3	39.2
Erie	30.9	32.2	41.1	53.7	64.6	74.0	78.2	77.0	71.0	60.1	47.1	35.7
Harrisburg	36.7	39.5	49.6	62.9	73.0	81.8	86.2	84.4	77.2	65.4	52.4	40.6
Philadelphia	38.6	41.1	50.5	63.2	73.0	81.7	86.1	84.6	77.8	66.5	54.1	43.0

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Pittsburgh	34.1	36.8	47.6	60.7	70.8	79.1	82.7	81.1	74.8	62.9	49.8	38.4
Slippery Rock	33.6	36.3	46.2	59.4	70.4	78.5	82.1	80.7	74.5	63.3	49.5	37.8
Wilkesbarre—Scranton	32.1	34.4	44.1	58.2	69.1	77.8	82.1	80.0	72.7	61.4	48.2	36.3
Williamsport	34.1	36.8	46.8	60.6	71.2	79.7	83.7	82.0	74.5	63.0	49.6	38.1
Rhode Island												
Block Island	37.2	36.9	42.8	51.8	60.7	69.8	76.0	75.8	69.7	60.8	51.5	41.9
Kingston	37.8	39.0	46.1	57.4	67.1	75.6	80.6	79.6	73.3	64.1	52.7	41.7
Providence	36.4	37.7	45.5	57.5	67.6	76.6	81.7	80.3	73.1	63.2	51.9	40.5
South Carolina												
Charleston	58.8	61.2	68.0	76.0	82.9	87.0	89.4	88.8	84.6	76.8	68.7	61.4
Columbia	56.2	59.5	67.1	77.0	83.8	89.2	91.9	91.0	85.5	76.5	67.1	58.8
South Dakota												
Aberdeen	18.9	26.1	37.9	56.5	69.6	78.6	85.3	84.4	73.4	61.3	41.0	26.5
Huron	21.9	28.6	39.4	57.7	70.2	80.3	87.3	85.5	74.7	62.2	43.2	29.0
Lemmon	22.3	29.2	38.2	54.0	66.8	76.0	83.9	82.8	71.1	59.3	40.7	29.3
Rapid City	32.4	37.4	44.2	57.0	68.1	77.9	86.5	85.7	75.4	63.2	46.7	37.4
Sioux Falls	22.9	29.3	40.1	58.1	70.5	80.3	86.2	83.9	73.5	62.1	43.7	29.3
Tennessee												
Bristol	44.5	48.4	57.6	68.3	76.3	82.9	85.5	85.2	80.4	69.5	57.3	48.1
Chattanooga	48.2	52.6	60.9	72.6	79.8	86.4	89.3	88.8	83.0	72.3	60.3	51.4
Kingsport	46.7	51.1	60.5	71.8	78.9	84.7	87.4	86.8	81.9	71.4	59.2	50.0
Knoxville	46.9	51.2	60.1	71.0	78.3	84.6	87.2	86.9	81.7	70.9	59.1	50.3
Memphis	48.3	53.0	61.4	72.9	81.0	88.4	91.5	90.3	84.3	74.5	61.4	52.3
Nashville	46.3	50.7	59.6	71.2	79.2	86.7	89.8	89.0	83.2	72.3	59.2	50.4
Oak Ridge	45.7	50.2	59.0	70.5	78.1	84.6	87.2	86.7	81.3	70.4	58.1	48.9
Texas												
Abiline	55.5	60.3	68.6	77.6	84.1	91.8	95.4	94.5	87.1	77.6	64.8	58.4
Amarillo	49.1	53.1	60.8	71.0	79.1	88.2	91.4	89.6	82.4	72.7	58.7	51.8
Austin	59.4	64.1	71.7	79.0	84.7	91.6	95.4	95.3	89.3	80.8	69.2	62.8
Brownsville	69.7	72.5	77.5	83.2	87.0	90.5	92.6	92.8	89.8	84.4	77.0	71.9

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Corpus Christi	66.5	69.9	76.1	82.1	86.7	91.2	94.2	94.1	90.1	83.9	75.1	69.3
Dallas	55.0	59.9	68.0	76.9	83.8	91.8	96.3	96.0	88.7	79.0	66.2	58.7
Del Rio	63.2	68.6	76.5	84.2	89.1	95.1	97.7	97.0	91.7	82.4	71.2	64.8
El Paso	57.9	62.7	69.6	78.7	87.1	95.9	95.3	93.0	87.5	78.5	65.7	58.2
Galveston	59.2	60.9	66.4	73.3	79.8	85.1	87.3	87.5	84.6	77.6	68.3	62.3
Lubbock	53.3	57.3	65.1	74.8	82.8	90.8	91.9	90.1	83.6	74.7	62.1	55.5
Midland	57.6	62.1	69.8	78.8	86.0	93.0	94.2	93.1	86.4	77.7	65.5	59.7
Port Arthur	61.7	65.4	71.8	78.5	85.0	90.5	92.5	92.2	88.6	81.5	71.4	65.0
San Angelo	58.7	63.3	71.5	80.2	86.3	93.4	96.5	95.4	88.0	79.2	67.2	61.2
San Antonio	61.7	66.3	73.7	80.3	85.5	91.8	94.9	94.6	89.3	81.5	70.7	64.6
Victoria	63.6	67.1	73.8	80.2	85.6	90.8	93.7	93.7	89.3	82.8	73.0	66.7
Waco	56.6	61.6	69.5	77.6	84.2	92.1	96.5	96.7	89.7	80.3	67.9	60.3
Wichita Falls	52.3	58.0	66.7	76.8	84.1	93.2	98.5	97.3	88.7	78.2	64.4	56.2
Utah												
Cedar City	42.1	46.6	52.4	61.2	71.6	83.3	90.1	87.3	79.9	67.8	52.7	43.9
Milford	39.4	45.3	52.7	62.2	73.1	84.8	92.9	89.9	81.2	67.8	51.5	41.5
Moab	41.8	50.9	60.8	71.2	81.9	92.7	99.4	96.1	88.0	74.9	57.4	44.5
Salt Lake City	37.4	43.7	51.1	61.1	72.4	83.3	93.2	90.0	80.0	66.7	50.2	38.9
Wendover	36.5	43.5	51.5	61.3	71.9	82.0	92.1	89.0	78.4	63.3	47.1	37.0
Vermont												
Burlington	25.4	27.3	37.1	52.6	66.4	75.9	80.5	77.6	68.8	57.0	43.6	30.3
Newport	24.4	27.8	37.8	51.2	65.1	74.9	79.3	76.7	68.5	56.5	41.8	28.4
Vernon	32.1	34.6	43.8	57.2	69.3	78.1	83.1	81.1	73.4	62.4	48.7	35.5
Virginia												
Lynchburg	44.4	47.1	56.2	68.1	75.8	82.5	86.1	85.0	78.8	68.1	57.2	47.5
Norfolk	48.1	49.9	57.5	68.2	75.7	83.2	86.9	85.7	80.2	69.8	60.8	51.9
Richmond	46.7	49.6	58.5	70.6	77.9	84.8	88.4	87.1	81.0	70.5	60.5	50.2
Roanoke	44.8	48.0	56.9	68.2	76.4	83.0	86.7	85.5	79.4	68.6	57.4	47.8
Wachington D.C.	40.9	43.9	53.5	65.7	74.6	82.6	87.0	85.8	79.3	68.0	55.9	44.9
Washington												
Olympia	43.6	49.1	52.5	58.7	65.7	70.8	77.2	76.2	71.0	60.8	50.3	45.1

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Quillavute	44.8	48.5	49.9	54.7	60.2	63.6	68.6	68.6	66.8	59.1	50.7	46.4
Seattle-Tacoma	43.9	48.8	51.1	56.8	64.0	69.2	75.2	73.9	68.7	59.5	50.3	45.6
Spokane	31.3	39.0	46.2	56.7	66.1	74.0	84.0	81.7	72.4	58.3	41.4	34.2
Stampede Pass	28.1	32.1	34.7	41.0	49.5	56.8	65.1	64.0	58.6	47.8	34.8	30.2
Walla Walla	40.1	47.3	54.3	62.2	70.9	79.3	88.8	86.0	77.3	64.0	49.0	43.0
Yakima	36.7	46.0	54.5	63.5	72.5	79.9	87.8	85.6	77.5	64.5	48.1	39.4
West Virginia												
Charleston	41.8	45.4	55.4	67.3	76.0	82.5	85.2	84.2	78.7	67.7	55.6	45.9
Elkins	39.0	41.6	50.9	62.2	71.3	77.9	80.7	79.6	74.4	63.8	52.0	42.7
Huntington	41.1	45.0	55.2	67.2	75.7	82.6	85.6	84.4	78.7	67.6	55.2	45.2
Parkersburg	39.5	42.7	53.1	65.3	74.8	82.0	84.9	84.0	78.0	66.7	53.9	43.5
Wisconsin												
Appleton	23.6	28.4	38.2	54.2	67.4	76.9	81.4	79.2	70.4	58.9	42.4	29.4
Green Bay	22.5	26.9	37.0	53.7	66.6	76.2	80.9	78.7	69.8	58.5	42.0	28.5
Madison	24.5	30.0	40.8	57.5	69.8	78.8	82.8	80.6	72.3	61.1	44.1	30.6
Milwaukee	26.0	30.1	39.2	53.5	64.8	75.0	79.8	78.4	71.2	59.9	44.7	32.0
Sheboygan	26.9	30.9	39.4	52.2	63.5	74.0	80.1	79.1	71.4	59.6	44.7	32.4
Wyoming												
Casper	32.5	37.4	43.4	54.9	66.2	78.1	87.1	84.8	74.2	61.0	43.9	35.6
Cheyenne	37.3	40.7	43.6	54.0	64.6	75.4	63.1	80.8	72.1	61.0	46.5	40.4
Lander	31.3	37.7	44.2	54.7	65.5	76.5	86.0	83.7	73.1	60.3	42.6	35.0
Sheridan	31.8	38.0	44.1	55.6	66.2	75.9	86.0	84.5	73.3	61.9	45.3	36.9
Puerto Rico												
Mayaguez	85.1	85.8	87.4	88.3	89.0	90.0	89.7	90.0	89.7	88.7	87.0	85.5
Ponce	86.1	85.9	86.6	87.3	87.9	89.0	89.8	89.9	89.6	89.0	88.3	86.9
San Juan	82.7	63.2	84.2	85.2	86.7	88.0	87.9	88.2	88.2	87.9	85.7	83.6
Pacific Islands												
Guam	83.4	83.4	84.4	85.7	86.5	86.9	86.4	86.0	85.8	85.7	85.3	84.2
Johnston	80.5	80.4	80.8	81.4	82.6	83.7	84.3	84.7	84.8	84.4	82.8	81.3
Koror	86.7	86.7	87.4	88.1	88.3	87.8	87.2	87.1	87.5	87.9	88.3	87.5

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Kwajalein	85.7	86.4	87.0	86.5	86.3	86.4	86.4	86.8	86.9	86.7	86.5	86.0
Majuro	84.7	85.1	85.3	85.2	85.4	85.5	85.5	85.9	86.0	86.0	85.6	85.0
Pago Pago	86.5	86.7	86.9	86.4	85.2	84.4	83.4	83.4	84.5	85.0	85.5	86.1
Ponape	86.2	86.2	86.7	86.7	87.0	87.2	87.4	87.8	87.8	87.9	87.7	86.8
Truk, Moen I	85.4	85.5	85.8	86.2	86.6	86.9	86.7	87.0	87.1	87.0	86.8	86.0
Wake	81.7	81.7	82.8	83.5	85.3	87.5	88.0	88.1	88.0	87.1	85.1	83.1
Yap	85.5	85.8	86.5	87.4	87.5	87.4	87.1	86.9	87.2	87.4	87.2	86.2
Virgin Islands												
Charlotte Amalie	82.4	82.4	82.9	84.0	85.0	86.4	87.4	87.9	87.8	87.3	86.0	83.8

Table 4— 30-Year Monthly Normal Maximum Temperature in Degrees Fahrenheit, Canada

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep.	Oct	Nov	Dec
British Columbia												
Dawson Creek	9.7	21.4	29.7	47.8	61.2	67.2	71.1	69.1	59.9	49.6	30.4	17.6
Kamloops	27.7	37.2	48.2	60.6	70.9	77.5	83.8	81.5	71.6	57.0	41.4	32.9
Prince George	18.5	30.2	38.5	50.5	61.0	67.1	71.6	69.4	60.6	49.3	33.6	25.0
Prince Rupert	37.9	42.3	43.7	48.6	54.0	57.4	60.8	61.7	59.2	52.2	44.8	40.6
Vancouver	41.4	46.0	48.9	55.0	61.7	66.6	71.4	70.7	64.9	56.1	48.2	43.7
Victoria	42.8	46.8	49.3	55.2	61.7	66.6	71.1	70.5	66.2	57.4	48.9	44.8
Yukon Territory												
Dawson	–17.1	–.9	22.1	42.6	58.6	68.9	73.0	67.3	53.6	31.1	8.1	–6.9
Whitehorse	2.5	17.1	27.9	42.1	54.9	65.1	68.5	65.1	54.3	39.9	22.5	9.5
Northwest Territories												
Yellowknife	–12.5	–4.5	8.4	29.8	50.0	64.0	69.3	64.6	49.8	34.2	13.8	–3.8
Alberta												
Calgary	21.2	29.1	35.1	48.9	60.8	67.8	73.9	71.8	63.3	54.1	37.9	28.8
Edmonton	12.7	23.4	31.5	49.3	63.0	69.7	73.4	70.9	61.7	52.0	32.7	20.8
Fort McMurray	2.3	15.8	28.0	47.7	62.4	69.8	73.6	70.5	58.6	47.5	25.7	10.0
Grande Prairie	9.7	20.3	29.3	47.1	61.5	67.8	71.8	70.0	60.6	49.8	30.0	17.2
Lethbridge	23.9	32.5	39.9	52.2	63.9	71.6	79.0	76.8	67.5	57.4	41.0	32.0
Medicine Hat	19.4	28.2	37.4	53.8	66.4	73.9	81.1	79.7	68.7	57.9	39.9	28.4
Saskatchewan												
Prince Albert	3.9	14.5	25.0	46.9	64.8	71.2	76.6	73.9	62.2	51.3	28.2	13.6
Regina	9.3	17.4	27.9	48.9	64.8	72.9	79.0	77.4	65.5	53.4	32.4	18.1
Saskatoon	6.6	15.6	26.2	48.4	64.6	72.1	77.7	75.6	63.9	52.0	30.4	15.4
Swift Current	14.7	22.5	30.9	48.7	62.8	70.9	77.5	76.3	64.6	53.2	34.2	23.0
Manitoba												
Brandon	6.3	14.9	26.8	47.7	63.9	73.0	78.6	76.5	64.8	52.9	30.9	15.4
Churchill	–10.5	–7.1	3.7	22.3	36.0	51.4	62.2	59.5	47.3	34.3	17.1	–.8
Flin Flon	–1.8	–9.9	23.4	42.4	57.7	67.8	73.4	70.3	56.7	44.4	23.5	6.4
Grand Rapids	1.4	9.0	23.0	41.5	54.9	68.4	74.3	71.6	59.4	47.3	27.1	9.0

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep.	Oct	Nov	Dec
Thompson	–5.4	4.8	19.6	38.7	53.4	66.6	72.7	69.4	54.0	39.6	19.8	2.1
Winnipeg	6.4	14.2	27.3	47.7	64.0	73.6	79.0	76.6	64.9	52.7	31.5	15.4
Ontario												
Cornwall	23.0	24.4	35.6	52.2	66.2	74.8	79.7	77.2	68.5	56.8	42.8	27.9
Kapuskasing	9.1	15.3	27.7	43.9	59.O	69.8	74.1	70.9	59.7	47.8	31.1	14.9
Kenora	7.2	15.6	28.8	46.0	61.0	70.3	75.9	72.7	61.0	49.1	28.9	14.4
London	27.1	28.6	37.9	53.2	65.1	75.0	79.5	77.9	70.2	58.3	44.4	32.4
Minden	22.6	25.2	36.1	51.1	64.6	73.2	77.2	75.1	67.1	55.6	41.2	27.3
Ottawa	20.5	23.4	34.3	51.3	65.5	74.7	79.3	76.5	67.3	55.4	40.8	25.3
Sault Ste Marie	21.9	23.7	32.4	46.8	59.7	70.0	75.0	72.7	64.2	53.6	39.6	27.3
Sudbury	16.2	18.9	30.4	45.9	61.3	71.1	75.7	72.7	62.8	51.1	35.8	21.4
Thunder Bay	15.1	20.8	31.6	46.9	59.9	69.3	75.7	73.0	62.6	52.0	35.4	21.6
Toronto	29.7	31.1	39.4	53.1	64.8	74.7	80.1	78.1	70.3	58.5	46.0	34.5
Windsor	29.8	32.0	41.7	56.1	67.8	77.5	81.9	79.9	72.9	61.2	46.8	34.9
Quebec												
Chibougamau	8.4	12.9	26.6	40.5	54.9	68.4	71.8	69.1	57.9	44.4	29.5	13.5
Chicoutimi	14.5	18.5	31.8	46.6	60.6	72.3	76.1	72.9	63.0	50.5	36.0	20.1
Montreal	21.7	24.1	34.9	51.1	65.3	74.5	79.0	76.6	67.8	55.9	41.7	26.6
Quebec	18.5	21.2	32.0	46.2	62.2	72.1	76.8	73.6	64.2	52.0	37.8	23.0
Senneterre	12.4	16.9	29.7	44.2	60.1	69.6	74.1	71.1	61.2	48.2	32.7	17.4
Seot-Iles	16.5	19.6	29.3	39.4	50.7	62.1	67.6	65.8	56.8	46.0	34.5	20.8
New Brunswick												
Bathurst	21.9	24.4	33.1	44.2	58.8	70.9	76.1	73.4	64.6	52.9	39.9	26.4
Campbellton	20.7	23.2	33.6	44.6	57.9	70.3	76.3	73.8	63.9	51.3	38.1	25.2
Chatham	23.9	26.2	34.9	46.2	59.9	71.6	77.4	75.2	66.0	54.0	41.0	28.0
Fredericton	25.2	27.5	36.9	48.9	62.8	72.9	78.3	76.3	67.1	55.6	42.6	29.3
Moncton	26.1	27.0	34.9	45.9	59.5	70.0	75.7	74.1	65.8	54.9	43.2	30.4
Saint John	27.3	28.0	35.8	46.2	57.9	66.6	72.0	71.1	63.7	53.8	43.3	31.8
Nova Scotia												
Debert	29.7	29.7	36.1	46.9	59.5	69.9	75.7	74.3	66.4	55.9	45.5	33.4
Halifax	29.7	29.7	36.1	46.9	59.9	69.6	75.7	74.3	66.4	55.9	45.5	37.4

Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep.	Oct	Nov	Dec
Sydney	30.6	29.1	34.5	42.8	54.5	66.0	73.6	72.7	65.3	54.9	45.1	35.1
Yarmouth	33.6	32.7	38.7	47.1	55.9	63.7	68.7	68.9	63.9	55.9	47.5	37.9
Prince Edward Island												
Charlottetown	26.6	26.2	33.0	43.1	56.1	67.0	73.4	72.1	64.2	53.6	43.1	31.6
Summerside	26.2	26.4	33.6	43.5	56.3	67.3	74.0	72.7	64.6	54.0	43.0	31.5
Newfoundland												
Churchill Falls	4.5	8.6	20.5	32.5	45.7	58.6	65.5	62.6	53.1	37.8	24.8	9.0
Corner Brook	28.8	27.7	34.3	42.4	52.3	63.1	70.9	69.3	61.3	50.9	42.3	32.5
Goose	10.8	15.4	26.2	37.0	49.8	62.6	70.2	66.7	56.7	43.7	31.8	16.3
Grand Falls	28.0	27.5	34.5	42.4	54.7	65.7	73.6	71.1	62.4	51.6	42.4	32.4
St. John’s	31.1	30.2	33.6	40.1	49.5	60.4	68.4	66.9	60.1	50.7	43.7	34.9
Stephenville	29.1	27.9	33.8	41.4	51.8	61.0	67.6	67.6	60.3	50.5	42.4	32.7

11. Bibliography

[B1] W. J. King, “Free convection” and “Radiation,” *Mech Eng.*, vol. 54, 1932.

[B2] Sigmund Fritz, “Solar radiation during cloudless days,” U. S. Weather Bureau, Heating and Ventilating, January 1949.

[B3] Fritz and MacDonald, “Average solar radiation in the United States,” U. S. Weather Bureau, Heating and Ventilating, July 1949.

[B4] G. W. Penney, “Temperature rise of electrical apparatus as affected by radiation,” *AIEE Trans.*, vol. 59, June 1940, pp. 338–344.

[B5] Frank Benford, “Duration and intensity of sunshine,” *Illum. Eng.* (New York), July 1948.

[B6] Ernest Freese, “Pathways of the sun,” *Amer. Architect*, Nov. 1934.

[B7] Cottony and Dill, “Solar heating of various surfaces,” U. S. Weather Bureau Abstract, July 1940.

[B8] *Climates of the United States, 1824–1941*, reprint, Yearbook of Agriculture.

[B9] Wetherill and Montsinger, “Effect of color of tank on temperature of self-cooled transformers under service conditions,” *AIEE*, Sept. 1929.

[B10] “Climatological data—National summary,” U. S. Weather Bureau Rep.

[B11] Surig and Frick, “Heating and current-carrying capacity of bare conductors for outdoor service,” *Gen. Elec. Rev.*, Mar. 1930.

[B12] W. H. McAdams, *Heat Transmission*, 3rd ed. New York: McGraw-Hill, 1954.

[B13] "Report no. 12," Astrophysical Lab., Smithsonian Inst., Washington, D. C.

[B14] "Weekly mean values of daily total solar and sky radiation," U. S. Weather Bureau, Tech. Paper 11, 1949.

[B15] J. D. Hall, *Industrial Applications of Infrared.* New York: McGraw-Hill, 1947.

[B16] "Climatography of the United States Nos. 81-1 through 81-45 (1931–1960)," U. S. Weather Bureau.

[B17] "Temperature and precipitation tables (1931–1960)," Meteorological Branch, Dept. Transport, Toronto, Ont., Canada.

[B18] "Climatography of the United States No.81 (by States)," National Oceanic and Atmospheric Administration.

[B19] "Canadian Climate Normals, Volume 2, Temperature, 1951–1980," Atmospheric Environment Service, Downsview, Ontario, Climatological Service Division.

[B20] R. H. Lee, "The Effect of color on temperature of electrical enclosures subject to solar radiation," (Sumpwr Abstract C73-388-6, T-PAS73 Nov/Dec 1806–1807 (1B08)).