

American National Standard

**guide for loading
mineral-oil-immersed power transformers**
up to and including 100 MVA with
55°C or 65°C winding rise

ANSI/IEEE C57.92-1981



american national standards institute, inc.

An American National Standard

IEEE Guide for Loading Mineral-Oil-Immersed Power Transformers Up to and Including 100 MVA with 55 °C or 65 °C Average Winding Rise

1. Scope

1.1 This guide covers general recommendations for loading mineral-oil-immersed power transformers, manufactured in accordance with ANSI C57.12.10-1976 [1]¹ and ANSI C57.12.30-1977 [2] and other oil-insulated power transformers up to and including 100 MVA maximum nameplate rating. It is based mostly on aging of the winding insulation. *Loading of transformers larger than 100 MVA may be limited by factors other than insulation aging such as stray flux, etc.* When it is known that such limitations do not exist and insulation aging rather than oil temperature, gassing, tank heating, etc is the controlling factor, this guide may be used. This guide may also be used for askarel filled transformers.

1.2 Recommendations for transformers with an insulation system which conforms to the 65 °C curve shown in Fig 1, those rated at an average winding temperature rise of 65 °C and a hottest-spot temperature rise of 80 °C, are contained in Section 4 of this guide. Recommendations for transformers with an insulation system which conforms to the 55 °C curve shown in Fig 1, those rated at an average winding temperature rise of 55 °C and a hottest-spot temperature rise of 65 °C, are contained in Section 5 of this guide.

1.3 The method used for computer calculation of the Capability Tables for Normal and Moderate Sacrifice of Life in Section 4 and Section 5 of this guide and examples for developing them by hand calculations are contained in Section 6 and Section 7.

¹The numbers in brackets correspond to the references listed in Section 2 of this guide.

2. References

- [1] ANSI C57.12.10-1976, American National Standard Requirements for Transformers 230 000 V and below, 833/958 through 8333/10 417 kVA Single Phase, 750/862 through 60 000/80 000/100 000 kVA Three Phase²
- [2] ANSI C57.12.30-1977, American National Standard Requirements Load-Tap-Changing Transformers 230 000 V and below, 3750/4687 through 60 000/80 000/100 000 kVA Three Phase
- [3] ANSI/IEEE C57.12.00-1980, General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
- [4] ANSI/IEEE C57.91-1981, Guide for Loading Mineral-Oil-Immersed Overhead-Type Distribution Transformers with 55 °C or 65 °C Average Winding Rise

3. General

3.1 Limitations

3.1.1 It must be recognized that there may be limitations to loads above rating which a transformer can carry other than the capacity of the windings and cooling system. Among these limitations are: oil expansion, pressure in sealed units, bushings, leads, tap changers and stray flux heating as well as the thermal capability of associated equipment such as cables, reactors, circuit breakers, disconnecting switches, and current transformers. High ambient temperatures will also restrict a transformer's loadability. Any of these items may limit loading and manufacturers should be

²ANSI documents are available from The American National Standards Institute, 1430 Broadway, New York, NY 10018.

consulted for advice on such limitations. Any transformer that is expected to carry heavy loads where the top-oil temperature may reach limiting values should have good oil with a flash point of not less than 145 °C since the oil in the cooling ducts adjacent to the windings may exceed the top-oil temperature by a number of degrees.

Operation at hottest-spot temperatures above 140 °C may cause gassing in the solid insulation and oil. Gassing may produce a potential risk to the dielectric strength integrity of the transformer and this risk should be considered when the guide is applied.

3.1.2 Transformers are sometimes installed in indoor vaults with natural ventilation. This type of installation results in a higher ambient temperature than the outdoor air. The increase in effective ambient temperature for expected transformer operation must be determined before loading limitations can be estimated.

3.2 Transformer Life Expectancy

3.2.1 Recommendations in this guide are based on the life expectancy of transformer insulation as affected by temperature and time.

3.2.2 Transformer life expectancy at various operating temperatures is not accurately known, but the information given regarding loss of insulation life at elevated temperatures is considered to be conservative and the best that can be produced from present knowledge of the subject. The word *conservative* is used in the sense that the actual insulation life at any temperature is expected to be not less than indicated in this guide. The effects of temperature on insulation life are subject to further investigation and new data may affect future revisions of this guide.

3.2.3 In Tables 3(a)–3(u) and 5(a)–5(u) the normal loss of life loads are loadings which result in a daily loss of life equal to that of a continuous winding hottest-spot temperature of 110 °C and 95 °C for 65 °C rise and 55 °C rise transformers, respectively. Normal life expectancy is $6.5 \cdot 10^4$ hours, a daily normal loss of life of 0.0369%. Aging at other than rated temperature is calculated using the equations for power transformer insulation life expectancy in Fig 1. The actual life should be considerably greater than $6.5 \cdot 10^4$ hours for the reasons mentioned in 4.1.2.4.

3.2.4 In Tables 3(a)–3(u) and 5(a)–5(u) the moderate sacrifice of life expectancy values are

daily loss of insulation life which are in addition to normal loss of insulation life.

3.3 Transformer Rated Output

3.3.1 The terms *rating*, *rated output*, *rated load* and *full load* used in this guide refer to nameplate rating.

3.3.2 The temperature rise on which the rating of a transformer is based takes into consideration the experience of the industry regarding:

(1) Insulation life as affected by operating temperatures

(2) The ambient temperature assumed to exist throughout the life of the transformer

3.3.3 The actual output which a transformer can deliver at any time in service with normal life expectancy may be more or less than the nameplate rating, depending upon the ambient temperature and other operating conditions.

3.4 Aging of Insulation

3.4.1 Aging or deterioration of insulation is a function of time and temperature. Since, in most apparatus, the temperature distribution is not uniform, that part which is operating at the highest temperature will ordinarily undergo the greatest deterioration. Therefore, in aging studies it is usual to consider the aging effects produced by the highest (hottest-spot) temperature.

3.4.2 Much of the fundamental data on aging of insulation at different temperatures has been based on laboratory and model tests in which the decrease in mechanical and electrical strength has been measured. Under the auspices of the IEEE, a series of life expectancy tests were made under controlled conditions on production-type distribution transformers. Data from these tests were used as the basis for the distribution transformer Life Expectancy Curves in ANSI/IEEE C57.91-1981. While these are the best insulation life data available at this time, they are not directly applicable to power transformers. Because the end point strength of insulation (the final strength of aged insulation) must be greater in power transformers and because model tests of power transformers have not yet been reported, the power transformer insulation life expectancy curves were selected to be more conservative than those used for distribution transformers.

The transformer life expectancy predictions contained herein are based on the insulation life expectancy curves shown in Fig 1 and do

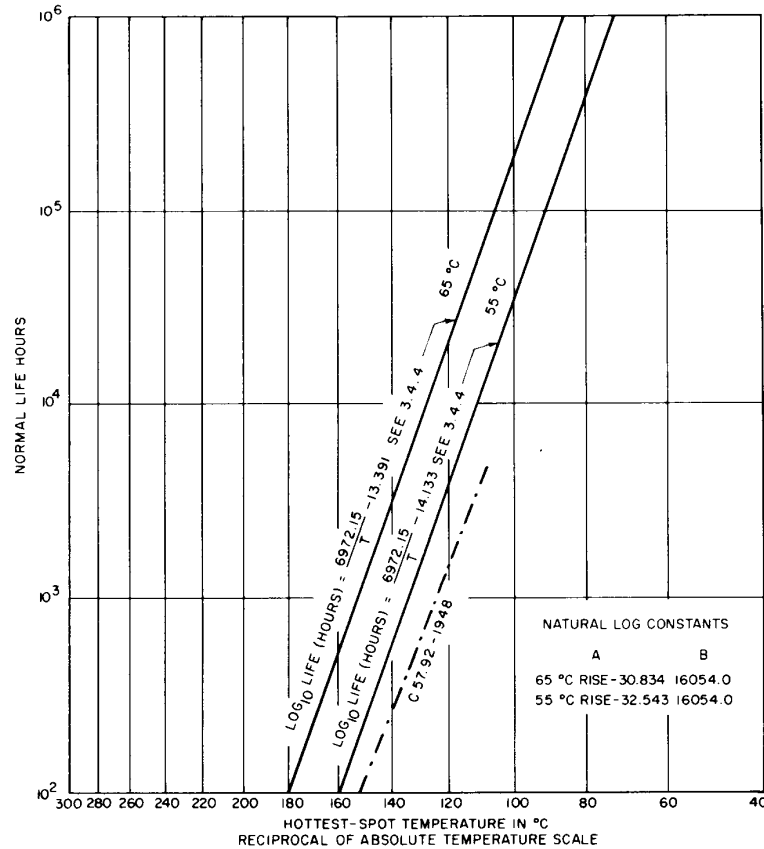


Fig 1
Life Expectancy Curve

not take into account deterioration of gaskets, rusting of tanks, etc which result from factors other than winding temperatures.

While the life expectancy curves are believed to be conservative, any estimates of transformer life derived therefrom are intended only as a guide.

3.4.3 Because the cumulative effects of temperature and time in causing deterioration of transformer insulation are not thoroughly established, it is not possible to predict with any great degree of accuracy the length of life of a transformer even under constant or closely controlled conditions, much less under widely varying service conditions.

3.4.4 The relation of insulation deterioration to changes in time and temperature is assumed to follow an adaptation of the Arrhenius

reaction rate theory which states that the logarithm of insulation life is a function of the reciprocal of absolute temperature:

$$\text{Log}_{10} (\text{hours of life}) = \frac{A+B}{T} \quad (\text{Eq 1})$$

where

T = absolute temperature in degrees Kelvin ($\theta_{\text{hs}} + 273$)

θ_{hs} = hottest-spot temperature, °C

A and B = constants from desired life expectancy curve

A and B values for both $\log_{10}$ and $\log_e$ are shown on Fig 1.

3.4.5 The many variables mentioned, and particularly the many varying conditions of load and ambient to which a transformer can be subjected in service, make it impossible to give definite rules for the loading of transformers. It is possible to give only suggested loadings under specified conditions with the expectation that the user will adjust this information to suit his particular application.

3.5 Ambient Temperatures and Its Influence on Loading. Ambient temperature is an important factor in determining the load capability of a transformer since the temperature rises for any load must be added to the ambient to determine operating temperatures.

Transformer ratings are based on a 24 h average ambient of 30 °C. This is the *standard* ambient used in this guide.

The ambient temperature to be used for water-cooled transformers is the cooling water temperature plus an added 5 °C to allow for possible loss of cooling efficiency due to deposits on cooling coil surfaces of water-cooled transformers in service.

Whenever the actual ambient can be measured, such ambients should be used in determining the transformer's temperature and loadability.

The ambient air temperature seen by a transformer is the air in contact with its radiators or heat exchangers. In some installations the transformer may be outdoors but surrounded by buildings or sound deadening walls. This may result in recirculation of heated air, the *ambient* should be adjusted accordingly.

3.5.1 Approximating Ambient Temperature for Air-Cooled Transformers. It is often necessary to predict the load which a transformer can safely carry at some future time in an unknown ambient.

The probable ambient temperature for any month may be approximated as follows from reports prepared by the National Weather Service of the US Department of Commerce for various sections of the country:

(1) *Average Temperature.* Use average daily temperature for the month involved averaged over a number of years.

(2) *Average of Maximum Daily Temperatures.* Use average of the maximum daily temperatures for month involved averaged over several years.

These ambients should be used as follows: for loads with normal life expectancy, use item (1) as the ambient for the month involved; for short-time loads with moderate sacrifice of life expectancy, use item (2) for the month involved.

During any one day the average or maximum temperatures may exceed the values derived from (1) or (2) above. To be conservative, it is recommended that these temperatures be increased by 5 °C since aging at higher than average temperature is not fully compensated by decreased aging at lower than average temperature. With this margin the approximated temperature will not be exceeded on more than a few days per month and, where it is exceeded, the additional loss of life will not be serious.

3.5.2 Influence of Ambient on Loading for Normal Life Expectancy. Average ambient temperatures should cover periods of 24 h with maximum temperatures not more than 10 °C greater than average temperatures for air and 5 °C for water. Table 1 gives the increase or decrease from rated loads for other than average daily ambients of 30 °C for air and 25 ° for water. It is recommended that the 5 °C margin described in 3.5.1 be used when applying the factors from Table 1. It should be pointed out that the increase or decrease obtained from Table 1 is more conservative than the corresponding values shown in Table 3(a)–3(u) and 5(a)–5(u) which are based on Tables 2 and 4 (assumed transformer characteristics), and therefore do not check these tabulations exactly. Table 1 is for quick approximations.

Loading on the basis of ambient temperature with loads permitted in Table 1 will give approximately the same life expectancy as if transformers were operated at nameplate rating and standard ambient temperatures over the same period.

Table 1 covers a range in ambients of 0 °C to 50 °C for cooling air. A check should be made with the manufacturer before loading on the basis of ambient air less than 0 °C or greater than 50 °C.

Since ambient temperature is an important factor in determining the load capability of a transformer, it should be controlled for indoor installations by adequate ventilation and should always be considered in outdoor installations.

Table 1
Loading on Basis of Temperatures
 (Ambient other than 30 °C and Average Winding Rise Less than Limiting Values)

(For Quick Approximation)		
(Ambient Temperature Range 0 °C to 50 °C)		
Type of Cooling	% of Rating	
	Decrease Load for Each °C Higher Temperature	Increase Load for Each °C Lower Temperature
Self-cooled — OA	1.5	1.0
Water-cooled — OW	1.5	1.0
Forced-air-cooled — OA/FA, OA/FA/FA	1.0	0.75
Forced-oil-cooled — FOA, FOW and OA/FOA/FOA	1.0	0.75

3.6 Operation with Part or All of the Cooling Out of Service. Where forced-cooling equipment, such as pumps or fans or both, is used to increase the cooling efficiency, the transformer may be required to operate for some time with this equipment inoperative. The permissible loading under such conditions is given in the following paragraphs.

For multi-rated transformers (OA/FA, OA/FA/FA, OA/FOA/FOA) with all or part of the forced cooling inoperative, use the nameplate rating based on the cooling in operation and load on this basis. When either the pumps or the fans of a cooling unit are out of service, the entire cooling unit should be considered inoperative.

For forced-oil-cooled (FOA or FOW) transformers with all pumps or fans or both inoperative, heeding the following guidelines should prevent undue injury to the transformer:³

(1) Rated load may be maintained for approximately 1 h following normal operation at nameplate rating in a 30 °C ambient

(2) Rated load may be carried for approximately 2 h if started with windings and oil in a 30 °C ambient.

(3) Rated voltage may be maintained for 6 h at no load, following continuous operation at nameplate rating in a 30 °C ambient with cooling equipment in operation.

(4) Rated voltage may be maintained for 12 h at no load starting with windings and oil in a 30 °C ambient

For forced-oil-cooled transformer (FOA or FOW) ratings with part of the coolers in operation, use the following reductions in permissible loading:

% of Total Coolers in Operation	Permissible Load in % of Nameplate Rating
100	100
80	90
60	78
50	70
40	60
33	50

These permissible loads give approximately the same temperature rises as would full load with all cooling in operation.

3.7 Supplemental Cooling of Existing Self-Cooled Transformers. The load which can be carried on existing self-cooled transformers can usually be increased by adding auxiliary cooling equipment such as fans, external forced-oil coolers, or water spray equipment. The amount of additional loading varies widely, depending upon:

- (1) Design characteristics of the transformer
- (2) Type of cooling equipment
- (3) Permissible increase in voltage regulation
- (4) Limitations in associated equipment

No general rules can be given for such supplemental cooling, and each transformer should be considered individually.

³The oil temperature for large units may exceed 110 °C. Check with the manufacturer for limitations.

4. Transformers Specified to have an Average Winding Rise of Not More Than 65 °C and Hottest-Spot Winding Rise of Not More Than 80 °C

4.1 Basic Loading for Normal Life Expectancy

4.1.1 Basic Conditions

(1) The basic loading of a transformer for normal life expectancy is continuous loading at rated output when operated under normal service conditions as indicated in 2.1.1 (1), 2.1.1 (2), and 2.1.1 (3) of ANSI/IEEE C57.12.00-1979 [3]. It is assumed that operation under these conditions is equivalent to operation in a continuous ambient temperature of 30 °C for cooling air or 25 °C for cooling water. Normal life expectancy will result from operating with a continuous hottest-spot conductor temperature of 110 °C (or equivalent variable temperature with 120 °C maximum) in any 24 h period.

(2) The hottest-spot conductor temperature determines loss of life due to loading. This temperature cannot be directly measured on commercial designs because of the voltage hazard when placing a temperature detector at the proper location. The hottest-spot allowances are based on tests of laboratory models.

(3) The hottest-spot temperature at rated load is usually taken as the sum of the average winding temperature and a 15 °C allowance⁴ for the hottest spot. For mineral oil-immersed transformers operating continuously under the foregoing conditions with normal life expectancy, this temperature has been assumed to be a maximum of 110 °C.

4.1.2 Loading for Normal Life Expectancy under Specified Conditions

4.1.2.1 Loading by Oil Temperature. Oil temperature alone should not be used as a guide for loading transformers. The hottest-spot to top-oil gradient at full load should be determined from factory tests using Eq 8 or, lacking data, a value should be assumed. The full-load hottest-spot to top-oil gradient should be corrected to that for the actual load carried using Eq 7 or Fig 9. This gradient subtracted from 110 °C will give the maximum permissible oil temperature for normal life expectancy.

⁴ If cooler inlet and outlet temperatures are available, a better estimate of the hottest-spot temperature is possible by making an adjustment in the 15 °C allowance. Consult with the manufacturer.

It should be recognized that, due to thermal lag in oil rise, time is required for a transformer to reach a stable temperature following any change in load. Therefore, higher peak loads may be carried for short durations. This is reflected in the loading tables and the basic equations in 6.7.3.

If the transformer characteristics are not accurately known, a maximum top-oil temperature derived from Fig 2 may be used as an approximation. Loading from Fig 2 is based on a difference of 25 °C between the hottest-spot temperature and top-oil temperature at rated load for self-cooled transformers, 30 °C for forced-air-cooled transformers (133% and under) and 35 °C for forced-oil-cooled transformers.

4.1.2.2 Continuous Loading on Basis of Average Winding Test Temperature Rise. For each °C in excess of 5° that the average winding test temperature rise is below 65 °C, the transformer load may be increased above rated load by the percentages given in Table 1. A 5° margin is used to provide a tolerance in the measurement of temperature rise. The loadability thus obtained is that which the transformer can carry at 65 °C rise. Since this may increase the loading beyond that contemplated by the designer, the limitations given in 3.1 should be checked before taking full advantage of this increased loadability.

Some transformers are designed to have the difference between the hottest-spot and average conductor temperatures greater than the 15 °C allowance. This will result in an average-winding temperature rise of less than 65 °C, but the hottest-spot winding temperature rise may be at the limiting value of 80 °C. Such transformers should not be loaded above their rating as outlined in this section. The manufacturer should be consulted for information on the hottest-spot allowances used for these designs. This condition may exist in transformers with large differences (greater than 30 °C) between top- and bottom-oil temperatures and may be checked approximately by measuring the top and bottom radiator temperatures. Whenever possible, data on hottest-spot and oil temperatures obtained from factory temperature tests should be used in calculating transformer loadability or when calculating temperatures for loads above rating.

4.1.2.3 Loading on Basis of Short-Time Loads above Rating. Transformers may be

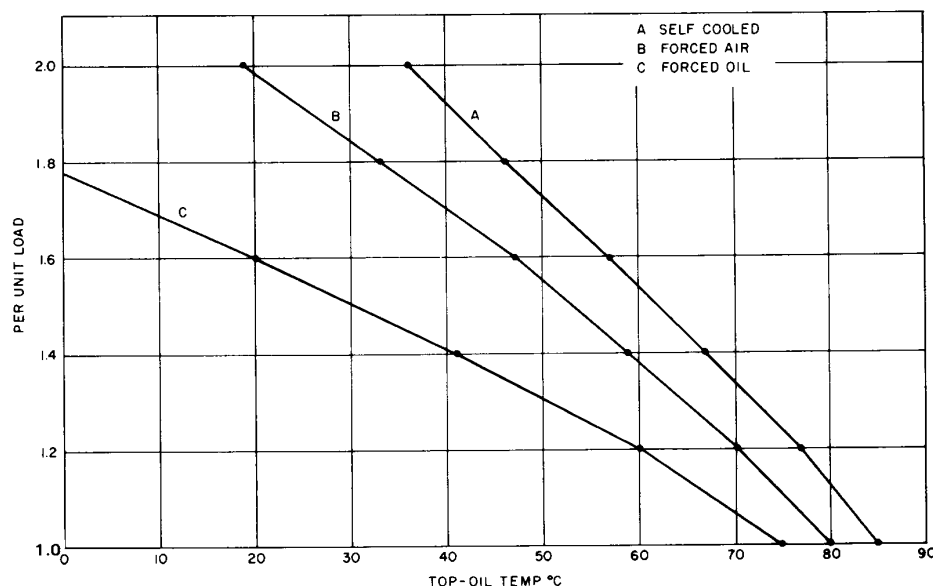


Fig 2
Approximate Continuous Loading for Normal Life Expectancy —
65 °C Rise Transformers

operated above 110 °C hottest-spot temperature for short periods provided they are operated for much longer periods at temperatures below 110 °C. This is due to the fact that thermal aging is a cumulative process and thus permits loads above the rating to be safely carried under many conditions without encroaching upon the normal life expectancy of the transformer. Suggested loadings for normal life expectancy are given in Tables 3(a)—3(u). For conservative use of these tables, it is suggested that the 5 °C margin described in 3.5.1 be used in determining the ambient temperature.

4.1.2.4 Loading by Hottest-Spot Temperature Indicator. Hottest-spot temperature devices are supplied, when specified, which indicate a simulated hottest-spot temperature. These devices may be used as a guide to limit loads.

Thermal relays, when supplied, indicate temperatures reached in the windings. These relays are calibrated for use with specific transformers and simulate the hottest-spot temperature by taking into account preceding loading, existing load and ambient temperature. Higher loads are permitted for short periods than for long periods of time because of the transformer's time constant.

4.1.2.5 Basis for Normal Loss of Life Loading in Tables 3(a)—3(u). The transformer capabilities for normal loss of life in Tables 3(a)—3(u) are based on operation at temperatures that result in aging equivalent to that for continuous operation at 110 °C hottest-spot temperature as determined from Fig 1 and the hottest-spot temperature profile resulting from the converted load cycle and ambient conditions during a 24 h period. The 110 °C hottest-spot temperature is based on the hottest-spot rise of 80 °C plus the standard ambient temperature of 30 °C. At 110 °C insulation temperature, Fig 1 indicates the life would be $6.5 \cdot 10^4$ hours or over seven years. Actually a transformer operating outdoors at rated capacity would have a much longer life because the annual average ambient air temperature in most locations in the US does not exceed 20 °C by more than a few degrees. At 100 °C (20 °C ambient temperature plus 80 °C hottest-spot rise), Fig 1 indicates the life would be $2 \cdot 10^5$ hours or over 22 years. If the loading over weekends is lighter, as is normally the case, the total life could extend to over 30 years.

In areas where the annual mean ambient temperature exceeds 25 °C, the capability values in the tables should be reduced 1.5% for

every degree the mean annual temperature exceeds 20 °C. This reduction in peak loading is intended to compensate for the fact that generally higher ambient temperatures throughout the year will result in higher winding temperatures, for any assumed annual load cycle, causing greater insulation deterioration. If this correction is made, no correction of the ambient temperatures shown in the table will be necessary, and these should be the anticipated values associated with the occurrence of the peak load.

The method used to calculate Tables 3(a)—3(u) is given in Section 6.

4.2 Short-Time Loading with Moderate Sacrifice of Life Expectancy

4.2.1 Aging of Insulation Due to Operation above 110 °C Hottest-Spot Temperature

(1) When the aging effect of one load cycle or the cumulative aging effect of a number of load cycles is greater than the aging effect of continuous operation at rated load over the same period of time, the insulation deteriorates at a faster rate than normal. The rate of deterioration is a function of time and temperature and is commonly expressed as a percentage loss of life. Charts and tables showing percent loss of life for various combinations of time and continuous temperature are given in Fig 3.

(2) It should be clearly understood that, while the insulation aging information used is considered to be conservative and helpful in estimating the relative loss of life due to loads above rating under various conditions, this information can only be an indicator of transformer insulation life. Deterioration of insulation is generally characterized by a reduction in both mechanical and dielectric strength, but these characteristics may not necessarily be directly related. In some cases, insulation in a charred condition will have sufficient strength to withstand normal operating electrical and mechanical stresses. A transformer having insulation in this condition may continue in service for many months or even years if undisturbed. On the other hand, any unusual movement of the conductors such as may be caused by expansion of the conductors, due to heating resulting from a heavy load or to large electromagnetic forces resulting from short circuit, may disturb the weakened insulation such that turn-to-turn or layer-to-layer failure will result.

(3) The uncertainty of service conditions

and the wide range in ratings covered are reasons why this loading guide is made conservative in its suggested loadings. Some of the variables are: wide differences in ambient temperature between localities; differences in elevation; restricted air circulation caused by buildings, fire walls, etc; previous emergency loading history which may not be known to the operator; and variations in design characteristics from those in Table 2. As a guide, an average loss of life of 1% per year or 4% in any one emergency operation is considered reasonable by some users.

4.2.2 Methods for Determining Loads above Rating with Some Sacrifice of Life Expectancy

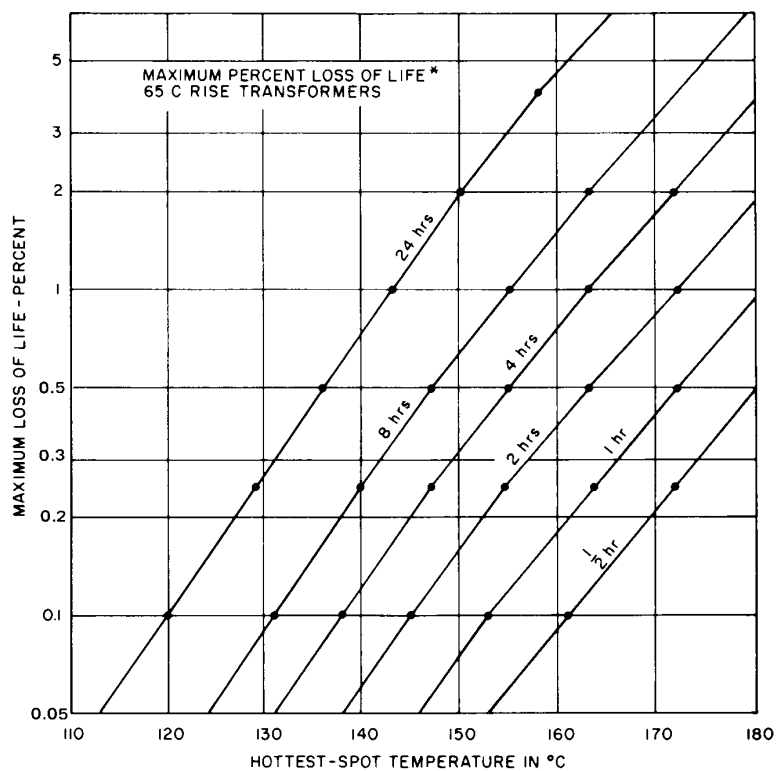
4.2.2.1 Transformers with Known Specific Characteristics. If the specific characteristics of a transformer are known and maximum recommended capability is required, the user may calculate the oil rise and hottest-spot temperature using either the graphic solution illustrated in Section 6 or the basic formulas in 6.7. With this data, the user may determine the allowable load for his conditions by taking into account the ambient temperature, probable number of such loads during the life of the transformer, and the approximate percentage of life he is willing to sacrifice.

4.2.2.2 Transformers with Unknown Specific Characteristics or Conservative Loads. When specific transformer characteristics are not known or when conservative operation above rating is satisfactory, refer to the Capability Tables, Table 3(a)—3(u), for tabulations of permitted loads of various durations following explicit preload conditions.

4.2.2.3 Assumed Characteristics for Transformers which Allow the Loadings in Tables 3(a)—3(u). Transformers vary widely in the characteristics which affect their short-time capabilities. Any general guide which applies to all transformers of a given class must be based on characteristics which give conservative results. The characteristics shown in Table 2 are considered typical of a power transformer and are for general use.

4.2.2.4 Temperature and Load Limitations. The following are recommended individually limiting temperatures and loads and are used in Tables 3(a)—3(u).

- (1) Maximum top-oil temperature — 110 °C
- (2) Maximum hottest-spot conductor temperature — 180 °C
- (3) Maximum short-time loading — 2 · rating



*Expressed as percent loss of life for one occurrence of specified time duration for operation at temperature indicated.

Hottest-Spot Temperature in Degrees
Maximum Loss of Life (%)

Duration Hours	0.1	0.25	0.50	1.00	2.00	4.00
1/2	161	172	180			
1	153	163	172	180		
2	145	155	163	172	180	
4	138	147	155	163	172	180
8	131	140	147	155	163	172
24	120	129	136	143	150	158

Fig 3
Maximum Loss of Life — 65 °C Rise Transformers

Table 2
65 °C Rise Transformers — Assumed Characteristics at Rated Load

	OA or OW	FA 133% or Less	Effective Cooling Mode		
			FA** over 133%	Non-Directed FOA or FOW	Directed FOA or FOW
Hottest-spot conductor temperature rise (above ambient) °C	80	80	80	80	80
Top-oil temperature rise (above ambient) °C	55	50	45	45	45
Top-oil time constant, (h)	3.0	2.0	1.25	1.25	1.25
Hottest-spot conductor time constant, (h)	0.08	0.08	0.08	0.08	0.08
Ratio of load to iron losses	3.2	4.5	6.5	6.5	6.5
*m (winding exponent)	0.8	0.8	0.8	0.8	1.0
*n (oil exponent)	0.8	0.9	0.9	1.0	1.0

*m is the exponential power of winding loss versus winding temperature rise.

*n is the exponential power of total loss versus top-oil temperature rise.

The indicated values of m and n are approximate, particularly in the more complicated designs, and are subject to further study.

**Some OA/FA/FA designs follow more closely the values for FA (133% or less).

4.2.2.5 Load Cycles. Transformers usually operate on a load cycle which repeats each 24 h. This load cycle may be constant or it may have one or more peaks during the 24 h period. The actual load cycle may be converted to a two-step cycle by the method given in 6.6. Where actual average loads before the peak load differ from those in the tabulations, sufficient accuracy can be obtained by interpolation.

4.2.2.6 Basis for Moderate Sacrifice of Life Loading in Tables 3(a)—3(u). Load values in Tables 3(a)—3(u) are based on the life expectancy data shown in Fig 1, the assumed transformer characteristics from Table 2 and the calculated hottest-spot temperature profile for the daily load cycle and ambient temperature condition that exists during the 24 h period. The loss of life values shown in Tables 3(a)—3(u) are in addition to the normal loss of life of 0.0369% per 24 h which would result from continuous operation at rated load in a constant 30 °C ambient.

Index for Table 3
65 °C Rise Transformers
(A Tabulation of Loads for Normal and Moderate Loss of Life)

Type of Cooling	Following initial load of:			
	50%	70%	90%	100%
Self-cooled (OA)	(a)	(b)	(c)	(d)
Water-cooled (OW)	(a)	(b)	(c)	(d)
Forced-air-cooled* (OA/FA)	(e)	(f)	(g)	(h)
Forced-oil-cooled, Directed flow, (FOA, FOW, OA/FOA/FOA**)	(i)	(j)	(k)	(l)
Forced-air-cooled** (OA/FA/FA)	(m)	(n)	(p)	(q)
Forced-oil-cooled, Non-directed flow, (FOA, FOW, OA/FOA/FOA**)	(r)	(s)	(t)	(u)

*Ratings 133% or less of self-cooled rating

**Ratings greater than 133% of self-cooled rating

Table 3(a)
Capacity Table for Normal and Moderate Sacrifice of Life
65°C Rise, Self-Cooled (OA) and Water-Cooled* (OW) Transformers
Equivalent Load Before Peak Load = 50% of Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0				10				20			
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1 2	Normal	2.00	121	46	2.00	131	56	2.00	141	66	2.00	151	76
	0.25												
	0.50												
	1.00												
1	2.00												
	4.00												
2	Normal	2.00	136	60	2.00	146	70	1.95	152	79	1.83	151	85
	0.25												
	0.50												
	1.00												
4	2.00												
	4.00												
8	Normal	1.89	147	78	1.79	147	83	1.69	146	88	1.57	145	93
	0.25												
	0.50												
	1.00												
24	2.00												
	4.00												
	Normal	1.63	140	85	1.54	139	89	1.45	138	93	1.34	137	97
	0.25												
	0.50												
	1.00												
	2.00												
	4.00												
	Normal	1.45	130	85	1.36	129	88	1.27	129	92	1.18	128	95
	0.25												
	0.50												
	1.00												
	2.00												
	4.00												
	Normal	1.28	113	76	1.20	113	79	1.11	113	83	1.02	113	87
	0.25												
	0.50												
	1.00												
	2.00												
	4.00												

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.

% loss of life is in addition to normal loss of life.

* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 3(b)
Capacity Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Self-Cooled (OA) and Water-Cooled* (OW) Transformers
Equivalent Load Before Peak Load = 70 % of Nameplate Rating

Hours Peak Load	% Loss of Life	Ambient °C											
		0			10			20			30		
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1	Normal	2.00	129	53	2.00	139	63	2.00	149	73	1.95	155	83
	0.25							2.00			2.00	159	83
	0.50												
	1.00												
	2.00												
1	Normal	2.00	143	67	1.98	151	77	1.86	150	83	1.72	148	89
	0.25							2.00	163	87	2.00	173	97
	0.50												
	1.00												
	2.00												
2	Normal	1.84	166	80	1.73	146	85	1.62	144	90	1.50	143	95
	0.25	2.00	164	88	1.97	171	97	1.87	170	102	1.77	169	107
	0.50				2.00	174	98	1.94	177	105	1.84	177	111
	1.00							2.00	184	108			
	2.00												
4	Normal	1.60	139	86	1.51	138	89	1.41	136	93	1.30	134	96
	0.25	1.80	163	99	1.71	162	103	1.62	161	107	1.52	160	110
	0.50	1.85	170	103	1.77	170	108	1.69	169	112	1.59	168	115
	1.00	1.91	179	108	1.84	178	112						
	2.00	1.93	188	113									
8	Normal	1.43	129	84	1.34	128	88	1.25	127	91	1.16	126	94
	0.25	1.60	152	98	1.52	151	102	1.44	150	105	1.35	149	108
	0.50	1.66	159	103	1.58	158	106	1.50	158	110	1.41	157	113
	1.00	1.71	167	108	1.63	166	111	1.55	165	115			
	2.00	1.77	175	113									
24	Normal	1.29	113	76	1.20	112	79	1.11	112	83	1.02	112	86
	0.25	1.44	133	88	1.36	133	92	1.28	133	96	1.20	132	99
	0.50	1.48	140	93	1.41	139	96	1.33	139	99	1.25	139	103
	1.00	1.54	147	97	1.46	146	101	1.38	146	104	1.30	146	107
	2.00	1.59	154	102	1.52	154	105	1.45	154	109	1.37	154	113
	4.00	1.64	162	107	1.57	162	111	1.50	162	114			

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.
*Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 3(c)
Capacity Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Self-Cooled (OA) and Water-Cooled* (OW) Transformers
Equivalent Load Before Peak Load = 90 % of Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																	
		0			10			20			30			40			50		
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1	Normal	2.00	139	63	2.00	149	73	1.94	154	82	1.73	149	89	1.00	115	90	1.78	172	110
	0.25							2.00	159	83	2.00	169	93	1.98	177	103	1.94	184	112
	1.00													2.00	179	103			
	2.00																		
1	Normal	2.00	151	75	1.87	149	81	1.72	147	87	1.53	142	92	1.00	115	90	1.56	164	113
	0.25				2.00	161	85	2.00	171	95	1.91	173	102	1.76	170	108	1.94	184	113
	0.50										2.00	181	105	1.88	180	111			
	2.00																		
2	Normal	1.77	145	83	1.65	143	87	1.52	140	91	1.34	134	94	0.94	112	90	1.36	156	115
	0.25	2.00	170	94	1.90	169	99	1.79	167	104	1.67	165	108	1.54	162	112			
	0.50				1.97	177	103	1.87	175	108	1.76	174	112						
	2.00				2.00	180	104	1.95	185	112									
4	Normal	1.56	137	86	1.46	135	89	1.34	132	92	1.20	128	94	0.94	113	90	1.20	148	114
	0.25	1.76	161	100	1.67	160	104	1.58	159	107	1.47	156	110	1.36	154	113			
	0.50	1.82	169	104	1.73	168	108	1.64	167	111	1.55	165	115						
	2.00	1.88	178	109	1.80	176	112												
8	Normal	1.41	127	84	1.32	126	87	1.22	124	89	1.10	120	91	0.91	110	89	1.10	140	111
	0.25	1.59	150	98	1.51	150	101	1.42	148	104	1.33	147	107	1.23	144	110			
	0.50	1.64	158	103	1.56	157	106	1.48	156	109	1.39	154	112						
	2.00	1.70	166	107	1.62	165	111	1.54	164	114									
24	Normal	1.27	112	75	1.19	112	79	1.10	111	82	1.01	111	86	0.91	110	89	0.79	109	92
	0.25	1.43	132	88	1.36	132	92	1.27	132	95	1.19	131	98	1.10	131	102	1.01	131	106
	0.50	1.48	139	92	1.41	139	96	1.33	139	99	1.24	138	103	1.16	138	106	1.06	137	109
	2.00	1.59	154	102	1.52	154	105	1.44	153	108	1.36	153	112	1.22	145	111	1.13	145	114

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 3(d)
Capacity Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Self-Cooled (OA) and Water-Cooled* (OW) Transformers
Equivalent Load Before Peak Load = 100% of Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																																			
		0						10						20						30						40						50					
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)												
1 2	Normal	2.00	144	68	2.00	154	78	1.80	149	85	1.00	110	85	1.84	172	106	1.00	130	105																		
	0.25							2.00	164	88	2.00	174	98	2.00	184	108	1.72	173	114																		
	0.50																																				
	1.00																																				
1	Normal	1.93	149	78	1.78	146	83	1.59	141	88	1.00	110	85	1.63	164	109	1.00	138	105																		
	0.25							1.97	173	99	1.81	169	104	1.77	175	113	1.50	164	116																		
	0.50							2.00	176	100	1.93	179	108																								
	1.00										2.00	186	110																								
2	Normal	1.71	142	83	1.59	140	88	1.42	135	91	1.00	110	85	1.44	156	111	1.00	130	105																		
	0.25							1.95	168	95	1.73	165	104	1.61	162	109	1.34	158	117																		
	0.50							2.00	173	98	1.93	174	109	1.70	172	113																					
	1.00										1.82	174	109																								
4	Normal	1.53	135	86	1.42	133	89	1.28	127	90	1.00	110	85	1.28	147	110	1.00	130	105																		
	0.25							1.73	158	100	1.43	153	109	1.39	159	117	1.22	151	117																		
	0.50							1.80	168	104	1.71	167	110																								
	1.00							1.86	176	109	1.78	176	113																								
8	Normal	1.40	126	83	1.30	124	86	1.19	120	87	1.00	110	85	1.19	140	107	1.00	130	105																		
	0.25							1.58	150	98	1.49	148	101	1.27	149	113	1.13	143	113																		
	0.50							1.63	157	102	1.55	155	105	1.27	149	113	1.13	143	113																		
	1.00							1.69	165	107	1.61	164	110	1.39	159	117	1.22	151	117																		
24	Normal	1.27	112	75	1.19	111	78	1.09	110	81	1.00	110	85	0.89	109	88	0.77	108	91																		
	0.25							1.43	132	88	1.35	132	95	1.19	131	98	1.00	130	105																		
	0.50							1.48	139	92	1.41	139	96	1.24	138	103	1.06	137	109																		
	1.00							1.53	146	97	1.46	146	100	1.30	145	107	1.13	144	114																		
4.00	Normal	1.59	154	102	1.52	154	105	1.44	153	108	1.36	153	112	1.22	145	111	1.06	137	109																		
	0.25							1.50	161	114	1.36	153	112	1.22	145	111	1.06	137	109																		
	0.50																																				
	1.00																																				

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.
* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 3(e)
Capacity Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Air-Cooled (OA/FA) Transformers Rated 133% or Less of Self-Cooled Rating
Equivalent Load Before Peak Load = 50% of Maximum Nameplate Rating

Hours Peak Load	% Loss of Life	Ambient °C											
		0	10	20	30	40	50	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1 2	Normal	2.00	140	150	160	170	180	2.00	150	160	170	180	190
	0.25												
	0.50												
	1.00												
	2.00												
1	Normal	1.93	154	163	173	183	193	1.93	163	173	1.93	173	183
	0.25												
	0.50												
	1.00												
	2.00												
2	Normal	1.68	148	158	168	178	188	1.68	158	168	1.68	168	178
	0.25												
	0.50												
	1.00												
	2.00												
4	Normal	1.48	138	148	158	168	178	1.48	148	158	1.48	158	168
	0.25												
	0.50												
	1.00												
	2.00												
8	Normal	1.35	127	137	147	157	167	1.35	137	147	1.35	147	157
	0.25												
	0.50												
	1.00												
	2.00												
24	Normal	1.24	112	122	132	142	152	1.24	122	132	1.24	132	142
	0.25												
	0.50												
	1.00												
	2.00												

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

Table 3(f)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Air-Cooled (OA/FA) Transformers Rated 133% or Less of Self-Cooled Rating
Equivalent Load Before Peak Load = 70% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0				10				20			
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1	Normal	2.00	148	57	2.00	158	67	1.89	158	74	1.78	156	81
	0.25	2.07	153	72	1.77	152	77	1.67	151	82	1.57	150	88
	0.50	2.07	178	82	1.99	178	88	1.90	177	93	1.81	176	99
	1.00	2.06	186	91	2.06	186	91	1.97	185	97	1.88	184	102
	2.00	1.87	153	72	1.77	152	77	1.67	151	82	1.57	150	88
2	Normal	1.87	153	72	1.77	152	77	1.67	151	82	1.57	150	88
	0.25	2.07	178	82	1.99	178	88	1.90	177	93	1.81	176	99
	0.50	2.06	186	91	2.06	186	91	1.97	185	97	1.88	184	102
	1.00	1.87	153	72	1.77	152	77	1.67	151	82	1.57	150	88
	2.00	1.87	153	72	1.77	152	77	1.67	151	82	1.57	150	88
4	Normal	1.64	147	80	1.56	145	84	1.47	144	89	1.37	142	92
	0.25	1.82	171	93	1.74	170	97	1.66	169	101	1.58	168	106
	0.50	1.88	179	97	1.80	179	102	1.72	177	106	1.64	176	110
	1.00	1.93	188	102	1.86	187	106	1.79	186	110	1.64	176	110
	2.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	113
8	Normal	1.46	137	82	1.39	136	85	1.31	135	89	1.22	134	92
	0.25	1.62	161	96	1.55	160	100	1.48	159	103	1.40	158	107
	0.50	1.67	169	101	1.60	168	104	1.53	167	108	1.46	166	111
	1.00	1.72	177	106	1.65	177	110	1.59	176	113	1.46	166	111
	2.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	111
24	Normal	1.35	126	78	1.28	125	81	1.20	125	85	1.12	124	88
	0.25	1.49	148	91	1.43	148	95	1.35	147	98	1.28	147	102
	0.50	1.53	155	96	1.47	155	99	1.40	154	103	1.33	153	106
	1.00	1.58	163	101	1.52	163	104	1.45	162	108	1.38	162	111
	2.00	1.63	171	106	1.57	171	109	1.50	170	113	1.38	162	111
50	Normal	1.24	111	69	1.17	111	73	1.09	111	76	1.01	110	80
	0.25	1.37	131	81	1.30	131	85	1.24	131	89	1.17	131	93
	0.50	1.41	137	85	1.35	138	89	1.28	137	93	1.21	137	97
	1.00	1.46	145	90	1.40	145	94	1.33	145	97	1.26	144	101
	2.00	1.50	152	94	1.45	152	98	1.38	152	102	1.31	152	106
102	Normal	1.55	160	99	1.50	161	103	1.43	160	107	1.37	160	111
	0.25	1.68	180	111	1.62	180	115	1.50	170	113	1.46	166	111
	0.50	1.72	186	111	1.65	177	110	1.59	176	113	1.46	166	111
	1.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	111
	2.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	111
113	Normal	1.35	126	78	1.28	125	81	1.20	125	85	1.12	124	88
	0.25	1.49	148	91	1.43	148	95	1.35	147	98	1.28	147	102
	0.50	1.53	155	96	1.47	155	99	1.40	154	103	1.33	153	106
	1.00	1.58	163	101	1.52	163	104	1.45	162	108	1.38	162	111
	2.00	1.63	171	106	1.57	171	109	1.50	170	113	1.38	162	111
113	Normal	1.24	111	69	1.17	111	73	1.09	111	76	1.01	110	80
	0.25	1.37	131	81	1.30	131	85	1.24	131	89	1.17	131	93
	0.50	1.41	137	85	1.35	138	89	1.28	137	93	1.21	137	97
	1.00	1.46	145	90	1.40	145	94	1.33	145	97	1.26	144	101
	2.00	1.50	152	94	1.45	152	98	1.38	152	102	1.31	152	106
113	Normal	1.55	160	99	1.50	161	103	1.43	160	107	1.37	160	111
	0.25	1.68	180	111	1.62	180	115	1.50	170	113	1.46	166	111
	0.50	1.72	186	111	1.65	177	110	1.59	176	113	1.46	166	111
	1.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	111
	2.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	111
113	Normal	1.35	126	78	1.28	125	81	1.20	125	85	1.12	124	88
	0.25	1.49	148	91	1.43	148	95	1.35	147	98	1.28	147	102
	0.50	1.53	155	96	1.47	155	99	1.40	154	103	1.33	153	106
	1.00	1.58	163	101	1.52	163	104	1.45	162	108	1.38	162	111
	2.00	1.63	171	106	1.57	171	109	1.50	170	113	1.38	162	111
113	Normal	1.24	111	69	1.17	111	73	1.09	111	76	1.01	110	80
	0.25	1.37	131	81	1.30	131	85	1.24	131	89	1.17	131	93
	0.50	1.41	137	85	1.35	138	89	1.28	137	93	1.21	137	97
	1.00	1.46	145	90	1.40	145	94	1.33	145	97	1.26	144	101
	2.00	1.50	152	94	1.45	152	98	1.38	152	102	1.31	152	106
113	Normal	1.55	160	99	1.50	161	103	1.43	160	107	1.37	160	111
	0.25	1.68	180	111	1.62	180	115	1.50	170	113	1.46	166	111
	0.50	1.72	186	111	1.65	177	110	1.59	176	113	1.46	166	111
	1.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	111
	2.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	111
113	Normal	1.35	126	78	1.28	125	81	1.20	125	85	1.12	124	88
	0.25	1.49	148	91	1.43	148	95	1.35	147	98	1.28	147	102
	0.50	1.53	155	96	1.47	155	99	1.40	154	103	1.33	153	106
	1.00	1.58	163	101	1.52	163	104	1.45	162	108	1.38	162	111
	2.00	1.63	171	106	1.57	171	109	1.50	170	113	1.38	162	111
113	Normal	1.24	111	69	1.17	111	73	1.09	111	76	1.01	110	80
	0.25	1.37	131	81	1.30	131	85	1.24	131	89	1.17	131	93
	0.50	1.41	137	85	1.35	138	89	1.28	137	93	1.21	137	97
	1.00	1.46	145	90	1.40	145	94	1.33	145	97	1.26	144	101
	2.00	1.50	152	94	1.45	152	98	1.38	152	102	1.31	152	106
113	Normal	1.55	160	99	1.50	161	103	1.43	160	107	1.37	160	111
	0.25	1.68	180	111	1.62	180	115	1.50	170	113	1.46	166	111
	0.50	1.72	186	111	1.65	177	110	1.59	176	113	1.46	166	111
	1.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	111
	2.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	111
113	Normal	1.35	126	78	1.28	125	81	1.20	125	85	1.12	124	88
	0.25	1.49	148	91	1.43	148	95	1.35	147	98	1.28	147	102
	0.50	1.53	155	96	1.47	155	99	1.40	154	103	1.33	153	106
	1.00	1.58	163	101	1.52	163	104	1.45	162	108	1.38	162	111
	2.00	1.63	171	106	1.57	171	109	1.50	170	113	1.38	162	111
113	Normal	1.24	111	69	1.17	111	73	1.09	111	76	1.01	110	80
	0.25	1.37	131	81	1.30	131	85	1.24	131	89	1.17	131	93
	0.50	1.41	137	85	1.35	138	89	1.28	137	93	1.21	137	97
	1.00	1.46	145	90	1.40	145	94	1.33	145	97	1.26	144	101
	2.00	1.50	152	94	1.45	152	98	1.38	152	102	1.31	152	106
113	Normal	1.55	160	99	1.50	161	103	1.43	160	107	1.37	160	111
	0.25	1.68	180	111	1.62	180	115	1.50	170	113	1.46	166	111
	0.50	1.72	186	111	1.65	177	110	1.59	176	113	1.46	166	111
	1.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	111
	2.00	1.77	186	111	1.65	177	110	1.59	176	113	1.46	166	111

Table 3(g)
Capacity Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Air-Cooled (OA/FA) Transformers Rated 133% or Less of Self-Cooled Rating
Equivalent Load Before Peak Load = 90% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																					
		0				10				20				30				40				50	
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	
1 2	Normal	2.00	157	67	1.88	156	73	1.76	154	80	1.61	150	86	1.23	130	88	1.64	173	107	1.77	185	110	
	0.25				2.15	183	81	2.04	182	88	1.94	181	95	1.81	178	101	1.81	178	101	1.81	178	101	
	0.50																						
	1.00																						
1	Normal	1.79	151	75	1.69	150	81	1.57	148	86	1.43	143	90	1.10	123	88	1.45	165	111				
	0.25	2.01	177	86	1.91	176	91	1.81	174	96	1.72	173	102	1.60	171	107	1.60	171	107	1.60	171	107	
	0.50				1.98	184	95	1.89	183	100	1.80	182	106	1.69	180	111							
	2.00																						
2	Normal	1.59	144	81	1.50	142	85	1.40	140	89	1.28	136	91	1.03	120	88	1.30	158	112				
	0.25	1.78	169	94	1.70	169	99	1.62	167	103	1.53	166	107	1.42	163	110	1.30	158	112				
	0.50	1.83	177	98	1.76	177	103	1.67	175	107	1.59	174	111										
	2.00	1.90	187	103	1.82	186	108	1.74	184	112													
4	Normal	1.44	136	82	1.36	134	85	1.27	132	88	1.16	128	90	0.97	115	86	1.17	148	110				
	0.25	1.60	159	96	1.53	158	99	1.45	157	103	1.37	156	106	1.28	153	108	1.17	148	110				
	0.50	1.64	167	100	1.58	166	104	1.50	165	107	1.43	163	110	1.34	162	113							
	2.00	1.75	184	111	1.69	184	115	1.56	174	113													
8	Normal	1.33	124	77	1.26	124	80	1.18	122	83	1.08	119	85	0.93	111	85	1.09	140	106	1.16	149	112	
	0.25	1.48	147	91	1.42	147	95	1.34	146	98	1.27	145	101	1.18	143	104	1.09	140	106	1.16	149	112	
	0.50	1.52	154	95	1.46	154	99	1.39	153	102	1.32	152	106	1.24	151	109	1.16	149	112				
	2.00	1.62	170	105	1.56	170	109	1.49	169	112	1.37	160	111	1.30	159	114							
24	Normal	1.24	111	69	1.16	110	72	1.08	110	76	1.00	110	80	0.92	110	84	1.00	130	100	1.05	136	104	
	0.25	1.37	131	81	1.31	131	85	1.24	131	88	1.16	130	92	1.08	130	96	1.00	130	100	1.05	136	104	
	0.50	1.41	137	85	1.35	137	89	1.28	137	92	1.21	137	96	1.13	136	100	1.05	136	104	1.11	143	108	
	2.00	1.51	152	94	1.44	152	98	1.38	152	102	1.31	151	105	1.24	152	109	1.11	143	108	1.17	151	113	

Table 3(h)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Air-Cooled (OA/FA) Transformers Rated 133% or Less of Self-Cooled Rating
Equivalent Load Before Peak Load = 100% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0				10				20			
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1	Normal	1.93	156	70	1.80	154	77	1.64	149	83	1.06	114	81
	0.25	2.19	183	78	2.08	182	85	1.98	181	92	1.84	178	98
	0.50							1.95				188	101
	1.00												
2	Normal	1.73	149	77	1.63	147	82	1.47	141	86	1.03	112	80
	0.25	1.96	176	88	1.87	175	93	1.76	173	98	1.65	170	103
	0.50	2.03	184	91	1.93	183	96	1.84	182	102	1.73	179	107
	1.00										1.82	189	111
4	Normal	1.55	142	81	1.46	140	85	1.33	134	87	1.03	112	81
	0.25	1.75	168	95	1.66	166	99	1.57	164	102	1.48	162	106
	0.50	1.81	177	99	1.73	176	103	1.65	174	107	1.55	171	111
	1.00	1.87	186	104	1.79	184	108	1.71	183	112			
8	Normal	1.42	134	81	1.34	132	84	1.23	127	85	1.02	111	81
	0.25	1.58	158	95	1.51	157	99	1.43	155	102	1.34	153	104
	0.50	1.63	166	100	1.56	165	104	1.49	163	107	1.41	161	110
	1.00	1.68	174	105	1.62	174	109	1.55	172	112			
24	Normal	1.33	124	76	1.25	122	79	1.16	119	82	1.01	110	80
	0.25	1.48	147	91	1.41	145	94	1.34	145	97	1.25	142	99
	0.50	1.52	154	95	1.46	153	99	1.38	152	102	1.31	151	105
	1.00	1.57	162	100	1.50	161	103	1.44	161	107	1.36	159	109
	2.00	1.62	170	105	1.56	170	109	1.49	169	112	1.42	168	115
	4.00	1.67	179	111	1.61	178	114						
	Normal	1.23	110	68	1.16	110	72	1.08	110	76	1.00	110	80
	0.25	1.37	131	81	1.30	131	85	1.23	130	88	1.16	130	92
	0.50	1.41	137	85	1.35	137	89	1.28	137	93	1.20	136	96
	1.00	1.46	144	89	1.40	144	93	1.33	144	97	1.26	144	100
	2.00	1.51	152	94	1.44	152	98	1.38	152	102	1.31	151	105
	4.00	1.55	160	99	1.49	160	103	1.43	159	106	1.36	159	110
	Normal	1.00	130	100	0.99	130	100	0.99	130	100	0.99	130	100
	0.25	1.05	135	103	1.05	135	103	1.05	135	103	1.05	135	103
	0.50	1.11	143	108	1.11	143	108	1.11	143	108	1.11	143	108
	1.00	1.16	151	112	1.16	151	112	1.16	151	112	1.16	151	112

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

Table 3(i)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Oil-Cooled (Directed Flow — FOA, FOA*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 50% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C															
		0			10			20			30			40			50
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	
1 2	Normal	1.76	160	52	1.70	160	59	1.63	159	66	1.56	159	74	1.48	158	81	
	0.25	1.91	186	59	1.84	185	66	1.79	185	74	1.73	185	81	1.66	184	88	
	0.50															95	
	1.00																
1	2.00																
	4.00																
	Normal	1.59	154	65	1.54	153	71	1.47	152	77	1.41	152	83	1.34	151	89	
	0.25	1.73	179	74	1.67	178	80	1.62	178	87	1.55	177	92	1.49	176	98	
2	0.50	1.77	187	78	1.72	187	84	1.66	186	90	1.60	185	95	1.54	185	102	
	1.00																
	2.00																
	4.00																
4	Normal	1.45	146	73	1.39	146	78	1.33	145	83	1.27	144	88	1.20	143	93	
	0.25	1.57	170	84	1.52	170	89	1.46	169	94	1.41	169	100	1.34	167	104	
	0.50	1.61	178	88	1.55	178	93	1.50	177	98	1.45	176	103	1.39	176	108	
	1.00	1.64	187	92	1.60	187	97	1.55	186	102	1.49	185	107	1.44	185	112	
8	2.00																
	4.00																
	Normal	1.34	136	73	1.28	135	78	1.22	135	82	1.16	134	87	1.09	133	91	
	0.25	1.45	158	85	1.40	158	90	1.34	157	94	1.29	157	99	1.23	157	103	
24	0.50	1.48	166	89	1.43	165	93	1.38	165	98	1.33	164	102	1.27	164	107	
	1.00	1.52	174	93	1.47	173	98	1.42	173	102	1.37	173	107	1.32	173	112	
	2.00	1.56	183	98	1.52	183	102	1.46	182	107	1.41	181	111	1.32	173	112	
	4.00																
8	Normal	1.27	124	68	1.21	124	73	1.15	124	77	1.09	123	82	1.02	123	87	
	0.25	1.38	146	80	1.32	146	84	1.27	145	89	1.21	145	93	1.16	145	98	
	0.50	1.41	153	83	1.36	153	88	1.31	153	93	1.25	152	97	1.20	152	102	
	1.00	1.45	160	87	1.40	161	92	1.35	160	97	1.29	160	101	1.24	159	106	
24	2.00	1.48	169	92	1.44	169	96	1.39	168	101	1.34	168	106	1.28	167	110	
	4.00	1.52	178	95	1.48	177	101	1.43	177	106	1.38	177	110	1.28	167	110	
	Normal	1.19	111	61	1.13	111	66	1.07	111	71	1.01	111	76	0.94	111	80	
	0.25	1.30	131	72	1.25	131	77	1.19	131	81	1.13	131	86	1.07	131	91	
24	0.50	1.33	137	75	1.28	137	80	1.23	137	85	1.17	138	90	1.11	137	94	
	1.00	1.37	144	79	1.32	144	84	1.27	145	86	1.21	145	93	1.15	144	98	
	2.00	1.41	152	83	1.36	152	88	1.30	152	92	1.25	152	97	1.20	152	102	
	4.00	1.44	160	87	1.39	160	92	1.34	160	96	1.29	160	101	1.24	159	106	

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 3(j)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Oil-Cooled (Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 70% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0				10				20			
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1	Normal	1.71	159	57	1.65	159	64	1.58	158	71	1.51	157	85
	0.25	1.87	185	64	1.80	184	71	1.74	184	78	1.68	184	92
	0.50												
	1.00												
	2.00												
2	Normal	1.56	152	67	1.50	152	73	1.44	151	79	1.37	150	90
	0.25	1.70	178	77	1.64	177	83	1.59	177	89	1.52	176	94
	0.50	1.74	186	80	1.69	185	86	1.63	185	92	1.57	184	98
	1.00												
	2.00												
4	Normal	1.43	145	73	1.37	144	78	1.31	144	83	1.24	142	88
	0.25	1.55	170	85	1.50	169	90	1.45	168	95	1.39	167	100
	0.50	1.59	178	89	1.54	176	94	1.48	176	98	1.43	175	103
	1.00	1.63	186	93	1.58	185	98	1.53	185	103	1.48	184	108
	2.00												
8	Normal	1.33	135	73	1.27	134	77	1.21	134	82	1.15	132	86
	0.25	1.45	158	85	1.39	157	89	1.34	157	94	1.28	156	98
	0.50	1.48	165	88	1.43	165	93	1.38	164	98	1.32	164	102
	1.00	1.52	173	93	1.47	173	97	1.42	172	102	1.37	172	107
	2.00	1.55	182	97	1.51	181	102	1.46	181	107	1.41	181	111
24	Normal	1.26	124	68	1.21	124	73	1.15	124	77	1.09	123	82
	0.25	1.38	146	80	1.32	145	84	1.27	145	89	1.21	144	93
	0.50	1.41	152	83	1.36	153	88	1.30	152	92	1.25	152	97
	1.00	1.45	160	87	1.39	160	92	1.34	160	96	1.29	159	101
	2.00	1.48	168	91	1.43	168	96	1.38	167	100	1.34	168	106
	Normal	1.19	111	61	1.13	111	66	1.07	111	71	1.00	111	75
	0.25	1.30	130	72	1.25	131	77	1.19	130	81	1.13	131	86
	0.50	1.33	137	75	1.28	137	80	1.23	137	85	1.17	137	89
	1.00	1.37	144	79	1.32	144	84	1.27	144	88	1.21	145	93
	2.00	1.40	152	83	1.36	152	88	1.30	152	92	1.25	152	97

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 3(k)
Capacity Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Oil-Cooled (Directed Flow – FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 90% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																	
		0			10			20			30			40			50		
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1 2	Normal	1.66	158	62	1.59	157	70	1.51	156	76	1.41	153	83	1.25	142	87	1.44	176	104
	0.25	1.81	184	69	1.75	184	77	1.68	182	83	1.61	181	90	1.59	189	100	1.52	187	107
	0.50																		
	1.00																		
1	Normal	1.52	151	70	1.45	149	76	1.38	148	81	1.30	145	86	1.14	134	88	1.31	167	107
	0.25	1.66	177	80	1.61	176	86	1.54	175	91	1.48	173	97	1.41	172	103	1.38	178	111
	0.50	1.71	185	83	1.65	184	89	1.59	184	95	1.53	182	100	1.46	181	106	1.38	178	111
	1.00																		
2	Normal	1.41	143	74	1.34	142	79	1.28	140	83	1.20	137	87	1.06	127	88	1.20	158	107
	0.25	1.53	167	85	1.48	167	90	1.42	166	95	1.36	165	100	1.29	162	104	1.27	168	112
	0.50	1.57	175	89	1.52	175	94	1.46	174	99	1.41	173	104	1.34	172	109	1.27	168	112
	1.00	1.61	184	93	1.56	184	98	1.51	183	103	1.45	182	108	1.39	180	113	1.27	168	112
4	Normal	1.32	134	73	1.26	132	76	1.20	131	81	1.12	128	84	1.01	121	85	1.13	149	105
	0.25	1.43	156	84	1.38	156	89	1.33	155	93	1.27	154	98	1.20	152	101	1.18	158	109
	0.50	1.47	163	88	1.42	164	93	1.37	163	97	1.31	162	102	1.25	160	106	1.18	158	109
	1.00	1.51	172	92	1.46	172	97	1.41	170	101	1.36	170	106	1.30	169	110	1.23	168	114
8	Normal	1.26	123	68	1.20	123	72	1.14	122	77	1.07	120	80	0.97	115	83	1.07	141	101
	0.25	1.37	145	79	1.32	144	84	1.27	144	88	1.20	143	92	1.14	142	97	1.12	148	105
	0.50	1.41	152	83	1.35	151	87	1.30	151	92	1.25	151	97	1.19	150	101	1.17	157	109
	1.00	1.44	160	87	1.39	159	91	1.34	159	96	1.29	159	101	1.23	158	105	1.22	166	114
24	Normal	1.19	111	61	1.13	111	66	1.07	111	71	1.00	110	75	0.93	110	80	0.85	110	84
	0.25	1.30	130	72	1.24	130	76	1.19	130	81	1.13	130	86	1.07	130	90	1.00	130	95
	0.50	1.33	137	75	1.28	137	80	1.23	137	85	1.17	137	89	1.11	137	94	1.04	136	98
	1.00	1.37	144	79	1.32	144	84	1.26	144	88	1.21	144	93	1.15	144	97	1.09	143	102
24	Normal	1.40	152	83	1.36	152	88	1.30	152	92	1.25	152	97	1.20	152	102	1.13	151	106
	0.25	1.52	176	95	1.47	176	100	1.42	176	105	1.37	175	109	1.32	175	114	1.18	159	110
	0.50	1.55	181	97	1.50	180	101	1.45	180	106	1.40	179	110	1.34	178	115	1.23	168	114
	1.00	1.58	188	101	1.53	188	105	1.48	188	110	1.43	187	115	1.38	186	120	1.27	168	114

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.

% loss of life is in addition to normal loss of life.

*Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 3(l)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Oil-Cooled (Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 100% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																			
		0			10			20			30			40			50				
		Peak Load (Per Unit)	Hot-Temp (°C)	Spot-Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Temp (°C)	Spot-Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Temp (°C)	Spot-Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Temp (°C)	Spot-Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Temp (°C)	Spot-Temp (°C)	Top-Oil Temp (°C)
1 2	Normal	1.61	157	182	66	73	72	80	78	1.00	110	173	99	1.00	130	175	95	1.00	130	175	95
	0.25	1.77	182						87	1.56	179	184	102	1.39	175	191	107	1.52	184	191	112
	0.50																				
	1.00																				
	4.00																				
1	Normal	1.49	149		71		77		81	1.00	110	164	75	1.00	130	175	95	1.00	130	175	95
	0.25	1.64	176		81		87		93	1.44	170	176	98	1.34	164	176	106	1.28	166	176	109
	0.50	1.68	184		84		90		96	1.49	179	187	101	1.41	176	187	110	1.39	183	187	115
	1.00									1.55	190		105	1.48	187		110	1.39	183		115
	4.00																				
2	Normal	1.39	142		74		78		81	1.00	110	156	75	1.00	130	175	95	1.00	130	175	95
	0.25	1.52	167		86		90		95	1.34	162	168	99	1.26	156	177	102	1.20	168	177	108
	0.50	1.56	175		89		94		99	1.38	170	177	103	1.31	168	177	107	1.20	177	177	116
	1.00	1.60	183		94		98		103	1.43	180		108	1.37	177		112	1.29	174		116
	4.00																				
4	Normal	1.31	132		72		76		79	1.00	110	147	75	1.00	130	175	95	1.00	130	175	95
	0.25	1.43	156		84		88		93	1.25	151	157	96	1.17	147	177	104	1.13	151	164	106
	0.50	1.46	163		88		92		97	1.30	159	166	101	1.23	157	177	109	1.21	164	177	112
	1.00	1.50	171		92		97		101	1.34	168	177	105	1.28	166	177	114	1.21	177	177	112
	4.00	1.54	180		97		101		106	1.39	178		110	1.34	177		114	1.21	177		112
8	Normal	1.25	122		67		72		75	1.00	110	139	75	1.00	130	175	95	1.00	130	175	95
	0.25	1.37	144		79		83		88	1.20	142	148	92	1.12	139	177	100	1.09	143	177	102
	0.50	1.40	151		83		87		92	1.24	149	157	96	1.17	148	177	104	1.15	154	177	107
	1.00	1.44	159		87		91		96	1.28	157	166	100	1.22	157	177	109	1.21	164	177	113
	4.00	1.48	167		91		96		100	1.33	166	177	105	1.27	165	177	114	1.21	177	177	113
24	Normal	1.19	110		61		66		70	1.00	110	110	75	0.93	110	109	84	0.85	109	84	84
	0.25	1.30	130		72		76		81	1.13	130	136	86	1.06	130	136	90	1.00	130	136	95
	0.50	1.33	137		75		80		84	1.16	136	142	89	1.11	136	142	94	1.04	136	142	98
	1.00	1.37	144		79		84		88	1.21	144	150	93	1.15	144	150	97	1.09	144	150	102
	4.00	1.40	152		83		87		92	1.25	151	157	97	1.19	151	157	101	1.13	151	157	106

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit. % loss of life is in addition to normal loss of life.

Table 3(m)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Air-Cooled (OA/FA/FA) Transformers Rated Over 133% of Self-Cooled Rating
Equivalent Load Before Peak Load = 50% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																					
		0				10				20				30				40				50	
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	
1	Normal	1.96	160	57	1.88	159	63	1.79	159	70	1.70	159	77	1.60	158	83	1.50	156	90	1.50	156	90	
	0.25	2.17	186	65	2.09	185	72	2.00	185	78	1.92	184	85	1.83	184	92	1.74	183	98	1.74	183	98	
	0.50																						
	1.00																						
1	Normal	1.74	154	69	1.66	153	74	1.58	152	80	1.50	152	85	1.40	150	90	1.31	150	96	1.31	150	96	
	0.25	1.91	179	80	1.84	178	85	1.77	178	91	1.69	177	96	1.61	176	101	1.53	176	107	1.53	176	107	
	0.50	1.97	188	84	1.90	186	89	1.83	186	95	1.75	185	100	1.67	184	105	1.59	184	110	1.59	184	110	
	1.00																						
2	Normal	1.54	146	76	1.47	145	80	1.40	145	85	1.32	144	89	1.23	142	93	1.14	141	98	1.14	141	98	
	0.25	1.70	170	89	1.63	170	93	1.56	169	98	1.49	168	102	1.42	167	106	1.34	166	111	1.34	166	111	
	0.50	1.74	178	93	1.68	177	97	1.61	177	101	1.54	176	106	1.47	176	111							
	1.00	1.80	187	98	1.73	186	102	1.67	186	106	1.60	185	111										
4	Normal	1.40	135	75	1.33	135	79	1.26	134	83	1.19	133	87	1.11	133	91	1.03	132	95	1.03	132	95	
	0.25	1.54	158	88	1.48	157	92	1.42	157	96	1.35	156	100	1.28	156	104	1.20	155	108	1.20	155	108	
	0.50	1.59	166	92	1.52	165	96	1.46	164	100	1.39	164	104	1.33	163	108	1.26	163	112	1.26	163	112	
	1.00	1.63	174	97	1.58	174	101	1.51	173	105	1.45	172	109	1.38	172	113							
8	Normal	1.68	182	102	1.63	182	106	1.57	182	110	1.50	181	114										
	0.25																						
	0.50																						
	1.00																						
8	Normal	1.32	124	69	1.25	123	74	1.18	123	78	1.11	123	82	1.03	123	86	0.94	122	90	0.94	122	90	
	0.25	1.45	145	82	1.39	145	86	1.32	145	90	1.25	144	94	1.19	144	98	1.11	144	103	1.11	144	103	
	0.50	1.49	152	86	1.43	152	90	1.37	152	94	1.30	152	98	1.23	151	102	1.16	151	107	1.16	151	107	
	1.00	1.54	160	90	1.48	160	95	1.42	160	98	1.35	159	102	1.28	159	107	1.22	159	111	1.22	159	111	
24	Normal	1.59	168	95	1.53	168	99	1.47	168	103	1.40	168	107	1.34	167	111							
	0.25	1.63	177	100	1.58	176	104	1.52	177	108	1.45	176	112										
	0.50																						
	1.00																						
24	Normal	1.23	111	62	1.16	111	66	1.09	111	71	1.01	110	75	0.92	110	79	0.84	110	84	0.84	110	84	
	0.25	1.36	131	73	1.29	130	78	1.23	130	82	1.15	130	86	1.08	130	90	1.00	130	95	1.00	130	95	
	0.50	1.40	137	77	1.34	137	81	1.27	137	85	1.20	136	90	1.13	137	94	1.06	137	99	1.06	137	99	
	1.00	1.44	144	81	1.38	144	85	1.31	143	89	1.25	144	94	1.18	143	98	1.11	144	103	1.11	144	103	
24	Normal	1.49	151	85	1.43	152	90	1.36	151	94	1.30	151	98	1.23	151	102	1.16	151	107	1.16	151	107	
	0.25	1.63	177	90	1.58	176	94	1.52	177	98	1.45	176	103	1.29	159	107	1.21	159	111	1.21	159	111	
	0.50																						
	1.00																						

Table 3(n)
Capacity Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Air-Cooled (OA/FA/FA) Transformers Rated Over 133% of Self-Cooled Rating
Equivalent Load Before Peak Load = 70% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																							
		0				10				20				30				40				50			
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)			
1 2	Normal	1.91	159	61	1.82	159	67	1.72	157	74	1.63	156	80	1.53	156	87	1.39	152	93						
	0.25	2.11	185	69	2.03	184	76	1.95	183	82	1.86	183	89	1.77	182	95	1.67	181	102						
	0.50																								
	1.00																								
	2.00																								
1	Normal	1.70	152	71	1.62	152	76	1.54	151	81	1.45	150	87	1.35	148	92	1.23	145	96						
	0.25	1.88	178	82	1.80	177	87	1.73	177	93	1.65	175	98	1.57	175	103	1.48	173	108						
	0.50	1.94	187	86	1.87	186	91	1.79	185	96	1.71	184	102	1.63	183	107	1.54	182	112						
	1.00																								
	2.00																								
2	Normal	1.52	145	76	1.45	144	81	1.37	143	85	1.29	142	89	1.20	140	93	1.10	137	96						
	0.25	1.68	169	89	1.61	169	94	1.54	168	98	1.47	167	102	1.39	166	106	1.31	164	110						
	0.50	1.73	177	93	1.66	177	98	1.59	176	102	1.52	175	106	1.45	174	111	1.25	162	112						
	1.00	1.78	186	98	1.71	185	102	1.65	185	107	1.58	183	111	1.49	180	114	1.21	159	111						
	2.00																								
4	Normal	1.40	134	75	1.32	133	78	1.25	133	82	1.18	132	86	1.10	131	90	1.00	128	94						
	0.25	1.54	158	88	1.47	157	92	1.41	156	96	1.34	156	100	1.26	154	103	1.19	154	108						
	0.50	1.58	165	92	1.52	164	96	1.46	164	100	1.39	163	104	1.32	162	108	1.25	162	112						
	1.00	1.63	173	97	1.57	173	101	1.50	172	105	1.44	172	109	1.38	171	113	1.21	159	111						
	2.00	1.68	182	102	1.62	181	105	1.56	181	110	1.49	180	114	1.38	171	113	1.25	162	112						
8	Normal	1.32	124	69	1.25	123	74	1.18	123	78	1.10	122	81	1.01	121	85	0.92	119	89						
	0.25	1.45	145	82	1.39	145	86	1.32	145	90	1.25	144	94	1.18	144	98	1.10	143	102						
	0.50	1.49	152	86	1.43	151	90	1.37	152	94	1.30	151	98	1.23	151	102	1.15	143	106						
	1.00	1.54	160	90	1.48	160	94	1.42	160	99	1.35	159	102	1.28	158	106	1.21	158	106						
	2.00	1.58	168	95	1.52	167	99	1.46	167	103	1.40	167	107	1.34	167	111	1.21	158	106						
24	Normal	1.23	110	62	1.16	111	66	1.08	110	70	1.01	110	75	0.92	110	79	0.83	110	84						
	0.25	1.36	130	73	1.29	131	78	1.23	130	82	1.16	130	86	1.08	130	90	1.00	130	95						
	0.50	1.40	137	77	1.33	137	81	1.27	137	86	1.20	137	90	1.13	136	94	1.06	137	99						
	1.00	1.44	144	81	1.38	144	85	1.31	144	89	1.25	144	94	1.18	143	98	1.10	143	102						
	2.00	1.48	151	85	1.42	151	89	1.36	151	94	1.30	151	98	1.23	151	102	1.16	151	107						

Table 3(p)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Air-Cooled (OA/FA/FA) Transformers Rated Over 133% of Self-Cooled Rating
Equivalent Load Before Peak Load = 90% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0	10	20	30	40	50	Peak Load (Per Unit)	Top- Oil Temp (°C)	Hot- Spot Temp (°C)	Peak Load (Per Unit)	Top- Oil Temp (°C)	Hot- Spot Temp (°C)
1	Normal	1.84	1.58	1.55	1.51	1.23	1.23	86	84	134	1.23	86	134
	0.25	2.04	1.83	1.82	1.81	1.67	1.67	99	94	179	1.67	99	179
	0.50					1.75	1.75	102	102	188	1.75	102	188
	1.00												
	2.00												
1	Normal	1.65	1.51	1.47	1.44	1.10	1.10	85	87	126	1.10	85	126
	0.25	1.83	1.76	1.75	1.73	1.49	1.49	104	99	171	1.49	104	171
	0.50	1.89	1.85	1.83	1.82	1.57	1.57	108	104	180	1.57	108	180
	1.00												
	2.00												
2	Normal	1.49	1.43	1.40	1.36	1.03	1.03	85	87	122	1.03	85	122
	0.25	1.66	1.68	1.66	1.64	1.35	1.35	105	102	162	1.35	105	162
	0.50	1.71	1.76	1.74	1.73	1.42	1.42	110	106	171	1.42	110	171
	1.00	1.76	1.85	1.82	1.82	1.56	1.56	111	108	182	1.56	111	182
	2.00												
4	Normal	1.38	1.33	1.30	1.27	0.98	0.98	83	84	117	0.98	83	117
	0.25	1.53	1.56	1.55	1.53	1.24	1.24	102	99	162	1.24	102	162
	0.50	1.57	1.64	1.62	1.62	1.30	1.30	107	103	160	1.30	107	160
	1.00	1.62	1.72	1.69	1.68	1.35	1.35	111	108	168	1.35	111	168
	2.00	1.67	1.81	1.79	1.79	1.48	1.48	113	113	179	1.48	113	179
8	Normal	1.31	1.23	1.21	1.19	0.95	0.95	81	80	113	0.95	81	113
	0.25	1.44	1.44	1.44	1.43	1.17	1.17	97	93	142	1.17	97	142
	0.50	1.49	1.52	1.51	1.50	1.22	1.22	101	98	149	1.22	101	149
	1.00	1.53	1.59	1.58	1.58	1.28	1.28	106	102	158	1.28	106	158
	2.00	1.58	1.67	1.67	1.67	1.33	1.33	110	107	166	1.33	110	166
24	Normal	1.22	1.10	1.10	1.10	0.92	0.92	79	75	109	0.92	79	109
	0.25	1.36	1.30	1.30	1.30	1.08	1.08	90	86	130	1.08	90	130
	0.50	1.40	1.37	1.36	1.36	1.12	1.12	94	90	136	1.12	94	136
	1.00	1.44	1.43	1.43	1.43	1.18	1.18	98	94	143	1.18	98	143
	2.00	1.49	1.51	1.51	1.51	1.23	1.23	102	98	151	1.23	102	151

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

Table 3(q)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Air-Cooled (OA/FA/FA) Transformers Rates Over 133% of Self-Cooled Rating
Equivalent Load Before Peak Load = 100% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0				10				20			
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1	Normal	1.78	156	68	1.68	155	74	1.54	149	80	1.06	115	76
	0.25	2.00	183	77	1.91	182	83	1.82	181	90	1.71	178	96
	0.50							1.80					99
	1.00												
	2.00												
2	Normal	1.62	150	74	1.52	147	79	1.40	142	82	1.03	112	76
	0.25	1.81	176	86	1.73	174	91	1.64	173	96	1.55	171	100
	0.50	1.86	184	89	1.79	183	94	1.71	182	100	1.62	180	104
	1.00												
	2.00												
4	Normal	1.48	142	76	1.39	139	80	1.28	134	82	1.02	111	75
	0.25	1.64	167	89	1.57	166	94	1.49	164	97	1.41	161	101
	0.50	1.69	175	94	1.62	174	98	1.54	172	102	1.47	171	106
	1.00	1.74	184	98	1.68	183	103	1.61	182	107	1.53	180	111
	2.00												
8	Normal	1.38	132	74	1.30	130	77	1.20	126	79	1.02	111	76
	0.25	1.52	156	87	1.46	155	91	1.38	153	94	1.30	151	98
	0.50	1.57	163	91	1.50	162	95	1.43	161	99	1.36	159	102
	1.00	1.61	171	96	1.55	171	100	1.49	170	104	1.42	169	108
	2.00	1.66	180	101	1.60	179	105	1.54	178	109	1.47	178	112
24	Normal	1.30	122	68	1.23	121	72	1.14	118	75	1.01	110	75
	0.25	1.45	144	81	1.38	144	85	1.31	143	89	1.23	142	92
	0.50	1.49	151	85	1.42	150	89	1.36	150	93	1.29	149	97
	1.00	1.53	159	90	1.47	159	94	1.40	157	97	1.34	157	101
	2.00	1.58	167	94	1.52	166	98	1.46	166	102	1.39	166	106
	Normal	1.62	175	99	1.57	175	103	1.51	175	107	1.45	175	112
	0.25	1.81	198	112	1.73	197	116	1.64	196	120	1.55	195	124
	0.50	1.86	206	116	1.79	205	120	1.71	204	124	1.62	203	128
	1.00												
	2.00												
	Normal	1.23	110	62	1.15	110	66	1.08	110	70	1.00	110	75
	0.25	1.36	130	73	1.29	130	77	1.22	130	82	1.15	129	86
	0.50	1.40	137	77	1.33	137	81	1.27	136	86	1.20	136	89
	1.00	1.44	143	81	1.38	143	85	1.31	143	89	1.25	143	94
	2.00	1.48	151	85	1.42	151	89	1.36	151	93	1.30	151	98
	Normal	1.53	159	99	1.47	159	103	1.41	159	107	1.35	159	112
	0.25	1.73	184	112	1.67	183	116	1.59	182	120	1.49	181	124
	0.50	1.78	192	116	1.73	191	120	1.65	190	124	1.59	189	128
	1.00												
	2.00												

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

Table 3(r)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Oil-Cooled (Non-Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 50% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																					
		0				10				20				30				40				50	
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	
1 2	Normal	1.94	161	60	1.85	160	66	1.77	159	72	1.68	159	78	1.59	158	84	1.49	156	90				
	0.25	2.12	187	70	2.05	186	76	1.97	185	82	1.89	185	88	1.81	184	94	1.72	184	100				
	0.50																						
	1.00																						
	2.00																						
1	Normal	1.71	155	72	1.63	154	77	1.55	153	82	1.48	152	87	1.39	151	92	1.30	150	96				
	0.25	1.87	180	85	1.80	179	89	1.73	178	94	1.66	178	99	1.59	177	104	1.51	176	109				
	0.50				1.85	188	94	1.79	187	98	1.72	186	103	1.64	185	108	1.57	185	113				
	1.00																						
	2.00																						
2	Normal	1.51	146	79	1.45	146	83	1.38	145	87	1.31	144	91	1.23	143	94	1.14	142	98				
	0.25	1.65	171	93	1.60	171	97	1.53	169	100	1.47	169	104	1.40	168	108	1.32	166	112				
	0.50	1.70	178	97	1.64	178	101	1.58	178	105	1.51	177	109	1.45	176	113							
	1.00	1.75	188	102	1.69	187	106	1.63	186	110	1.57	186	114										
	2.00																						
4	Normal	1.38	136	77	1.32	135	81	1.25	134	84	1.18	133	88	1.11	133	92	1.03	132	95				
	0.25	1.51	158	91	1.45	158	95	1.39	157	98	1.33	157	102	1.26	157	106	1.19	155	109				
	0.50	1.55	166	96	1.49	166	99	1.43	165	103	1.37	165	107	1.31	164	110	1.24	163	113				
	1.00	1.59	174	101	1.54	174	104	1.48	173	107	1.42	173	112										
	2.00	1.63	183	106	1.58	182	110	1.53	182	113													
8	Normal	1.30	124	71	1.23	124	75	1.17	124	79	1.10	123	82	1.02	122	86	0.94	122	90				
	0.25	1.42	146	84	1.37	146	88	1.30	145	91	1.24	145	96	1.17	145	99	1.10	144	103				
	0.50	1.46	152	88	1.40	152	92	1.35	153	96	1.29	152	100	1.22	152	104	1.15	152	107				
	1.00	1.50	160	93	1.45	160	97	1.39	160	100	1.33	160	105	1.27	159	108	1.20	159	112				
	2.00	1.54	168	98	1.49	168	102	1.43	168	106	1.38	168	110	1.32	167	113							
24	Normal	1.21	111	63	1.15	111	67	1.08	110	71	1.01	111	75	0.93	110	79	0.84	110	83				
	0.25	1.33	130	75	1.27	130	79	1.21	130	82	1.15	130	87	1.08	130	91	1.01	130	95				
	0.50	1.37	137	79	1.31	137	83	1.25	137	87	1.19	137	91	1.12	137	95	1.05	137	99				
	1.00	1.41	144	83	1.35	144	87	1.30	144	91	1.23	144	95	1.17	143	99	1.10	144	103				
	2.00	1.45	151	88	1.40	151	91	1.34	151	95	1.28	151	99	1.21	151	103	1.15	151	107				
	Normal	1.50	159	93	1.44	159	96	1.39	159	100	1.33	160	104	1.26	159	108	1.20	159	112				
	0.25																						
	0.50																						
	1.00																						
	2.00																						

Table 3(s)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Oil-Cooled (Non-Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 70% Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																							
		0				10				20				30				40				50			
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)			
1	Normal	1.88	159	64	1.80	159	70	1.71	158	76	1.62	157	82	1.52	156	88	1.39	153	93	1.39	153	93			
	0.25	2.07	185	73	2.00	185	80	1.92	184	86	1.83	184	91	1.75	183	98	1.66	182	104	1.66	182	104			
	0.50																								
	1.00																								
	2.00																								
2	Normal	1.67	154	74	1.59	152	79	1.52	152	84	1.43	150	88	1.34	148	93	1.23	145	97	1.23	145	97			
	0.25	1.83	179	86	1.77	178	91	1.70	177	96	1.62	177	101	1.54	175	105	1.46	174	110	1.46	174	110			
	0.50	1.89	187	91	1.82	186	95	1.75	186	100	1.68	185	105	1.61	184	110									
	1.00																								
	2.00																								
4	Normal	1.49	145	79	1.43	145	83	1.36	144	87	1.28	142	90	1.19	140	94	1.10	137	97	1.10	137	97			
	0.25	1.64	170	93	1.57	169	96	1.51	168	100	1.44	167	104	1.37	166	108	1.30	165	112	1.30	165	112			
	0.50	1.68	178	97	1.62	177	101	1.56	177	105	1.49	176	109	1.43	175	113									
	1.00	1.73	187	103	1.67	186	106	1.61	185	110	1.55	184	114												
	2.00																								
8	Normal	1.37	134	76	1.31	134	80	1.24	133	84	1.17	132	87	1.09	131	91	1.00	128	93	1.00	128	93			
	0.25	1.50	158	91	1.44	157	94	1.38	156	98	1.32	156	101	1.25	155	105	1.18	154	108	1.18	154	108			
	0.50	1.54	165	95	1.48	164	99	1.42	164	102	1.36	163	106	1.30	162	109	1.23	161	113	1.23	161	113			
	1.00	1.59	174	101	1.53	173	104	1.47	173	108	1.41	172	111	1.35	171	115									
	2.00	1.63	182	106	1.58	182	109	1.52	181	113															
24	Normal	1.29	123	71	1.23	123	74	1.16	123	78	1.10	123	82	1.01	121	86	0.92	120	89	0.92	120	89			
	0.25	1.42	145	84	1.36	145	88	1.30	145	91	1.24	144	95	1.17	144	99	1.10	143	102	1.10	143	102			
	0.50	1.46	152	88	1.40	152	92	1.34	151	95	1.28	151	99	1.22	151	103	1.15	150	107	1.15	150	107			
	1.00	1.50	160	93	1.44	159	97	1.39	159	100	1.33	159	104	1.26	158	107	1.20	158	111	1.20	158	111			
	2.00	1.54	168	98	1.49	168	102	1.43	168	105	1.37	167	109	1.31	167	113									
24	Normal	1.21	110	63	1.14	110	67	1.08	110	71	1.01	110	75	0.92	110	79	0.84	110	83	0.84	110	83			
	0.25	1.33	130	75	1.27	130	79	1.21	130	83	1.14	130	87	1.08	130	91	1.00	130	95	1.00	130	95			
	0.50	1.37	137	79	1.31	137	83	1.25	137	87	1.19	136	90	1.12	136	94	1.05	136	99	1.05	136	99			
	1.00	1.41	144	83	1.35	144	87	1.29	144	91	1.23	144	95	1.17	143	99	1.10	143	103	1.10	143	103			
	2.00	1.45	152	88	1.40	151	92	1.34	151	96	1.28	151	99	1.21	151	103	1.15	151	107	1.15	151	107			
24	Normal	1.21	110	63	1.14	110	67	1.08	110	71	1.01	110	75	0.92	110	79	0.84	110	83	0.84	110	83			
	0.25	1.33	130	75	1.27	130	79	1.21	130	83	1.14	130	87	1.08	130	91	1.00	130	95	1.00	130	95			
	0.50	1.37	137	79	1.31	137	83	1.25	137	87	1.19	136	90	1.12	136	94	1.05	136	99	1.05	136	99			
	1.00	1.41	144	83	1.35	144	87	1.29	144	91	1.23	144	95	1.17	143	99	1.10	143	103	1.10	143	103			
	2.00	1.45	152	88	1.40	151	92	1.34	151	96	1.28	151	99	1.21	151	103	1.15	151	107	1.15	151	107			
24	Normal	1.21	110	63	1.14	110	67	1.08	110	71	1.01	110	75	0.92	110	79	0.84	110	83	0.84	110	83			
	0.25	1.33	130	75	1.27	130	79	1.21	130	83	1.14	130	87	1.08	130	91	1.00	130	95	1.00	130	95			
	0.50	1.37	137	79	1.31	137	83	1.25	137	87	1.19	136	90	1.12	136	94	1.05	136	99	1.05	136	99			
	1.00	1.41	144	83	1.35	144	87	1.29	144	91	1.23	144	95	1.17	143	99	1.10	143	103	1.10	143	103			
	2.00	1.45	152	88	1.40	151	92	1.34	151	96	1.28	151	99	1.21	151	103	1.15	151	107	1.15	151	107			
24	Normal	1.21	110	63	1.14	110	67	1.08	110	71	1.01	110	75	0.92	110	79	0.84	110	83	0.84	110	83			
	0.25	1.33	130	75	1.27	130	79	1.21	130	83	1.14	130	87	1.08	130	91	1.00	130	95	1.00	130	95			
	0.50	1.37	137	79	1.31	137	83	1.25	137	87	1.19	136	90	1.12	136	94	1.05	136	99	1.05	136	99			
	1.00	1.41	144	83	1.35	144	87	1.29	144	91	1.23	144	95	1.17	143	99	1.10	143	103	1.10	143	103			
	2.00	1.45	152	88	1.40	151	92	1.34	151	96	1.28	151	99	1.21	151	103	1.15	151	107	1.15	151	107			
24	Normal	1.21	110	63	1.14	110	67	1.08	110	71	1.01	110	75	0.92	110	79	0.84	110	83	0.84	110	83			
	0.25	1.33	130	75	1.27	130	79	1.21	130	83	1.14	130	87	1.08	130	91	1.00	130	95	1.00	130	95			
	0.50	1.37	137	79	1.31	137	83	1.25	137	87	1.19	136	90	1.12	136	94	1.05	136	99	1.05	136	99			
	1.00	1.41	144	83	1.35	144	87	1.29	144	91	1.23	144	95	1.17	143	99	1.10	143	103	1.10	143	103			
	2.00	1.45	152	88	1.40	151	92	1.34	151	96	1.28	151	99	1.21	151	103	1.15	151	107	1.15	151	107			
24	Normal	1.21	110	63	1.14	110	67	1.08	110	71	1.01	110	75	0.92	110	79	0.84	110	83	0.84	110	83			
	0.25	1.33	130	75	1.27	130	79	1.21	130	83	1.14	130	87	1.08	130	91	1.00	130	95	1.00	130	95			
	0.50	1.37	137	79	1.31	137	83	1.25	137	87	1.19	136	90	1.12	136	94	1.05	136	99	1.05	136	99			
	1.00	1.41	144	83	1.35	144	87	1.29	144	91	1.23	144	95	1.17	143	99	1.10	143	103	1.10	143	103			
	2.00	1.45	152	88	1.40	151	92	1.34	151	96	1.28	151	99	1.21	151	103	1.15	151	107	1.15	151	107			
24	Normal	1.21	110	63	1.14	110	67	1.08	110	71	1.01	110	75	0.92	110	79	0.84	110	83	0.84	110	83			
	0.25	1.33	130	75	1.27	130	79	1.21	130	83	1.14	130	87	1.08	130	91	1.00	130	95	1.00	130	95			
	0.50	1.37	137	79	1.31	137	83	1.25	137	87	1.19	136	90	1.12	136	94	1.05	136	99	1.05	136	99			
	1.00	1.41	144	83	1.35	144	87	1.29	144	91	1.23	144	95	1.17	143	99	1.10	143	103	1.10	143	103			
	2.00	1.45	152	88	1.40	151	92	1.34	151	96	1.28	151	99	1.21	151	103	1.15	151	107	1.15	151	107			
24	Normal	1.21	110	63	1.14	110	67	1.08	110	71	1.01	110	75	0.92	110	79	0.84	110	83	0.84	110	83			
	0.25	1.33	130	75	1.27	130	79	1.21	130	83	1.14	130	87	1.08	130	91	1.00	130	95	1.00	130	95			
	0.50	1.37	137	79	1.31	137	83	1.25	137	87	1.19	136	90	1.12	136	94	1.05	136	99	1.05	136	99			
	1.00	1.41	144	83	1.35	144	87	1.29	144	91	1.23	144	95	1.17	143	99	1.10	143	103	1.10	143	103			
	2.00	1.45	152	88	1.40	151	92	1.34	151	96	1.28	151	99	1.21	151	103	1.15	151	107	1.15	151	107			
24	Normal	1.21	110	63	1.14	110	67	1.08	110	71	1.01	110	75	0.92	110	79	0.84	110	83	0.84	11				

Table 3(t)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Oil-Cooled (Non-Directed Flow – FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 90% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																					
		0				10				20				30				40				50	
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	
1 2	Normal	1.80	158	68	1.71	157	74	1.61	155	80	1.49	151	85	1.52	175	106	1.62	186	110				
	0.25	2.01	185	78	1.92	184	84	1.84	183	90	1.75	182	96										
	0.50																						
	1.00																						
1	Normal	1.62	151	76	1.54	150	81	1.45	148	85	1.34	145	88	1.36	167	110							
	0.25	1.79	178	89	1.72	177	93	1.64	175	98	1.56	174	102										
	0.50	1.85	186	93	1.77	185	97	1.70	184	102	1.63	183	107										
	1.00																						
2	Normal	1.47	143	79	1.39	142	82	1.32	140	86	1.22	136	88	1.05	124	86	1.23	157	109				
	0.25	1.62	169	93	1.55	167	97	1.48	166	100	1.41	165	104	1.33	162	107	1.30	168	115				
	0.50	1.66	176	97	1.60	175	101	1.53	174	105	1.46	173	109	1.39	171	112							
	1.00	1.71	185	103	1.65	184	106	1.59	184	110	1.52	182	114										
4	Normal	1.36	133	76	1.29	132	79	1.22	131	82	1.13	127	85	1.00	119	84	1.14	149	105				
	0.25	1.49	156	90	1.43	156	94	1.37	155	97	1.30	154	100	1.23	152	103	1.20	158	111				
	0.50	1.53	164	95	1.48	164	98	1.42	163	102	1.35	162	105	1.28	160	108							
	1.00	1.58	172	100	1.52	172	103	1.46	171	107	1.40	170	110	1.33	169	113							
8	Normal	1.29	123	70	1.22	122	74	1.15	121	77	1.07	119	80	0.96	114	81	1.07	139	100				
	0.25	1.42	145	84	1.36	144	87	1.30	144	91	1.23	143	94	1.16	142	98	1.13	148	105				
	0.50	1.45	152	88	1.40	151	92	1.34	151	95	1.28	151	99	1.20	149	102	1.19	157	110				
	1.00	1.49	159	93	1.44	159	96	1.38	159	100	1.32	158	104	1.26	158	107							
24	Normal	1.21	110	63	1.15	110	67	1.08	110	71	1.00	110	75	0.92	110	79	1.00	129	94				
	0.25	1.33	130	75	1.27	130	79	1.21	130	83	1.14	129	86	1.07	129	90	1.05	136	98				
	0.50	1.37	137	79	1.31	137	83	1.25	137	87	1.18	136	90	1.12	136	94	1.10	143	102				
	1.00	1.41	144	83	1.35	144	87	1.29	144	91	1.23	144	95	1.17	143	99	1.15	151	107				
	Normal	1.45	151	88	1.39	151	91	1.34	151	95	1.28	151	99	1.21	151	103	1.20	159	112				
	0.25	1.58	176	103	1.53	175	106	1.48	176	110	1.42	175	114	1.31	166	112	1.26	168	119				
	0.50																						
	1.00																						

Table 3(u)
Capability Table for Normal and Moderate Sacrifice of Life
65 °C Rise, Forced-Oil-Cooled (Non-Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 100% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																	
		0			10			20			30			40			50		
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1 2	Normal	1.75	157	71	1.65	154	77	1.52	149	81	1.06	115	76	1.55	173	102	1.02	131	95
	0.25	1.96	183	81	1.88	183	87	1.79	181	93	1.69	179	98	1.66	185	107	1.47	174	109
	0.50										1.76	188	102				1.62	191	115
	1.00																		
1	Normal	1.59	150	77	1.49	147	81	1.38	142	84	1.03	113	76	1.39	164	105	1.02	131	95
	0.25	1.76	176	90	1.69	175	94	1.61	173	99	1.52	170	102	1.49	177	111	1.33	166	111
	0.50	1.81	184	94	1.75	184	99	1.67	182	103	1.59	180	107						
	1.00																		
2	Normal	1.45	141	78	1.37	139	82	1.27	134	83	1.02	111	75	1.28	157	104	1.01	130	95
	0.25	1.60	167	93	1.54	166	97	1.46	164	100	1.38	162	103	1.35	167	110	1.22	158	110
	0.50	1.65	175	98	1.58	174	101	1.51	172	105	1.44	170	108						
	1.00	1.70	184	103	1.63	183	106	1.57	182	110	1.50	180	113						
4	Normal	1.35	132	75	1.28	130	78	1.19	126	80	1.01	111	75	1.20	147	101	1.00	130	95
	0.25	1.48	155	89	1.42	155	93	1.36	153	96	1.29	152	99	1.26	157	106	1.15	150	106
	0.50	1.53	163	94	1.47	162	98	1.41	162	101	1.34	160	104	1.32	167	112	1.23	163	114
	1.00	1.57	171	99	1.51	171	103	1.45	170	106	1.39	169	110						
8	Normal	1.29	122	70	1.22	121	73	1.13	118	76	1.00	110	75	1.13	138	96	1.00	130	95
	0.25	1.41	144	83	1.35	143	87	1.29	143	90	1.22	141	93	1.20	148	101	1.09	143	102
	0.50	1.45	151	88	1.39	151	91	1.33	150	95	1.27	149	98	1.25	156	106	1.17	154	109
	1.00	1.49	159	92	1.43	158	96	1.38	158	100	1.32	157	103	1.30	165	112	1.23	164	115
24	Normal	1.21	110	63	1.14	110	67	1.07	110	71	1.00	110	75	1.07	129	90	1.05	136	98
	0.25	1.33	130	75	1.27	130	79	1.21	130	82	1.14	129	86	1.12	136	94	1.09	143	102
	0.50	1.37	136	79	1.31	137	83	1.25	136	86	1.18	136	90	1.16	143	98	1.09	143	102
	1.00	1.41	144	83	1.35	144	87	1.29	143	91	1.23	143	95	1.21	150	103	1.15	151	107

NOTE: Underlined values, though beyond recommended limits (see 4.2.2.4), are given to assist in interpolation of the maximum limit.

% loss of life is in addition to normal loss of life.

* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

5. Transformers Specified to have an Average Winding Rise of Not More Than 55 °C and Hottest-Spot Winding Rise of Not More Than 65 °C

5.1 Basic Loading for Normal Life Expectancy

5.1.1 Basic Conditions

(1) The basic loading of a transformer for normal life expectancy is continuous loading at rated output when operated under normal service conditions as indicated in 2.1.1 (1), 2.1.1 (2), 2.1.1 (3) of ANSI/IEEE C57.12.00-1979 [3]. It is assumed that operation under these conditions is equivalent to operation in a continuous ambient temperature of 30 °C for cooling air or 25 °C for cooling water. Normal life expectancy will result from operating with a continuous hottest-spot temperature of 95 °C (or equivalent variable temperature with 105 °C maximum) in any 24 h period.

(2) The hottest-spot winding temperature determines loss of life due to loading. This temperature cannot be directly measured on commercial designs because of the voltage hazard when placing a temperature detector at the proper location. The hottest-spot allowances are based on tests of laboratory models.

(3) The hottest-spot temperature at rated load is usually taken as the sum of the average winding temperature and a 10 °C allowance⁵ for the hottest spot. For mineral-oil-immersed transformers operating continuously under the foregoing conditions with normal life expectancy, this temperature has been assumed to be a maximum of 95 °C.

5.1.2 Loading for Normal Life Expectancy under Specified Conditions

5.1.2.1 Loading by Oil Temperature. Oil temperature alone should not be used as a guide for loading transformers. The hottest-spot to top-oil gradient at full load should be determined from factory tests using Eq 8 or, lacking data, a value should be assumed. The full-load hottest-spot to top-oil gradient should be corrected to that for the actual load carried using Eq 7 or Fig 9. This gradient subtracted from 95 °C will give the maximum permissible oil temperature for normal life expectancy. It should be recognized that, due to thermal lag

in oil rise, time is required for a transformer to reach a stable temperature following any change in load. Therefore, higher peak loads may be carried for short durations. This is reflected in the Loading Tables and the basic equations in 6.7.3.

If the transformer characteristics are not accurately known, a maximum top-oil temperature derived from Fig 4 may be used as an approximate guide. Loading from Fig 4 is based on a difference of 20 °C between the hottest-spot temperature and top-oil temperature at rated load for self-cooled transformers, 25 °C for forced-air-cooled transformers (133% and under), and 28 °C for forced-oil-cooled transformers.

5.1.2.2 Continuous Loading on Basis of Average Winding Test Temperature Rise. For each °C in excess of 5° that the average winding test temperature rise is below 55 °C the transformer load may be increased above rated load by the percentage given in Table 1. A 5° margin is taken to provide a tolerance in the measurement of temperature rise. The loadability thus obtained is that which the transformer can carry at 55 °C rise. Since this may increase the loading beyond that contemplated by the designer, the limitations given in 3.1 should be checked before taking full advantage of this increased loadability.

Some transformers are designed to have the differences between the hottest-spot and average conductor temperatures greater than the 10 °C allowance. This will result in an average-winding temperature rise of less than 55 °C, but the hottest-spot winding temperature rise may be at the limiting value of 65 °C. Such transformers should not be loaded above their rating as outlined in this section. The manufacturer should be consulted for information on the hottest-spot allowances used for these designs. This condition may exist in transformers with large differences (greater than 20 °C) between top- and bottom-oil temperatures and may be checked approximately by measuring the top and bottom radiator temperatures. Whenever possible, data on hottest-spot and oil temperatures obtained from factory temperature tests should be used in calculating transformer loadability or when calculating temperatures for loads above rating.

5.1.2.3 Loading on Basis of Short-Time Loads above Rating. Transformers may be operated above 95 °C hottest-spot temperature

⁵ If cooler inlet and outlet temperatures are available, a better estimate of the hottest-spot temperature is possible by making an adjustment in the 10 °C allowance. Consult with the manufacturer.

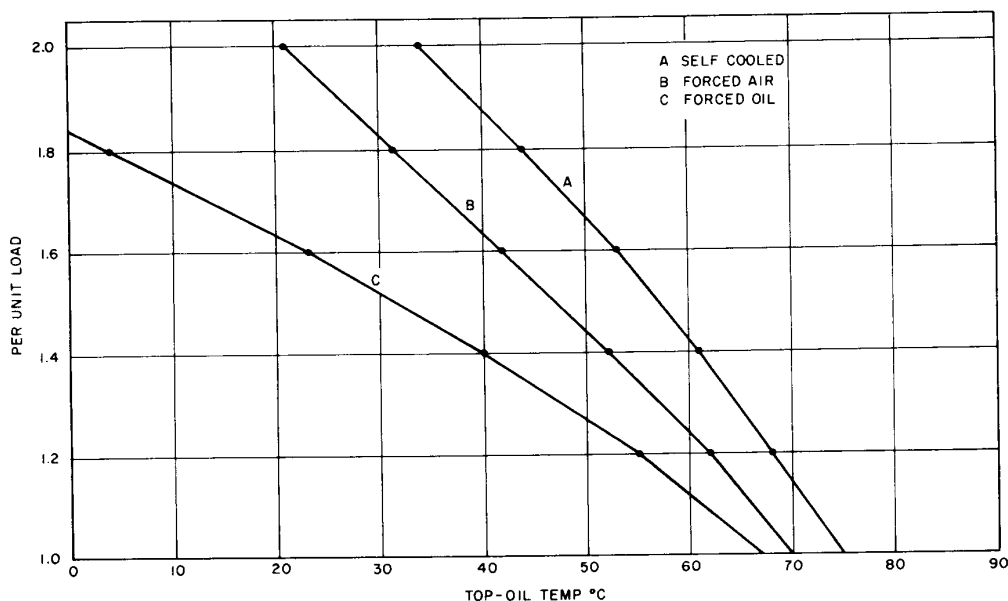


Fig 4
Approximate Continuous Loading for Normal Life Expectancy—
55 °C Rise Transformers

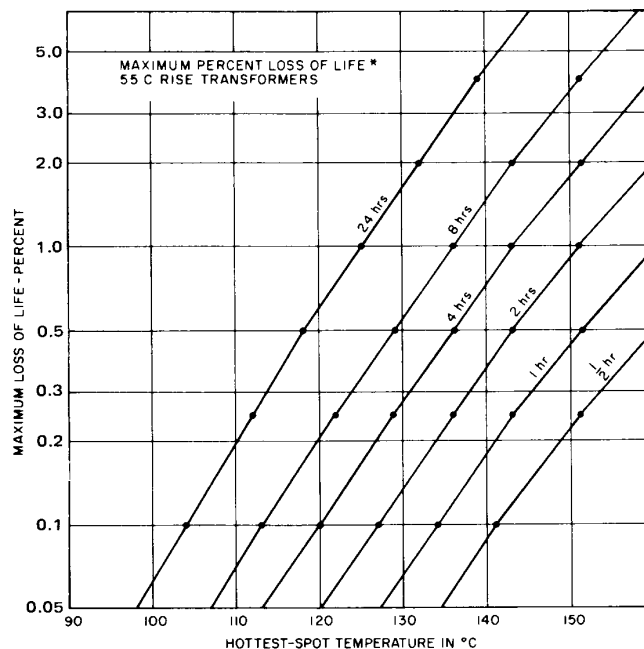
for short periods provided they are operated for much longer periods at temperatures below 95 °C. This is due to the fact that thermal aging is a cumulative process and thus permits loads above the rating to be safely carried under many conditions without encroaching upon the normal life expectancy of the transformer. Suggested loadings for normal life expectancy are given in Tables 5(a)—5(u). For conservative use of these tables, it is suggested that the 5 °C margin described in 3.5.1 be used in determining the ambient temperature.

5.1.2.4 Loading by Hottest-spot Temperature Indicator. Hottest-spot temperature devices are supplied, when specified, which indicate a simulated hottest-spot temperature. These devices may be used as a guide to limit loads.

Thermal relays, when supplied, indicate temperatures reached in the windings. These relays are calibrated for use with specific transformers and simulate the hottest-spot temperature by taking into account preceding loading, existing load and ambient temperature. Higher loads are permitted for short periods than for long periods of time because of the transformer's time-constant.

5.1.2.5 Basis for Normal Loss of Life Loading in Tables 5(a)—5(u). The transformer capabilities for normal loss of life in Tables 5(a)—5(u) are based on operation at temperatures that result in aging equivalent to that for continuous operation at 95 °C hottest-spot temperature as determined from Fig 1 and the hottest-spot temperature profile resulting from the converted load cycle and ambient conditions during a 24 h period. The 95 °C hottest-spot temperature is based on the hottest-spot rise of 65 °C plus the standard ambient temperature of 30 °C. At 95 °C insulation temperature, Fig 1 indicates the life would be $6.5 \cdot 10^4$ hours or over seven years. Actually a transformer operating outdoors at rated capacity would have a much longer life because the annual average ambient air temperature in most locations in the US does not exceed 20 °C by more than a few degrees. At 85 °C (20 °C ambient temperature plus 65 °C hottest-spot rise), Fig 1 indicates the life would be $2 \cdot 10^5$ hours or over 22 years. If the loading over weekends is lighter, as is normally the case, the total life could extend to over 30 years.

In areas where the annual mean ambient



*Expressed as percent loss of life for one occurrence of specified time duration for operation at temperature indicated.

**Hottest-Spot Temperature in Degrees
Maximum Loss of Life (%)**

Duration Hours	0.1	0.25	0.50	1.00	2.00	4.00
$\frac{1}{2}$	141	<u>151</u>				
1	134	143	<u>151</u>			
2	127	136	143	<u>151</u>		
4	120	129	136	143	<u>151</u>	
8	113	122	129	136	143	<u>151</u>
24	104	112	118	125	132	139

**Fig 5
Maximum Percent Loss of Life — 55 °C Rise Transformers**

temperature exceeds 25 °C the capability values in the tables should be reduced 1.5% for every degree the mean annual temperature exceeds 20 °C. (See 3.1.2.5 for explanation).

The method used to calculate Tables 5(a)—5(u) is given in Section 7.

5.2 Short-Time Loading with Moderate Sacrifice of Life Expectancy

5.2.1 Aging of Insulation Due to Operation above 95 °C Hottest-Spot Temperature

(1) When the aging effect of one load cycle

or the cumulative aging effect of a number of load cycles is greater than the aging effect of continuous operation at rated load over the same period of time, the insulation deteriorates at a faster rate than normal. The rate of deterioration is a function of time and temperature and is commonly expressed as a percentage loss of life. Charts and tables showing percent loss of life for various combinations of time and continuous temperature are given in Fig 5.

(2) It should be clearly understood that, while the insulation aging information used is considered to be conservative and helpful in estimating the relative loss of life due to loads above rating under various conditions, this information can only be an indicator of transformer insulation life. Deterioration of insulation is generally characterized by a reduction in both mechanical and dielectric strength, but these characteristics may not necessarily be directly related. In some cases, insulation in a charred condition will have sufficient strength to withstand normal operating electrical and mechanical stresses. A transformer having insulation in this condition may continue in service for many months or even years if undisturbed. On the other hand, any unusual movement of the conductors, such as may be caused by expansion of the conductors due to heating resulting from a heavy load or to large electromagnetic forces resulting from short circuit, may disturb the weakened insulation such that turn-to-turn or layer-to-layer failure will result.

(3) The uncertainty of service conditions and wide range in ratings covered are reasons why this loading guide is made conservative in its suggested loadings. Some of the variables are: wide differences in ambient temperature between localities; differences in elevation;

restricted air circulation caused by buildings, fire walls, etc; previous emergency loading history which may not be known to the operator; and variations in design characteristics from those in Table 4. As a guide, an average loss of life of 1% per year or 4% in any one emergency operation is considered reasonable by some users.

5.2.2 Methods for Determining Loads above Rating with Some Sacrifice of Life Expectancy

5.2.2.1 Transformers with Known Specific Characteristics. If the specific characteristics of a transformer are known and maximum recommended capability is required, the user may calculate the oil-rise and hottest-spot temperature using either the graphic solution illustrated in Section 6, or the basic formulas in 6.7. With this data, the user may determine the allowable load for his conditions by taking into account the ambient temperature, probable number of such loads during the life of the transformer, and the approximate percentage of life he is willing to sacrifice.

5.2.2.2 Transformers with Unknown Specific Characteristics or Conservative Loads. When specific transformer characteristics are not known or when conservative operation above rating is satisfactory, refer to the Capability Tables, Tables 5(a)—5(u), for tabulations

Table 4
55 °C Rise Transformers — Assumed Characteristics at Rated Load

	OA or OW	FA 133% or Less	FA** over 133%	Non-Directed FOA or FOW	Directed FOA or FOW
Hottest-spot conductor temperature rise (above ambient) °C	65	65	65	65	65
Top-oil temperature rise (above ambient) °C	45	40	37	37	37
Top-oil time constant, (h)	3.0	2.0	1.25	1.25	1.25
Hottest-spot conductor time constant, (h)	0.08	0.08	0.08	0.08	0.08
Ratio of load to iron losses	3.0	3.5	5.0	5.0	5.0
*m (winding exponent)	0.8	0.8	0.8	0.8	1.0
*n (oil exponent)	0.8	0.9	0.9	1.0	1.0

*m is the exponential power of winding loss versus winding temperature rise.

*n is the exponential power of total loss versus top-oil temperature rise.

The indicated values of m and n are approximate, particularly in the more complicated designs, and are subject to further study.

**Some OA/FA/FA designs follow more closely the values for FA (133% or less).

of permitted loads of various durations following explicit preload conditions.

5.2.2.3 Assumed Characteristics for Transformers which Allow the Loadings in Tables 5(a)–5(u). Transformers vary widely in the characteristics which affect their short-time capabilities. Any general guide which applies to all transformers of a given class must be based on characteristics which give conservative results. The characteristics shown in Table 4 are considered typical of a power transformer and are for general use.

5.2.2.4 Temperature and Load Limitations. The following are recommended individually limiting temperatures and loads and are used in Tables 5(a)–5(u).

- (1) Maximum top-oil temperature — 100 °C
- (2) Maximum hottest-spot conductor temperature — 150 °C
- (3) Maximum short-time loading — 2 · rating

5.2.2.5 Load Cycles. Transformers usually operate on a load cycle which repeats each 24 h. This load cycle may be constant or it may have one or more peaks during the 24 h period. The actual load cycle may be converted to a two-step cycle by the method given in 6.6. Where actual average loads before the peak load differ from those in the tabulations, sufficient accuracy can be obtained by interpolation.

5.2.2.6 Basis for Moderate Sacrifice of Life in Tables 5(a)–5(u). Load values in Tables 5(a)–5(u) are based on the life expectancy

data shown in Fig 1, the assumed transformer characteristics from Table 4 and the calculated hottest-spot temperature profile for the daily load cycle and ambient temperature condition that exists during a 24 h period. The loss of life values shown in Tables 5(a)–5(u) are in addition to the normal loss of life of 0.0369% per 24 h which would result from continuous operation at rated load in a constant 30 °C ambient.

Index for Table 5
55 °C Rise Transformers
(A Tabulation of Loads for Normal and Moderate Loss of Life)

Type of Cooling	Following initial load of:			
	50%	70%	90%	100%
Self-cooled (OA)	(a)	(b)	(c)	(d)
Water-cooled (OW)	(a)	(b)	(c)	(d)
Forced-air-cooled* (OA/FA)	(e)	(f)	(g)	(h)
Forced-oil-cooled, Directed flow, (FOA, FOW, OA/FOA/FOA**)	(i)	(j)	(k)	(l)
Forced-air-cooled** (OA/FA/FA)	(m)	(n)	(p)	(q)
Forced-oil-cooled, Non-directed flow, (FOA, FOW, OA/FOA/FOA**)	(r)	(s)	(t)	(u)

*Ratings 133% or less of self-cooled rating

**Ratings greater than 133% of self-cooled rating

Table 5(a)
Capacity Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Self-Cooled (OA) and Water-Cooled* (OW) Transformers
Equivalent Load Before Peak Load = 50% of Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0				10				20			
		Peak Load (Per Unit)	Hot- Temp (°C)	Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Temp (°C)	Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Temp (°C)	Spot Temp (°C)	Top- Oil Temp (°C)
1/2	Normal	2.00	98	110	128	2.00	108	120	138	2.00	118	130	148
	0.25												
	0.50												
	1.00												
1	Normal	2.00	110	128	148	2.00	120	138	158	2.00	130	150	170
	0.25												
	0.50												
	1.00												
2	Normal	2.00	128	158	188	2.00	138	168	198	2.00	148	178	208
	0.25												
	0.50												
	1.00												
4	Normal	1.73	122	144	166	1.63	122	144	166	1.53	122	144	166
	0.25												
	0.50												
	1.00												
8	Normal	1.53	113	133	153	1.43	113	133	153	1.33	113	133	153
	0.25												
	0.50												
	1.00												
24	Normal	1.35	98	117	136	1.25	98	116	135	1.14	97	115	134
	0.25												
	0.50												
	1.00												

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.
* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 5(b)
Capacity Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Self-Cooled (OA) and Water-Cooled* (OW) Transformers
Equivalent Load Before Peak Load = 70% of Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																		
		0			10			20			30			40			50			
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	
1 2	Normal	2.00	104	44	54	2.00	114	64	2.00	124	64	2.00	134	74	1.81	133	81	1.31	117	86
	0.25																			
	0.50																			
	1.00																			
1	2.00																			
	Normal	2.00	115	54	64	2.00	125	74	1.95	132	73	1.78	130	79	1.56	126	85	1.13	111	87
	0.25																			
	0.50																			
1	1.00																			
	2.00																			
	4.00																			
	Normal	1.95	128	69	74	1.70	127	79	1.54	124	84	1.34	120	88	0.97	106	87			
2	0.25	2.00	131	71	81	2.00	141	90	1.97	149	90	1.84	148	95	1.70	146	100	1.53	143	104
	0.50																			
	1.00																			
	2.00																			
2	4.00																			
	Normal	1.70	121	74	78	1.59	120	82	1.47	119	82	1.33	117	85	1.16	113	88	0.88	103	87
	0.25	1.92	143	86	90	1.81	142	94	1.70	141	94	1.59	140	98	1.46	138	102	1.31	135	104
	0.50	1.98	150	90	95	1.89	150	98	1.78	149	98	1.67	148	102						
4	1.00																			
	2.00																			
	4.00																			
	Normal	1.52	112	73	77	1.41	111	80	1.30	110	80	1.17	109	83	1.02	105	85	0.78	98	84
8	0.25	1.71	133	86	89	1.61	132	93	1.51	131	92	1.41	131	96	1.29	129	99	1.16	127	102
	0.50	1.77	139	90	93	1.67	139	97	1.58	138	97	1.47	137	100	1.36	136	103			
	1.00	1.83	147	94	98	1.74	147	101	1.64	145	101									
	2.00	1.90	155	99	102	1.80	154	102												
8	4.00																			
	Normal	1.35	98	65	68	1.24	97	72	1.13	97	72	1.02	96	76	0.88	96	79	0.73	95	83
	0.25	1.52	116	77	80	1.43	116	84	1.33	115	84	1.23	115	88	1.12	115	91	0.99	114	95
	0.50	1.58	122	80	84	1.49	122	88	1.39	122	88	1.29	121	91	1.18	121	95	1.06	120	98
24	1.00	1.64	129	85	88	1.55	128	92	1.45	128	92	1.36	128	96	1.25	128	99	1.14	127	103
	2.00	1.70	135	89	93	1.61	135	96	1.52	135	96	1.42	135	100	1.32	134	103			
	4.00	1.76	143	93	97	1.67	143	101	1.59	143	101									

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 5(c)
Capacity Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Self-Cooled (OA) and Water-Cooled* (OW) Transformers
Equivalent Load Before Peak Load = 90% of Nameplate Rating

Hours Peak Load	% Loss of Life	Ambient °C											
		0	10	20	30	40	50						
1/2	Normal	112	122	132	142	152	161	Peak Load (Per Unit)	Top-Oil Temp (°C)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)
	0.25	2.00	2.00	2.00	2.00	2.00	1.75	1.80	71	130	81	1.75	147
	0.50						1.98	2.00	79	142	81	1.98	161
	1.00												
	2.00												
1	Normal	121	131	141	151	158	140	Peak Load (Per Unit)	Top-Oil Temp (°C)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)
	0.25	2.00	2.00	2.00	2.00	1.83	1.53	1.56	76	122	81	1.53	140
	0.50					1.95		2.00	81	151	91	1.95	158
	1.00												
	2.00												
2	Normal	126	146	155	165	165	134	Peak Load (Per Unit)	Top-Oil Temp (°C)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)
	0.25	1.89	1.75	1.59	1.38	1.59	1.34	1.38	80	116	83	1.34	134
	0.50	2.00	2.00	1.91	1.76	1.59		1.76	92	145	96		
	1.00			1.98	1.86	1.59		1.86	95	154	100		
	2.00												
4	Normal	119	125	139	147	155	128	Peak Load (Per Unit)	Top-Oil Temp (°C)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)
	0.25	1.66	1.55	1.41	1.16	0.63	1.19	1.22	81	110	83	1.19	128
	0.50	1.89	1.78	1.66	1.39	1.39		1.54	94	138	98		
	1.00	1.95	1.85	1.74	1.47	1.39		1.63	99	146	102		
	2.00	2.00	1.92	1.82	1.55				103				
8	Normal	111	110	108	104	91	98	Peak Load (Per Unit)	Top-Oil Temp (°C)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)
	0.25	1.50	1.39	1.27	1.11	0.81	1.08	1.11	79	104	80	1.08	121
	0.50	1.70	1.59	1.49	1.38	1.25		1.38	92	128	95	1.25	131
	1.00	1.76	1.66	1.55	1.37	1.33		1.45	96	136	100	1.33	134
	2.00	1.82	1.73	1.63	1.44				101				
24	Normal	97	97	96	96	95	94	Peak Load (Per Unit)	Top-Oil Temp (°C)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)
	0.25	1.34	1.24	1.13	1.01	0.88	0.72	1.01	72	96	75	0.88	94
	0.50	1.52	1.43	1.33	1.15	1.11		1.22	84	115	87	1.11	114
	1.00	1.58	1.48	1.39	1.22	1.17		1.28	88	121	91	1.17	120
	2.00	1.63	1.55	1.45	1.28	1.25		1.35	92	128	95	1.25	127
24	Normal	135	143	152	162	162	134	Peak Load (Per Unit)	Top-Oil Temp (°C)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)
	0.25	1.70	1.67	1.58	1.42	1.32	1.03	1.42	96	135	100	1.32	134
	0.50	1.76							100				
	1.00												
	2.00												

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 5(d)
Capacity Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Self-Cooled (OA) and Water-Cooled* (OW) Transformers
Equivalent Load Before Peak Load = 100% of Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																	
		0			10			20			30			40			50		
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1 2	Normal	2.00	116	55	2.00	126	65	1.92	131	74	1.00	95	75	1.91	150	94	1.72	149	102
	0.25							2.00	136	75	2.00	146	85						
	0.50																		
	1.00																		
1	Normal	2.00	125	64	1.92	129	72	1.70	124	78	1.00	95	75	1.69	143	97	1.50	142	103
	0.25							2.00	145	84	2.00	155	94	1.86	155	101			
	0.50																		
	1.00																		
2	Normal	1.04	125	72	1.70	123	77	1.50	118	80	1.00	95	75	1.47	136	99	0.50	92	85
	0.25	2.00	138	78	2.00	148	88	1.86	146	92	1.69	142	96	1.63	147	104	1.31	135	104
	0.50							1.95	154	96	1.80	151	100						
	1.00																		
4	Normal	1.64	118	74	1.51	116	77	1.34	112	80	1.00	95	75	1.31	129	98	0.81	103	88
	0.25	1.87	141	87	1.76	140	91	1.63	138	94	1.50	135	97	1.44	140	104	1.10	129	103
	0.50	1.94	149	91	1.83	147	95	1.72	146	99	1.59	143	101						
	1.00	2.00	155	95	1.91	155	99	1.80	154	103									
8	Normal	1.48	110	72	1.37	108	75	1.23	104	77	1.00	95	75	1.20	122	95	0.94	110	92
	0.25	1.69	131	85	1.59	130	88	1.48	129	91	1.36	127	94	1.30	131	101	1.13	125	101
	0.50	1.75	138	90	1.65	137	93	1.55	136	96	1.43	134	99						
	1.00	1.81	146	94	1.72	145	97	1.62	144	100	1.51	142	103						
24	Normal	1.34	97	65	1.23	96	68	1.13	96	72	1.00	95	75	0.86	94	78	0.70	93	81
	0.25	1.52	116	77	1.42	115	80	1.32	114	83	1.22	115	87	1.10	114	90	0.98	113	94
	0.50	1.58	122	80	1.48	122	84	1.38	121	87	1.28	121	91	1.17	120	94	1.05	119	97
	1.00	1.63	128	84	1.54	128	88	1.45	127	91	1.35	128	95	1.24	127	98	1.13	126	102
	Normal	1.70	135	89	1.61	135	93	1.52	135	96	1.41	134	99	1.31	134	103			
	0.25	1.76	143	93	1.67	143	97	1.58	142	100	1.48	142	104						
	0.50																		
	1.00																		

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

*Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 5(e)
Capability Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Air-Cooled (OA/FA) Transformers Rated 133% or Less of Self-Cooled Rating
Equivalent Load Before Peak Load = 50% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0			10			20			30		
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1	Normal	2.00	114	40	2.00	124	50	2.00	134	60	1.91	138	75
	0.25							2.00			2.00		
	0.50												
	1.00												
2	Normal	2.00	133	57	1.91	134	63	1.80	133	70	1.67	132	81
	0.25	2.25	158	67	2.14	157	73	2.04	157	79	1.93	156	90
	0.50												
	1.00												
4	Normal	1.76	129	67	1.66	128	71	1.56	127	76	1.45	126	85
	0.25	1.95	151	78	1.87	151	83	1.77	150	87	1.68	149	96
	0.50										1.74	157	100
	1.00												
8	Normal	1.55	120	69	1.47	120	73	1.37	118	77	1.27	118	85
	0.25	1.73	142	82	1.65	142	86	1.56	141	90	1.47	140	97
	0.50	1.78	149	86	1.70	148	90	1.61	147	94	1.53	147	101
	1.00	1.84	157	91	1.76	156	94	1.68	156	98	1.59	154	102
24	Normal	1.42	110	66	1.33	110	70	1.24	109	74	1.14	109	81
	0.25	1.58	130	78	1.50	130	82	1.41	129	86	1.33	129	93
	0.50	1.63	137	82	1.55	137	86	1.47	136	90	1.38	135	97
	1.00	1.68	144	87	1.61	144	91	1.52	143	94	1.44	143	102
78	Normal	1.30	96	58	1.21	96	62	1.12	96	66	1.01	95	74
	0.25	1.45	114	69	1.37	115	73	1.28	114	77	1.19	114	85
	0.50	1.50	121	73	1.42	121	77	1.33	120	81	1.24	120	88
	1.00	1.55	127	77	1.47	127	81	1.39	126	85	1.30	126	92
101	Normal	1.60	134	81	1.52	134	85	1.44	134	89	1.36	133	96
	0.25	1.65	141	85	1.57	141	89	1.50	141	93	1.42	141	101
	0.50												
	1.00												

NOTE: Underlined values, though beyond recommended limits (see 5.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

Table 5(f)
Capacity Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Air-Cooled (OA/FA) Transformers Rated 133% or Less of Self-Cooled Rating
Equivalent Load Before Peak Load = 70% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																	
		0			10			20			30			40			50		
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1 2	Normal	2.00	120	45	2.00	130	55	1.96	138	64	1.81	136	71	1.65	134	78	1.38	126	84
	0.25				2.24	162	71	2.12	161				78	1.99	160	85	1.84	158	92
	0.50																		
	1.00																		
	2.00																		
1	Normal	1.97	134	60	1.85	133	66	1.73	132	72	1.60	130	77	1.45	128	83	1.20	119	85
	0.25	2.19	157	69	2.09	156	75	1.98	155	81	1.87	154	86	1.75	154	92	1.61	151	97
	0.50																		
	1.00																		
	2.00																		
2	Normal	1.73	128	68	1.63	127	72	1.53	126	77	1.40	124	81	1.27	121	85	1.06	114	86
	0.25	1.93	151	79	1.84	150	84	1.74	149	88	1.64	148	93	1.53	146	97	1.41	144	101
	0.50							1.81	157	92	1.70	155	96	1.60	154	101			
	1.00																		
	2.00																		
4	Normal	1.54	120	70	1.45	119	73	1.35	117	77	1.25	116	81	1.11	113	83	0.93	107	84
	0.25	1.71	141	82	1.63	140	86	1.55	140	90	1.45	139	94	1.35	138	97	1.24	136	100
	0.50	1.77	148	86	1.69	148	90	1.60	147	94	1.51	146	98	1.42	145	101			
	1.00	1.82	156	90	1.75	156	95	1.67	155	98	1.57	153	102						
	2.00																		
8	Normal	1.41	109	66	1.33	109	70	1.23	108	73	1.13	107	77	1.01	106	80	0.85	101	82
	0.25	1.57	130	78	1.49	129	82	1.41	128	85	1.32	128	89	1.22	127	93	1.12	126	96
	0.50	1.62	136	82	1.55	136	86	1.46	136	90	1.38	135	93	1.29	134	97	1.18	133	100
	1.00	1.68	144	87	1.60	143	90	1.52	143	94	1.43	142	97	1.35	142	101			
	2.00	1.73	151	91	1.66	151	95	1.58	150	98	1.50	150	102						
24	Normal	1.29	96	58	1.20	95	62	1.11	96	66	1.01	95	70	0.90	95	74	0.77	94	78
	0.25	1.45	114	69	1.36	114	73	1.28	114	77	1.19	114	81	1.09	114	85	0.99	113	89
	0.50	1.50	121	73	1.41	120	76	1.33	120	81	1.25	120	85	1.15	119	88	1.05	119	92
	1.00	1.54	127	77	1.47	127	81	1.39	127	84	1.30	127	89	1.21	126	92	1.11	126	96
	2.00	1.60	134	81	1.52	134	85	1.44	134	89	1.36	133	92	1.27	133	97	1.18	133	101
	Normal	1.65	141	85	1.58	141	89	1.50	141	93	1.42	141	97	1.34	141	101			
	0.25																		
	0.50																		
	1.00																		
	2.00																		

Table 5(g)
Capability Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Air-Cooled (OA/FA) Transformers Rated 133% or Less of Self-Cooled Rating
Equivalent Load Before Peak Load = 90% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0				10				20			
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
$\frac{1}{2}$	Normal	2.00	128	53	1.98	137	62	1.84	135	69	1.64	130	75
	0.25	<u>2.39</u>	<u>162</u>	62	<u>2.27</u>	<u>161</u>	69	<u>2.15</u>	<u>161</u>	76	<u>2.01</u>	<u>159</u>	83
	0.50												
	1.00												
1	2.00												
	4.00												
	Normal	1.89	132	63	1.77	131	68	1.64	129	74	1.46	124	78
	0.25	<u>2.13</u>	<u>156</u>	72	<u>2.02</u>	<u>155</u>	78	1.91	<u>154</u>	83	1.79	<u>152</u>	89
2	0.50												
	1.00												
	2.00												
	4.00												
4	Normal	1.69	126	69	1.58	125	73	1.46	122	77	1.29	117	79
	0.25	<u>1.89</u>	<u>149</u>	80	<u>1.79</u>	<u>148</u>	84	1.69	<u>147</u>	89	1.59	<u>146</u>	93
	0.50	<u>1.95</u>	<u>157</u>	84	<u>1.86</u>	<u>155</u>	88	1.76	<u>154</u>	93	1.66	<u>153</u>	97
	1.00												
8	2.00												
	4.00												
	Normal	1.52	118	69	1.43	117	73	1.31	114	76	1.18	111	78
	0.25	<u>1.69</u>	<u>140</u>	82	<u>1.61</u>	<u>139</u>	85	1.52	<u>138</u>	89	1.42	<u>137</u>	93
24	0.50	<u>1.75</u>	<u>147</u>	86	<u>1.66</u>	<u>146</u>	90	1.58	<u>146</u>	94	1.49	<u>144</u>	97
	1.00	<u>1.81</u>	<u>155</u>	91	<u>1.72</u>	<u>154</u>	94	1.64	<u>154</u>	98	1.55	<u>152</u>	102
	2.00												
	4.00												
8	Normal	1.41	109	66	1.31	108	69	1.21	106	72	1.09	103	74
	0.25	<u>1.57</u>	<u>129</u>	78	<u>1.48</u>	<u>128</u>	81	1.40	<u>128</u>	85	1.30	<u>126</u>	88
	0.50	<u>1.62</u>	<u>135</u>	82	<u>1.54</u>	<u>135</u>	85	1.46	<u>135</u>	89	1.36	<u>133</u>	92
	1.00	<u>1.67</u>	<u>143</u>	86	<u>1.59</u>	<u>142</u>	90	1.51	<u>142</u>	94	1.43	<u>141</u>	97
24	2.00	<u>1.72</u>	<u>150</u>	91	<u>1.65</u>	<u>150</u>	94	1.57	<u>149</u>	98	1.49	<u>149</u>	102
	4.00							1.63	<u>158</u>	<u>103</u>			
	Normal	1.29	96	58	1.20	95	62	1.11	95	66	1.01	95	70
	0.25	<u>1.45</u>	<u>114</u>	69	<u>1.36</u>	<u>114</u>	73	1.28	<u>114</u>	77	1.18	<u>113</u>	81
24	0.50	<u>1.49</u>	<u>120</u>	73	<u>1.41</u>	<u>120</u>	77	1.33	<u>120</u>	80	1.24	<u>120</u>	85
	1.00	<u>1.54</u>	<u>127</u>	77	<u>1.46</u>	<u>126</u>	80	1.38	<u>126</u>	84	1.29	<u>126</u>	88
	2.00	<u>1.60</u>	<u>134</u>	81	<u>1.52</u>	<u>133</u>	85	1.44	<u>133</u>	89	1.35	<u>133</u>	92
	4.00	<u>1.65</u>	<u>141</u>	85	<u>1.57</u>	<u>141</u>	89	1.50	<u>141</u>	93	1.42	<u>140</u>	97
24	Normal	1.29	96	58	1.20	95	62	1.11	95	66	1.01	95	70
	0.25	<u>1.45</u>	<u>114</u>	69	<u>1.36</u>	<u>114</u>	73	1.28	<u>114</u>	77	1.18	<u>113</u>	81
	0.50	<u>1.49</u>	<u>120</u>	73	<u>1.41</u>	<u>120</u>	77	1.33	<u>120</u>	80	1.24	<u>120</u>	85
	1.00	<u>1.54</u>	<u>127</u>	77	<u>1.46</u>	<u>126</u>	80	1.38	<u>126</u>	84	1.29	<u>126</u>	88
24	2.00	<u>1.60</u>	<u>134</u>	81	<u>1.52</u>	<u>133</u>	85	1.44	<u>133</u>	89	1.35	<u>133</u>	92
	4.00	<u>1.65</u>	<u>141</u>	85	<u>1.57</u>	<u>141</u>	89	1.50	<u>141</u>	93	1.42	<u>140</u>	97
	Normal	1.29	96	58	1.20	95	62	1.11	95	66	1.01	95	70
	0.25	<u>1.45</u>	<u>114</u>	69	<u>1.36</u>	<u>114</u>	73	1.28	<u>114</u>	77	1.18	<u>113</u>	81
24	0.50	<u>1.49</u>	<u>120</u>	73	<u>1.41</u>	<u>120</u>	77	1.33	<u>120</u>	80	1.24	<u>120</u>	85
	1.00	<u>1.54</u>	<u>127</u>	77	<u>1.46</u>	<u>126</u>	80	1.38	<u>126</u>	84	1.29	<u>126</u>	88
	2.00	<u>1.60</u>	<u>134</u>	81	<u>1.52</u>	<u>133</u>	85	1.44	<u>133</u>	89	1.35	<u>133</u>	92
	4.00	<u>1.65</u>	<u>141</u>	85	<u>1.57</u>	<u>141</u>	89	1.50	<u>141</u>	93	1.42	<u>140</u>	97
24	Normal	1.29	96	58	1.20	95	62	1.11	95	66	1.01	95	70
	0.25	<u>1.45</u>	<u>114</u>	69	<u>1.36</u>	<u>114</u>	73	1.28	<u>114</u>	77	1.18	<u>113</u>	81
	0.50	<u>1.49</u>	<u>120</u>	73	<u>1.41</u>	<u>120</u>	77	1.33	<u>120</u>	80	1.24	<u>120</u>	85
	1.00	<u>1.54</u>	<u>127</u>	77	<u>1.46</u>	<u>126</u>	80	1.38	<u>126</u>	84	1.29	<u>126</u>	88
24	2.00	<u>1.60</u>	<u>134</u>	81	<u>1.52</u>	<u>133</u>	85	1.44	<u>133</u>	89	1.35	<u>133</u>	92
	4.00	<u>1.65</u>	<u>141</u>	85	<u>1.57</u>	<u>141</u>	89	1.50	<u>141</u>	93	1.42	<u>140</u>	97
	Normal	1.29	96	58	1.20	95	62	1.11	95	66	1.01	95	70
	0.25	<u>1.45</u>	<u>114</u>	69	<u>1.36</u>	<u>114</u>	73	1.28	<u>114</u>	77	1.18	<u>113</u>	81
24	0.50	<u>1.49</u>	<u>120</u>	73	<u>1.41</u>	<u>120</u>	77	1.33	<u>120</u>	80	1.24	<u>120</u>	85
	1.00	<u>1.54</u>	<u>127</u>	77	<u>1.46</u>	<u>126</u>	80	1.38	<u>126</u>	84	1.29	<u>126</u>	88
	2.00	<u>1.60</u>	<u>134</u>	81	<u>1.52</u>	<u>133</u>	85	1.44	<u>133</u>	89	1.35	<u>133</u>	92
	4.00	<u>1.65</u>	<u>141</u>	85	<u>1.57</u>	<u>141</u>	89	1.50	<u>141</u>	93	1.42	<u>140</u>	97

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

Table 5(h)
Capacity Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Air-Cooled (OA/FA) Transformers Rated 133% or Less of Self-Cooled Rating
Equivalent Load Before Peak Load = 100% of Maximum Nameplate Rating

		Ambient °C											
		0				10				20			
Hours of Peak Load	% Loss of Life	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)
		Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)
1	Normal	2.00	133	57	1.92	136	65	1.73	132	71	1.06	98	70
	0.25				2.22	161	72	2.08	159	79	1.94	157	85
	0.50												
	1.00												
2	Normal	1.84	131	64	1.72	129	70	1.55	124	74	1.06	98	71
	0.25	2.09	155	74	1.98	154	80	1.86	153	85	1.72	149	90
	0.50												
	1.00												
4	Normal	1.66	125	69	1.54	123	73	1.39	118	76	1.03	97	71
	0.25	1.86	148	80	1.77	147	85	1.66	146	89	1.54	143	93
	0.50	1.93	156	84	1.83	154	89	1.73	153	93	1.62	151	97
	1.00												
8	Normal	1.50	116	69	1.40	115	72	1.27	111	74	1.02	96	70
	0.25	1.68	139	82	1.59	138	85	1.50	136	89	1.39	134	91
	0.50	1.74	146	86	1.65	145	89	1.56	144	93	1.46	142	96
	1.00	1.80	154	90	1.71	153	94	1.62	152	97	1.54	151	101
24	Normal	1.40	108	65	1.30	107	68	1.19	104	71	1.01	95	70
	0.25	1.56	129	78	1.48	128	81	1.39	127	84	1.29	125	87
	0.50	1.61	135	81	1.53	134	85	1.45	134	89	1.35	132	92
	1.00	1.67	143	86	1.59	142	89	1.51	141	93	1.42	140	96
	Normal	1.29	95	58	1.20	95	62	1.10	95	65	1.00	95	70
	0.25	1.45	114	69	1.36	113	73	1.27	113	77	1.18	113	81
	0.50	1.49	120	73	1.41	120	77	1.33	120	80	1.24	119	84
	1.00	1.54	127	77	1.46	127	80	1.38	126	84	1.30	126	88
	Normal	1.59	133	81	1.52	133	85	1.44	133	88	1.36	133	92
	0.25	1.65	141	85	1.57	140	89	1.50	141	93	1.41	140	96
	0.50												
	1.00												

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit. % loss of life is in addition to normal loss of life.

Table 5(i)
Capacity Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Oil-Cooled (Directed Flow — FOA, POW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 50% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																	
		0			10			20			30			40			50		
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1 2	Normal	1.84	141	46	1.77	140	53	1.69	140	60	1.60	139	67	1.51	138	75	1.41	138	82
	0.25	2.00	164	52	1.93	164	59	1.86	163	60	1.79	163	74	1.70	162	81	1.63	162	88
	0.50																		
	1.00																		
	2.00																		
1	Normal	1.67	135	57	1.60	134	63	1.52	134	69	1.44	133	75	1.35	132	81	1.26	131	86
	0.25	1.82	158	66	1.75	157	72	1.68	157	78	1.61	156	84	1.53	155	89	1.45	155	95
	0.50																		
	1.00																		
	2.00																		
2	Normal	1.51	128	64	1.45	128	69	1.37	127	74	1.29	126	79	1.21	125	84	1.12	123	83
	0.25	1.64	150	74	1.58	149	79	1.52	149	84	1.45	148	89	1.38	147	94	1.30	146	99
	0.50	1.69	158	78	1.63	157	83	1.56	156	88	1.50	155	93	1.63	155	98	1.35	156	103
	1.00																		
	2.00																		
4	Normal	1.39	118	64	1.33	118	69	1.25	117	73	1.18	117	78	1.09	115	82	1.01	115	87
	0.25	1.52	139	75	1.46	139	79	1.39	138	84	1.33	138	89	1.26	138	93	1.18	137	98
	0.50	1.56	146	78	1.50	146	83	1.44	145	88	1.37	145	92	1.30	144	97	1.23	143	101
	1.00	1.60	153	82	1.54	153	87	1.48	153	91	1.42	152	96	1.35	152	101			
	2.00																		
8	Normal	1.32	108	68	1.25	108	64	1.18	107	69	1.10	108	74	1.02	107	78	0.92	106	82
	0.25	1.44	128	70	1.38	127	74	1.31	127	79	1.24	127	84	1.17	127	88	1.09	126	93
	0.50	1.48	134	73	1.41	134	78	1.35	134	82	1.29	134	87	1.22	133	92	1.14	133	96
	1.00	1.52	141	77	1.46	141	82	1.40	141	86	1.33	140	91	1.27	140	95	1.20	140	100
	2.00	1.56	149	81	1.50	148	85	1.44	148	90	1.38	148	95	1.31	147	99			
24	Normal	1.60	157	85	1.54	156	89	1.48	156	94	1.43	156	99	1.36	155	103			
	0.25	1.23	96	53	1.16	96	58	1.09	96	63	1.01	96	67	0.91	95	72	0.82	96	77
	0.50	1.36	114	63	1.29	114	67	1.22	114	72	1.15	114	77	1.07	114	82	0.99	114	87
	1.00	1.39	120	66	1.33	120	71	1.27	120	76	1.20	120	80	1.12	120	85	1.04	120	89
	2.00	1.43	126	69	1.37	127	74	1.30	126	79	1.24	126	83	1.17	126	88	1.09	127	93
	Normal	1.47	134	73	1.41	134	78	1.35	134	82	1.29	133	87	1.22	134	92	1.14	133	97
	0.25	1.50	141	77	1.45	140	81	1.39	141	86	1.33	141	91	1.27	140	96	1.20	140	100
	0.50																		
	1.00																		
	2.00																		

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 5(j)
Capability Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Oil-Cooled (Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 70% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0	10	20	30	40	50						
1	Normal	1.80	1.40	1.39	1.38	1.37	1.31	78	84	84	84	84	84
	0.25	1.97	1.64	1.63	1.62	1.61	1.57	132	160	160	160	160	160
	0.50												
	1.00												
	2.00												
1	Normal	1.64	1.34	1.33	1.31	1.30	1.17	82	91	91	91	91	91
	0.25	1.79	1.57	1.56	1.55	1.54	1.41	125	153	153	153	153	153
	0.50												
	1.00												
	2.00												
2	Normal	1.50	1.27	1.25	1.25	1.22	1.06	83	95	95	95	95	95
	0.25	1.63	1.43	1.43	1.43	1.41	1.27	122	146	146	146	146	146
	0.50	1.67	1.57	1.56	1.55	1.54	1.41	122	146	146	146	146	146
	1.00												
	2.00												
4	Normal	1.39	1.18	1.16	1.15	1.14	1.03	81	93	93	93	93	93
	0.25	1.52	1.39	1.38	1.37	1.36	1.25	114	136	136	136	136	136
	0.50	1.55	1.46	1.44	1.44	1.43	1.29	114	136	136	136	136	136
	1.00	1.59	1.53	1.52	1.51	1.50	1.22	114	136	136	136	136	136
	2.00												
8	Normal	1.31	1.07	1.07	1.07	1.06	0.90	77	88	88	88	88	88
	0.25	1.44	1.28	1.27	1.27	1.26	1.09	106	126	126	126	126	126
	0.50	1.48	1.34	1.34	1.33	1.32	1.16	106	126	126	126	126	126
	1.00	1.52	1.41	1.41	1.40	1.39	1.19	106	126	126	126	126	126
	2.00	1.55	1.48	1.48	1.47	1.46	1.22	106	126	126	126	126	126
24	Normal	1.23	0.96	0.96	0.96	0.95	0.81	72	81	81	81	81	81
	0.25	1.36	1.14	1.14	1.14	1.13	0.99	95	114	114	114	114	114
	0.50	1.39	1.20	1.20	1.20	1.19	1.04	95	114	114	114	114	114
	1.00	1.43	1.26	1.26	1.26	1.25	1.09	95	114	114	114	114	114
	2.00	1.47	1.33	1.33	1.33	1.32	1.14	95	114	114	114	114	114

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 5(k)
Capability Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Oil-Cooled (Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 90% of Maximum Nameplate Rating

		Ambient °C																	
		0			10			20			30			40			50		
Hours of Peak Load	% Loss of Life	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)
1 2	Normal	1.74	139	54	1.66	138	61	1.57	137	68	1.45	133	74	1.13	111	76	1.45	153	94
	0.25	1.91	163	60	1.84	162	67	1.77	162	75	1.68	160	82	1.58	158	88			
	0.50																		
	1.00																		
	2.00																		
1	4.00																		
	Normal	1.60	133	61	1.52	132	67	1.44	130	72	1.32	126	77	1.06	108	77	1.31	145	97
	0.25	1.76	156	70	1.69	155	76	1.61	154	81	1.53	153	87	1.44	150	92	1.41	156	101
	0.50																		
	1.00																		
2	2.00																		
	4.00																		
	Normal	1.47	125	65	1.40	124	69	1.32	123	74	1.22	119	78	1.00	104	76	1.20	137	97
	0.25	1.61	148	75	1.55	147	80	1.48	146	85	1.41	145	90	1.32	143	94	1.28	148	102
	0.50	1.66	156	79	1.59	155	84	1.52	153	88	1.45	152	93	1.38	151	98			
4	1.00																		
	2.00																		
	4.00																		
	Normal	1.38	116	63	1.30	115	68	1.23	114	72	1.13	111	75	0.95	99	74	1.12	129	94
	0.25	1.50	137	74	1.44	137	79	1.38	136	83	1.30	135	88	1.23	134	92	1.19	138	99
8	0.50	1.55	145	78	1.48	144	82	1.42	144	87	1.35	142	91	1.27	141	95	1.25	147	103
	1.00	1.59	152	82	1.53	151	86	1.46	151	91	1.40	150	95	1.33	149	99	1.25	147	103
	2.00													1.38	157	104			
	4.00																		
	Normal	1.31	107	59	1.24	107	64	1.16	106	68	1.07	104	71	0.92	96	72	1.05	122	90
	0.25	1.43	127	69	1.37	127	74	1.30	126	79	1.23	126	83	1.16	125	87	1.12	130	95
	0.50	1.47	134	73	1.41	133	77	1.35	133	82	1.28	133	87	1.20	131	91	1.12	130	95
	1.00	1.51	141	77	1.45	140	81	1.39	140	86	1.32	139	90	1.26	139	95	1.18	138	99
	2.00	1.55	148	81	1.50	148	85	1.44	148	90	1.38	147	94	1.30	146	99	1.23	146	103
	4.00	1.59	156	84	1.54	155	89	1.48	155	94	1.42	155	98	1.36	155	103			
24	Normal	1.23	96	53	1.16	96	58	1.09	96	63	1.00	95	67	0.91	95	72	0.81	95	77
	0.25	1.36	114	63	1.29	114	67	1.22	114	72	1.15	114	77	1.07	114	81	0.98	113	86
	0.50	1.39	120	66	1.33	120	71	1.26	120	75	1.19	120	80	1.12	120	85	1.04	120	89
	1.00	1.43	126	69	1.37	126	74	1.30	126	79	1.24	126	83	1.16	126	88	1.09	126	93
	2.00	1.47	133	73	1.41	133	77	1.35	133	82	1.28	133	87	1.21	133	92	1.14	133	96
	4.00	1.51	141	77	1.45	140	81	1.39	141	86	1.33	140	91	1.27	140	96	1.20	140	100

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 5(1)
Capacity Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Oil-Cooled (Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 100% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																					
		0				10				20				30				40				50	
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	
1 2	Normal	1.71	138	57	1.62	137	63	1.50	133	70	1.00	95	67										
	0.25	1.88	162	63	1.80	161	70	1.73	160	77	1.63	158	84					1.41	152	89	1.41	152	97
	0.50																						
	1.00																						
	2.00																						
1	Normal	1.57	131	62	1.49	130	68	1.38	125	72	1.00	95	67										
	0.25	1.73	155	71	1.66	154	77	1.59	153	83	1.49	150	88					1.28	144	92	1.42	161	98
	0.50																						
	1.00																						
	2.00																						
2	Normal	1.46	124	65	1.38	122	69	1.28	119	73	1.00	95	67										
	0.25	1.60	147	76	1.53	146	80	1.46	145	85	1.38	142	89					0.50	76	92	0.50	76	60
	0.50	1.64	154	79	1.58	153	84	1.51	152	88	1.43	151	93					1.19	137	97	1.30	152	97
	1.00																						
	2.00																						
4	Normal	1.37	115	63	1.30	114	67	1.20	111	70	1.00	95	67										
	0.25	1.50	137	74	1.44	136	79	1.37	135	83	1.29	133	87					0.75	90	89	0.75	90	76
	0.50	1.54	144	77	1.48	143	82	1.41	143	87	1.34	141	91					1.13	130	94	1.13	130	95
	1.00	1.58	152	81	1.52	151	86	1.46	150	91	1.39	149	95					1.22	143	98	1.22	143	101
	2.00																						
8	Normal	1.30	106	59	1.23	106	63	1.15	104	67	1.00	95	67										
	0.25	1.43	126	69	1.37	126	74	1.30	126	78	1.23	125	83					0.94	108	86	0.94	108	83
	0.50	1.47	133	73	1.41	132	77	1.34	132	82	1.27	132	86					1.08	125	90	1.08	125	92
	1.00	1.51	140	76	1.45	140	81	1.39	139	85	1.32	139	90					1.16	135	94	1.16	135	97
	2.00	1.55	148	80	1.49	147	85	1.43	147	89	1.37	146	94					1.22	144	102	1.22	144	102
24	Normal	1.23	96	53	1.16	95	58	1.09	96	63	1.00	95	67										
	0.25	1.35	114	62	1.29	114	67	1.22	114	72	1.15	114	77					0.98	113	85	0.98	113	86
	0.50	1.39	120	66	1.33	120	71	1.26	120	75	1.19	120	80					1.04	119	81	1.04	119	89
	1.00	1.43	126	69	1.37	126	74	1.30	126	79	1.23	126	83					1.09	126	88	1.09	126	93
	2.00	1.47	133	73	1.41	133	77	1.35	133	82	1.28	133	87					1.21	132	91	1.21	132	96
	Normal	1.23	96	53	1.16	95	58	1.09	96	63	1.00	95	67					0.80	94	71	0.80	94	76
	0.25	1.35	114	62	1.29	114	67	1.22	114	72	1.15	114	77					0.98	113	85	0.98	113	86
	0.50	1.39	120	66	1.33	120	71	1.26	120	75	1.19	120	80					1.04	119	81	1.04	119	89
	1.00	1.43	126	69	1.37	126	74	1.30	126	79	1.23	126	83					1.09	126	88	1.09	126	93
	2.00	1.47	133	73	1.41	133	77	1.35	133	82	1.28	133	87					1.21	132	91	1.21	132	96
	Normal	1.30	106	59	1.23	106	63	1.15	104	67	1.00	95	67					0.80	94	71	0.80	94	76
	0.25	1.43	126	69	1.37	126	74	1.30	126	78	1.23	125	83					0.98	113	85	0.98	113	86
	0.50	1.47	133	73	1.41	132	77	1.34	132	82	1.27	132	86					1.08	125	90	1.08	125	92
	1.00	1.51	140	76	1.45	140	81	1.39	139	85	1.32	139	90					1.16	135	94	1.16	135	97
	2.00	1.55	148	80	1.49	147	85	1.43	147	89	1.37	146	94					1.22	144	102	1.22	144	102

Table 5(m)
Capability Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Air-Cooled (OA/FA/FA) Transformers Rated Over 133% of Self-Cooled Rating
Equivalent Load Before Peak Load = 50% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0				10				20			
		Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)	Peak Load (Per Unit)	Hot-Spot Temp (°C)	Top-Oil Temp (°C)
$\frac{1}{2}$	Normal	2.00	133	48	1.97	140	57	1.87	139	63	1.76	139	70
	0.25				2.21	164	64	2.11	163	71	2.00	163	78
	0.50												
	1.00												
	2.00												
1	Normal	1.84	135	61	1.74	134	66	1.64	133	71	1.54	132	77
	0.25	2.04	159	71	1.95	158	76	1.85	157	82	1.76	156	87
	0.50												
	1.00												
	2.00												
2	Normal	1.62	127	67	1.54	127	71	1.45	126	76	1.35	125	80
	0.25	1.80	150	79	1.72	149	83	1.63	149	87	1.54	148	91
	0.50				1.77	157	87	1.69	156	91	1.61	155	95
	1.00												
	2.00												
4	Normal	1.48	118	66	1.39	117	70	1.30	116	74	1.21	116	78
	0.25	1.63	139	78	1.55	138	82	1.47	138	86	1.39	138	90
	0.50	1.68	146	82	1.61	146	86	1.53	145	90	1.45	145	94
	1.00	1.73	153	86	1.66	152	90	1.58	152	94	1.50	151	98
	2.00												
8	Normal	1.38	107	61	1.30	107	65	1.21	107	69	1.12	106	73
	0.25	1.53	127	72	1.46	127	76	1.37	127	80	1.29	127	85
	0.50	1.58	134	76	1.50	133	80	1.42	133	84	1.35	133	88
	1.00	1.63	141	80	1.55	140	84	1.48	141	88	1.40	140	92
	2.00	1.68	148	84	1.61	148	88	1.53	148	92	1.46	148	96
24	Normal	1.28	96	54	1.19	95	58	1.11	95	63	1.01	95	67
	0.25	1.43	114	64	1.35	114	68	1.26	114	73	1.18	114	77
	0.50	1.47	120	68	1.39	120	72	1.32	120	76	1.23	120	81
	1.00	1.52	126	71	1.44	126	76	1.37	126	80	1.28	126	84
	2.00	1.57	133	75	1.49	133	79	1.42	133	84	1.34	133	88
76	Normal	1.62	140	79	1.55	140	84	1.48	140	88	1.40	140	92
	0.25												
	0.50												
	1.00												
	2.00												

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit. % loss of life is in addition to normal loss of life.

Table 5(n)
Capability Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Air-Cooled (OA/FA/FA) Transformers Rated Over 133% of Self-Cooled Rating
Equivalent Load Before Peak Load = 70% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C															
		0			10			20			30			40			50
1 2	Normal	2.00	140	53	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
	0.25																
	0.50																
	1.00																
	2.00																
1	Normal	1.81	134	62	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
	0.25																
	0.50																
	1.00																
	2.00																
2	Normal	1.61	127	67	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
	0.25																
	0.50																
	1.00																
	2.00																
4	Normal	1.46	117	65	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
	0.25																
	0.50																
	1.00																
	2.00																
8	Normal	1.38	107	61	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
	0.25																
	0.50																
	1.00																
	2.00																
24	Normal	1.28	95	54	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
	0.25																
	0.50																
	1.00																
	2.00																

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

Table 5(p)
Capability Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Air-Cooled (OA/FA/FA) Transformers Rated Over 133% of Self-Cooled Rating
Equivalent Load Before Peak Load = 90% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0				10				20			
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1/2	Normal	1.96	139	57	1.84	138	64	1.72	137	70	1.56	132	75
	0.25	2.19	163	65	2.09	162	71	1.98	161	78	1.86	160	84
	0.50												
	1.00												
1	Normal	1.75	133	64	1.65	131	69	1.53	129	74	1.38	125	78
	0.25	1.96	156	74	1.87	156	80	1.77	154	85	1.66	153	90
	0.50												
	1.00												
2	Normal	1.58	125	67	1.49	124	71	1.38	122	75	1.24	117	77
	0.25	1.76	148	79	1.67	147	83	1.58	146	87	1.49	144	91
	0.50	1.81	156	83	1.73	155	87	1.65	154	92	1.56	152	96
	1.00												
4	Normal	1.46	116	65	1.37	115	69	1.27	113	72	1.15	110	75
	0.25	1.61	137	77	1.54	137	81	1.45	136	85	1.37	135	89
	0.50	1.66	144	81	1.59	144	85	1.51	143	89	1.42	142	93
	1.00	1.71	151	85	1.64	151	89	1.56	150	93	1.48	149	97
8	Normal	1.37	107	60	1.29	106	64	1.20	105	68	1.08	103	71
	0.25	1.53	127	72	1.44	126	75	1.37	126	80	1.28	125	84
	0.50	1.57	133	76	1.50	133	79	1.42	132	83	1.33	131	87
	1.00	1.62	140	79	1.55	140	84	1.47	140	88	1.39	139	92
24	Normal	1.67	148	84	1.60	148	88	1.53	147	92	1.45	146	96
	0.25	1.72	155	88	1.66	155	92	1.58	155	96	1.51	154	100
	0.50												
	1.00												
96	Normal	1.28	95	54	1.19	95	58	1.10	95	62	1.00	94	66
	0.25	1.42	113	64	1.34	113	68	1.26	113	73	1.18	113	77
	0.50	1.47	119	67	1.39	119	72	1.31	119	76	1.23	119	80
	1.00	1.52	126	71	1.44	126	75	1.37	126	80	1.29	126	84
104	Normal	1.57	132	75	1.49	132	79	1.42	133	84	1.34	132	88
	0.25	1.62	140	80	1.55	140	83	1.47	140	88	1.40	140	92
	0.50												
	1.00												

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

Table 5(q)
Capacity Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Air-Cooled (OA/FA/FA) Transformers Over 133% of Self-Cooled Rating
Equivalent Load Before Peak Load = 100% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C											
		0	10	20	30	40	50						
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
		Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
1	Normal	1.91	138	59	1.79	136	65	1.63	132	71	1.06	99	68
	0.25	2.15	162	67	2.05	161	73	1.93	160	80	1.80	157	86
	0.50												
	1.00												
2	Normal	1.72	131	65	1.61	130	70	1.47	125	74	1.06	99	68
	0.25	1.93	156	75	1.83	154	80	1.73	153	85	1.62	150	90
	0.50												
	1.00												
4	Normal	1.56	124	67	1.46	122	71	1.34	118	73	1.03	97	68
	0.25	1.74	147	79	1.66	146	83	1.56	144	87	1.46	142	91
	0.50	1.80	155	83	1.71	153	87	1.63	152	91	1.54	151	95
	1.00												
8	Normal	1.45	115	64	1.35	113	68	1.24	110	71	1.02	96	67
	0.25	1.61	137	77	1.53	136	81	1.45	135	84	1.34	132	87
	0.50	1.66	143	81	1.58	143	84	1.50	142	88	1.41	141	92
	1.00	1.71	151	85	1.63	150	89	1.56	150	93	1.48	149	97
24	Normal	1.37	106	60	1.28	105	64	1.17	103	67	1.01	95	67
	0.25	1.52	126	71	1.45	126	76	1.36	125	79	1.27	124	83
	0.50	1.57	133	75	1.49	132	79	1.41	132	83	1.33	131	87
	1.00	1.62	140	79	1.55	140	83	1.46	139	87	1.38	138	91
	Normal	1.67	147	83	1.60	147	88	1.52	147	92	1.45	146	96
	0.25	1.73	156	88	1.65	155	92	1.58	154	96	1.50	154	100
	0.50												
	1.00												
	Normal	1.28	95	54	1.19	95	58	1.10	95	62	1.00	95	67
	0.25	1.42	113	64	1.34	113	68	1.26	113	73	1.17	113	77
	0.50	1.47	120	68	1.39	119	72	1.31	119	76	1.23	119	80
	1.00	1.52	126	71	1.44	126	75	1.37	126	80	1.28	126	84
	Normal	1.57	133	75	1.49	132	79	1.42	133	84	1.34	133	88
	0.25	1.62	140	79	1.54	140	83	1.48	140	88	1.39	140	92
	0.50	1.67	147	83	1.59	147	87	1.53	147	92	1.44	147	96
	1.00	1.72	154	87	1.64	154	91	1.58	154	96	1.49	154	100

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

Table 5(r)
Capability Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Oil-Cooled (Non-Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 50% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																							
		0				10				20				30				40				50			
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)			
1	Normal	2.00	137	52	1.95	140	59	1.85	140	66	1.74	139	72	1.62	138	78	1.50	137	84	1.50	137	84			
	0.25				2.16	165	68	2.07	163	74	1.97	163	80	1.87	163	86	1.76	161	92	1.76	161	92			
	0.50																								
	1.00																								
1	Normal	1.80	136	64	1.71	135	69	1.62	134	74	1.52	133	78	1.42	132	83	1.30	131	88	1.30	131	88			
	0.25	1.97	158	75	1.90	158	80	1.81	157	85	1.72	156	90	1.64	156	95	1.53	155	99	1.53	155	99			
	0.50																								
	2.00																								
2	Normal	1.59	128	69	1.51	128	73	1.43	127	77	1.33	126	81	1.24	124	85	1.13	122	88	1.13	122	88			
	0.25	1.74	150	82	1.67	150	86	1.60	149	90	1.51	148	94	1.43	148	98	1.34	147	102	1.34	147	102			
	0.50							1.65	157	94	1.57	156	98	1.49	155	102									
	2.00																								
4	Normal	1.44	118	68	1.37	118	71	1.29	117	75	1.20	116	79	1.11	115	82	1.00	114	86	1.00	114	86			
	0.25	1.59	140	81	1.52	139	84	1.44	138	88	1.37	138	91	1.29	137	95	1.20	136	93	1.20	136	93			
	0.50	1.63	146	85	1.56	145	88	1.50	145	92	1.42	144	95	1.34	144	99	1.26	143	103	1.26	143	103			
	2.00	1.68	154	89	1.61	153	93	1.54	153	97	1.47	152	100	1.39	151	103									
8	Normal	1.35	108	62	1.28	108	66	1.20	107	70	1.11	107	74	1.02	106	78	0.91	105	81	0.91	105	81			
	0.25	1.49	128	74	1.43	128	78	1.35	127	82	1.27	126	85	1.19	126	88	1.11	126	93	1.11	126	93			
	0.50	1.54	134	79	1.47	134	82	1.40	133	86	1.32	133	89	1.24	133	93	1.16	132	97	1.16	132	97			
	1.00	1.58	141	83	1.51	141	86	1.45	141	90	1.38	141	94	1.30	140	97	1.22	140	101	1.22	140	101			
24	Normal	1.63	149	87	1.56	148	91	1.50	148	95	1.42	147	98	1.35	148	102									
	0.25	1.68	157	92	1.61	156	96	1.55	156	100	1.48	156	103												
	0.50																								
	1.00																								
8	Normal	1.26	95	55	1.18	96	59	1.10	95	63	1.01	95	67	0.91	95	71	0.80	95	75	0.80	95	75			
	0.25	1.40	114	66	1.32	113	70	1.25	114	74	1.17	114	78	1.08	113	82	0.99	113	86	0.99	113	86			
	0.50	1.44	120	70	1.37	120	74	1.29	119	77	1.22	120	81	1.13	119	85	1.05	120	89	1.05	120	89			
	1.00	1.48	126	74	1.41	126	77	1.34	126	81	1.27	126	85	1.19	126	89	1.10	126	93	1.10	126	93			
24	Normal	1.53	133	78	1.46	133	82	1.39	133	85	1.32	133	89	1.24	133	93	1.16	132	97	1.16	132	97			
	0.25	1.57	140	82	1.51	140	86	1.44	140	90	1.37	140	94	1.30	140	97	1.22	139	101	1.22	139	101			
	0.50																								
	1.00																								

Table 5(s)
Capability Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Oil-Cooled (Non-Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 70% of Maximum Nameplate Rating

Hours of Peak Load	% Loss of Life	Ambient °C																					
		0				10				20				30				40				50	
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	
1 2	Normal	1.99	141	56	1.89	140	62	1.79	139	68	1.67	138	74	1.54	136	80	1.35	129	84	1.35	129	84	
	0.25	2.21	165	65	2.11	163	71	2.02	163	77	1.92	163	83	1.81	162	89	1.69	160	95	1.69	160	95	
	0.50																						
	1.00																						
	4.00																						
1	Normal	1.76	134	65	1.67	133	70	1.58	133	75	1.47	131	79	1.36	129	84	1.19	123	86	1.19	123	86	
	0.25	1.95	158	77	1.87	158	82	1.78	156	86	1.68	155	91	1.59	154	96	1.48	152	100	1.48	152	100	
	0.50																						
	1.00																						
	4.00																						
2	Normal	1.57	127	69	1.49	126	73	1.40	125	77	1.31	124	81	1.20	122	84	1.05	116	86	1.05	116	86	
	0.25	1.73	150	83	1.66	149	86	1.58	148	90	1.50	148	94	1.41	146	97	1.31	144	101	1.31	144	101	
	0.50				1.71	157	91	1.63	156	94	1.55	155	98	1.47	154	102							
	1.00																						
	4.00																						
4	Normal	1.44	117	67	1.36	117	71	1.28	116	74	1.19	115	78	1.09	113	81	0.95	109	83	0.95	109	83	
	0.25	1.58	139	80	1.51	138	84	1.44	138	87	1.36	137	91	1.28	136	94	1.19	135	98	1.19	135	98	
	0.50	1.63	146	85	1.56	145	88	1.49	144	92	1.41	144	95	1.33	143	98	1.25	142	102	1.25	142	102	
	1.00	1.68	154	89	1.61	152	93	1.54	152	96	1.47	152	100	1.39	151	103							
	4.00																						
8	Normal	1.35	107	62	1.28	107	66	1.19	107	70	1.10	106	73	1.01	105	77	0.88	102	80	0.88	102	80	
	0.25	1.49	127	74	1.42	127	78	1.35	127	82	1.27	126	85	1.19	126	89	1.10	125	93	1.10	125	93	
	0.50	1.54	134	78	1.47	133	82	1.40	133	86	1.32	133	89	1.24	133	93	1.15	132	97	1.15	132	97	
	1.00	1.58	141	83	1.51	141	86	1.44	140	90	1.37	140	94	1.29	139	97	1.21	139	101	1.21	139	101	
	2.00	1.63	149	87	1.56	148	91	1.50	148	95	1.43	148	98	1.35	147	102							
8	4.00	1.67	156	92	1.61	156	96	1.55	156	100	1.48	155	103										
	Normal	1.26	95	55	1.18	95	59	1.10	95	63	1.01	95	67	0.91	95	71	0.80	95	75	0.80	95	75	
	0.25	1.40	114	66	1.33	114	70	1.25	113	74	1.17	113	78	1.08	113	82	0.98	113	86	0.98	113	86	
	0.50	1.44	120	70	1.37	119	73	1.29	119	77	1.21	119	81	1.13	120	85	1.04	119	89	1.04	119	89	
	1.00	1.48	126	74	1.41	126	77	1.34	126	81	1.27	126	85	1.19	126	89	1.10	125	93	1.10	125	93	
24	2.00	1.53	133	78	1.46	133	82	1.39	133	85	1.32	133	89	1.24	133	93	1.16	133	97	1.16	133	97	
	4.00	1.57	140	82	1.51	140	86	1.44	140	90	1.37	140	94	1.30	140	98	1.22	140	101	1.22	140	101	
	Normal	1.35	107	62	1.28	107	66	1.19	107	70	1.10	106	73	1.01	105	77	0.88	102	80	0.88	102	80	
	0.25	1.49	127	74	1.42	127	78	1.35	127	82	1.27	126	85	1.19	126	89	1.10	125	93	1.10	125	93	
	0.50	1.54	134	78	1.47	133	82	1.40	133	86	1.32	133	89	1.24	133	93	1.15	132	97	1.15	132	97	

Table 5(t)
Capability Table for Normal and Moderate Sacrifice of Life
55 °C Rise, Forced-Oil-Cooled (Non-Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 90% of Maximum Nameplate Rating

		Ambient °C											
		0				10				20			
Hours of Peak Load	% Loss of Life	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
		Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1/2	Normal	1.92	139	60	1.81	138	66	1.70	137	72	1.54	132	77
	0.25	2.14	163	69	2.04	163	75	1.94	161	81	1.83	160	87
	0.50												
	1.00												
1	Normal	1.71	133	67	1.62	132	72	1.52	130	76	1.38	126	79
	0.25	1.91	157	79	1.82	156	83	1.73	154	87	1.63	153	92
	0.50												
	1.00												
2	Normal	1.55	126	70	1.46	124	73	1.36	122	76	1.24	119	79
	0.25	1.71	148	82	1.63	147	86	1.55	147	90	1.46	145	93
	0.50	1.76	156	87	1.69	155	91	1.61	154	94	1.52	152	98
	1.00												
4	Normal	1.43	116	67	1.34	115	70	1.26	114	73	1.15	110	76
	0.25	1.57	137	80	1.50	137	83	1.42	136	87	1.34	135	90
	0.50	1.62	145	84	1.55	144	87	1.48	143	91	1.40	142	94
	1.00	1.67	152	89	1.60	151	92	1.53	151	96	1.45	150	99
8	Normal	1.35	107	62	1.27	106	65	1.18	105	69	1.08	103	72
	0.25	1.49	127	74	1.42	127	78	1.34	126	81	1.26	125	85
	0.50	1.53	134	78	1.46	133	81	1.39	132	85	1.31	132	89
	1.00	1.58	140	82	1.51	140	86	1.44	139	89	1.37	139	93
24	Normal	1.26	95	55	1.18	95	59	1.09	95	62	1.00	94	66
	0.25	1.40	114	66	1.32	114	70	1.24	113	73	1.17	113	78
	0.50	1.44	120	70	1.36	119	73	1.29	120	77	1.21	119	81
	1.00	1.48	126	73	1.41	126	77	1.34	126	81	1.26	126	85
	Normal	1.53	133	78	1.46	133	82	1.39	132	85	1.31	132	89
	0.25	1.67	140	82	1.51	140	86	1.44	140	90	1.37	140	93
	0.50												
	1.00												

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

*Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

Table 5(u)
Capacity Table for Normal and Moderate Sacrifice of Life
55 °C Rise Forced-Oil-Cooled (Non-Directed Flow — FOA, FOW*, and OA/FOA/FOA) Transformers
Equivalent Load Before Peak Load = 100% of Maximum Nameplate Rating

Hours of Peak Load	% Loss Life	Ambient °C											
		0	10	20	30	40	50						
		Peak Load (Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)	Peak Load (Per Unit)	Hot- Spot Temp (°C)	Top- Oil Temp (°C)
1	Normal	1.88	139	62	1.76	133	73	1.06	99	68	1.59	151	92
	0.25	<u>2.10</u>	<u>162</u>	71	<u>2.00</u>	<u>162</u>	83	1.77	<u>157</u>	88	1.47	150	98
	0.50												
	1.00												
1	Normal	1.68	132	67	1.58	130	72	1.44	125	68	1.44	145	95
	0.25	<u>1.88</u>	<u>156</u>	79	<u>1.79</u>	<u>155</u>	84	<u>1.70</u>	<u>154</u>	92	<u>1.54</u>	<u>160</u>	<u>107</u>
	0.50												
	1.00												
2	Normal	1.53	124	69	1.44	123	73	1.31	118	74	1.30	136	93
	0.25	<u>1.69</u>	<u>147</u>	82	<u>1.61</u>	<u>145</u>	86	<u>1.53</u>	<u>145</u>	89	<u>1.39</u>	<u>147</u>	<u>99</u>
	0.50	<u>1.74</u>	<u>155</u>	87	<u>1.67</u>	<u>153</u>	91	<u>1.59</u>	<u>153</u>	94	<u>1.47</u>	<u>158</u>	<u>106</u>
	1.00												
4	Normal	1.42	115	66	1.33	114	69	1.23	110	71	1.21	128	90
	0.25	<u>1.57</u>	<u>137</u>	80	<u>1.50</u>	<u>136</u>	83	<u>1.41</u>	<u>135</u>	86	<u>1.29</u>	<u>138</u>	<u>96</u>
	0.50	<u>1.61</u>	<u>144</u>	84	<u>1.54</u>	<u>143</u>	87	<u>1.46</u>	<u>142</u>	90	<u>1.35</u>	<u>147</u>	<u>101</u>
	1.00	<u>1.66</u>	<u>152</u>	89	<u>1.59</u>	<u>151</u>	92	<u>1.52</u>	<u>150</u>	95	<u>1.43</u>	<u>153</u>	<u>103</u>
8	Normal	1.34	106	61	1.26	105	65	1.16	103	67	1.14	120	86
	0.25	<u>1.49</u>	<u>127</u>	74	<u>1.41</u>	<u>126</u>	77	<u>1.34</u>	<u>125</u>	81	<u>1.21</u>	<u>129</u>	<u>91</u>
	0.50	<u>1.53</u>	<u>133</u>	78	<u>1.46</u>	<u>132</u>	81	<u>1.38</u>	<u>132</u>	85	<u>1.21</u>	<u>137</u>	<u>96</u>
	1.00	<u>1.58</u>	<u>140</u>	82	<u>1.51</u>	<u>140</u>	86	<u>1.44</u>	<u>139</u>	89	<u>1.27</u>	<u>145</u>	<u>101</u>
24	Normal	1.26	95	54	1.18	95	59	1.09	95	63	1.08	113	82
	0.25	<u>1.39</u>	<u>113</u>	66	<u>1.32</u>	<u>113</u>	69	<u>1.24</u>	<u>113</u>	73	<u>1.13</u>	<u>118</u>	<u>85</u>
	0.50	<u>1.44</u>	<u>119</u>	69	<u>1.37</u>	<u>119</u>	73	<u>1.29</u>	<u>119</u>	77	<u>1.13</u>	<u>125</u>	<u>89</u>
	1.00	<u>1.48</u>	<u>126</u>	73	<u>1.41</u>	<u>126</u>	77	<u>1.34</u>	<u>126</u>	81	<u>1.18</u>	<u>132</u>	<u>93</u>

NOTE: Underlined values, though beyond recommended limits (see 5.2.2.4), are given to assist in interpolation of the maximum limit.
% loss of life is in addition to normal loss of life.

* Actual water temperature should be 5 °C lower than the ambient temperatures shown above (see 3.5), and must be above zero °C.

6. Calculation of Temperature and Loss of Life for Short-Time Loads above Transformer Rating

The calculations shown in this section are for 65 °C rise transformers. These methods can be used for 55 °C rise transformers.

6.1 General. Short-time loads above the rating which use up different amounts of insulation life for transformers having the characteristics shown in Table 2 are given in Tables 3(a)–3(u). Transformers which have other characteristics will have different load capabilities than those indicated in this guide. Section 6 gives information from which similar values can be derived for those transformers.

Where a graphical solution is desired, use may be made of Figs 6–9. As an example of the use of these figures, consider an OA transformer with a short-time load of 167% for 2 h following a 33% load. Assumed transformer characteristics at nameplate rating are:

Ratio of losses (R)	3.2
Top-oil rise over ambient temperature at rated load	50 °C
Time constant	3.5 h
Hottest-spot conductor rise over oil	30 °C
n (oil exponent)	0.8
m (winding exponent)	0.8

6.2 Top-oil Rise Determination

(1) On Fig 6(a), start at initial percent rating (33%) and move horizontally to the ratio of losses curve ($R = 3.2$). Go down to the line for full-load oil rise (50 °C). Move horizontally to read initial oil rise (21 °C).

(2) Determine the ultimate top-oil temperature rise for the short-time load (167%). On Fig 8(a), locate 167% on right side of the graph and move horizontally across to the ratio of losses curve ($R = 3.2$). Move down to the full-load oil-rise curve (50 °C). Move horizontally and read the ultimate oil rise (99 °C) at left of graph.

(3) On Fig 7(a), set a straight edge at the initial oil-temperature rise on the left scale (21 °C) and at the ultimate top-oil rise on the right scale (99 °C). At the intersection of the

line so determined and the vertical line through the intersection of line for the desired time (2 h) and time constant (3.5 h), determine the top-oil temperature rise (54 °C) at the end of the short-time period (2 h).

6.3 Hottest-Spot Conductor Rise to Top-Oil Gradient. On Fig 9(a), start at percent load (167%) on the horizontal scale and go up the curve for full-load hottest-spot conductor rise (30 °C). Go to the left and read hottest-spot conductor rise over top oil (68 °C) for the short-time load.

6.4 Hottest-Spot Conductor Temperature. Obtain the hottest-spot conductor temperature by adding ambient temperature (30 °C), top-oil rise (54 °C) and hottest-spot rise over top oil (68 °C) giving 152 °C.

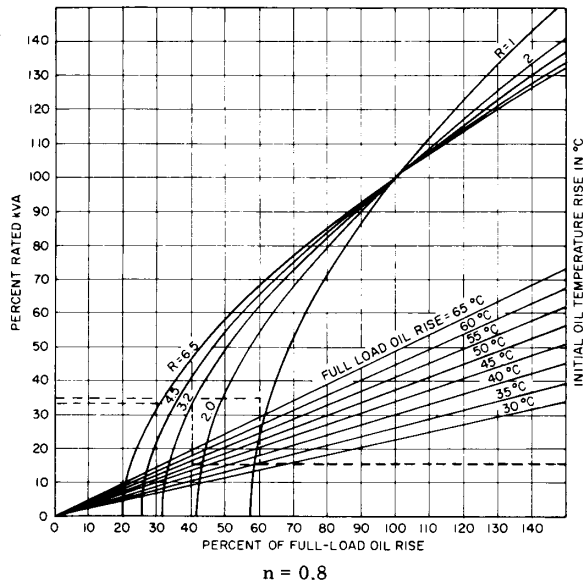
6.5 Percent Loss of Life. From Fig 3, obtain the loss of life (0.19%) for the hottest-spot temperature (152 °C) and the duration of the load (2 h). In using this simplified procedure, it is assumed that the hottest-spot temperature is constant at its final value throughout the peak load period. When this assumption is made, the loss of life during the cooling period and during the period prior to the peak load can be ignored. This is only a convenient and simplified procedure for approximating the loss of life for short-time loading conditions. A more mathematically precise procedure was used in preparing the values in Tables 3(a)–3(u) and 5(a)–5(u), wherein a computer program used the 24 h hottest-spot conductor temperature profile developed from various two-step load cycles, the transformer characteristics and ambient temperatures shown in these tables.

6.6 Method of Converting Actual to Equivalent Load Cycle

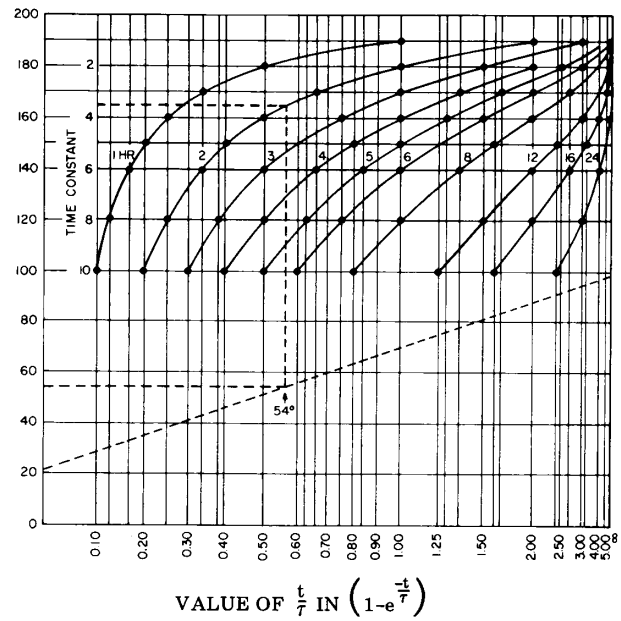
6.6.1 Permissible loading as obtained from Tables 3(a)–3(u) and 5(a)–5(u) is a function of the initial load and the peak load and their durations. Each loading combination in the tables is the result of a simple two-step load cycle consisting of a constant initial load of 50%, 70%, 90% or 100% of rating followed by a rectangular peak of the magnitude and duration given in the table. The assumed loading for the calculations in the tables is illustrated by Fig 10.

6.6.2 Ordinarily the daily load cycle is not so simple but is like the cycle represented by the solid line in Fig 11 consisting of load fluctua-

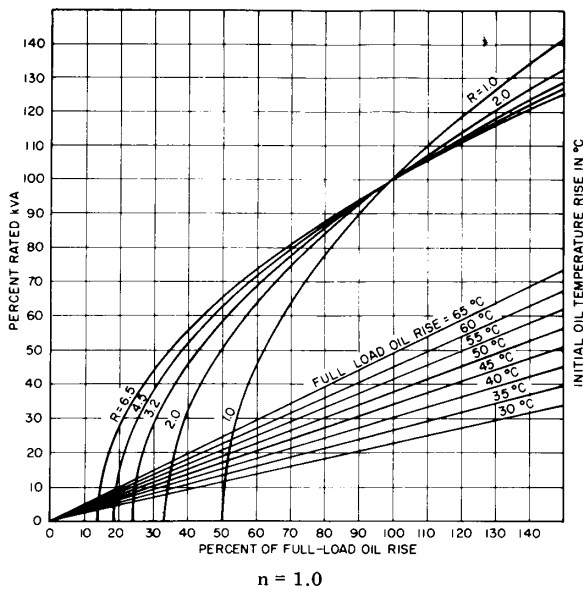
TRANSFORMERS UP TO 100 MVA WITH 55 °C OR 65 °C AVERAGE WINDING RISE



(a)

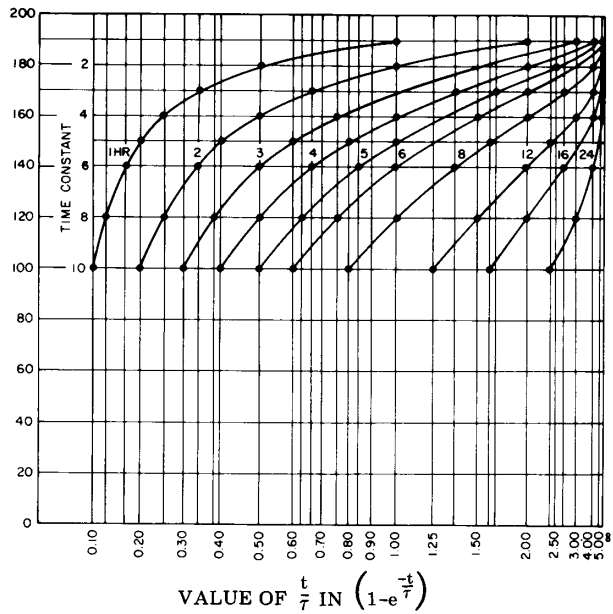


(a)



(b)

Fig 6
Initial Oil Rise



(b)

Fig 7
Top-Oil Temperature at End of Specified Load Period

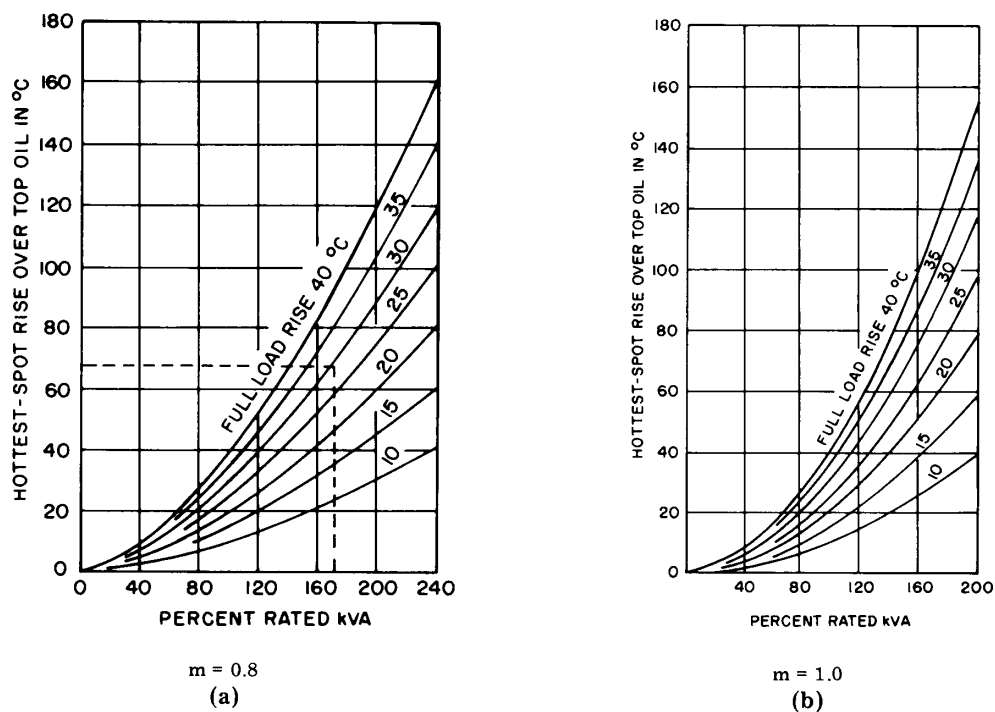


Fig 9
Hottest-Spot Conductor To
Top-Oil Gradient

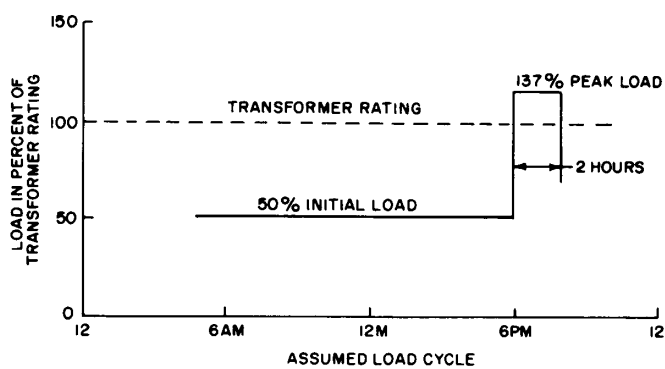


Fig 10
Assumed Load Cycle

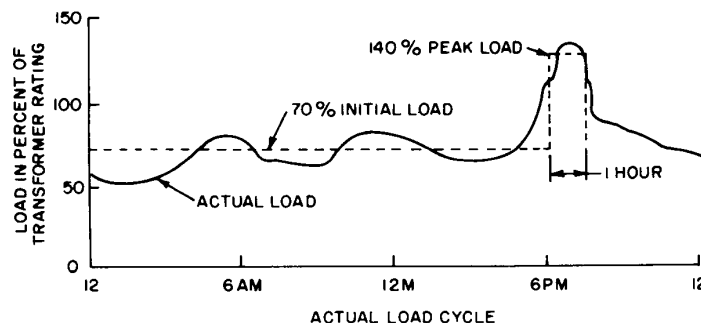


Fig 11
Actual Load Cycle

tions throughout the day. There is usually one period in the daily load cycle when the load builds up to a considerably greater value than any reached at other times. Generally, the maximum value or peak load is not reached and passed suddenly, but builds up and falls off gradually.

6.6.3 To use the loading recommendations, the actual fluctuating load cycle should be converted to a thermally equivalent two-step load cycle such as is represented by the dashed line in Fig 11. A transformer supplying a fluctuating load generates a fluctuating loss, the effect of which is about the same as that of an intermediate load held constant for the same period of time. This is due to the heat storage characteristics of the materials in the transformer. A constant load which generates losses at the same rate as the average rate caused by the fluctuating load is an equivalent load from a temperature standpoint. Equivalent load for any part of a daily-load cycle may be expressed by Eq 2.

Equivalent load or rms value =

$$\sqrt{\frac{L_1^2 t_1 + L_2^2 t_2 + L_3^2 t_3 + \dots + L_n^2 t_n}{t_1 + t_2 + t_3 + \dots + t_n}} \quad (\text{Eq 2})$$

where:

L_1, L_2, L_3 , etc = various load steps in %, per unit, or in actual kVA or current

t_1, t_2 , etc = respective durations of these loads

6.6.4 Equivalent initial load is the rms load obtained by Eq 2 over a chosen period preceding the peak load. Experience with this method indicates that quite satisfactory results are obtained by considering only the 12 h period preceding the peak in determining the equivalent initial load. Time intervals (t) of 1 h are suggested as a further simplification of the equation which, for a 12 h period, becomes Eq 3.

Equivalent initial load =

$$0.29 \sqrt{L_1^2 + L_2^2 + L_3^2 + \dots + L_{12}^2} \quad (\text{Eq 3})$$

where:

$L_1, L_2, \dots, L_{12}$ = average load by inspection for each 1 h interval of the 12 h period preceding peak load

6.6.5 Equivalent peak load of a load cycle is the rms load obtained using Eq 2 for the limited period over which the major part of the actual irregular peak seems to exist. The estimated duration of the peak has considerable influence over the rms peak value. If the duration is overestimated, that is, if the time period to which Eq 2 is applied is too long, the rms peak value may be considerably below the maximum peak demand. To guard against

overheating due to brief, high loads during the peak period, the rms value for the peak load period should not be less than 90% of the integrated half-hour maximum demand.

6.6.6 The above method may be used to convert an irregular load cycle as shown in Fig 11 to a two-step load cycle. In this case the continuous part is 70% and the peak 140% of rated load. Table 3(b) shows that in a 30 °C ambient temperature the permissible 1 h load following 70% load is 172%, therefore, the transformer can carry this load cycle daily without sacrifice of normal life expectancy.

6.7 Equations for Calculating Transient Heating of Oil-Immersed Transformers

6.7.1 General. The loading tables in this guide are based on average characteristics of a wide range of transformer ratings. Tables 2 and 4 give the characteristics used in calculating the loadings in the Tables 3(a)—3(u) and 5(a)—5(u). When the characteristics of a particular transformer vary appreciably from those in the tables or when more accurate loading capabilities are desired, the basic equations in this section may be used.

6.7.2 List of Symbols. Unless otherwise expressed, all temperatures are in °C and all times are in hours.

θ_a	= ambient temperature
θ_g	= hottest-spot conductor rise over top-oil temperature
$\theta_g(fl)$	= hottest-spot conductor rise over top-oil temperature at rated load
θ_{hs}	= hottest-spot winding temperature
θ_o	= top-oil rise over ambient temperature
θ_{fl}	= top-oil rise over ambient temperature at rated load
θ_i	= initial top-oil rise for $t = 0$
θ_u	= ultimate top-oil rise for load L
K	= ratio of load L to rated load
L	= load under consideration, in any units
R	= ratio of load loss at rated load to no-load loss
e	= 2.71828 (base of natural logarithm)
t	= duration of load in hours

τ_o = thermal time constant of transformer for any load L and for any specific temperature differential between the ultimate top-oil rise and the initial top-oil rise, or

$$\tau_o = C(\theta_u - \theta_i)/P$$

τ_{hs} = hottest-spot time constant

P = change in total loss in watts due to change in load

τ_r = time constant of transformer for rated load beginning with initial temperature rise of zero °C

P_{fl} = total loss in watts at rated load

C = thermal capacity of transformer (Wh/°C)

6.7.3 Temperature Determination Equations

Hottest-spot temperature:

$$\theta_{hs} = \theta_a + \theta_o + \theta_g \quad (\text{Eq 4})$$

Transient heating equation for top-oil rise over ambient temperature:

$$\theta_o = (\theta_u - \theta_i) \left(1 - e^{-\frac{t}{\tau_o}}\right) + \theta_i \quad (\text{Eq 5})$$

Ultimate top-oil rise for load L :

$$\theta_u = \theta_{fl} \left[\frac{(K^2 R + 1)}{(R + 1)} \right]^n \quad (\text{Eq 6})$$

Ultimate hottest-spot conductor rise over top-oil for load L :

$$\theta_g = \theta_g(fl) K^{2m} \quad (\text{Eq 7})$$

$\theta_g(fl)$ = average conductor rise over top oil⁶ + 15 °C⁷ (Eq 8)

m = 0.8 for OA, OA/FA, OA/FA/FA and non-directed FOA, FOW, OA/FA/FOA, OA/FOA/FOA

m = 1.0 for directed flow FOA, FOW

n = 0.8 for OA

n = 0.9 for OA/FA, OA/FA/FA

⁶ At rated kVA from manufacturer's test.

⁷ Hottest-spot conductor rise over average conductor rise is assumed to be 15 °C for 65 °C rise transformer, 10 °C for 55 °C rise transformers. (Values are usually lower than the 15 °C and 10 °C, but may be higher for a few designs).

- $n = 1.0$ for FOA, FOW, OA/FA/FOA, OA/FOA/FOA
 $n =$ the exponential power of total loss versus top-oil temperature rise
 $m =$ the exponential power of winding loss versus winding temperature rise

Time constant at rated kVA:

$$\tau_r = \frac{C\theta_n}{P_n} \quad (\text{Eq 9})$$

For non-directed flow transformers:

$$C = 0.06 \text{ (weight of core and coil assembly in pounds)} + 0.04 \text{ (weight of tank and fittings in pounds)} + 1.33 \text{ (gallons of oil)}$$

For directed flow transformers:

$$C = 0.06 \text{ (weight of core and coil assembly in pounds)} + 0.06 \text{ (weight of tank and fittings in pounds)} + 1.93 \text{ (gallons of oil)}$$

6.7.4 Equation Corrections. Theoretically, several corrections should be made when using the foregoing equations in calculating transient oil rises, such as corrections for change in:

- (1) Time constant for load above rating
- (2) Ultimate conductor loss at end of load period
- (3) Oil viscosity

In making general calculations based on assumptions of transformer characteristics and maximum hottest-spot conductor temperatures which generally have a large factor of safety, results close enough for all practical purposes are obtained if all of these corrections are omitted, and the simpler formulas are used. Using these corrections implies greater accuracy than is present in the basic data, therefore the load values shown in Tables 3(a)–3(u) and 5(a)–5(u) were calculated using the equations without corrections.

6.7.5 Time Constant. The time constant is the length of time which would be required for the temperature of the oil to change from initial value to the ultimate value if the initial rate of change were continued until the ultimate temperature was reached.

If n (the exponential power of total loss versus top-oil temperature rise) equals unity, 63% of the temperature change occurs in a length of time equal to the time constant regardless of the relationship of initial temper-

ature rise and ultimate temperature rise. If n is not unity, the percentage varies and is a function of both initial temperature rise and ultimate temperature rise. In particular, if n equals 0.8, the percentage of 67 if the initial temperature rise is zero.

If the initial temperature rise is greater than zero, the percentage is lower than 67 and decreases as the initial temperature rise approaches a given ultimate temperature rise. If the initial temperature is approximately equal to the final temperature, whether just above or just below it, the percentage is approximately 63. If the initial temperature is greater than the ultimate temperature, the percentage is less than 63.

Since evaluation of the exact percentage for cases where n is not unity and where the initial temperature rise is not zero becomes very laborious, it is frequently advisable to use the approximate value of 63%. In the more frequently encountered cases where n is approximately 0.8, the error resulting from this procedure is not large compared to the expected error in input data.

If $n = 1.0$, Eq 9 is correct for any load and any starting temperature. If n or m is less than 1.0, Eq 9 holds only for full-rating starting cold. If n is less than 1, the time constant for any load and for any starting temperature for either a heating cycle or cooling cycle is given in Eqs 10 and 11.

$$\tau_o = \tau_r \frac{\left(\frac{\theta_u}{\theta_{rl}}\right) - \left(\frac{\theta_i}{\theta_{rl}}\right)}{\left(\frac{\theta_u}{\theta_{rl}}\right)^{\frac{1}{n}} - \left(\frac{\theta_i}{\theta_{rl}}\right)^{\frac{1}{n}}} \quad (\text{Eq 10})$$

If starting cold, as $\theta_i = 0$, Eq 10 reduces to:

$$\tau_o = \tau_r \left(\frac{\theta_u}{\theta_{rl}}\right)^{\left(1 - \frac{1}{n}\right)} \quad (\text{Eq 11})$$

6.7.6 Winding Loss (Load Loss). As the resistance of the winding for ultimate conditions is greater when the temperature is greater for loads above rating than it is for rated load conditions, a resistance correction factor may be applied to Eqs 6 and 7. The correction factor is a multiplier to be applied to the K^2 in each equation to reflect the change in winding loss due to the increase in winding resistance.

The values of the exponents, m and n , used in the equation may not be correct when resistance corrections are applied. The manufacturer should be consulted when such corrections are to be included.

6.7.7 Viscosity of Oil. The ultimate temperature rise of oil for a constant heat input decreases slightly as the temperature of the oil increases. This is due to a decrease in the viscosity of the oil. The viscosity change tends to offset the effect of increased resistance.

7. Method Used for Computer Calculation of Loading Capability Tables

The methods and calculations described in 6.6.3 through 6.7.5 were used in developing a computer program designed to provide more accurate values for Tables 3(a)–3(u) and 5(a)–5(u) than would be possible using the hand method covered in 6.2 – 6.5 of this guide. See ANSI/IEEE C57.91-1981 [4] for a more complete explanation of the computer program.

The program computes and prints the maximum peak load that can be impressed on a power transformer and meet specified loss of life limitations within a $\pm 4\%$ tolerance.

Input to the program consists of the following: (1) transformer characteristics (loss ratio,

top-oil rise, hottest-spot rise, and time constant, all at rated load), (2) the aging curve constants for the insulation system (from Fig 1), (3) ambient temperatures, (4) initial continuous load, (5) peak load durations and the specified daily percent loss of life.

The loss of life indicated in the tables is based on a 24 h load cycle. For 65°C units it is the loss in excess of the 0.0369% per day produced by continuous operation at 110°C . For 55°C units it is the loss in excess of the 0.0369% per day produced by continuous operation at 95°C .

A systematic convergence process is used to obtain the highest allowable peak load. An initial trial is made with an assumed peak load midway between the minimum (continuous) load and the maximum permitted peak load (200%). Using this peak load, aging calculations are made at varying time intervals (depending on the time duration of the peak load) during the 24 h, to determine the total daily insulation aging, imposed by the load cycle. A comparison is made between the calculated and the specified percent loss of life.

Depending on the results the peak value is changed and the calculation repeated until the calculated value of total percent loss of life is within $\pm 4\%$ of the desired value. At this point the peak load and corresponding values of peak hottest-spot temperature, peak top-oil temperature, total percent loss of life, and the specified percent loss of life are printed out.

Appendix

(This Appendix is not a part of ANSI/IEEE C57.92-1981, IEEE Guide for Loading Mineral-Oil-Immersed Power Transformers Up To and Including 100 mVA with 55 °C or 65 °C Average Winding Rise.)

Unusual Temperature and Altitude Conditions

Table A1
Maximum Allowable Average Temperature* of Cooling Air for Carrying Rated kVA

Method of Cooling Apparatus	1000 Meters (3300 Feet)	2000 Meters (6600 Feet)	3000 Meters (9900 Feet)	4000 Meters (13 200 Feet)
	Degrees C			
Liquid-Immersed Self-Cooled	30	28	25	23
Liquid-Immersed Forced-Air-Cooled	30	26	23	20
Liquid-Immersed Forced-Oil-Cooled with Oil-to-Air Cooler	30	26	23	20

*It is recommended that the average temperature of the cooling air be calculated by averaging 24 consecutive hourly readings. When the outdoor air is the cooling medium, the average of the maximum and minimum daily temperatures may be used. The value obtained in this manner is usually slightly higher, by not more than 0.3 °C, than the true daily average.

A1. Unusual Temperatures and Altitude Service Conditions

Transformers may be applied at higher ambient temperatures or at higher altitudes than specified in ANSI C57.12.00-1980, but performance may be affected and special consideration should be given to these applications.

NOTES: (1) See ANSI/IEEE C57.12.00-1980, 4.3.2 for transformer insulation capability at altitudes above 3300 ft (1000 m).

(2) Operation in low ambient temperature with the top liquid at a temperature lower than -20 °C may reduce dielectric strength between internal energized components below design levels.

A4. Operation at Less than Rated kVA

Transformers may be operated at altitudes greater than 3300 ft (1000 m) without exceeding temperature limits, provided the load to be carried is reduced below rating by the percentages given in Table A2 for each 330 ft (100 m) that the altitude is above 3300 ft (1000 m).

Table A2
Rated kVA Correction Factors for Altitudes Greater than 3300 ft (1000 m)

Types of Cooling	Derating Factor (%)
Liquid-immersed air-cooled	0.4
Liquid-immersed water-cooled	0.0
Liquid-immersed forced-air-cooled	0.5
Liquid-immersed forced-liquid-cooled with liquid-to-air cooler	0.5
Liquid-immersed forced-liquid-cooled with liquid-to-water cooler	0.0

A3. Operation at Rated kVA

Transformers may be operated at rated kVA at altitudes greater than 3300 ft (1000 m) without exceeding temperature limits, provided the average temperature of the cooling air does not exceed the values of Table A1 for the respective altitudes.