

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



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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

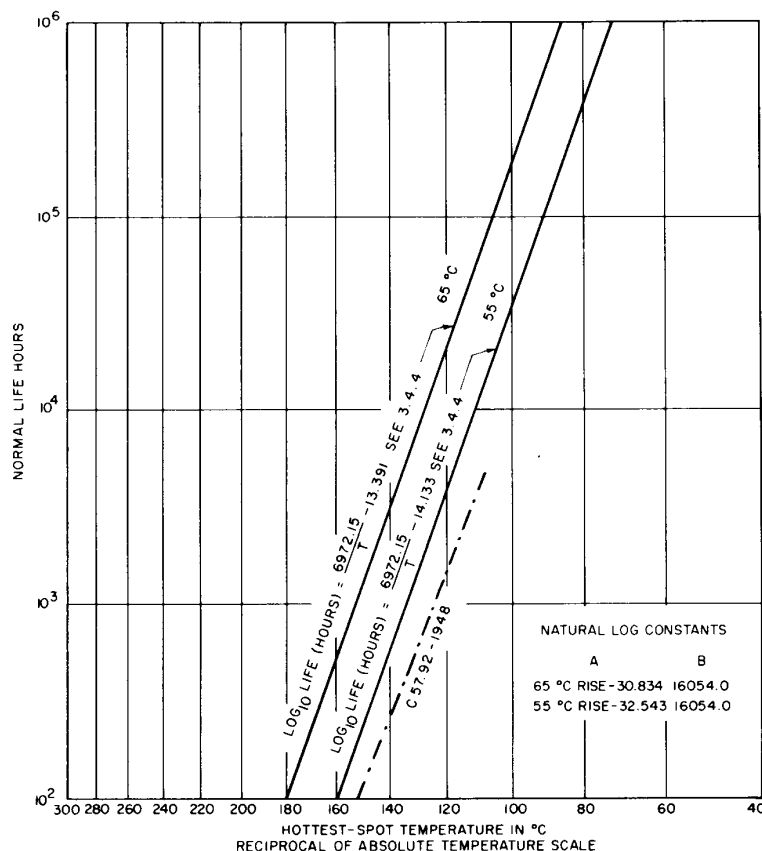


Fig 1
Life Expectancy Curve

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 ($\theta_{hs} + 273$)

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)

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

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

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.

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

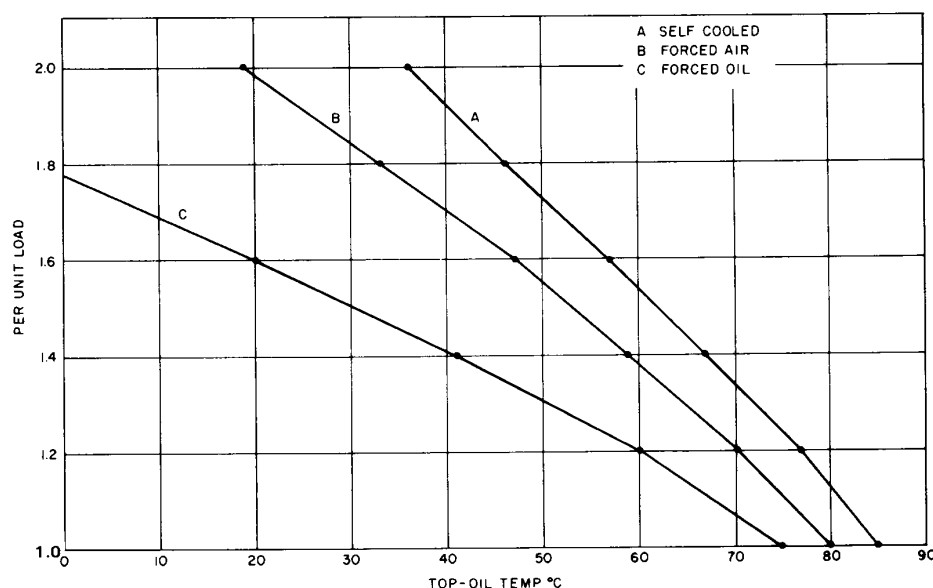


Fig 2
Approximate Continuous Loading for Normal Life Expectancy —
65 °C Rise Transformers

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

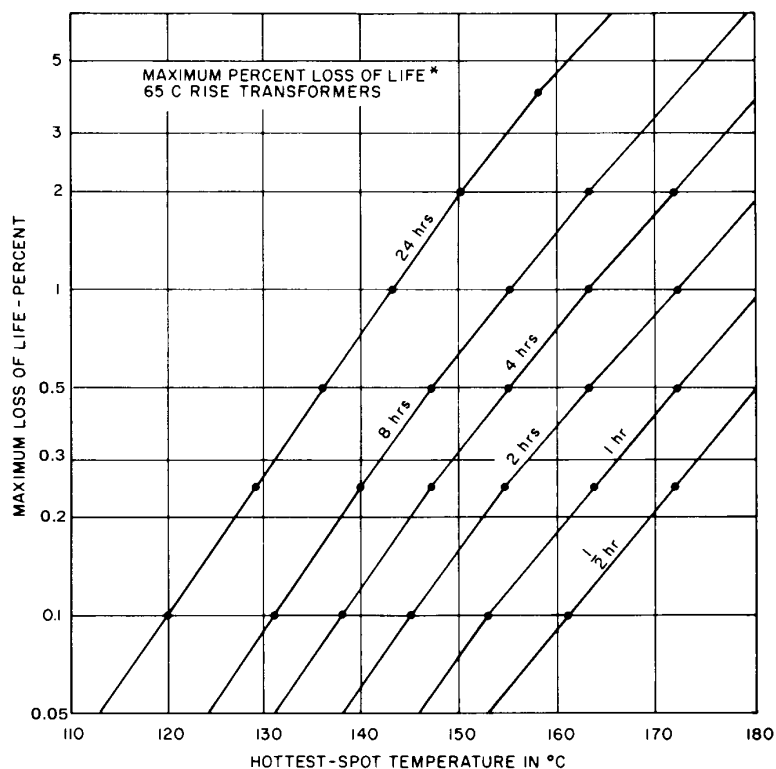
4.2.2.1 Transformers with Known Specific Characteristics. If the specific characteristics of a transformer are known and maximum recommended capability is required, the user may calculate the oil rise and hottest-spot temperature using either the graphic solution illustrated in Section 6 or the basic 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 — $2 \cdot \text{rating}$



*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												
4	Normal	1.63	140	85	1.54	139	89	1.45	138	93	1.34	137	97
	0.25												
	0.50												
	1.00												
8	2.00												
	4.00												
24	Normal	1.45	130	85	1.36	129	88	1.27	129	92	1.18	128	95
	0.25												
	0.50												
	1.00												
4	2.00												
	4.00												
8	Normal	1.28	113	76	1.20	113	79	1.11	113	83	1.02	113	87
	0.25												
	0.50												
	1.00												
24	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			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 1 2	Normal	2.00	129	53	2.00	139	63	2.00	149	73	1.95	155	83	1.80	154	90	
	0.25							2.00			2.00	159	83	2.00	169	93	
	0.50																
	1.00																
	2.00																
1 1 2 4.00	Normal	2.00	143	67	1.98	151	77	1.86	150	83	1.72	148	89	1.56	146	95	
	0.25							2.00			2.00	173	97	1.91	174	104	
	0.50										2.00	183	107	2.00	183	107	
	1.00																
	2.00																
1 1 2 4.00	Normal	1.84	166	80	1.73	146	85	1.62	144	90	1.50	143	95	1.36	140	99	
	0.25	2.00	164	88	1.97	171	97	1.87	170	102	1.77	169	107	1.65	167	111	
	0.50				2.00	174	98	1.94	177	105	1.84	177	111				
	1.00							2.00		108							
	2.00																
2 2 4 4.00	Normal	1.60	139	86	1.51	138	89	1.41	136	93	1.30	134	96	1.17	131	99	
	0.25	1.80	163	99	1.71	162	103	1.62	161	107	1.52	160	110	1.42	158	114	
	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													
4 4 4 4.00	Normal	1.60	139	86	1.51	138	89	1.41	136	93	1.30	134	96	1.17	131	99	
	0.25	1.80	163	99	1.71	162	103	1.62	161	107	1.52	160	110	1.42	158	114	
	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													
4 4 4 4.00	Normal	1.43	129	84	1.34	128	88	1.25	127	91	1.16	126	94	1.05	124	97	
	0.25	1.60	152	98	1.52	151	102	1.44	150	105	1.35	149	108	1.27	148	112	
	0.50	1.66	159	103	1.58	158	106	1.50	156	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													
8 8 8 4.00	Normal	1.43	129	84	1.34	128	88	1.25	127	91	1.16	126	94	1.05	124	97	
	0.25	1.60	152	98	1.52	151	102	1.44	150	105	1.35	149	108	1.27	148	112	
	0.50	1.66	159	103	1.58	158	106	1.50	156	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													
8 8 8 4.00	Normal	1.29	113	76	1.20	112	79	1.11	112	83	1.02	112	86	0.91	111	89	
	0.25	1.44	133	88	1.36	133	92	1.28	133	96	1.20	132	99	1.11	132	103	
	0.50	1.48	140	93	1.41	139	96	1.33	139	99	1.25	139	103	1.16	138	107	
	1.00	1.54	147	97	1.46	146	101	1.38	146	104	1.30	146	107	1.23	146	111	
	2.00	1.59	154	102	1.52	154	105	1.45	154	109	1.37	154	113				
24 24 24 4.00	Normal	1.64	162	107	1.57	162	111	1.50	162	114							
	0.25	1.29	113	76	1.20	112	79	1.11	112	83	1.02	112	86	0.91	111	89	
	0.50	1.44	133	88	1.36	133	92	1.28	133	96	1.20	132	99	1.11	132	103	
	1.00	1.54	147	97	1.46	146	101	1.38	146	104	1.30	146	107	1.16	138	107	
	2.00	1.59	154	102	1.52	154	105	1.45	154	109	1.37	154	113				
24 24 24 4.00	Normal	1.64	162	107	1.57	162	111	1.50	162	114							
	0.25	1.29	113	76	1.20	112	79	1.11	112	83	1.02	112	86	0.91	111	89	
	0.50	1.44	133	88	1.36	133	92	1.28	133	96	1.20	132	99	1.11	132	103	
	1.00	1.54	147	97	1.46	146	101	1.38	146	104	1.30	146	107	1.16	138	107	
	2.00	1.59	154	102	1.52	154	105	1.45	154	109	1.37	154	113				
24 24 24 4.00	Normal	1.64	162	107	1.57	162	111	1.50	162	114							
	0.25	1.29	113	76	1.20	112	79	1.11	112	83	1.02	112	86	0.91	111	89	
	0.50	1.44	133	88	1.36	133	92	1.28	133	96	1.20	132	99	1.11	132	103	
	1.00	1.54	147	97	1.46	146	101	1.38	146	104	1.30	146	107	1.16	138	107	
	2.00	1.59	154	102	1.52	154	105	1.45	154	109	1.37	154	113				

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	2.00	177	103	1.94	184	112
	1.00																		
	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	112
	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)
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	2.00	156	80	2.00	166	90	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	1.85	167	100	1.73	165	104	1.61	162	109				1.34	158	117
	0.50	2.00	173	98	1.93	176	104	1.82	174	109	1.70	172	113						
	1.00				2.00	183	108	1.91	183	113									
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	160	100	1.64	158	103	1.55	157	107	1.43	153	109	1.39	159	117	1.22	151	117
	0.50	1.80	168	104	1.71	167	108	1.62	165	111	1.52	163	115						
	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	1.41	147	104	1.30	144	106	1.27	149	113	1.13	143	113
	0.50	1.63	157	102	1.55	155	105	1.46	154	108	1.38	153	111						
	1.00	1.69	165	107	1.61	164	110	1.53	163	114									
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	91	1.27	132	95	1.19	131	98	1.09	130	101	1.00	130	105
	0.50	1.48	139	92	1.41	139	96	1.32	138	99	1.24	138	103	1.16	138	106	1.06	137	109
	1.00	1.53	146	97	1.46	146	100	1.38	146	104	1.30	145	107	1.22	145	111	1.13	144	114
	Normal	1.59	154	102	1.52	154	105	1.44	153	108	1.36	153	112						
	0.25	1.64	162	107	1.57	162	110	1.50	161	114									
	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	60	70	80	90	100	110
1	Normal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	0.25	140	150	158	160	164	166	168	170	172	174	176	178
	0.50	140	150	158	160	164	166	168	170	172	174	176	178
	1.00	140	150	158	160	164	166	168	170	172	174	176	178
	2.00	140	150	158	160	164	166	168	170	172	174	176	178
2	Normal	1.93	1.83	1.74	1.64	1.54	1.44	1.34	1.24	1.14	1.04	0.94	0.84
	0.25	140	150	158	160	164	166	168	170	172	174	176	178
	0.50	140	150	158	160	164	166	168	170	172	174	176	178
	1.00	140	150	158	160	164	166	168	170	172	174	176	178
	2.00	140	150	158	160	164	166	168	170	172	174	176	178
4	Normal	1.68	1.59	1.51	1.42	1.33	1.24	1.14	1.04	0.94	0.84	0.74	0.64
	0.25	140	150	158	160	164	166	168	170	172	174	176	178
	0.50	140	150	158	160	164	166	168	170	172	174	176	178
	1.00	140	150	158	160	164	166	168	170	172	174	176	178
	2.00	140	150	158	160	164	166	168	170	172	174	176	178
8	Normal	1.35	1.28	1.21	1.13	1.04	0.94	0.84	0.74	0.64	0.54	0.44	0.34
	0.25	140	150	158	160	164	166	168	170	172	174	176	178
	0.50	140	150	158	160	164	166	168	170	172	174	176	178
	1.00	140	150	158	160	164	166	168	170	172	174	176	178
	2.00	140	150	158	160	164	166	168	170	172	174	176	178
24	Normal	1.24	1.17	1.09	1.01	0.92	0.82	0.72	0.62	0.52	0.42	0.32	0.22
	0.25	140	150	158	160	164	166	168	170	172	174	176	178
	0.50	140	150	158	160	164	166	168	170	172	174	176	178
	1.00	140	150	158	160	164	166	168	170	172	174	176	178
	2.00	140	150	158	160	164	166	168	170	172	174	176	178

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						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	148	57	2.00	158	67	1.89	158	74	1.78	156	81	1.65	155	88	1.49	151	94																		
	0.25																																				
	0.50																																				
	1.00																																				
	4.00																																				
1	Normal	1.87	153	72	1.77	152	77	1.67	151	82	1.57	150	88	1.45	148	93	1.30	143	98																		
	0.25	2.07	178	82	1.99	178	88	1.90	177	93	1.81	176	99	1.71	175	104	1.60	173	109																		
	0.50																																				
	1.00																																				
	4.00																																				
2	Normal	1.64	147	80	1.56	145	84	1.47	144	89	1.37	142	92	1.27	140	96	1.14	136	99																		
	0.25	1.82	171	93	1.74	170	97	1.66	169	101	1.58	168	106	1.49	167	110	1.40	165	114																		
	0.50	1.88	179	97	1.80	179	102	1.72	177	106	1.64	176																									
	1.00	1.93	188	102	1.86	187	106	1.79	186	110																											
	4.00																																				
4	Normal	1.46	137	82	1.39	136	85	1.31	135	89	1.22	134	92	1.13	132	96	1.01	129	98																		
	0.25	1.62	161	96	1.55	160	100	1.48	159	103	1.40	158	107	1.32	157	110	1.23	155	113																		
	0.50	1.67	169	101	1.60	168	104	1.53	167	108	1.46	166																									
	1.00	1.72	177	106	1.65	177	110	1.59	176	113																											
	4.00	1.77	186	111																																	
8	Normal	1.35	126	78	1.28	125	81	1.20	125	85	1.12	124	88	1.03	123	91	0.92	120	94																		
	0.25	1.49	148	91	1.43	148	95	1.35	147	98	1.28	147	102	1.21	146	105	1.12	145	109																		
	0.50	1.53	155	96	1.47	155	99	1.40	154	103	1.33	153	106	1.26	153	110	1.18	152	113																		
	1.00	1.58	163	101	1.52	163	104	1.45	162	108	1.38	162																									
	4.00	1.63	171	106	1.57	171	109	1.50	170	113																											
24	Normal	1.24	111	69	1.17	111	73	1.09	111	76	1.01	110	80	0.92	111	84	0.83	110	88																		
	0.25	1.37	131	81	1.30	131	85	1.24	131	89	1.17	131	93	1.09	130	96	1.00	130	100																		
	0.50	1.41	137	85	1.35	138	89	1.28	137	93	1.21	137	97	1.14	137	100	1.06	136	104																		
	1.00	1.46	145	90	1.40	145	94	1.33	145	97	1.26	144	101	1.19	144	104	1.12	144	108																		
	4.00	1.50	152	94	1.45	152	98	1.38	152	102	1.31	152	106	1.24	152	109	1.17	152	113																		

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(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	1.91	188	104	
	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	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	1.80	182	106	1.69	180	111	
	1.00																						
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	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	1.42	163	110	1.42	163	110	
	0.50	1.83	177	98	1.76	177	103	1.67	175	107	1.59	174	111	1.42	163	110	1.42	163	110	1.42	163	110	
	1.00	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	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	1.28	153	108	1.28	153	108	
	0.50	1.64	167	100	1.58	166	104	1.50	165	107	1.43	163	110	1.34	162	113	1.34	162	113	1.34	162	113	
	1.00	1.70	176	105	1.63	175	109	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	1.09	140	106	
	0.25	1.48	147	91	1.42	147	95	1.34	146	98	1.27	145	101	1.18	143	104	1.18	143	104	1.18	143	104	
	0.50	1.52	154	95	1.46	154	99	1.39	153	102	1.32	152	106	1.24	151	109	1.24	151	109	1.24	151	109	
	1.00	1.57	162	100	1.51	162	104	1.44	161	107	1.37	160	111	1.30	159	114	1.30	159	114	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	1.00	130	100	
	0.25	1.37	131	81	1.31	131	85	1.24	131	88	1.16	130	92	1.08	130	96	1.08	130	96	1.08	130	96	
	0.50	1.41	137	85	1.35	137	89	1.28	137	92	1.21	137	96	1.13	136	100	1.13	136	100	1.13	136	100	
	1.00	1.46	144	89	1.40	145	93	1.33	145	97	1.26	144	101	1.18	136	104	1.18	136	104	1.18	136	104	
	Normal	1.51	152	94	1.44	152	98	1.38	152	102	1.31	151	105	1.24	152	109	1.24	152	109	1.24	152	109	
	0.25	1.55	160	99	1.49	160	103	1.43	159	106	1.36	159	110	1.29	159	114	1.29	159	114	1.29	159	114	
	0.50																						
	1.00																						
	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	1.00	130	100	
	0.25	1.37	131	81	1.31	131	85	1.24	131	88	1.16	130	92	1.08	130	96	1.08	130	96	1.08	130	96	
	0.50	1.41	137	85	1.35	137	89	1.28	137	92	1.21	137	96	1.13	136	100	1.13	136	100	1.13	136	100	
	1.00	1.46	144	89	1.40	145	93	1.33	145	97	1.26	144	101	1.18	136	104	1.18	136	104	1.18	136	104	
	Normal	1.51	152	94	1.44	152	98	1.38	152	102	1.31	151	105	1.24	152	109	1.24	152	109	1.24	152	109	
	0.25	1.55	160	99	1.49	160	103	1.43	159	106	1.36	159	110	1.29	159	114	1.29	159	114	1.29	159	114	
	0.50																						
	1.00																						
	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	1.00	130	100	
	0.25	1.37	131	81	1.31	131	85	1.24	131	88	1.16	130	92	1.08	130	96	1.08	130	96	1.08	130	96	
	0.50	1.41	137	85	1.35	137	89	1.28	137	92	1.21	137	96	1.13	136	100	1.13	136	100	1.13	136	100	
	1.00	1.46	144	89	1.40	145	93	1.33	145	97	1.26	144	101	1.18	136	104	1.18	136	104	1.18	136	104	
	Normal	1.51	152	94	1.44	152	98	1.38	152	102	1.31	151	105	1.24	152	109	1.24	152	109	1.24	152	109	
	0.25	1.55	160	99	1.49	160	103	1.43	159	106	1.36	159	110	1.29	159	114	1.29	159	114	1.29	159	114	
	0.50																						
	1.00																						
	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	1.00	130	100	
	0.25	1.37	131	81	1.31	131	85	1.24	131	88	1.16	130	92	1.08	130	96	1.08	130	96	1.08	130	96	
	0.50	1.41	137	85	1.35	137	89	1.28	137	92	1.21	137	96	1.13	136	100	1.13	136	100	1.13	136	100	
	1.00	1.46	144	89	1.40	145	93	1.33	145	97	1.26	144	101	1.18	136	104	1.18	136	104	1.18	136	104	
	Normal	1.51	152	94	1.44	152	98	1.38	152	102	1.31	151	105	1.24	152	109	1.24	152	109	1.24	152	109	
	0.25	1.55	160	99	1.49	160	103	1.43	159	106	1.36	159	110	1.29	159	114	1.29	159	114	1.29	159	114	
	0.50																						
	1.00																						
	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	1.00	130	100	
	0.25	1.37	131	81	1.31	131	85	1.24	131	88	1.16	130	92	1.08	130	96	1.08	130	96	1.08	130	96	
	0.50	1.41	137	85	1.35	137	89	1.28	137	92	1.21	137	96	1.13	136	100	1.13	136	100	1.13	136	100	
	1.00	1.46	144	89	1.40	145	93	1.33	145	97	1.26	144	101	1.18	136	104	1.18	136	104	1.18	136	104	
	Normal	1.51	152	94	1.44	152	98	1.38	152	102	1.31	151	105	1.24	152	109	1.24	152	109	1.24	152	109	
	0.25	1.55	160	99	1.49	160	103	1.43	159	106	1.36	159	110	1.29	159	114	1.29	159	114	1.29	159	114	
	0.50																						
	1.00																						

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			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	1.93	156	70	1.80	154	77	1.64	149	83	1.06	114	81	1.67	172	103	1.02	131	100
	0.25	2.19	183	78	2.08	182	85	1.98	181	92	1.84	178	98	1.81	184	107	1.59	175	111
	0.50										1.95	188	101						
	2.00																		
2	Normal	1.73	149	77	1.63	147	82	1.47	141	86	1.03	112	80	1.50	164	107	1.02	131	100
	0.25	1.96	176	88	1.87	175	93	1.76	173	98	1.65	170	103	1.61	175	111	1.41	165	113
	0.50	2.03	184	91	1.93	183	96	1.84	182	102	1.82	189	111						
	2.00																		
4	Normal	1.55	142	81	1.46	140	85	1.32	134	87	1.03	112	81	1.34	156	108	1.01	130	100
	0.25	1.75	168	95	1.66	166	99	1.57	164	102	1.48	162	106	1.44	167	114	1.28	159	114
	0.50	1.81	177	99	1.73	176	103	1.65	174	107	1.55	171	111						
	2.00	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	1.23	148	106	1.00	130	100
	0.25	1.58	158	95	1.51	157	99	1.43	155	102	1.34	153	104	1.31	158	112	1.17	150	111
	0.50	1.63	166	100	1.56	165	104	1.49	163	107	1.41	161	110						
	2.00	1.74	184	111	1.68	183	114	1.55	172	112									
24	Normal	1.33	124	76	1.25	122	79	1.16	119	82	1.01	110	80	1.16	139	102	0.99	130	100
	0.25	1.48	147	91	1.41	145	94	1.34	145	97	1.25	142	99	1.22	148	107	1.11	143	108
	0.50	1.52	154	95	1.46	153	99	1.38	152	102	1.31	151	105	1.29	158	113	1.20	155	115
	2.00	1.67	179	111	1.61	178	114	1.49	169	112	1.42	168	115						
	Normal	1.23	110	68	1.16	110	72	1.08	110	76	1.00	110	80	1.08	128	95	1.00	130	100
	0.25	1.37	131	81	1.30	131	85	1.23	130	88	1.16	130	92	1.13	136	100	1.05	135	103
	0.50	1.41	137	85	1.35	137	89	1.28	137	93	1.20	136	96	1.18	143	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	151	109	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.