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RELIABILITY TESTING: A COST ANALYSIS

by Fred Fredricks, reliability manager, Television Products
John Reichen, value engineer, Component Engineering

INTRODUCTION

When is 100% electrical testing economically justified? What level of reliability screening is cost effective? At what point does the cost savings from reduced plant or field failures balance out the additional cost of testing and/or reliability screening (preconditioning)?

The subject of how the reliability of our products relates to customer satisfaction (and hence sales) is full of intangibles that are difficult, if not impossible, to accurately quantify. However, it is possible to develop some guidelines for economical component testing decisions by weighing the cost of plant or field repairs against the cost of testing and/or reliability screening.

This article describes a cost analysis worksheet that is relatively simple and efficient to use when deciding whether it is economical to perform 100% DC electrical testing at 25°C, or reliability screening at the following two levels:

Level 1 – Burn-in and/or high temperature reverse bias (HTRB)
Temperature cycling
Hermetic seal (when applicable)
DC parameter electrical test

Level 2 – Stabilization bake
Temperature cycling
DC parameter electrical test

This technique is based on the various cost factors associated with plant and field failures and testing efficiency. Because accurate cost data on failures is difficult to obtain, we've made certain assumptions and estimations. These are described in the following text along with worksheet instructions.

A more detailed description of the development and mathematical derivation of this reliability cost analysis technique is contained in the Appendix.

continued on page 2

ALSO IN THIS ISSUE

DEFINITION

This cost analysis technique provides the preliminary information necessary for determining whether 100% testing or one of two reliability screening levels is economically justified. The analysis involves the use of a worksheet (see page 5) and a minimum of calculations to yield a recommendation based on properly weighted cost factors.

This method is based on an estimate of plant and/or field failure rates of the component in question. The weighted factors reflect **average** cost elements and yields, rather than specific component cost and usage figures.

The recommendation to test or not to test at a particular level does not constitute a final decision. Other factors, such as reliability demands, customer satisfaction, ease of testing, etc., also enter into the picture. But the results obtained provide a more definitive point of reference than we've had in the past.

ASSUMPTIONS

We developed a reliability cost analysis technique around the assumption that the cost savings from reduced plant and/or field failure rates will provide the economic justification for the additional cost of testing and/or preconditioning.

Certain estimates were made for repair and testing costs and for failure rate reductions. These were based on quotes and estimates from vendors, test houses and Tek experience.

Repair costs were estimated to be:

Field failure repair cost, C_{FF}	\$ 150.00
Plant failure repair cost, C_{PF}	\$ 15.00
Repair cost ratio, $K = C_{PF}/C_{FF}$	0.10

Typical testing costs, C_T, are listed below for various component types at the three test levels. These values include extra handling costs associated with testing.

Component type	Testing cost (C_T): 100% DC electrical testing	Testing cost (C_T): Reliability screening level 2	Testing cost (C_T): Reliability screening level 1
Diodes	\$ 0.015	\$ 0.035	\$ 0.095
Transistors	0.020	0.040	0.120
Logic IC's	0.030	0.050	0.140
Linear IC's	0.030	0.050	0.140
Complex IC's (LSI, etc.)	0.055	0.075	0.195

We estimated the reduction in field failures as a result of testing and/or preconditioning to be:

	Failure rate reduction		
	100% DC electrical testing	Reliability screening	
		level 2	level 1
Field (r_F)	N/A	35%	85%
Plant (r_P)	70%	N/A	N/A

These conservative estimates of costs and failure rate reductions can be used to assure a net benefit. Once the maximum price for improving quality and reliability has been paid, additional spending will be matched by additional savings. The bias, if any, should be in favor of customer satisfaction.

For a more detailed discussion of the use and derivation of the various cost factors used in this model, refer to the Appendix.

APPLICATION

In order to perform a cost analysis for a particular component, approximate plant and field failure rates of the unscreened component must be known or estimated.

Note: *Reliability Engineering (Clair Gruver, ext. 5279) can provide you with component plant and field failure rate data if rates from your product line are not readily available. However, considerable discretion must be used in applying these rates, especially if:*

- *the field failure rate is shown as zero*
- *the plant failure rate is for parts already receiving 100% DC electrical testing.*

Contact Clair Gruver or Fred Fredricks to determine applicability and risks involved. For example, you may consider a plan such as the one developed by TV Products which provides more accurate failure rate data by eliminating location-peculiar failures. The resulting failure rates more truly indicate vendor and/or lot-related problems.

using the worksheet

Refer to the example shown in the worksheet on page 5 for the following discussion.

1. **Description** – Fill in the Tek part number, part description, your name and date.

2. **Calculation** – Enter the plant and field failure rates, as shown. Multiply these failure rates by the factors:

   Krp (repair cost ratio x plant failure rate reduction = 0.07)

   r_{F2} (field failure rate reduction resulting from level 2 screening = 0.35)

   r_{F1} (field failure rate reduction resulting from level 1 screening = 0.85)

3. **Comparison** – Compare the values from step 2 to the respective component balance value (e.g. diode, transistor, logic IC, etc.):

   If the sum is greater than (>) the component balance value, testing is **economically justified**.

   If the sum for that level is less than (<) the component balance value, that particular level of testing is **not proven justified**. That is, we cannot be sure the cost of failures and repair justifies the testing cost.

   Note: *If the component under consideration is already being subjected to 100% DC electrical testing, its recorded plant failure rate is not "raw" and therefore that portion of the worksheet which modifies the plant failure rate is not applicable.*

4. **Recommendation** – The recommendation to test or not test at a particular level does not constitute a final decision but should be weighted with other factors such as customer satisfaction. In this example, level 2 reliability screening is the only action that is economically justified for this linear IC.

Copies of the blank worksheet can be obtained from Fred Fredricks, ext. 6890 or John Reichen, ext. 6512.

Figure 1

Reliability Testing Value Analysis Form

Tek part number 156-XXXX-XX

1. Part Description: Linear IC

Analysis performed by: John Reichen Date: Dec. 9, 1977

RELIABILITY TESTING VALUE ANALYSIS	Test Level		
		Reliability screening	
	100% testing at 25°C, D.C. electrical parameters	Level 2 Stabilization Bake Temperature Cycling Electrical test (100%) (D.C. parameters)	Level 1 Burn-in and/or HTRB Temperature Cycling Hermetic Seal* Electrical test (100%) (D.C. parameters)
2. Calculation Failure rate, λ_U in % (untested component) Plant, λ_{PU} .200 Field, λ_{FU} .080	Krp x 0.07 = .014	r_{F2} X 0.35 = .028	r_{F1} x 0.85 = .068
3. Comparison	if the above value is greater than: Component Balance Value (100 C_T/C_{FF})		
Diode	0.010 ☐	0.023 ☐	0.063 ☐
Transistor	0.013 ☐	0.027 ☐	0.080 ☐
Logic IC	0.020 ☐	0.033 ☐	0.093 ☐
Linear IC	0.020 ✓	0.033 ✓	0.093 ✓
Complex IC (LSI, etc.)	0.037 ☐	0.050 ☐	0.130 ☐
4. Recommendation (based only on economical aspects)	100% D.C. parameter testing is justified ☐	Level 2 action is justified ☐	Level 1 action is justified ☐
	If none of the above are justified individually, perform the following summations:		
	λ_{PU}Krp (from above)	= .014	= .014
	$\lambda_{FU} r_{Fn}$ (from above)	= .028	= .068
	sum =	= .042	= .082
	If the above sum is greater than the corresponding value in section 3, above,		
		Level 2 action is justified ✓	Level 1 action is justified ☐

*when applicable

CONCLUSION

This technique can be used to determine a specific **failure rate,** below which the cost of screening is greater than the potential savings from reduced failures, and above which the reverse is true. Using the model in this manner, the number of analyses for specific components can be reduced.

The present method is not restricted to the components or levels shown. Any component that is subject to pretesting, aging and the like can be analyzed by this method where the respective cost elements and failure rates can be estimated.

The levels used in this analysis were selected to agree with the grouping shown in Figure 2 ("Early detection saves electronic product lives," by E. R. Hnateck, **Quality,** March 76, p. 18-20). These levels are the same as those used on about 80 part numbers in TV Products.

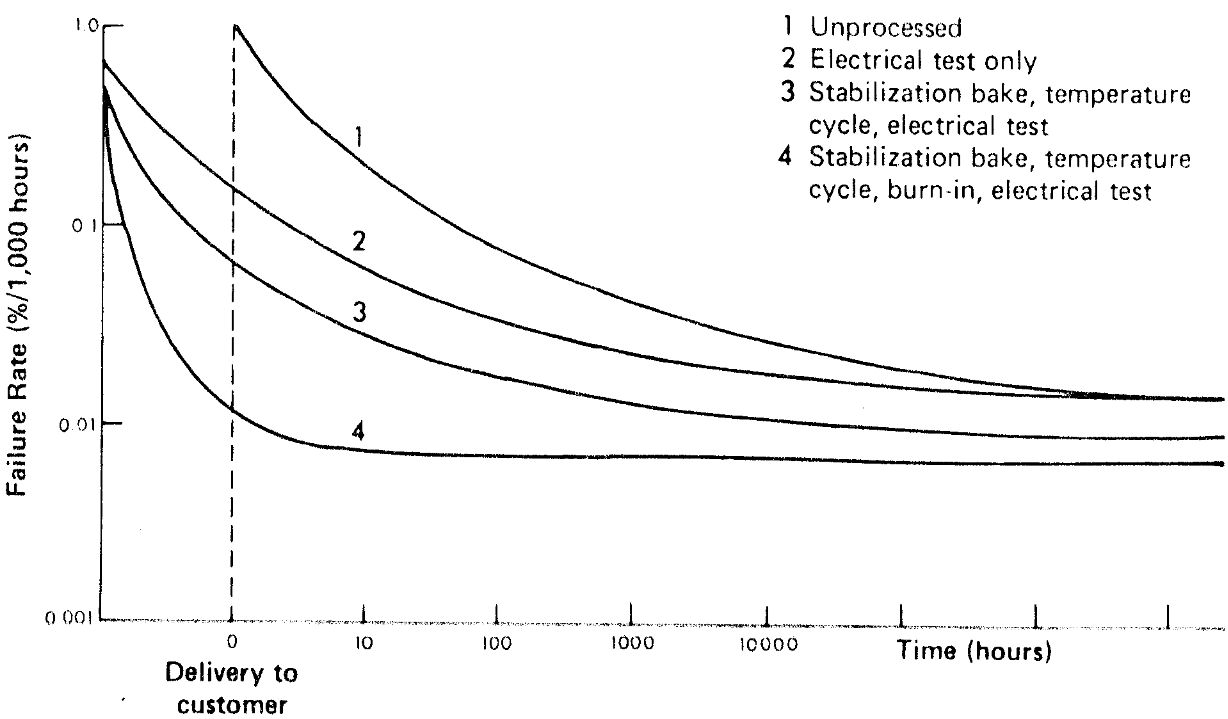


Figure 2 – Selection of screening tests influence component failure rates

We welcome your comments or suggestions regarding this method. If you have questions or need more details, feel free to contact us.

Fred Fredricks, ext. 6890
John Reichen, ext. 6512

APPENDIX

The derivation of the reliability cost analysis technique is included to enable any adjustments you may wish to make for specific component applications.

parameter definitions

C_T – component test cost (including extra handling costs)

C_{Tn} – component test cost for test levels 1 and 2

C_F – cost per failure

C_{FF} – cost per field failure

C_{PF} – cost per plant failure

K – ratio of C_{PF}/C_{FF}

λ_U – failure rate of untested component

λ_T – failure rate of tested/preconditioned component

λ_{FU} – field failure rate for untested component

λ_{PU} – plant failure rate for untested component

λ_{FT} – field failure rate for tested component

λ_{PT} – plant failure rate for tested component

λ_{FTn}, λ_{PTn} – as above, for test levels 1 and 2

$\Delta\lambda_F$ – field failure rate reduction resulting from testing

$\Delta\lambda_P$ – plant failure rate reduction resulting from testing

r_F, r_P – decimal form of the expected percentage reduction of λ_F and λ_P, resulting from testing

basic relationships

$$\lambda_{FT} = \lambda_{FU}(1 - r_F) \qquad (1)$$

$$\begin{aligned}\Delta\lambda_F &= \lambda_{FU} - \lambda_{FT} \\ &= \lambda_{FU} - \lambda_{FU}(1 - r_F) \qquad (2) \\ &= r_F\lambda_{FU}\end{aligned}$$

similarly $\Delta\lambda_P = r_P\lambda_{PU}$ (3)

We must determine the **cut-off failure** rate (λ_U') for an untested component for which the savings in failure costs just equals the added cost of testing. This balance equation is expressed as:

cost/failure x failure rate reduction = test cost

i.e. $C_F(\lambda_U' - \lambda_T) = C_T$ (4)

or $C_F\Delta\lambda' = C_T$

but $\Delta\lambda = r\,\lambda_U'$

therefore, $C_F\, r\, \lambda_U' = C_T$

so, $\lambda_U' = \dfrac{C_T}{r\, C_F}$ (5)

Equation 5 states that the cutoff raw failure rate value (λ_U') varies directly with the test cost (C_T), and inversely with the cost of failure (C_F) and the testing effectiveness (r) in reducing the failure rate.

However the generalized formula (Equation 5) is difficult to apply because of differences between the cost of plant and field failures and between plant and field failure rates for a given component.

Taking these differences into account:

$$C_{FF}(\lambda_{FU}' - \lambda_{FT}) + C_{PF}(\lambda_{PU}' - \lambda_{PT}) = C_T \qquad (6)$$

$$C_{FF}\Delta\lambda_F' + C_{PF}\Delta\lambda_P' = C_T$$

$$C_{FF}\, r_F\, \lambda_{FU}' + C_{PF}\, r_P\, \lambda_{PU}' = C_T$$

To simplify calculations, substitute KC_{FF} for C_{PF}. (By definition, $K = C_{PF}/C_{FF}$):

then $$C_{FF}\, r_F\, \lambda_{FU}' + KC_{FF}\, r_P\, \lambda_{PU}' = C_T$$

and $$r_F\, \lambda_{FU}' + Kr_P\, \lambda_{PU}' = C_T/C_{FF} \qquad (7)$$

Since failure rates are usually given in percentages (% per warranty year), then:

$$r_F\, \lambda_{FU}'(\text{in } \%) + Kr_P\, \lambda_{PU}'(\text{in } \%) = \frac{100\, C_T}{C_{FF}} \qquad (8)$$

To determine whether testing or preconditioning is economically justified, the following comparison is made:

if $r_F\, \lambda_{FU} + Kr_P\, \lambda_{PU} > \frac{100\, C_T}{C_{FF}}$, testing/screening is economically justified

$< \frac{100\, C_T}{C_{FF}}$, testing/screening is **not** economically justified

calculation of values

The **component balance values** are obtained by using the test and failure cost data (see previous section) and the right hand side of equation 8:

$$\frac{100\, C_T}{C_{FF}}$$

For example, a transistor, tested at level 2 (described on page 1 or on the worksheet) would yield the following balance value:

$$\frac{100\, C_T}{C_{FF}} = (.04/150) \times 100 = 0.027$$

These balance values are given on the worksheet in the comparison section (see page 5).

The **failure rate multiplying factors** are obtained from the failure rate reduction factors:

Type of failure	How obtained
Field	by using the field failure reduction factor, r_F (see page 3).
Plant	by multiplying the plant failure reduction factor, r_P, by K (see page 2).

Weighting the plant failure rate allows a combination of plant and field failure rates for their comparison to the predetermined break-even (cut off) failure rate. For example:

Level 2 $\quad r_P \times K = 0.70 \times 0.10 = 0.07$

$r_F = 0.35$

Multiplying these factors by their respective failure rates, λ_{PU} and λ_{FU}, allows them to be added directly, for comparison to $100\ C_T/C_{FF}$.

Refining burn-in techniques to remove early failures

by Roy Leventhal

During the past year Component Reliability Engineering has conducted a series of accelerated, "end of life" tests on transistors. This test information is useful for:

1. Reliability ratings, both relative and absolute, for the vendors supplying a particular part.
2. Guidelines to designers on what stress levels can be tolerated by the particular parts.
3. Refining burn-in techniques so that early failures can be removed effectively, inexpensively, and with minimal impact on normal devices.
4. Indicating limits beyond which the expected life of normal parts will be unacceptably short.

This article is specifically addressed to items 2 and 3 above and is intended to enable the user to decide what stress levels to use or whether part screening will be required for acceptable reliability.

general models

To date, 61 vendor part type samples have been tested. From the data accumulated, two general models can be proposed that fit about 65% of the data. One model applies to metal can parts and the other applies to small-signal plastic parts. Life test results were:

Metal can parts (225°C junction temperature)

1. Main population – median life of 3000 hours.
2. Freak population (weak or marginal parts) – median life of 5 hours. The freak population proportion is usually between 5 and 25%. Some freak populations up to 50% have been noted, particularly in high stress applications (high voltage).

The standard deviation of both populations was 1.5.

Plastic parts (150°C junction temperature)

1. Main population – median life of 5000 hours.
2. Freak population – life of 50 hours. The freak percentage is usually 5 to 25%.

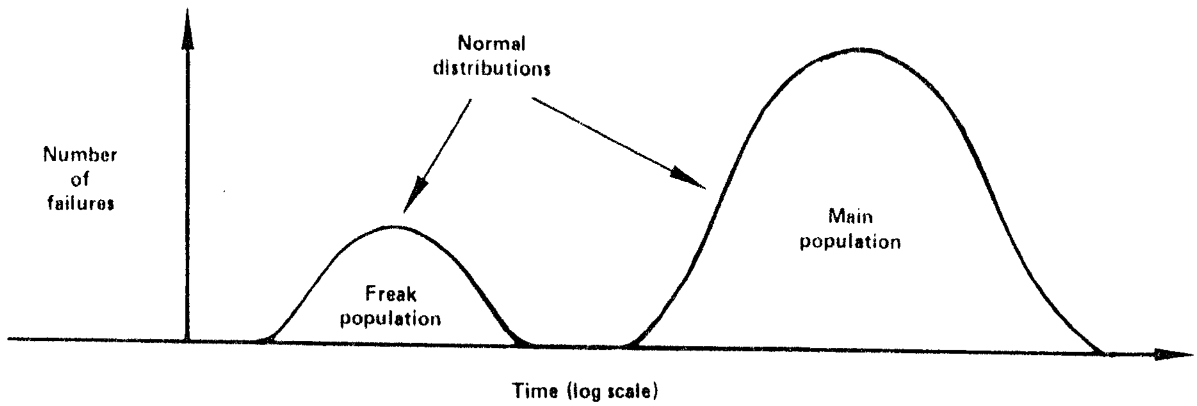
The remaining 35% of the data is still close enough to the general models that the techniques developed can still be applied to aid in decision making.

graphing results

A population of parts is defined as any large sample of parts whose distribution of a given parameter or variable is normal about some product mean. For example, the distribution of beta measured on a sample of parts shows a normal distribution.

Further, many samples may show bimodal populations; that is, two populations whose mean values are widely separated. This is particularly true of the distribution of values for part "strength" as measured by time-to-failure at a given stress condition. This can be represented visually as:

Figure 1



Normal distributions are difficult to work with compared to straight lines. However we can use lognormal probability paper which will represent a normal distribution as a straight line. Examples of such grids are shown in Figures 2 and 3.

Figure 2

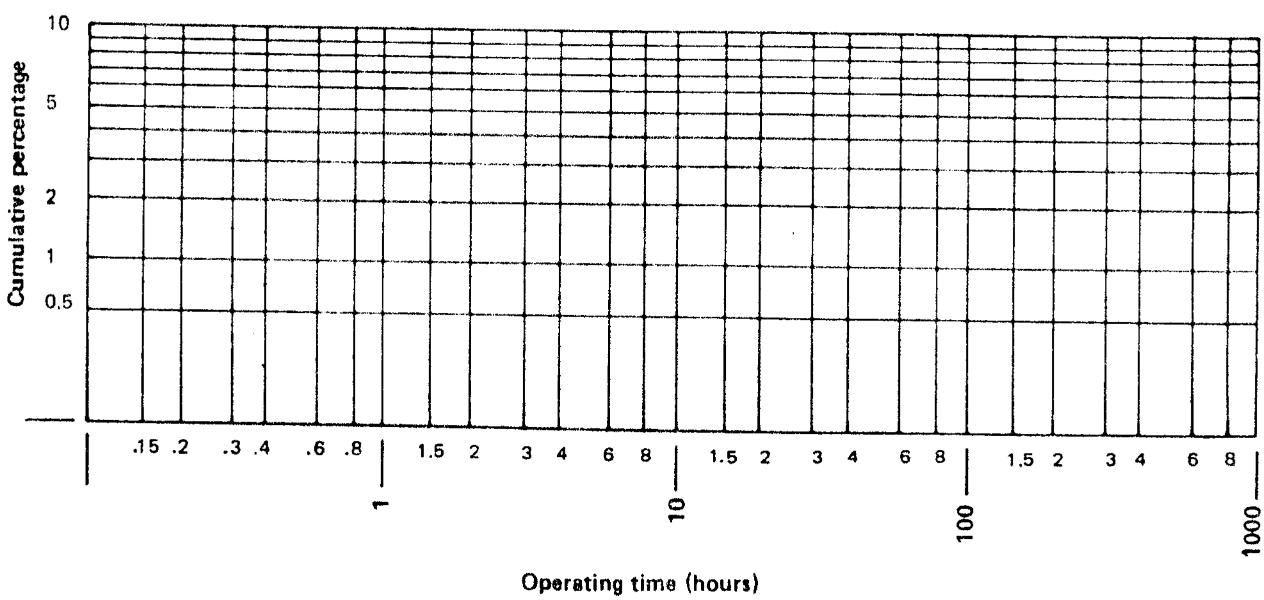
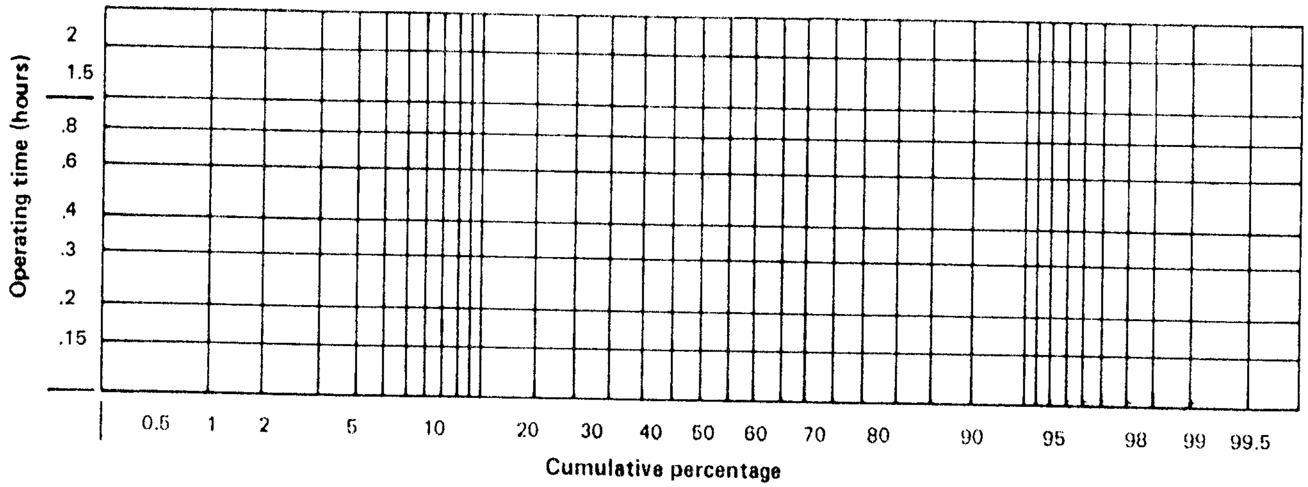


Figure 3



acceleration due to temperature

Failure rates increase exponentially with junction temperature. This physical fact can be used to obtain data on the long-term reliability of a part as long as the failure mechanisms experienced in actual usage are reflected in the life test failures, and new failure mechanisms are not introduced by the elevated temperature in an "end of life" test.

The Arrhenius equation has been demonstrated to fit life test data accurately:

$$R = R_O \exp \frac{E_A}{KT_K}$$

Where R = reaction rate

R_O = a constant

E_A = activation energy in eV

K = Boltzmann's constant (8.6×10^{-5} eV/K)

T_K = absolute temperature in Kelvin

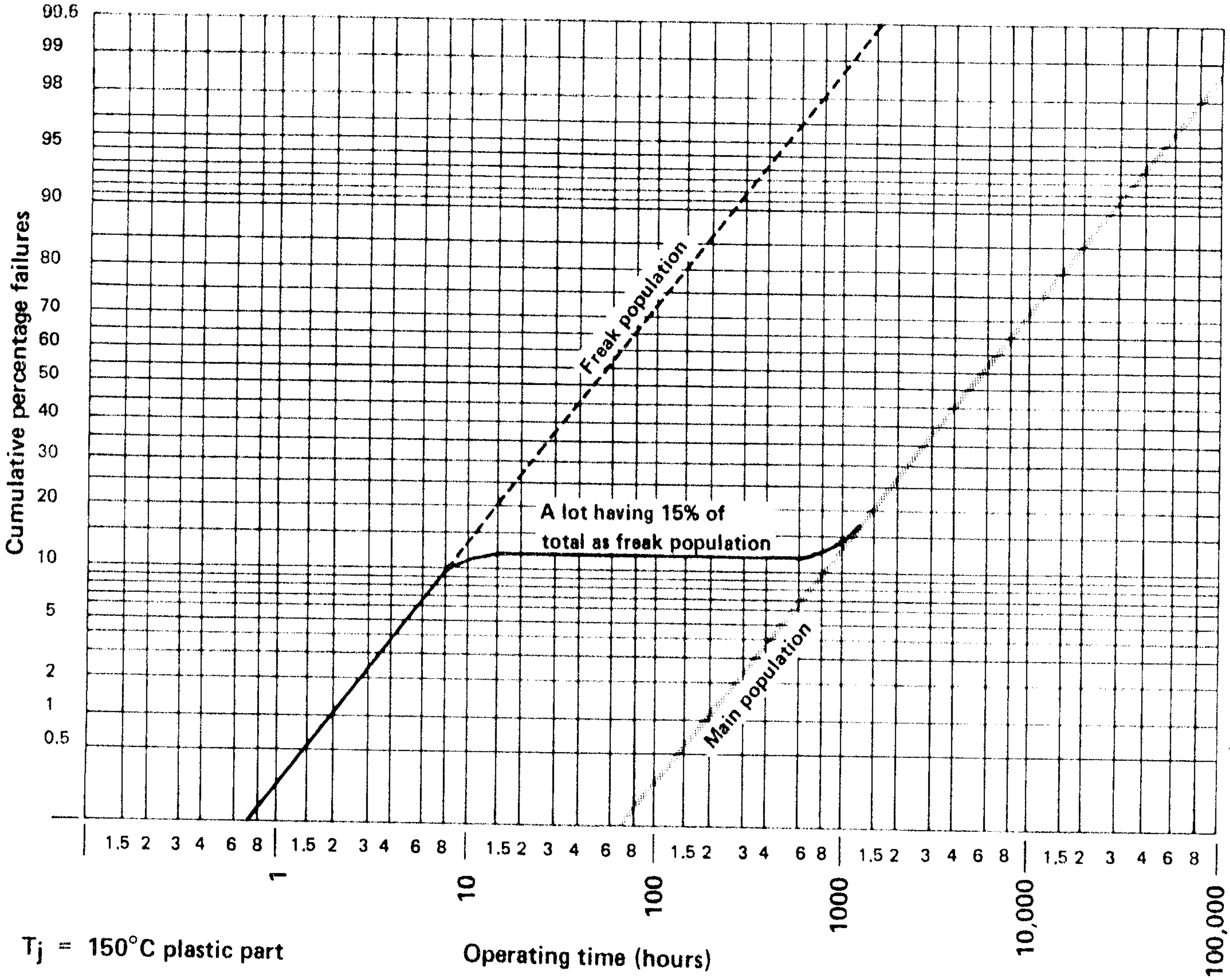
Thus, the acceleration factor (AF) for the failure rate is:

$$AF = \exp \frac{E_A}{K} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$$

where T_1 is the test temperature (or reference temperature) and T_2 is the desired temperature in degrees Kelvin.

A typical plot of data is shown in Figure 4. Failures (dependent variable) are plotted vertically versus time (independent variable), plotted horizontally.

Figure 4



T_j = 150°C plastic part

how to use the graphs

The graphs in Figures 5 and 6 can be used to determine the following for a device operating at a given junction temperature:

1. whether the freak population of parts will fail within warranty
2. the effects of instrument burn-in for removing freaks
3. the effectiveness of part burn-in
4. the expected results from derating junction temperature

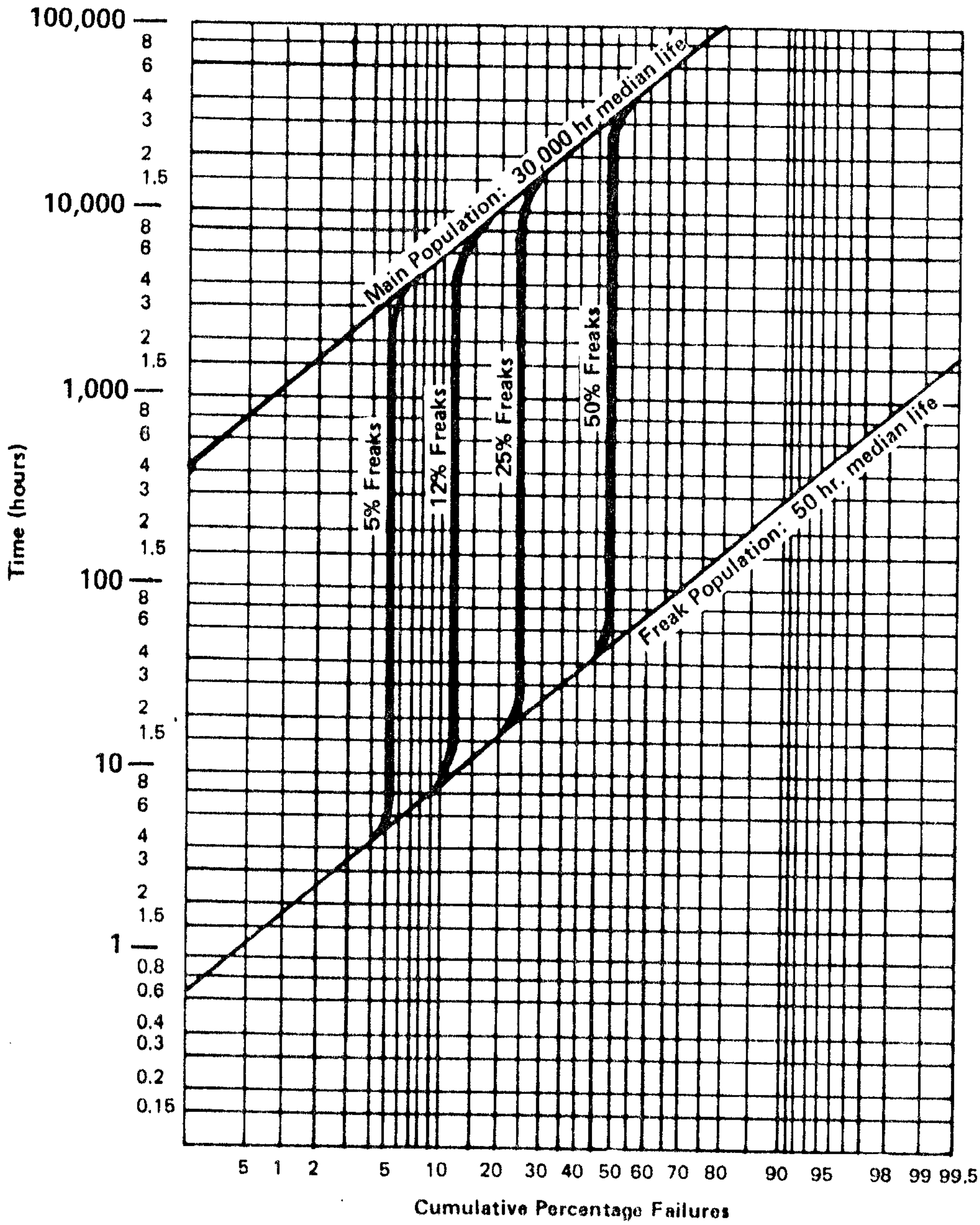
To illustrate how to use the graphs, examples are given below for each of the four possibilities. These examples will use a metal can transistor (Figure 5) and assume a freak population of 12%.

Figure 5

Metal can transistors

Experimental results at 225°C Tj, translated to 180°C (acceleration factor ≅ 10). Median life at 225°C: 3,000 hours on main, 5 hours on freaks.

x 10 T_j ≈ 142°C
x 100 T_j = 110°C
x 1000 T_j = 83.5°C
x 10,000 T_j = 60.2°C



Other factors to 180° data:

200°C ∿ 0.34	100°C ∿ 250
175°C ∿ 1.3	80°C ∿ 143
125°C ∿ 35	

Example 1 — A metal-can transistor has an average junction temperature of 100°C (instrumer ambient is 35°C). We want to know what percent failures will occur during the warranty peri (assumed to be 2000 hours).

- For 100°C T_j, multiply the 180°C time scale by 250 (the acceleration factor betwee 100°C to 180°C).
- Locate 2000 hours on your modified time scale for 100°C T_j.
- Follow the line marked 12% freaks. Note that the cumulative percentage failures at 20 hours is approximately 12%. This means that all the freak population would have fai during the warranty period.

Example 2 — Suppose we introduce an instrument burn-in of 72 hours at 50°C ambien raises the metal can transistors junction temperature to 125°C. What percent failures wil during warranty.

- For 125°C T_j, multiply the 180°C time scale by 35 (acceleration factor between 12 and 180°C).
- Locate 2000 hours on the modified time scale and follow the 12% freak line, as in th procedure in Example 1.
- With cumulative percentage failures at 1% and a freak population of 12%, we conclude th 11% of the freaks will fail during warranty (with only 1% failing during instrument bu in).

Example 3 — As an alternative, consider burning in this metal can transistor in a power burn-in rack at 180°C for 72 hours. What percent failures can we expect from burn-in?

- Use the 180°C T_j time scale.
- Locate 72 hours on this scale and follow the 12% freak line.
- Since the cumulative percent failure at 72 hours is 12%, we can expect to encounter the failure of all 12% freak population during the 72-hour part burn-in. Thus we would not expect to see failures of the main population exceed 0.1% at 100°C T_j until about 1 operational hours.

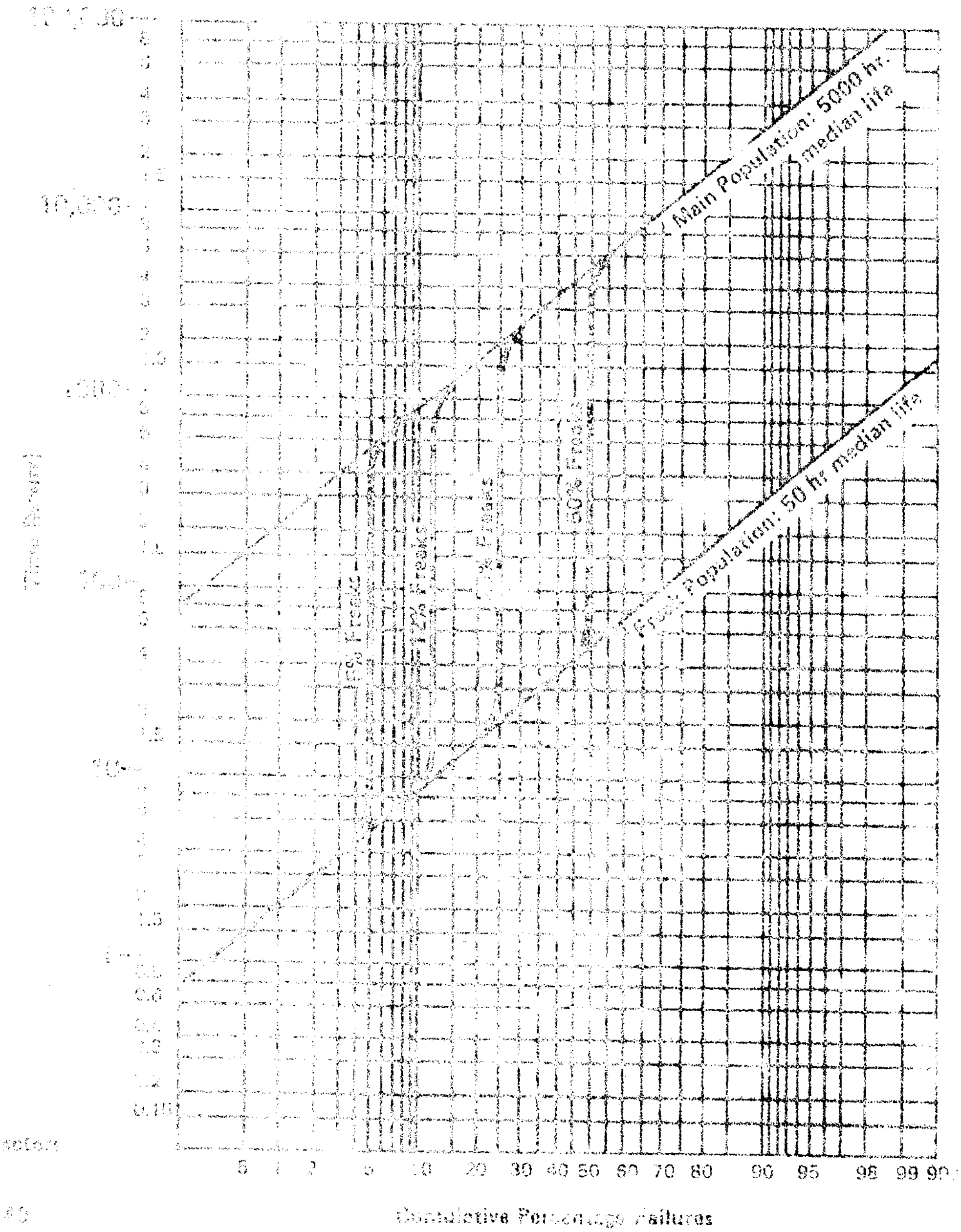
Example 4 — To evaluate the effects of derating on this metal can transistor, assume the junction temperature has been reduced to 60°C and there is no instrument or part burn-in. What failure r can be expected?

- Use the 60°C T_j scale (multiply the 180°C scale by 10K).
- Failures are not likely to exceed 0.1% until 10K hours of operation.

With expected cumulative percent failures in a given time frame, and knowledge of the cost field failures and the cost of part burn in, you will be able to make some intelligent choices of which parts to choose for reliability screening. Freak percentages for some commonly used Tek transisto are listed in Appendix ...

Figure 8

Plastic transistor
Experimental results at 150°C T_j



x 10 T_j = [illegible]°C
x 100 T_j = [illegible]°C
x 1000 T_j = [illegible]°C

Other acceleration factors
to 150°C data

at 100°C ~40
at 80°C ~230
at 60°C ~1600

an approach using reliability sample tests

As an alternative to either 100% burn-in or no burn-in, lot sample reliability tests may be considered (see Appendix B for example).

Since a relatively small sample (50 to 100 parts) was used in our life test, a reliability sample test could be applied on each lot at Incoming Inspection to assure continued levels of reliability and would provide some assurance against the acceptance of a low-reliability lot of parts.

These requirements are being added to most high usage bipolar transistor specs.

effects of voltage stress on transistor reliability

Our life tests have demonstrated that the effects of voltage stress on transistor reliability are at least as significant as the effects of temperature stress (at least for high voltage parts).

While my work on a general model of this phenomenon is not yet complete, I can provide recommendations on when to use 100% burn-in to remove freaks.

My recommendations based on results to date are:

○ — Prestressing recommended for freak removal

□ — Beyond recommended stress levels for any parts

	Tj, junction temperature	% of rated voltage in Application	Rated voltage 40+	120+	500+
Metal can only	200°C	25%	○	○	□
		50%	□	□	□
		75%	□	□	□
	175°C	25%	○	○	○
		50%	○	○	□
		75%	○	□	□
	150°C	25%		○	○
		50%	○	○	○
		75%	○	○	□
Plastic or metal can	125°C	25%			○
		50%		○	○
		75%	○	○	○
	100°C	25%			○
		50%		○	○
		75%	○	○	○
	80°C	25%			
		50%			○
		75%	○	○	○
	60°C	25%			
		50%			
		75%			○

Appendix A

Part Number	Vendor	Qualified?	Freak %
151-0103-00	Motorola	yes	8
	Fairchild	yes	20
	T.I.		12
151-0126-00	Motorola		4
	National		4
	Fairchild		0
	Teledyne	yes	4
	Raytheon	yes	4
151-0127-00	Motorola		2
	Fairchild	yes	2
151-0150-00	Motorola	yes	(10)
	Fairchild	yes	(10)
	RCA	yes	40
151-0188-00	Motorola	yes	(20)
	T.I.	yes	(10)
	National	yes	(7)
151-0190-00	Motorola	yes	< 2
	Sprague		8
	T.I.	yes	(25)
151-0190-06	Motorola		4*
(151-0460-00)	T.I.	yes	0
151-0199-00	Motorola	yes	15
151-0216-00	Motorola	yes	0
	T.I.	yes	0
151-0220-00	Fairchild	yes	(12)
151-0225-00	Teledyne	yes	100
	National	yes	12
151-0228-00	Fairchild	yes	25
151-0250-00	Fairchild	yes	12
151-0259-00	Fairchild	yes	4
151-0279-00/01	Fairchild	yes	(25)
	Motorola	yes	(25)
	National	yes	(12)
	T.I.	yes	(25)
151-0289-00	Motorola	yes	25
151-0333-00	Motorola	yes	0
151-0347-00	Motorola	yes	6
	Fairchild	yes	12
	National	yes	50
151-0358-00	G.E.	yes	5
151-0423-00	Fairchild	yes	0
	T.I.	yes (E)	45
151-0427-00	National	yes	11
151-0443-00	Motorola	yes	(15)
151-0451-00	RCA	yes	19
	SSS		15
151-0462-00	T.I.	yes	40
	RCA	yes	20
	Motorola		0
	Fairchild		5
	National		0
151-0478-00	T.I.	yes	15
	RCA	yes	0
	Motorola		0

(x) indicates freak % somewhat dependent on stress level.

E emergency source

* metal can version of -0190

Note: Some vendor/part combinations have shown in excess of 50% freaks. (For a part with 50% "freaks" the question of what constitutes the freak population arises. This article has simply been using the term freak to be synonymous with early failures.) Contact Component Reliability Engineering (ext. 6511) for details on the part you are interested in.

Cross Reference List

Life test and freak percentage results can be considered applicable to other parts as follows:

Type tested	Similar type (Same basic chip)
151-0103-00	151-0302-00 151-0309-00
151-0126-00	151-0104-00 151-0232-00 151-0308-00
151-0150-00	151-0169-00 151-0297-00
151-0188-00	151-0220-00
151-0190-00	151-0224-00 151-0192-00
151-0199-00	151-0221-00 151-0325-00
151-0228-00	151-0443-00
151-0347-00	151-0250-00 151-0444-01, 02 151-0624-00
151-0462-00	151-0482-00
151-0478-00	151-0464-00 151-0476-00

Appendix B

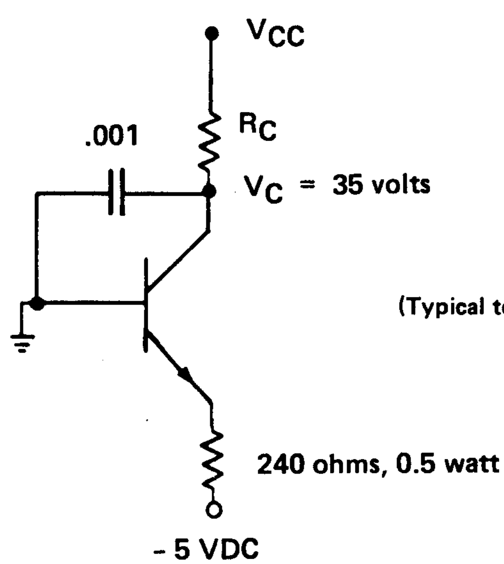
reliability requirements

Parts purchased to this specification shall be capable of passing reliability tests specified herein.

high temperature life test

1. Draw a sample of 50 units from the lot and test at 25°C for all specified DC parameters.
2. Put samples on life test at 25°C ± 3°C for 96 ± 4 hours in circuit below.
3. After completion of life test, remove emitter bias voltage, wait 15 minutes, then remove collector supply voltage.
4. Retest sample units at 25°C as in Step 1 within 24 hours of completion of life test.
5. Lots with 5 or fewer failures shall be considered acceptable.

These tests shall be used when qualifying new vendors, requalifying existing vendors, or as a reliability acceptance test to determine lot acceptability.



(Typical test condition for 151-0190-00)

Semiconductor Memory Reliability
4K and 16K RAMS

Component Reliability Engineering has completed life tests on the 4096 type 4K x 1 dynamic memory (156-0862-00).

Tests were performed at 125°C with nominal voltages applied. A logic one and zero pattern was continuously written to and read from the parts while on life test. Electrical tests were performed at various intervals at room temperature using an S-3455 (Bldg. 70).

Results were:

Vendor	Cumulative failure percentage				
	16 hrs.	36 hrs.	52 hrs.	100 hrs.	150 hrs.
Mostek	3	0	6	0	0
Motorola	3	0	0	0	0

This 150 hours of life testing is equivalent to about 20 years of average instrument operation (assuming part ambient in instrument of 60°C and 2000 hours operation per year). The data indicates that a high temperature burn-in is necessary to remove early failures.

Projected field failure rates are:

No burn-in	0.3	%/1000 hrs.
With burn-in	< 0.1	%/1000 hrs.

The part user in this case has opted for a 96-hour, 125°C burn-in which costs about 25-30¢ extra per part.

other memory reliability experience

The first large scale user of burn-in for semiconductor memories was the 4051 line in IDS Manufacturing.

The 4051 uses a 4K x 1 dynamic RAM (156-0635-01). This part was not very reliable in the field before 100% dynamic burn-in at 125°C for 96 hours was instituted. Comparison data showed:

No. of memory failures — year ending June 1977:	175
No. of memory failures since June 1977: (burn-in part usage commenced June 1977)	1

Available data on other memory part types such as the 4027 (4K) and 4116 (16K) shows 4 to 6% infant mortality just as was found on our 40% life test. Users of the 4027 and 4116 type memories have now requested 100% burned-in parts for their instruments.

Component Reliability Engineering plans additional memory life tests on new part types as they become available. We do expect to find the infant mortality present in all memory part types. Therefore, for best instrument field reliability, we strongly recommend 100% burn-in of memory devices.

Contact Ron Schwartz or Steve Hui of Component Reliability Engineering, ext. 6511 for details on how to get screened parts for your application.