systems that they contain elements whose failure leads merely to deterioration of certain parameters of the system (precision, the quality of a transient response, etc.). The failure of other elements impairs the efficiency of the system, i.e., in the reliability sense the elements are not equivalent. In computing the reliability, only those elements must be taken into account whose nonfunctioning leads to failure.

Thus, before computing reliability, we must define rigorously what is meant by the failure of the system.

In using the coefficient method for computing the reliability of complex automated systems, it is useful to adopt the following order of computation.

1) Formulate the concept of failure for the given system.

2) Construct a plan for computing the reliability (a set of elements representable in graph form, and indicate how these are connected in the reliability sense). In the computational plan, show the time interval for the work of every element of the computation. It is expedient to divide the elements into groups, according to their working times, and to form these groups into the elements of the computation.

3) Select the principal element of the system, i.e., an element whose likelihood of failure is known with certainty. Most often such elements are resistors, capacitors, inductors, etc.

Let us assume that, for the computation, a resistor was taken as the principal element. Then it may turn out that the automated system consists of resistors of various types (MLT, ULM, VS, etc.), whereas resistors of the same type are distinguished by nominal values of the principal parameter. In this case it is expedient to find a weighted mean value of the likelihood of failure of all resistors of the system and to take this value as the principal value ($\lambda_0$).

Clearly the $\lambda$ of the resistors in the blocks will be different from $\lambda_0$, and the mean weighted reliability coefficients of the resistors in the various blocks will be different from unity.

4) Construct a computational table (Table 2).

In Table 2, $n_i$ is the number of elements of type $i$ in the block which lead to failure as defined in point 1; $k_{i,\max}$ and $k_{i,\min}$ are the maximum and minimum values of the reliability coefficients of the elements, taken from Table 1.

5) From the data of Table 2, construct for each block the relations $P = f(\lambda_0 t)$ for the maximum and minimum values of the reliability coefficients of the elements.

6) Construct a table of relative values of the mean time of failure-free performance of the blocks. The ratios are computed from formulas (4) and the data of Table 2.

**Table 3**

| Name of block | block 1 | block 2 | block 3 | ... | block $n$ |
|---|---|---|---|---|---|
| $\frac{T_{av,i}}{T_{av,1}}$ | 1 | 0.8 | 0.6 | ... | 0.95 |

Table 3 provides a graphic comparison of the reliability of the blocks and enables us to pinpoint the least reliable blocks of the system.

7) From the data of point 5, construct for $k_{i,\max}$ and $k_{i,\min}$ curves for the probability of failure-free performance of the automatic system as a function of $\lambda_0 t$.

8) From the known time $t$ of continuous work of the system and the likelihood of failure of the principal element $\lambda_0$, compute the probability of failure-free performance of the automated system.

9) From the known probability of failure-free performance compute, using formulas (1), the average failure-free performance time and the likelihood of failure of the system.

If the curve $P = f(\lambda_0 t)$ has discontinuity points, then the parameters are computed using formulas (1):

$$T_{av} = \int_0^\infty P(t)dt$$

$$a(t) = -P'(t) \qquad \lambda(t) = a(t)P(t)$$

The data which were obtained as a result of the computation are compared with those required, and a conclusion is then reached about the work of the system in the sense of its reliability.

*—Submitted May 25, 1960*

## References

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[2] Polovko, A. M. and Tsukreev, P. A., "Accelerated testing of the reliability of electrical elements of engineering systems," Izv. Akad. Nauk SSSR, Otdel. Tech. Nauk, Energ. i Avtomat. (Bull. Acad. Sci. USSR, Div. Tech. Sci., Power and Automation), no. 2 (1959).

## Reviewer's Comment

A method of calculating the reliability of a system is presented which is not startling and does not portray any powerful mathematical tool. The author describes the standard reliability formulas which have appeared countless times in the literature and which are the common foundations for all reliability work. However, he does show an interesting technique that has been overlooked by most reliability engineers, who are striving constantly for hairline accuracy in their calculations. This scheme is presented very clearly and is well summarized. It would make a valuable addition to any tutorial symposium or reliability training session.

Instead of using absolute values of failure rates for parts, which is the usual American practice, a table of relative minimum and maximum constants is used. This constant value technique has been developed because of the unavailability of mean failure rate data. These constants are directly related to some principal part whose likelihood of failure is known, i.e., a resistor with a $k$ of unity.

Since the constants are both minimum and maximum, the conclusion gives a relative spread or estimated reliability band.

When this technique is used for a single system, it does not have much value because its true failure rate $\lambda$ is difficult to reclaim. When used as a method of comparing different systems or designs, it is handy and worth while. Most American companies have developed curves and tables that present the failure rates of parts as some function of stress. However, in many cases, these failure rates are not true estimates of the mean and are not accurate. When only limited data are available, it might be better to show the system reliability as a spread or band as the author proposes.

—M. Raphelson
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