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FAILURE RATE FOR REPAIRED AND NOT REPAIRED OBJECTS

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ABSTRACT: *Article discusses the differences in the perception of the failure rates parameter for repaired and not repaired objects. As indicated below, these differences are significant. A proper understanding the scope of failure rate parameter is a good contribution for machines maintenance. How many random values is needed and what must be credible interval for determining the failure rates is few discussing the problem in literature. This problem goes beyond article. Another view of the statistical reliability of the parameters gives consideration severity of the faults.*
KEYWORDS: *failure rate, not repaired objects, density function*

INTRODUCTION

Failure rate or hazard function expresses the ratio of the possibility that a random event (failure) occurs in the time interval $[t, t+\Delta t]$ against the possibility that it occurs in time t [1]. Hazard (risk of failure) increases when increasing the probability that the next time there is an accidental phenomenon, as it has yet to occur. Hazard function has no probabilistic nature; it can take values greater than the number 1. It expresses for the operation time, what is the risk that the next time a failure occurs.

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{F(t+\Delta t) - F(t)}{\Delta t R(t)} = \frac{f(t)}{R(t)} \tag{1}$$

$\lambda(t)$ - failure rate function
$F(t)$ - distribution function
$f(t)$ - probability density function
$R(t)$ - reliability function

It should strictly distinguish between cases hazard function for the repaired and not repaired objects. No repaired objects have a specific, but at the same time a time-invariant density distribution of failures. It became one of the same objects and hence the same failures. It can be deduced various shapes of hazard function according to equation (1).

To calculate the hazard function of the measured values is used the following relationship (2) [2]:

$$\lambda(t) = \frac{n(t+\Delta t) - n(t)}{n - n(t)} \tag{2}$$

$n(t)$ - number of damaged products that had been distorted for the period t
$n(t+\Delta t)$ - number of damaged products that had been distorted for the period $t+\Delta t$
n - number of all the monitored products in the same way loaded

FAILURE RATE FOR NOT REPAIRED OBJECTS

Computational scheme using histogram distribution and the correct choice of the size class interval is as follows (Figure 1).

Relationship to calculate the failure rate for n identical and equally loaded objects:

$$\lambda_i = \frac{f(\Delta t_i)}{R(\Delta t_i)} \tag{3}$$

Δt_i - i-th class interval

λ_i - failure rate in i-th class interval

FAILURE RATE FOR REPAIRED OBJECTS

The hazard function shape of repaired objects is the most often mentioned as a bathtub curve. It draws on the notion that at the beginning of the operation as well as at the end of life is an increased incidence of failures. The fundamental difference to the not repaired object is the fact that there is a no set of damaged and undamaged object for given time of operation. Faults can be replicated at one object and can be varied. Limitation a finite number of observed objects is not possible. Nature of the likelihood of failure at the beginning of the operation as well as at the end of life is variable. Computational scheme may well be similar to the not repaired objects, but are based on different assumptions (Figure 2).

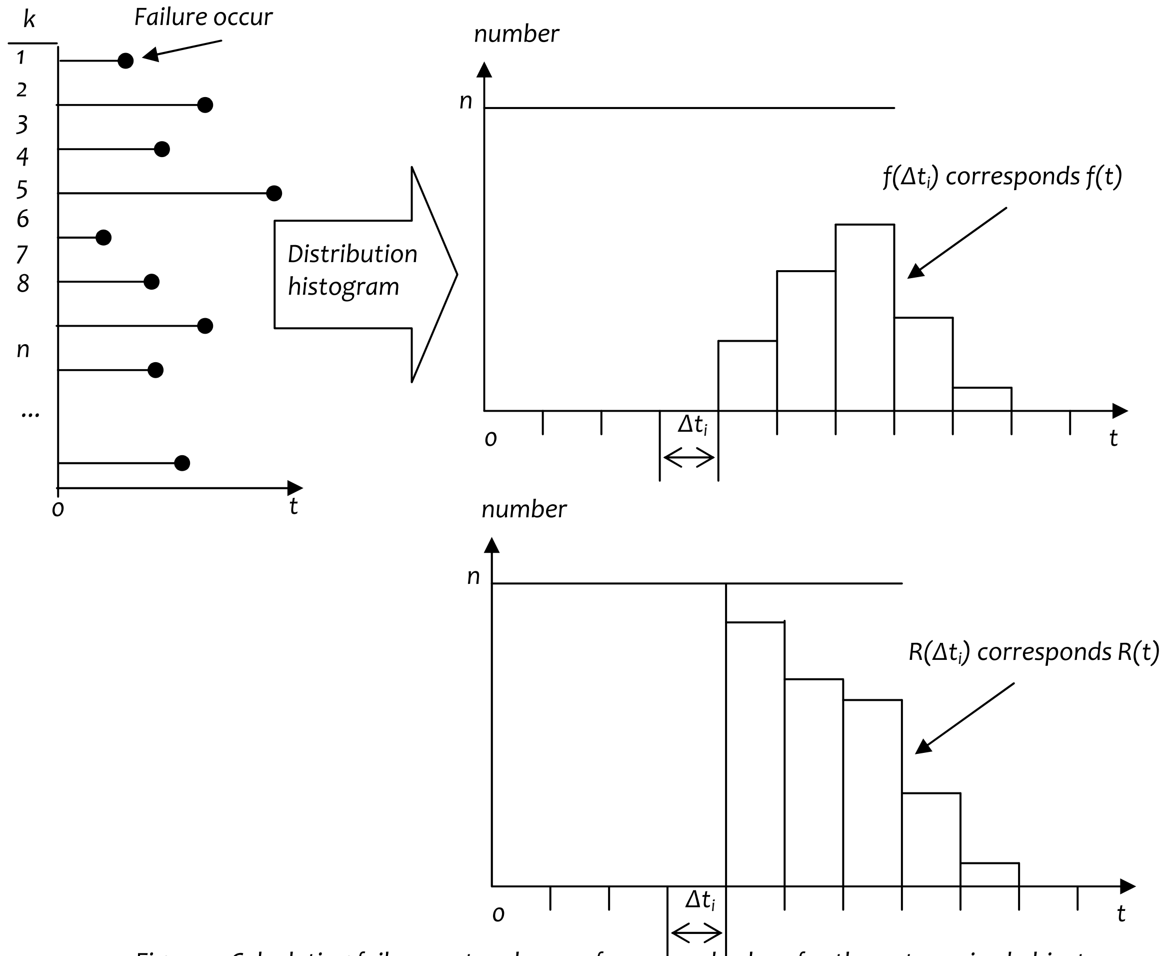

Figure 1: Calculating failures rate scheme of measured values for the not repaired objects.

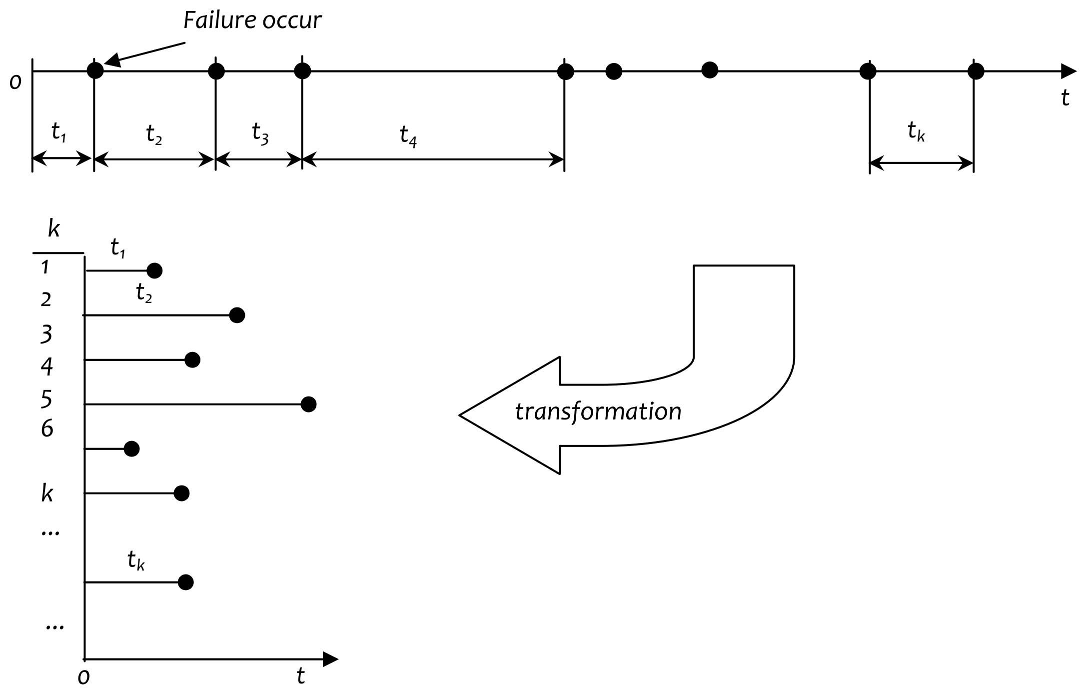

Figure 2: Time record transformation repaired faults into the not repaired type of faults

The calculation is the same as in the previous case, with the only difference that the last recorded value k will be same as the value corresponding to the value n in not repaired objects. Using this scheme, you can get failure rate running depending on the time interval Δt, which in general may not be constant. Then it arguable that in the bathtub curve due time give to the maximum, minimum, or average. Exception is the exponential distribution of failures. In this case, the failure rate is constant throughout the whole period of time Δt.

The failure density distribution repaired objects usually close to exponential distribution. The significance of the exponential distribution of failure supports the Drenick's theorem which states that parts of a serial system with arbitrary distribution of failure, that are independent of each other and the occurrence of failures, the system is immediately repaired (affect the length of downtime is neglected), then in the long run, the total distribution system failure approaching to exponential distribution [4].

Relationship of mean time between failures:

$$MTBF = \int_0^{\infty} R(t)dt \tag{4}$$

For exponential distribution is valid:

$$MTBF = \int_0^{\infty} R(t)dt = \int_0^{\infty} e^{-\lambda t}dt = \frac{1}{\lambda} \tag{5}$$

So the upside just monitored change mean time between failures for a time period t and based on that reconstruct hazard function respective failure rate.

On this basis, if chosen arbitrarily large time interval from the beginning zero, so the number of failures versus time is unchanged and reflects the failure rate [6].

$$\lambda(t) = \frac{n(t)}{t} \tag{6}$$

$n(t)$ - number of failures to time t

t - time monitoring failures since the beginning of the object operation.

With increasing the number of observed objects in the result of not repaired objects over the failure rate will inevitably converge to a particular course. These are the same objects, the same mistakes and same load.

In contrast, increasing the time monitoring of repaired objects outcome failure rate will not be converge, but will somewhat vary depending on the number of input data from the previous course of failures [3]. This fact greatly reduces a practical use of the failure rate parameter for repaired objects.

Taking two simple examples of failures, one can show that the failure rate is significantly influenced by the values of previous failures and thus distorts the real state.

Example: Let the two different courses of faults (Fig. 3), then the corresponding failure rate in Table 1. The failure rate is calculated according to equation (6).

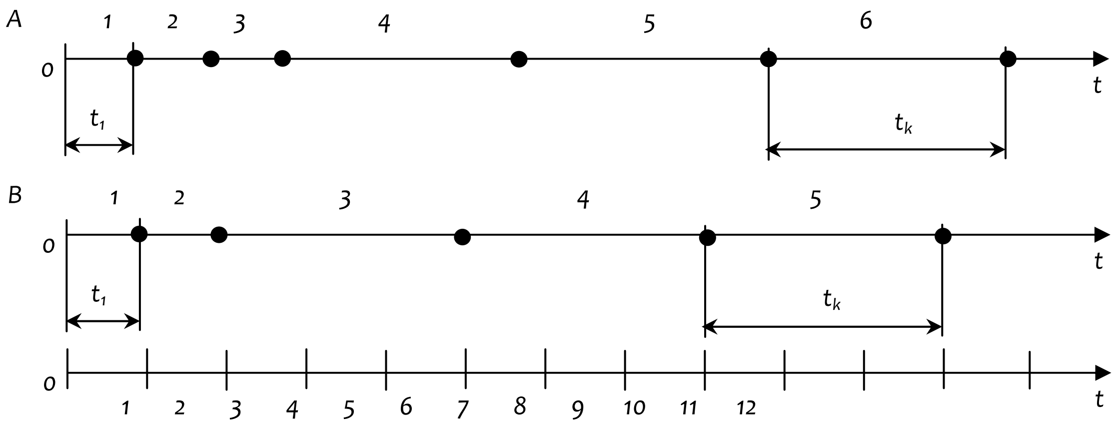

Figure 3: Two different cases of the failure rate development for repaired objects

In case B of i=5 is failure rate equal 5/11 = 0.45. Around the same time, if A is the failure rate equal 6/12 = 0.5. Therefore, A has higher failure rate than B, simply because at the beginning of the process were more failures. There is a dependence on the previous state. Fault of repaired objects do not have (or are rarely) depending on the nature of the previous state. Thus in both cases should expect the same risk of failure or identical values for the failure rate.

This disadvantage is also reflected in the evaluation of the increased failure rate in the end life phase of the object. If the previous period of low intensity failures that has been long the onset of increased intensity of failures occurs belatedly to the computation time. Practically this means that no disturbance will occur densely in some time, but will still compute small failure rate. Speed of failure rate change depends on the length of time the last period when the intensity was still low.

Table 1: Failure rate for two cases of repaired objects

i	A[λi]	B[λi]
1	1/1	1/1
2	2/2	2/2
3	3/3	3/5
4	4/6	4/8
5	5/9	5/11
6	6/12	-

In terms of maintenance and reliability assessment is appropriate parameter to monitor the probability density function. It also for repaired objects does not distort. Practically it is feasible so that the selected appropriately long time interval, *which will at the same time the class interval. The average incidence of failures in a given time interval is the mean time between failures and the reciprocal value of it better corresponds to what is now known as the failure rate. Failure rate for repaired objects have not entirely constant character of the object life. From a mathematical point of view the value of steady failure rate can be reached only with stationary random process speech and the choice of sufficiently long time units [8], [5].*

CONCLUSIONS

How many random values is needed and what must be credible interval for determining the failure rates is few discussing the problem in literature. This problem goes beyond article. Another view of the statistical reliability of the parameters gives consideration severity of the faults. Number reporting failure rate, availability, reliability and even other associated parameters may give a completely distorted picture of the real problems if the same does not reflect the severity of failures in some way. It is meeting with high-intensity of few serious failures and on the other hand, low intensity, but very serious failures [7]. The principal value of the failure rates for not repaired objects in terms of failure risk in the following operating point. The importance of parameter for repaired objects is lost. For practical use should be made any other parameter, would by better characterize the original meaning. *Contribution was created under grant projects KEGA 047TUKE-4/2011 and VEGA 1/0810/11.*

REFERENCES

[1.] BEN-DAYA, Mohamed et al.: Handbook of Maintenance Managementand Engineering , Springer-Verlag London Limited 2009, 737 s., ISBN 978-1-84882-471-3.

[2.] DANĚK A., ŠIROKÝ J.: Teórie obnovy dopravných prostredku, VŠB Technická univerzita Ostrava (1999), 156 s., ISBN 80-7078-568-3.

[3.] DOBRÁNSKY, J., KREHEĽ, R.: Determinácia prevádzkovej spoľahlivosti strojného zariadenia pomocou tribotechnickej diagnostiky In: Opotřebení, spolehlivost, diagnostika 2009. - Brno : Tribun EU, 2009 P. 39-44. - ISBN 9788073998479.

[4.] KECECIOGLU, D. B.: Reliability Engineering Handbook, Volume 2.,Lancaster, USA: DEStech Publications, 541s. ISBN 1-932078-01-0.

[5.] KRENICKÝ, T., JACKO, P.: Real-time monitoring prevádzky technických systémov. In: Strojárstvo Extra. Č. 5 (2011), s. 32/1-32/2. - ISSN 1335-2938

[6.] PAČAIOVÁ, H.: Riadenie údržby, Košice: SjF TU Košice, 2006, 127 s. ISBN 978-80-8073-751-1.

[7.] SZILÁGYI, A.: Lineáris vezetékrendszerek geometriai hibáinak vizsgálata lézeres méréstechnika segítségével. microCAD'95 International Computer Science Conference, Miskolc – Egyetemváros, 1995. Feb. 23, pp: 91 – 94.

[8.] SZILÁGYI, A. – PATKÓ, Gy. – TAKÁCS, Gy.: Improvement of a Superfinishing Device Based on Dynamical Analysis. In: 8th REM 2007 June 14 – 15, Tallin – Estonia. ISBN: 978-9985-59-707-1, pp.:128 – 130.

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