

SYSTEMICALLY CONNECTIONS IN THEORETICAL AND PRACTICAL RELIABILITY

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Abstract: This paper presents the main reliability connection principles between elements or systems with a view to develop new methods to calculate the optimum values of reliability parameters. There are many techniques to obtain a specified level of reliability and the authors propose some models to estimate the optimal values of these parameters.

Keywords: reliability models, connections, optimization.

1. INTRODUCTION

The reliability of an item F can be estimated from relationship between the load S which influences the item and the strength C . The load can be a constant or a random variable, but C decreases in time, being influenced by the maintenance M . In chapter 2 we will describe the relationship between C - S and F - M . The system reliability can be estimated from the reliability of its elements and its structure (the structural reliability model) MSF . In chapter 3 we will describe relationship between F - MSM .

2. CONNECTIONS BETWEEN SYSTEM COMPONENTS

From some practical wear phenomenon, the principal ways to increase the items reliability F are:

- a. outsize items that result from the design stage and can lead to select the great factors of safety and that lead to additional costs;
- b. decreasing coefficient of variation of strength using the decrease nominal tolerance limits guaranteed by manufactures;
- c. decreasing coefficient of variation of load (special a overload) using protection equipment (discharge, protective system to over-currents);
- d. decreasing speed of strength degradation that can be achieved using the following ways:
 - d₁. choosing the materials with a slow aging;
 - d₂. conditions for a slow weakness;
 - d₃. reduction of loads for that the speed of strength degradation depends by load.
- e. maintenance can be split in the following categories:
 - e₁. preventive maintenance (sometimes referred to as scheduled maintenance) suppose to keep the failure probability (because of performance degradation) to slow values by providing systematic operations to bring back the item's performance to initial values. Preventive maintenance may be further split into two sub-categories:
 - e'₁. reliability centered maintenance suppose to keep out the item's probability by a restrictive region;
 - e''₁. total productive maintenance suppose to maximize the productivity achieved by respective item, with the risk to put off the maintenance schedule.

Depending on the schedule of maintenance, the preventive maintenance may be:

e_{11} -systematic preventive maintenance (or periodic maintenance) – the criterion to beginning of maintenance operation is established by duration or number of function cycles from last maintenance. Early criterions and/or cost of outages may establish the periodicity.

e_{12} -conditional preventive maintenance (or opportune) - the criterion to beginning of maintenance operation is established by degradation in time of item.

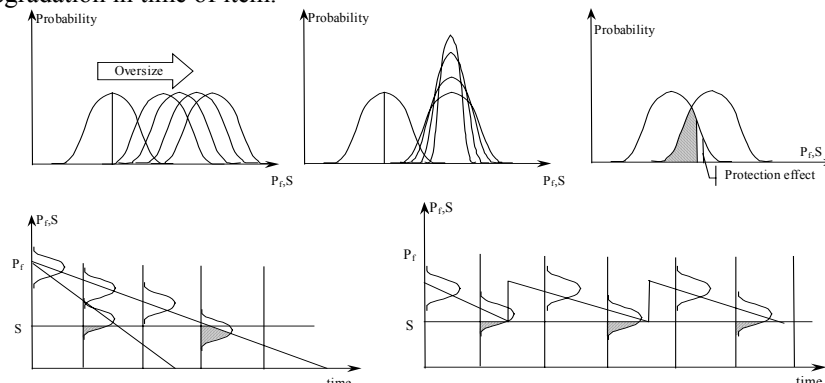


Fig. 1.- Warmer diagram using the normal distributions.

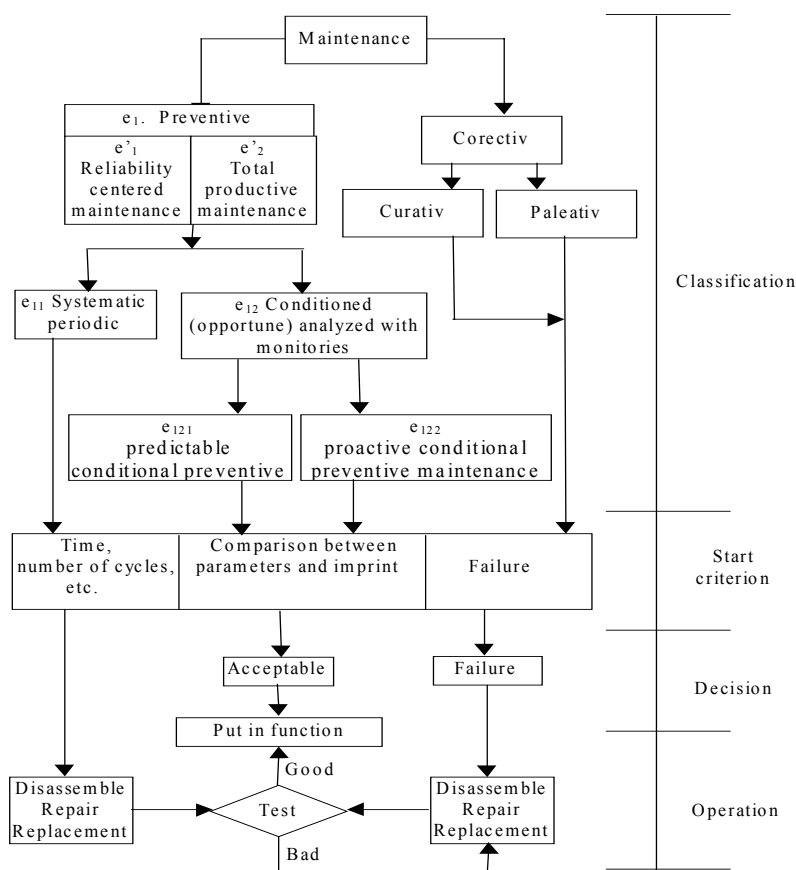


Fig. 2.- Block diagram showing the maintenance concept.

e_{121} -predictable conditional preventive maintenance depends by supervises evolution analyses of main parameters of degradation performance, that allow to delay and to be planned the maintenance operations.

e_{122} -proactive conditional preventive maintenance that operate to the root causes of the potential failure. This kind of maintenance supposes a very well knowledge of aging mechanism and request empirical knowledge.

The criterions to beginning of preventive maintenance operation are established by the vectors of state parameter, known as imprint, that will be compare with vectors of parameters limit, mentioned to e'_1 and e''_2 .

e_2 .-corrective (unscheduled) maintenance represents the operations to restore a failed item to functionally conditions. This kind of maintenance supposes to point out, to localize, to fix the failure and to restore the item to plenum or partial satisfactory conditions.

e_{21} .-corrective palliative maintenance suppose to restore a failed item to functional conditions providing immediately corrections, possible temporarily solutions;

e_{22} .-corrective curative maintenance suppose to restore a failed item to nominal functional conditions providing corrections with permanent character.

The philosophy of maintenance operations has many steps, starting from ad-hoc form to optimization techniques. Figure 2 show this concept, conformable to SMRP (Society for Maintenance & Reliability Professionals).

3. CONNECTIONS BETWEEN SYSTEMS

System modelling supposes the following criterions and categories:

Criterions:

Rs_1 – number of state;

Rs_2 – external structure;

Rs_3 – internal structure;

Rs_4 - dependency;

Rs_5 - redundant;

Rs_6 - mission time.

Fundamental, for the systems is their internal and external structure. Categories of systems using the external structure Ss_2 are:

Ss_{21} – simple bipolar (bi-terminal);

Ss_{22} - bipolar, multiple (one in); Ex. Power delivery systems.

Ss_{23} - bipolar, multiple (one out); Ex. Generating systems.

Ss_{24} – multi-polar; Ex. Power transmission systems.

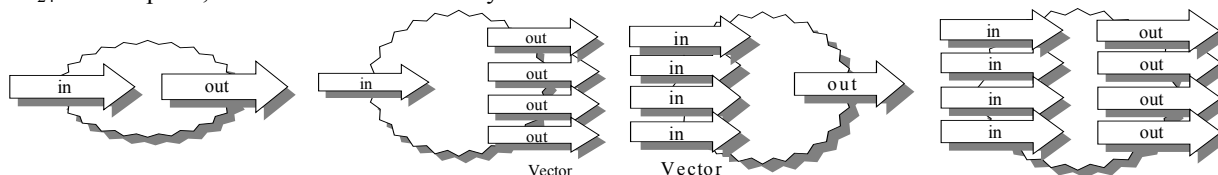


Fig. 3.- Systems categories.

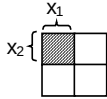
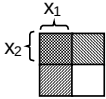
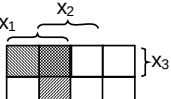
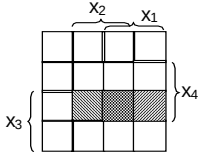
The reliability system depends on the component or subsystem reliability and the internal structure, influenced by:

-item position in system;

-reliability of components;

-reliability of analyzed component.

	Indicator	System			
		Series	Parallel	Series-parallel	Series-parallel
1	Reliability block diagram				
2	Structure function	$y = x_1 \cdot x_2$	$y = x_1 + x_2 - x_1 \cdot x_2$	$y = x_1 \cdot x_2 + x_1 \cdot x_3 - x_1 \cdot x_2 \cdot x_3$	$y = x_1 \cdot x_2 \cdot x_3 \cdot x_4 + x_1 \cdot x_2 \cdot x_3 \cdot x_4 + x_1 \cdot x_2 \cdot x_3 \cdot x_4$
3	Simple structure function	$y = x_1 \cdot x_2$	$y = x_1 + x_2$	$y = x_1(x_2 + x_3)$	$y = (x_1 + x_2)x_3 \cdot x_4$

4	Karnaugh Table				
5	Component weight	$g(x_1) = \frac{1-0}{2^{2-1}} = 0.5$ $g(x_2) = \frac{1-0}{2^{2-1}} = 0.5$	$g(x_1) = \frac{2-1}{2^{2-1}} = 0.5$ $g(x_2) = \frac{2-1}{2^{2-1}} = 0.5$	$g(x_1) = \frac{3-0}{2^{3-1}} = \frac{3}{4}$ $g(x_2) = \frac{2-1}{2^{3-1}} = \frac{1}{4}$ $g(x_3) = \frac{2-1}{2^{3-1}} = \frac{1}{4}$	$g(x_1) = \frac{2-1}{2^{4-1}} = \frac{1}{8}$ $g(x_2) = \frac{2-1}{2^{4-1}} = \frac{1}{8}$ $g(x_3) = \frac{3-0}{2^{4-1}} = \frac{3}{8}$ $g(x_4) = \frac{3-0}{2^{4-1}} = \frac{3}{8}$
6	Reliability function	$P_s = p_1 \cdot p_2$	$P_s = p_1 + p_2 - p_1 \cdot p_2$	$P_s = p_1 \cdot p_2 + p_1 \cdot p_3 - p_1 \cdot p_2 \cdot p_3$	$P_s = p_1 \cdot p_2 \cdot p_3 \cdot p_4 + p_1 \cdot q_2 \cdot p_3 \cdot p_4 - q_1 \cdot p_2 \cdot p_3 \cdot p_4$
7	Component importance	$I_1 = p_2$ $I_2 = p_1$	$I_1 = 1 - p_2 = q_2$ $I_2 = 1 - p_1 = q_1$	$I_1 = p_2 + q_2 \cdot p_3$ $I_2 = p_1 - p_1 \cdot p_3 = p_1 \cdot q_3$ $I_3 = p_1 - p_1 \cdot p_3 = p_1 \cdot q_3$	$I_1 = q_2 \cdot p_3 \cdot p_4, I_2 = q_2 \cdot p_3 \cdot p_4$ $I_3 = (p_1 + q_1 \cdot p_2) p_4$ $I_4 = (p_1 + q_1 \cdot p_2) p_3$
8	Component contribution	$A_1 = p_1 \cdot p_2$ $A_2 = p_1 \cdot p_2$	$A_1 = q_2 \cdot p_1$ $A_2 = q_1 \cdot p_2$	$A_1 = (p_2 + q_2 \cdot p_3) p_1$ $A_2 = p_1 \cdot p_2 \cdot q_3$ $A_3 = p_1 \cdot q_2 \cdot p_3$	$A_1 = p_1 \cdot q_2 \cdot p_3 \cdot p_4$ $A_2 = q_1 \cdot p_2 \cdot p_3 \cdot p_4$ $A_3 = (p_1 + q_1 \cdot p_2) p_4 p_3$ $A_4 = (p_1 + q_1 \cdot p_2) p_3 p_4$

For these influence ways, we have the established some indices. To determine the position of component internal to system, we will use the *weight index* that follows from structure function. The component weight may be calculated using relationship:

$$g(x_i) = \frac{l'_i - f_i}{2^{m-i}} \dots \dots \dots (1)$$

Other index of component, influencing the reliability system is the importance (I), defined as:

$$\frac{\partial P_s}{\partial p_i} = I_i = \frac{P_{si}^{(1)} - P_{si}^{(0)}}{1 - 0} = \frac{P_s - p_{si}^{(0)}}{p_i} \dots \dots \dots (2)$$

where P_s is the function probability of system, $P_{si}^{(0)}$ is the function probability of system when $p_i = 0$ and $P_{si}^{(1)}$ is the function probability of system when $p_i = 1$. Using the importance indicator, will calculate the aport (A) (or contribution) indicator, definite by relationship:

$$A = \frac{\partial P_s}{\partial p_i} p_i = I_i p_i \dots \dots \dots (3)$$

We will se these indices to determine the optimal reliability of system, choice that component that will be subject of operation mentioned in previous chapter. Other connection between systems is reliability F - cost K . The costs may be split in the following costs: investment cost K_i (initial and certain), operation and maintenance cost K_m and cost of system or component malfunction K_d , that can be measured economically or in special for considerable systems may be a restriction in optimization models.

4. CONCLUSION

Items or systems reliability is estimate from many parameters or actions, a special level of reliability may be established from combinations of that. The paper presents correlation between parameters, to obtain an optimal reliability.

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