SOME THEOREMS ON STANDBYS

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1. Introductory remarks

The investigation of the effect of having standbys, that is, of the insertion of redundant elements, modules, blocks, or even whole units, occupies a leading position in modern reliability theory. One can become acquainted with the principles of the theory of standbys from many monographs [1], [2], [3], which have recently appeared, as well as from the excellent paper of A. D. Soloviev [4].

Henceforth, our use of the word "unit" will be associated with each specific problem. If elements are in standby, then the unit will be an element; if a whole machine is in standby, then the unit will be this machine. We designate the operating unit and its attached standbys as a standby system.

Hot, warm, and cold standbys are differentiated according to the state in which the standby is placed. For hot standbys the units are loaded in exactly the same way as the operating units; for warm standbys they have a diminished load, and cold standbys are completely unloaded. The probability of loss of operational ability is the same for the hot standby as for the operating regime. Warm standby units may fail, but the failure rate is less than for the operational units. It is customary to assume that cold standby units may not lose their operational ability. This assumption distorts the true situation somewhat; however, it may be considered a good approximation to reality for a majority of items.

Standbys are differentiated as being repairable or not repairable. In repairable standbys each unit which has failed can be repaired and after recovery can be put into standby. In standbys without repair, the unit which has failed is eliminated and it no longer takes part in the system's operation. We shall henceforth deal only with repairable systems. We shall therefore pay particular attention to the case of greatest practical interest, when the time to repair is short compared to the time of faultless operation of the individual unit.

The distribution of the time of faultless operation of a standby system consisting either of operating units and one standby, or of one basic unit and some number of standby units, is studied here.

2. The case of n operating units and one standby

In this section we start from the following assumptions.

1. There are n operating units and one standby; the time of faultless operation of the system is random and distributed according to the law $F(x) = 1 - e^{-\lambda x}$