BULLETIN 60 - 2H

TEN COMMANDMENTS FOR DESIGN RELIABILITY

1. Provide for absolute mechanical simplicity.

Every element of the system which is not "absolutely reliable" should be challenged in an effort to: eliminate it, simplify it, or otherwise improve its reliability. The components which cannot be eliminated should be studied in every detail for simplicity and maximum reliability. As a rule of thumb, absolute reliability may be taken to be an average of less than one failure in 10,000 parts.

2. There shall be no component in the system which by any stretch of the imagination or ingenuity can be avoided.

A relentless challenge of each component must be made to make sure that it cannot be eliminated by an acceptable change in system configurations or an acceptable change in specified functional requirements or design conditions. Repeatedly challenge each component throughout the program to see if a situation change or an inventive thought can make it possible to remove it. When requirements are added to the system, and it must perform this way and that, then take this golden opportunity for re-examination, rearrangement, elimination, etc. — don't let it just grow. The only sure way to make a functional piece of equipment absolutely reliable is to remove it from the system.

3. Simple mechanical mechanisms are more reliable than complex ones.

The ultimate is no moving parts. Challenge every moving part and every separate part to prove that it cannot be eliminated, simplified, or improved. As the saying goes, "If it moves kill it." Avoid delicate hardware. Avoid snap rings. Avoid flow passages small enough to clog with contaminant which could conceivably be present. Close clearance sliding fits are generally to be avoided. Guides of all types, lengths, sizes, and shapes must be carefully designed and tested when used in a component. Materials, lubrication, storage life etc., must be studied in detail.

4. Functional equipment which is already in quantity production is more reliable than equipment developed and built especially for the system.

This is proving out especially in ground support equipment, where costs have been cut considerably. Why use them? Because they have been proved, the bugs have been worked out, and they have been tested, both in the laboratory and in service. Recently the Services, after being requested to make a study to see if they could devise some new method to prove reliability without the increased costs of additional life testing, reported they had found no new method.

An efficient packaging of components, of which there is a trend today, will result in a possible elimination of moving parts and surely less plumbing or wiring, thus eliminating potential points of leakage or power losses.

5. The system shall be designed to have liberal performance margins rather than to be just adequate.

The performance margins shall be judiciously distributed among related functions to avoid a relatively weak link. The system analysis shall show the distribution of margin among related functions. For example: Design vital springs for 20% of normal design stress for the material. Also avoid difficult-to-accomplish physical functions, such as low volume leakage, which is vital.

6. The equipment design specification shall specify the type of air-weapon system the part is to be used for, and that reliability is the major design requirement.

It shall establish detail requirements to protect our reliability philosophy into the design of the component. The liberal performance margins provided by the system design shall not be wasted by allowing loose performance requirements in the equipment design specifications.

Under "notes," in the detail component specification, the following should be included: "After successfully passing all qualification tests, approval of a submitted part constitutes authority for the vendor to proceed with the manufacture of additional duplicate parts. If any deviations or substitutions of design, methods, materials or dimensions are made after approval, immediate notification and/or written consent of the engineering department shall be required."

7. The system shall provide for checking every vital function of every component by the System Inspection Test after assembly is complete.

It must be possible to inspect every locking device as installed. Design so that physical interference prevents mis-assembly or mis-installation that is not readily obvious.

8. Provide for absolute minimum vital-complex functions.

By "vital functions" is meant functions which must take place in order for the mission to be completed. By "complex functions" is meant operations of complex mechanisms such as: electrically actuated valves which require signals, external electrical circuits, and electrical reactions such as mechanical mechanisms which involve more than a few maximum reliability physical parts working together.

9. Provide for absolute minimum vital human functions.

By "vital human functions" is meant functions which must be performed by either flight or ground personnel, which require any degree of human judgement or memory, and which must be accomplished properly to complete the mission. "Absolute minimum" in this case not only means the fewest number but, also the simplest, least likely to be done improperly, functions. The need for this objective is based on the relatively high probability that any human function, no matter how simple on paper, will some time or other be done wrong or omitted.

10. Levels of reliability which have been accepted as inevitable for manned aircraft systems and components are generally inadequate for complex missiles.

A new set of relative values must be developed, wherein reliability stands higher with respect to design time, component cost, weight, fabrication convenience, and ground testing cost.

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B. Bradford Richardson,
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