5TH edition

an elementary guide to Reliability

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Contents

Introduction

An Elementary Guide to Reliability explains in simple, largely non-technical language what is meant by reliability and the various factors that make an equipment or machine reliable. It deals with basic considerations which apply equally to electrical, electronic or mechanical designs.

The Guide has been written to provide an introduction to reliability for those without any previous knowledge of it. However, even those who are already familiar with some aspects of reliability should find the book of interest, since it covers all basic facets of reliability.

Those who need to obtain some knowledge of reliability in the course of their studies, of their training or of their work, can use this Guide to acquire the basic concepts, on which more detailed and more technical knowledge can subsequently be based. In particular the Guide will serve as a textbook for teachers and students concerned with the following courses:

- *City and Guilds of London Institute*
  - Course 2750 Industrial Measurement and Control Technicians Certificate, Part III Section 07 – Maintenance and fault diagnostics of a complete control system.
  - Course 7430 Certificate in Quality Assurance, Part II Section 07 – Evaluating and predicting reliability.
  - Course 8030 (This course is primarily designed for overseas students) Electrical Engineering Technicians Certificate, Part II Section 7 – Reliability.
- *Business and Technology Education Council*
  College devised course units at BTEC National and Higher National levels that include the basic concepts of reliability or of quality assurance in the syllabus.
- *Institute of Quality Assurance (UK)*
  Reliability syllabus in the C subject of the qualifying examination.

Those, whether technical or not, who are interested in learning something about reliability in an age when it is assuming more and more importance, will find the background they need in these pages. In order to give readers an opportunity to put their newly acquired knowledge into practice, we have included a number of 'self-assessment' questions at various points within the text. The answers to these questions appear at the end of the book.

Many books on reliability deal mainly with particular aspects in specialized language, which is usually beyond the grasp even of the technical person without previous knowledge of the subject. *An Elementary Guide to Reliability* is intended to fill this gap.

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1 The importance of reliability

Electrical, electronic and mechanical equipment is used in a number of fields – in industry for the control of processes, in computers, in medical electronics, atomic energy, communications, navigation at sea and in the air, and in many other fields. It is essential that this equipment should operate reliably under all the conditions in which it is used. In the air navigation, military and atomic energy fields, for instance, failure could result in a dangerous situation. Very complicated systems, involving large numbers of separate units, such as avionic and aerospace electronic systems, are coming into use more and more. These systems are extremely complex and use a large number of component parts. As each individual part is liable to failure, the overall reliability will decrease unless the reliability of each component part can be improved.

Suppose, for example, it is known that one component out of half a million would break down every hour. Then an item of equipment using 100 000 of these components would break down at an average interval of 5 hours.

Self-assessment Question 1.1

Tests reveal that, on average, an item of equipment using 1000 similar components fails after a period of 100 hours. If the number of components were to be reduced by half, what would be the new average time before a failure occurs?

The requirement for reliability is different for each application. In the transatlantic cable service, for instance, the underwater amplifiers must operate for 20 years or so without failure, because the cost of raising the cable to repair a failure would be about £500 000 (since it would be necessary to send a cable ship to the location, find the failure under several miles of ocean, supply and install a new amplifier, lower the cable to the bottom again and return to port). Added to this is the loss of revenue while the cable is out of action, which might bring the total to £1 000 000, or more.

In Britain the Air Registration Board will only license aircraft to use a blind

landing system if the fault rate for the total system is less than one in ten million.

In the case of military aircraft on a combat mission, or a missile flight, it is vital for the equipment to operate for the period of flight, or the mission and perhaps a battle might be lost. It has been estimated that unreliability costs the RAF alone up to £100 million each year in spares and servicing costs. In the case of an equipment controlling a chemical plant or some complex industrial process, the cost of 'shutdown' may be considerable in spoiled production and loss of output.

It is essential to 'build-in' reliability by sound design and construction and to carry out enough tests to make sure that this has been done.

The 'availability' or time an equipment is functioning correctly while in use depends both on reliability and on maintainability. Reliability is defined in detail in the next chapter, but may be said to be a measure of an equipment's ability to perform its functions consistently under given conditions. Maintainability is a measure of the speed with which loss of performance is detected, diagnosed and made good, and this is discussed in Chapter 8.

Reliability is of course a most important factor in the safety of an equipment, but it is by no means the only factor. A system or equipment can 'perform its required function' (see definition on page 5) and yet be unsafe. There are well-documented major disasters caused not by mechanical or electronic breakdown but by human failure. Such human failures can be due to failures of operators, of maintenance staff, or of management.

Breakdowns and disasters can arise from failure of management to establish proper operating procedures and regulations. Management's share of the responsibility for 'failure' has been estimated to be above 50%. They can also arise from operators' failure, accidental or deliberate, to observe laid-down operating procedures and regulations. The results of accidental failure can be allowed for to some extent by anticipating, during the equipment design stage, what accidental operating mistakes might be made and introducing safeguards. However, it is impossible to anticipate deliberate failure to follow operating procedures, and it is essential to impress on operators and on maintenance staff, during their training, how vital it is that they never depart from laid-down procedures and regulations however safe it may appear to do so.

Self-assessment Question 1.2

A small manufacturing company produces a range of switches for use in mains operated domestic appliances. The Production Manager has asked you to give a brief presentation to new employees on the 'Importance of Reliability'. Identify THREE key factors that should form part of your presentation and write brief notes (using not more than a single A4 page) that will help you when you deliver your talk.

Figures 1.1, 1.2 and 1.3 illustrate in a lighthearted way the importance of reliability and some of its aspects.

Figure 1.1 'It's only a random failure, Sir.'

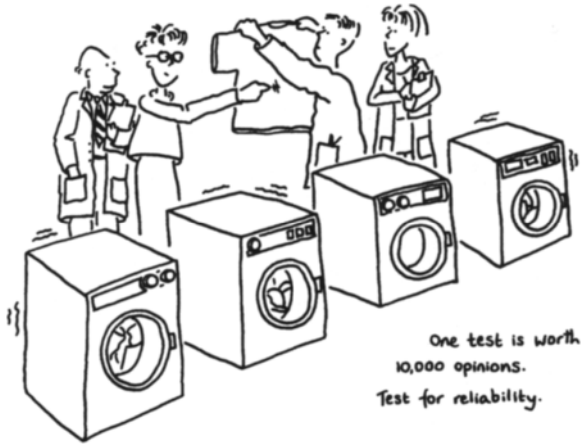

Figure 1.2 One test is worth 10 000 opinions.

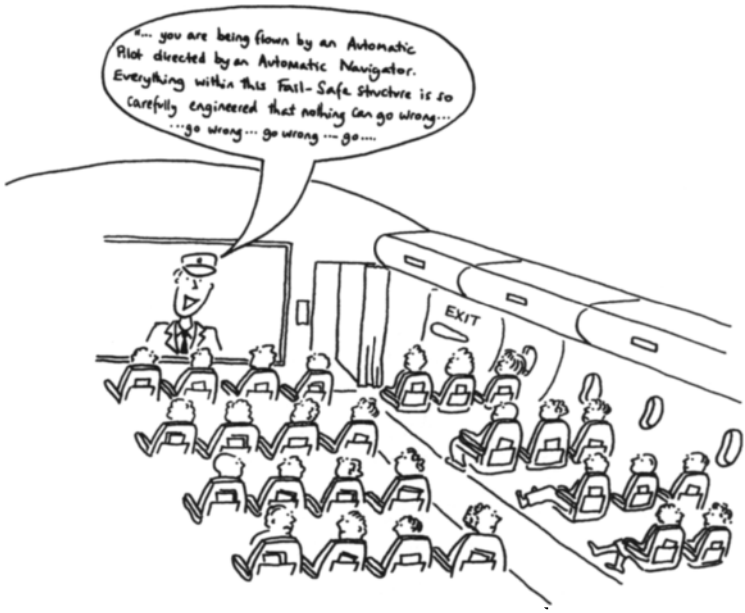

Figure 1.3 You are being flown by an automatic pilot.