Automotive Vehicle Safety

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This unique book is both a practical design guide and a valuable reference book. The information it contains is essential for specialists such as designers, engineers, manufacturers and lawyers, who need to make well-informed decisions in order to ensure automotive safety. The inclusion of discussion topics and worked examples makes the book relevant to students as well as professionals.

Automotive Vehicle Safety is an internationally-oriented discussion of how to evaluate products, processes, services and systems. The authors identify key generic safety principles and discuss their applications. Decision-making criteria are also explained, and in-depth information on human simulation, human error control and driver distractions is provided. The book details reconstruction techniques and methods of crash testing, and looks at future vehicle safety and universal design.

George A. Peters is a licensed attorney, engineer, and psychologist. He is a 25 year member of the Society of Automotive Engineers and has been elected a Fellow of the American Association for the Advancement of Science and the Royal Society of Health.

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Dedication

This book is dedicated to Roberta B. Peters who reviewed and constructively questioned the drafts of each chapter, typed and proofed the manuscript several times, and encouraged the two already overworked authors by stating that the information contained in this work could materially help those who are in a position to improve automobile vehicle safety.

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Preface

This book is intended to fulfill a rapidly growing need for useful information on how best to meet the demands and achieve an ever higher level of safety for products, assemblies, systems, processes, and services. It should be rather obvious that design safety has become far more important because of the more severe consequences from failures, defects, discrepancies, recalls, improper risk assessments, and purely subjective decision-making. This is an era of increasing competition, shorter design cycles, rapid transition and change, pervasive electronics, and the delegation of design safety to many suppliers, subassemblers, and outsourced assemblies. Some of the resultant issues are: how can there be an assurance of safety with decentralized control? What are the important design and system concepts necessary for the attainment of a high level of safety throughout the design-to-disposal and recycling process? What is needed, expected, and effective? And how is it done with the existing tools of the trade?

Form

This is not an argumentative, opinionated, or advocacy publication. It does not represent the unique views of any special interest group. There are no tales of disastrous consequences, no specific product or name identification, nor any controversial speculative opinions or conclusions. Instead, the book attempts to present helpful, straightforward, reliable, and factual information that is reasonable, acceptable, practical, contains a fair balance of interests, and with an expression of cultural limitations that might be realistically expected. A balance has been attempted so that there will be minimal burdens commensurate with the desired product and system improvement, successful attainment of safety goals and requirements, and compliance with social expectations.

Application

There are many types, brands, and models of automotive vehicles to which design safety procedures could be applied. A partial sampling of the universe might include passenger vehicles, trucks, buses, motorcycles, snowmobiles, lawn and garden tractors, and other self-propelled vehicles. It might include construction equipment, such as excavators, motor graders, bulldozers, backhoes, trench diggers, and other earthmoving vehicles. It might include farmstead equipment such as tractors, mowers, and combine harvesters. It could include original or aftermarket accessories from hitching devices to electronic entertainment. It could include consideration of the effects of agricultural chemicals in

vehicle mounted tanks, hazardous material in refuse trucks, and environmental factors on military vehicles. Whatever the application, there is significant communality in terms of the application of design safety techniques, concepts, principles, and methodology.

Acceptability

The contents of this volume have been discussed by the authors in lectures that have been sponsored by professional associations and government agencies. Key concepts have been published, by the authors, in peer-reviewed journals. Drafts have been reviewed by sophisticated and experienced specialists. These efforts have proved very helpful in formulating and presenting information that can be considered acceptable by peer-review publication standards. Much of the information is new in published form, but it springs from and is conditioned by actual experience. The hope is that it will serve to help others in the difficult task of improving safety for the benefit of all persons, interests, and enterprises.

Integrated safety

The authors of this book believe that the contents are an application of the basic principles of what they call **integrated safety**. This is in sharp contrast with the separate application, by various disciplines at different times and locations, of a variety of special techniques such as those that predominate in system safety, reliability engineering, human factors, quality, risk management, loss control, behavioral safety, traffic and transportation engineering, intelligent vehicle research, accident reconstruction, and, in particular, design engineering.

Gender, dollars and measurements

In the text that follows, measurements are given in English units, with some conversions to metric units where it might be helpful. English units are the most commonly used in the automobile industry, but there is a gradual shift toward the International System of Units (SI); there are many symbols and terminology that could be used, and even the notation for kinetic energy may be in any one of four symbols. For conversions and precision, we recommend the use of references such as *The CRC Handbook of Mechanical Engineering* (1998), 19–2 to 19–11 (F. Krieth, ed.), Bacon Raton, Fl: CRC Press. The monetary units are given in US dollars, which may be converted into any currency as of a given date.

For simplicity, the masculine word 'he' is meant to apply to both sexes. It also reflects an industry heavily populated by males. However, it is a fact that some very talented females now occupy positions in every aspect and corner of the industry, from entrance level occupations to chief executive officers of corporations. This growing sexual diversity is accompanied by cultural diversity resulting from the assimilation of various national groups into the increasingly international operations of various enterprises.

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The authors wish to express their appreciation to those publications and organizations that permitted an author's reservation of book rights or otherwise made this volume possible. This includes, in whole or in part, publications and lectures from the *Journal of System Safety*, the *Journal of the Royal Society of Health*, the *Journal of the International Society for Technology, Law and Insurance*, the Human Factors and Ergonomics Society, the National Research Council of the National Academies of Science (USA), and the Society of Automotive Engineers.

Disclaimer

The authors and the publisher must strongly disclaim any and all liability that could conceivably result from the use of the information, in whole or in part, contained in this book. This is because of the unique circumstances that may arise during the application of such information, the wide variation in competence and capability of users or appliers, and the need for highly skilled specialists. Before any detrimental reliance, the reader is urged to obtain consultation, advice, and opinions from appropriate licensed professionals. This is particularly important when decisions and actions are being taken that are within the realm of a licensed professional practice. Decisions on safety issues often involve matters relating to several disciplines such as a branch of engineering, medicine, and the law. What each specialist might perceive, understand, and recommend may be based on limited data that is material to human health and safety. Every application is unique, novel, and requires balancing of a variety of interests and alternatives.

1 Introduction to vehicle safety

(a) Objectives

The purpose of this publication is to provide useful information that could save lives, prevent personal injury, reduce property damage, and generally improve the individual's quality of life.

It is assumed that a better understanding of good design practices will enable product improvement that manifests significantly less risk to humans, machines, and the environment. A better comprehension of the overall requirements may help to reduce system errors and faults. A broader appreciation of societal interests may help in balancing risks and determining what is reasonable under the circumstances. In some respects, this document could serve as a complementary 'safety design manual' or supplemental 'safety training handbook' for a wide variety of industrial and commercial enterprises. Its academic importance should be self-evident.

(b) Good intentions are not enough!

Despite the good intentions of many engineers, safety problems regularly occur in a wide variety of products, processes, and systems. If safety were merely a matter of good intentions and common sense, there would be few if any accidents, recalls, liability fears, lost profits, or problems of insurability, loss of use of cash reserves, and possible adverse publicity that could affect market shares. Design safety is not achieved by chance or hope, complacency or compliance, the application of ethical and moral values, or simple exhortations as to exemplary safety objectives. Achieving safety is a fairly sophisticated process and requires special effort.

We have entered a new era of fairly constant design improvements, more radical changes in design, ever more compressed design-to-market cycles, high-volume production schedules, more diverse marketplaces, and significant world trade competition. Safety problems can suddenly appear and have dramatic consequences. Assurance of acceptable levels of product safety cannot be left to chance and the good intentions of individuals or companies. Specific techniques and assurance procedures are corporate health essentials.

(c) Adequacy of knowledge

A design engineer may have had very little academic preparation or on-the-job training in terms of specific design safety principles, techniques, or knowledge. The engineer

may be suddenly assigned an important design safety function in connection with his work. There may be little or nothing available in terms of sources of information. The company safety guidelines, engineering manuals, or policy documents may abound with good-sounding generalities, but fail to address specific questions or provide the necessary help. The design supervisor or reviewer may have had little more in terms of design safety experience and knowledge, except for some highly specialized but very limited applications. The engineer may try to the best of his capability, but a lack of relevant knowledge or available tools of the trade may convert an otherwise capable engineer into a mistake-prone learner. This book may furnish some guidance and awareness that could serve to compensate for the lack of knowledge that is so prevalent in many industries.

(d) Someone else's responsibility

During the design process, the focus is usually on iteratively obtaining desired product performance, correcting problems as they arise, meeting strict schedules, obtaining design approvals, attempting to meet all specifications and requirements, and seeking to obtain customer satisfaction. Under such circumstances, safety may be assumed to be adequate and relegated to a secondary service function. It is also assumed that if there are potential safety problems, they will receive attention, testing, and correction by others. In some companies, safety is considered almost as a non-design or after-design function. In essence, design safety may be delegated, relegated, or simply overlooked in a large compartmentalized company bureaucracy. It may be a broadly shared responsibility, superficially implemented by all, with no real accountability.

An example of 'shifting responsibility' may be found in an engineer's opinion as to the 'safe use' of a product. The eventual product user is generally urged or expected to apply common sense in dealing with the product, to follow directions and instructions correctly, to avoid misuse and abuse, and to exercise due care for his own safety. This shifts the responsibility to the consumer who, logically, should act with great care as to his own personal safety. If there should be effective safe-use communication with the consumer, user, operator, worker, or bystander, it could reduce accidents. But history has shown that it will not eliminate accidents and sometimes is virtually ineffective. This is the reason why a reverse shifting of responsibility has occurred. The engineer may be considered to have more pertinent knowledge and be in a better position to design-out problems (hazard prevention) to completely eliminate the prospective source of injury. In essence, the reverse-shift is urging the engineer to exercise greater care in the design of a product, process, or service.

The lesson to be learned is that design safety is a sophisticated task, there should be clear responsibility for it, and it should not be diffused as always being someone else's responsibility.

(e) The hear-no-evil problem

During the design process, those who convey 'good news' are very welcome. This is particularly true if it involves meeting a difficult schedule milepost, passing a key test, achieving a higher than expected performance level, or coming in under budget. Those who convey negative messages usually suffer the fate of the unwelcome messenger. Unfortunately, the discovery of a possible safety problem is 'bad news' because of its

negative effect in terms of required problem resolution efforts, added cost, and time delay consequences. Since design managers do not welcome bad news and this may be perceived as a desire to hear no evil, the design engineer may not want to frustrate the managers by conveying bad news about safety problems. In essence, it is politically unpopular to discuss a safety problem unless there is overwhelming credible evidence as to its actual existence, and even that may be vigorously challenged. This suggests that the design safety process be established and conducted in such a manner that it cannot be neutralized, fudged, or subjectively contorted to produce only good news. The philosophical approach should be that early discovery of a potential safety problem saves the considerable time and cost that would have to be expended at a later date.

(f) Generic implications

This book may seem to focus on product safety, but the principles and techniques are actually generic and have wide potential application. The obvious emphasis is on automotive vehicles, but this could be considered illustrative in character and analogous to what might be applied in other industries.

Vehicle safety may seem to be exclusively a design engineering function. But, as this book clearly reveals, vehicle safety problems may originate from damage during fabrication, assembly-line errors and omissions, and flaws during manufacture that are intentional in character. Safety problems may be caused by damage during vehicle transport to the dealer, particularly for import vehicles. Dealers may introduce problems during showroom demonstrations and rides, or from service and repair discrepancies. The owner-operator may subject the vehicle to misuse, abuse, or a failure to understand proper care. Aftermarket accessories and customizing of vehicles may affect vehicle safety. Thus, examples of causation from a variety of sources and relevant remedies are a hallmark of this volume.

The achievements of the automotive industry surround us and have fundamentally changed the world in which we live. The benefits are obvious. The resulting safety problems are well known and some are highly publicized. There are now many more companies in the automotive industry, they are more widely dispersed geographically around the world, they produce many more diverse and complex products, and the market for a greater variety of self-propelled vehicles in more countries is increasing. This increases the probability that more safety problems will emerge, and these may challenge objectives relating to corporate and social responsibility. Therefore, this book, which provides a comprehensive review on how to prevent vehicle safety problems, is needed by engineers, managers, and corporate officers. Safety assurance is not good luck; it must be earned by attention to detail.