

## BOOK REVIEW

### *PRINCIPLES OF FIRE BEHAVIOR*

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Delmar Publishers  
Albany, New York, 1997  
(800) 347-7707  
ISBN 0-8273-7732-0

This book was written for personnel engaged in the field of fire safety/technology, fire services/management, fire investigation, law enforcement and code consulting. This book can be used as a textbook for junior level fire science courses at community colleges and is suitable as a reference guide for the students in a fire protection engineering curriculum at the university level. This book originates from a series of training course materials developed for the Bureau of Alcohol, Tobacco and Firearms (BATF) arson program conducted at the University of Maryland, College Park. The goal of this book is to provide an introduction to important principles of fire dynamics and to show, through the use of examples, how these principles apply to the fire hazard analysis, fire investigation/reconstruction and special fire hazards applications.

The dynamic nature of fire is a quantitative and mathematically complex subject. It combines physics, chemistry, mathematics and engineering principles and can be difficult to comprehend for those who have a limited background in these areas. With this in mind, the author has provided the concepts, tools, techniques and simple mathematical model and expressions developed by the fire research community, to solve problems of fire in buildings and structures. The content of this book deals with the fundamental aspects of the subject, but not to the same depth of theory or detail given in a graduate level degree course in fire protection and safety engineering. The mathematical skills required to understand the concepts described in this book will include reading graphs, scientific notation, formulas and use of some simple mathematical functions available on a basic scientific calculator.

A significant number of examples, reference tables, graphs and a wealth of experimental data and information on material properties are used throughout the book to solidify the concepts. The appendices of the book provide useful reference information necessary for the computation of fire engineering problems. The author also provides a glossary that is helpful where terms are not defined in detail in the text. One feature of the book that will help readers in understanding fire phenomena is the illustrations and conceptual drawings. The author has presented numerous illustrations and drawings to expand the reader's appreciation in visualizing and retaining the material contained in this book and diagnostic signs of fire origin and behavior.

The subject matter of this book covers almost all aspects of fire dynamics and contains very good qualitative descriptions of most of the important fire processes. The first chapter is an overview of the fire problem including background information of fire science and research, statistics of fire deaths and some visualization of fire process. This chapter also contains nomenclature, units and conversion factors used in fire related problems.

Chapters 2 and 3 provide the basic concepts for understanding fire dynamics. The material in these two chapters involves heat transfer and thermal process analysis. Chapter 2 contains fundamental principles of the combustion process. Types of fires, concepts of pre-mixed and diffusion flames (laminar and turbulent) and jet flames are described. Limits of flammability are discussed. The section on flammability limits

contains a qualitative description on how these limits are obtained experimentally. A presentation on candle flame is included in this chapter from lectures given at the Royal Institution in London by Michael Faraday. The lectures have been archived in a book entitled "Faraday's Chemical History of a Candle." A qualitative discussion of smoldering and spontaneous combustion process is given, followed by the presentation of experimental data and practical applications.

The concepts of heat and energy are discussed in Chapter 3. Principle forms of heat transfer (i.e., conduction, convection and radiation) are described with figures, examples and solved problems to develop a basic understanding of the thermal process in a fire. A brief description of the configuration factor is given. Heat flux and its effects to objects are explained with some experimentally measured results. Computations of heat release rate, radiation heat transfer to a target (heat flux) and hazards of heat transfer from fire are explained using models and drawings.

Chapters 4, 5 and 6 outline specific fire processes involved in fire growth including ignition, flame spread and burning rate. Ignition is the subject of Chapter 4, which covers the process of initiation of combustion of a fuel system (i.e., ignition of thin and thick solid or liquid fuels). The mechanisms of piloted, nonpiloted and autoignition are discussed. Simple correlations for estimating the ignition time of solid and liquid fuels are provided. Experimentally derived ignition properties and ignition data are also a part of this chapter.

Chapter 5 examines the process of flame spread over solids and liquids. The theory of opposed and wind-aided flame spread is outlined in this chapter. The qualitative discussion of flame spread processes on solid, liquid and porous surfaces are presented. Theoretical models of flame spread and experimental data are given. A section on flame spread rate on materials is also included. Standard test methods of flame spread are also briefly described.

Chapter 6 deals with the burning rates of materials. This chapter presents the theory of burning rate and discusses related parameters and

expressions to predict the mass loss of materials. An extensive amount of burning rate data has been provided in this chapter. In discussing burning rate, the concepts of heat of gasification, heat of combustion, burning flux and energy release rate are explained using common material and fire situations as examples. Typical measured results of burning rates and heat release rates of residential and industrial items are presented to provide a view of a material's behavior in a real fire.

Chapter 7 introduces fire plume theory and presents correlations for calculating flame height, plume velocity and plume temperature. Jets and buoyant plumes, air entrainment and buoyancy are discussed, as expected, supported by the use of examples and diagrams. Flame height and temperature calculations for various fuels are also provided to understand plume models and correlations.

Chapter 8 is devoted to discussing the hazards created by combustion products from fires involving various fuels. The chemical kinetics of fire, yield, species and concentration of products of combustion are discussed. Toxicity of combustion products is also addressed with effects of smoke, heat, visibility and irritant gases on humans.

Chapter 9 describes the development of a fire in a compartment. The presentation and description of fire growth in a compartment are excellent. This chapter focuses on methods for assessing the smoke temperatures and flow rates from compartment fires utilizing models. Stages of fire development, fire-induced flows and smoke movement are also included. Compartment flashover phenomena are discussed and the concept of ventilation-limited fires and fully developed fire size is introduced. This chapter ends with a section on single room fire analysis and brings together the materials previously covered with a detailed discussion.

The book concludes with a chapter on fire analysis. The chapter begins with a discussion on analytical applications in fire safety design and their application to fire investigation and reconstruction. Examples are used to explain performance based fire codes. Several examples are discussed to introduce readers to the methods of fire investigations and reconstruction, using scientifically

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based analysis techniques. Particularly interesting is Dr. Quintiere's statement and analysis of fire at the Branch Davidian Compound near Waco, Texas, April 19, 1993.

Dr. Quintiere's book, *Principles of Fire Behavior*, provides clear information on most aspects of fire dynamics in a simplified way and is a valuable contribution to fire science publications. There is no other book available that contains the simple style of explanations of fire dynamics principles that are presented in *Principles of Fire Behavior*. This book is highly recommended to entry level students of fire science, private and federal/state fire investigators and for those seeking an introduction to the field of fire investigation and reconstruction and non-engineering practitioners of fire safety. This book should be required reading

for all professionals involved in fire protection and safety engineering. The book will definitely improve the computational skills of those dealing with fire issues and will make the readers aware of sources of information and methods that can be applied to the understanding and assessment of fire issues. A reader will find the book of considerable assistance in understanding phenomena of fire in buildings, its effects on material, the response and effects on people.

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