Risk - Informed, Performance - Based Industrial Fire Protection

An Alternative to Prescriptive Codes

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First Edition

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The book cover was designed by Christopher G. Barry.

Dedicated to

Karin, Christopher, Mackenzie, Irene, and Gerald Barry

With Love

Preface

The concept of performance-based fire protection engineering, although introduced into practice in the United States during the past decade, is not new. The 1965 National Fire Protection Association Meeting in Washington, D.C., included the presentation of the following paper: "Fire Protection and the Performance Concept." In addition, in 1978 the National Bureau of Standards published a study report entitled: "Toward a Performance Approach to Life Safety From Fire in Building Codes and Regulations."

In this book, Tom Barry has successfully merged the concepts of fire risk analysis, risk assessment, and probability modeling into the performance code process being introduced in fire protection engineering today. As defined by Barry, Risk-Informed, Performance-Based Fire Protection is an integration of decision analysis and quantitative risk assessment with a defined step approach for quantifying the performance success of fire protection systems.

There is no doubt that the concept of performance-based fire protection engineering requires that today's fire protection engineer be thoroughly educated in the means to quantify the judgmental decisions of yesterday. As Tom Barry has indicated: "Risk-based analysis and decision making is widely used by many agencies of the U.S. government, the chemical process industry, the telecommunications industry, the aviation industry, and others. The application of fire and explosion risk and performance-based decision analysis will certainly become an alternative to prescriptive codes." Risk-informed, performance-based fire protection engineering involves applying quantitative risk assessment evaluation techniques in conjunction with traditional fire protection engineering methods to make informed decisions about the effect of fire and explosion risk on the safety of personnel and the continued operation of the business.

This book is a definite necessity for every practicing fire protection professional. The author has examined and explained the sometimes complicated procedures with excellent examples and outstanding graphics, which benefit both the novice and the practitioner.

Dr. John L. Bryan

From the Author

The steps, methods, and tools described in this book are intended to bridge the gap between qualitative and quantitative fire risk assessment by filling the void between educated opinion and objective decision support information.

The book presents a risk-based decision support process to help identify fire safe design and protection alternatives and then select the best alternative(s) based on risk tolerance, meeting the performance intent of applicable codes, and cost/benefit criteria.

Fire safe design responsibility includes many groups; architects, facility and process designers, fire protection and safety engineers, loss control and risk managers; review and approval groups including building code officials, fire marshals, regulatory agencies, and insurance companies. In this book, all these groups are placed under one title, "Risk-Based Decision Makers."

"Risk-Informed" provides another dimension to the traditional approaches taken towards life safety and fire protection design methods and practices. It provides a path forward for situations where applying prescriptive codes is not feasible or cost-effective, where applying performance-based deterministic modeling has many uncertainties, or where there is a desire to conduct cost/benefit analysis of numerous fire protection alternatives.

I have worked in the industrial fire protection field for 24 years. My Masters degree is in Fire Protection Engineering from Worcester Polytechnic Institute (WPI), Worcester, MA. My professional engineering registration is in Fire Protection. Since 1989, most of my consulting work has been in the chemical, oil, gas, electronics, government, and nuclear sectors and has involved some or all of the steps described in this book. More and more plant managers and risk managers are asking for risk-informed, performance-based information so that they can make more intelligent decisions concerning fire and explosion risk reduction.

All the information in this book is based on real world experience using established risk and reliability analysis techniques specifically applied to fire and explosion risk. The chapter numbering follows the step numbering, which leads the reader from project definition (Chapter 1, Step 1) to the cost/benefit analysis of risk reduction alternatives (Chapter 8, Step 8).

A Fire Risk Forum (FRF) web site has been set up to provide an online continuing education resource. The web site address is www.fireriskforum.com and is described in Chapter 9, Moving Forward.

I hope you enjoy this book and find it useful.

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Acknowledgments

I am indebted to a number of individuals who helped make this book a reality.

First I would like to acknowledge the contributions of Ken Dungan, Risk Technologies, LLC. Ken, who is a past president and fellow of the Society of Fire Protection Engineers, is a leader in the fire protection community concerning the advancement of performance-based and risk-based fire protection methods. Ken's advice, chapter reviews, and suggestions were invaluable in the development of this book.

I wanted to develop a book which was part "how-to," part "textbook," and part "application-insight." The risk-informed, performance-based concept needs to be integrated into undergraduate and graduate fire safety and fire protection programs. I am very grateful to Dr. John Bryan, who was appointed Professor Emeritus at the University of Maryland following his retirement from acting Chair, Department Head, and Professor of the school's Fire Protection Engineering program. Dr. Bryan reviewed the book from an educational perspective, and provided some excellent suggestions.

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I would like to thank the management at HSB Professional Loss Control, Inc. specifically Mike Mowrer, Harvey Goranson, and Wayne Holmes, for sponsoring and supporting fire and explosion risk assessment seminars. These seminars helped formalize the risk-informed steps described in this book.

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Acronyms

AHP analytic hierarchy process
AIChE American Institute of Chemical Engineers
AIT Auto-ignition temperature
ALARA as low as reasonably achievable
ARB annualized risk benefit

B/C benefit/cost
BI business interruption
BLEVE boiling liquid expanding vapor explosion
BPC basic process controls
BPCS basic process control system

CCF common cause failure
CCPS Center for Chemical Process Safety
CFD computational fluid dynamics
CO carbon monoxide
CPQRA Chemical Process Quantitative Risk Analysis

DA decision analysis
DAB design application basis
DOE U.S. Department of Energy

ECS emergency control system
EMVs equivalent monetary values
ESD emergency shutdown device
ESO emergency system operation
ESS emergency shutdown system
ETA event tree analysis
EVA expected value analysis

F&E fire and explosion
FDS Fire Dynamics Simulator
FHA fire hazard analysis
FM Factory Mutual
FMEA failure mode and effect analysis
FMRC Factor Mutual Research Center
FOD failure-on-demand
FPS fire protection system
FRF Fire Risk Forum
FTA fault tree analysis

GPA grade point average

HAZOP hazard and operability study
HCI hydrogen chloride
HEP human error probability
HRA human risk assessment
HRR heat release rate

IEEE Institute of Electrical and Electronics Engineers
IMT inspection, maintenance, and testing
IR infrared
ISA Instrument Society of America

LE loss expectancy (analysis)
LEL lower explosive limit
LFG liquefied flammable gas
LFL lower flammability limit
LNG liquefied natural gas
LOC lower oxygen concentration
LPG liquefied propane gas

MDT mean downtime
MFL maximum foreseeable loss
MOC management of change
MTBF mean time between failures
MTTF mean time to failure
MSDS material safety and data sheets

NERC National Electric Reliability Council
NFPA National Fire Protection Association

NLE normal loss expectancy
NPRD Nonelectric Parts Reliability Data

OLA on-line availability
OPR operational reliability

P&IDs piping and instrumentation diagrams
PD property damage
PIM performance integrity measure
PLC programmable logic controller
PML probable maximum loss

QRA quantitative risk assessment

RAC Reliability Analysis Center
RCM risk- and reliability-centered maintenance
RE response effectiveness
RNG random number generation
ROR rate of return
RTI response time index
RV replacement value

S→P→T source→pathway→target
SFPE Society of Fire Protection Engineers
SIL safety integrity level
SIS safety instrumented systems
SRT system response time
STA success tree analysis

TDLs threshold damage limits
TNO Netherlands Organization for Applied Scientific Research
TNT Trinitrotoluene
TRC thermal response coefficient

UEL upper explosive limit
UFL upper flammability limit
UV ultraviolet
UVCE unconfined vapor cloud explosion

VCE vapor cloud explosion