Praise for *Taguchi's Quality Engineering Handbook*

"Classic! This handbook is an excellent reference for engineers and quality professionals in any field."

Kevin W. Williams
Vice President, Quality
General Motors North America

"ITT has learned from experience that Dr. Taguchi's teachings can prevent variation before it happens. This book is a great demonstration of this powerful approach and how it can make a meaningful difference in any type of business. It takes a dedicated engineering approach to implement, but the pay back in customer satisfaction and growth is dramatic."

Lou Giuliano
Chairman, President and CEO
ITT Industries

"Dr. Taguchi's enduring work is of great importance to the field of quality."

Dr. A.V. Feigenbaum
President and CEO
General Systems Company, Inc.

"This handbook represents a new bible for innovative technical leadership."

Saburo Kusama
President
Seiko Epson

"It is a very well thought out and organized handbook, which provides practical and effective methodologies to enable you to become the best in this competitive world for product quality."

Sang Kwon Kim
Chief Technical Officer
Hyundai Motor Company & Kia Motors Corporation

"For those who see the world as connected, this landmark book offers significant insights in how to design together, build together, and lead together."

Dr. Bill Bellows
Associate Technical Fellow
The Boeing Company

Taguchi's Quality Engineering Handbook. Genichi Taguchi, Subir Chowdhury and Yuin Wu

"Dr. Taguchi has been an inspiration and has changed the paradigm for quality with his concept of loss function. Robust Engineering is at the heart of our innovation process and we are proud to be associated with this work."

Donald L. Runkle
Vice Chairman and CTO
Delphi Corporation

"The elegantly simple Taguchi theory is demonstrated through many successful case studies in this excellent book."

Don Dees
Vice President, Manufacturing
DaimlerChrysler

"We have and are practicing the methods and teachings in this valuable handbook; it simply works."

Dr. Aly A. Badawy
Vice President, Engineering
TRW Automotive

"To have all of the theories and application of the lifetime of learning from these three gentlemen in one book is amazing. If it isn't in here, you probably don't need it."

Joseph P. Sener, P.E.
Vice President, Business Excellence
Baxter Healthcare

" *Taguchi's Quality Engineering Handbook* is a continuation of the legacy by Dr. Taguchi, Subir Chowdhury and Yuin Wu in Robust Engineering, which is increasingly being recognized in the automotive industry as a 'must have' tool to be competitive.

Dan Engler
Vice President, Engineering and Supply Management
Mark IV Automotive

"Taguchi's principles, methods, and techniques are a fundamental part of the foundation of the most highly effective quality initiatives in the world!"

Rob Lindner
Vice President, Quality, CI and Consumer Service
Sunbeam Products, Inc.

"The value of Dr. Genichi Taguchi's thinking and his contributions to improving the productivity of the engineering profession cannot be overstated. This handbook captures the essence of his enormous contribution to the betterment of mankind."

John J. King
Engineering Methods Manager, Ford Design Institute
Ford Motor Company

"I am glad to see that *Taguchi's Quality Engineering Handbook* will now be available for students and practitioners of the quality engineering field. The editors have done a great service in bringing out this valuable handbook for dissemination of Taguchi Methods in quality improvement."

C. R. Rao, Sc.D., F.R.S.
Emeritus Eberly Professor of Statistics and Director of the Center for Multivariate Analysis
The Pennsylvania State University

"This book is very practical and I believe technical community will improve its competence through excellent case studies from various authors in this book."

Takeo Koitabashi
Executive Vice President
Konica-Minolta

"Digitization, color, and multifunction are the absolute trend in imaging function today. It is becoming more and more difficult for product development to catch up with market demand. In this environment, at Fuji Xerox, Taguchi's Quality Engineering described in this handbook is regarded as an absolutely necessary tool to develop technology to meet this ever-changing market demand."

Kiyoshi Saitoh
Corporate Vice President, Technology & Development
Fuji Xerox Co., Ltd.

"In the today's IT environment, it is extremely critical for technical leaders to provide an effective strategic direction. We position Taguchi Methods of Robust Engineering as a trump card for resolving difficulty during any stage of technology development. Technology is advancing rapidly and competition is getting global day by day. In order to survive and to win in this environment, we use the Taguchi Methods of Robust Engineering described in this handbook to continue developing highly reliable products one product after another product."

Haruo Kamimoto
Executive Vice President
Ricoh

"I was in a shock when I have encountered Taguchi Methods 30 years ago. This book will provide a trump card to achieve improved 'Product Cost' and 'Product Quality' with less 'R&D Cost' simultaneously."

Takeshi Inoo
Executive Director
Isuzu Motor Co.
Director
East Japan Railroad Co.

Taguchi's Quality Engineering Handbook

Genichi Taguchi
Subir Chowdhury
Yuin Wu

Associate Editors
Shin Taguchi and Hiroshi Yano

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To our colleagues, friends, and families
for their enormous support over the years

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Preface

To compete successfully in the global marketplace, organizations must have the ability to produce a variety of high-quality, low-cost products that fully satisfy customers' needs. Tomorrow's industry leaders will be those companies that make fundamental changes in the way they develop technologies and design and produce products.

Dr. Genichi Taguchi's approach to improving quality is currently the most widely used engineering technique in the world, recognized by virtually any engineer, though other quality efforts have gained and lost popularity in the business press. For example, in the last part of the twentieth century, the catch phrase "total quality management" (TQM) put Japan on the global map along with the revolution in automotive quality. Americans tried with less success to adopt TQM into the American business culture in the late 1980s and early 1990s. Under Jack Welch's leadership, GE rediscovered the Six Sigma Quality philosophy in the late 1990s, resulting in corporations all over the world jumping on that bandwagon.

These methods tend to be but a part of a larger, more global quality effort that includes both upstream and downstream processes—espoused by Dr. Taguchi since the 1960s. It is no surprise that the other methods use parts of his philosophy of Robust Engineering in what they try to accomplish, but none is as effective.

Dr. Taguchi strongly feels that an engineering theory has no value unless it is effectively applied and proven to contribute to society. To that end, a Taguchi study group led by Dr. Taguchi has been meeting on the first Saturday of every month in Nagoya, Japan, since 1953. The group has about one hundred members—engineers from various industries—at any given time. Study group members learn from Dr. Taguchi, apply new ideas back on the job, and then assess the effectiveness of these ideas. Through these activities, Dr. Taguchi continues to develop breakthrough approaches. In Tokyo, Japan, a similar study group has been meeting monthly since 1960. Similar activities continue on a much larger scale among the more than two thousand members of the Quality Engineering Society.

For the past fifty years, Dr. Taguchi has been inventing new quality methodologies year after year. Having written more than forty books in the Japanese language, this engineering genius is still contributing profoundly to this highly technical field, but until now, his work and its implications have not been collected in one single source. *Taguchi's Quality Engineering Handbook* corrects that omission. This powerful handbook, we believe, will create an atmosphere of great excitement in the engineering community. It will provide a reference tool for every engineer

and quality professional of the twenty-first century. We believe that this book could remain in print for one hundred years or more.

The handbook is divided into three sections. The first, "Theory," consists of ten parts:

- ❏ Genichi Taguchi's Latest Thinking
- ❏ Quality Engineering: A Historical Perspective
- ❏ Quality Loss Function
- ❏ Signal-to-Noise Ratio
- ❏ Robust Engineering
- ❏ Mahalanobis–Taguchi System (MTS)
- ❏ Software Testing and Application
- ❏ On-Line Quality Engineering
- ❏ Experimental Regression
- ❏ Design of Experiments

After presenting the cutting-edge ideas Dr. Taguchi is currently working on in Part I, we provide an overview of the quality movement from earliest times in Japan through to current work in the United States. Then we cover a variety of quality methodologies, describe them in detail, and demonstrate how they can be applied to minimize product development cost, reduce product time-to-market, and increase overall productivity.

Dr. Taguchi has always believed in practicing his philosophy in a real environment. He emphasizes that the most effective way to learn his methodology is to study successful and failed case studies from actual applications. For this reason, in Section 2 of this handbook we are honored to feature ninety-four case studies from all over the world from every type of industry and engineering field, mechanical, electrical, chemical, electronic, etc. Each of the case studies provides a quick study on subject areas that can be applied to many different types of products and processes. It is recommended that readers study as many of these case studies as they can, even if they are not ones they can relate to easily. Thousands of companies have been using Dr. Taguchi's methodologies for the past fifty years. The benefits some have achieved are phenomenal.

Section 3 features an explanation of how Dr. Taguchi's work contrasts with other quality philosophies, such as Six Sigma, Deming, Axiomatic Design, TRIZ, and others. This section shows readers ways to incorporate Taguchi Methods into existing corporate activities.

In short, the primary goals of this handbook are

- ❏ To provide a guidebook for engineers, management, and academia on the Quality Engineering methodology.
- ❏ To provide organizations with proven techniques for becoming more competitive in the global marketplace.
- ❏ To collect Dr. Taguchi's theories and practical applications within the confines of one book so the relationships among the tools will be properly understood.
- ❏ To clear up some common misinterpretations about Taguchi's Quality Engineering philosophy.

- ❑ To spread the word about Quality Engineering throughout the world, leading to greater success in all fields in the future.

We strongly believe that every engineer and engineering manager in any field, every quality professional, every engineering faculty member, research and development personnel in all types of organizations, every consultant, educator, or student, and all technical libraries will benefit from having this book.

Subir Chowdhury
Yuin Wu
April 14, 2004

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To all of the contributors and their organizations for sharing their successful case studies.

To the American Supplier Institute, ASI Consulting Group, LLC, and its employees, Board of Directors, and customers for promoting Dr. Taguchi's works over the years.

To our two associate editors, Shin Taguchi of the United States and Hiroshi Yano of Japan, for their dedication and hard work on the manuscript development.

To two of the finest teachers and consultants, Jim Wilkins and Alan Wu, for nonstop passionate preaching of Dr. Taguchi's philosophy.

To our colleagues and friends, Dr. Barry Bebb, Jodi Caldwell, Ki Chang, Bill Eureka, Craig Jensen, John King, Don Mitchell, Gopi Palamaner, Bill Sutherland, Jim Quinlan, and Brad Walker, for effectively promoting Dr. Taguchi's philosophy.

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About the Authors

DR. GENICHI TAGUCHI is Executive Director of American Supplier Institute (ASI). Over the past three decades, he has promoted his continually evolving philosophy of quality engineering (called Taguchi Methods™ in the United States) through the Japanese Society for Quality Control, Japanese Standards Association (JSA), Japanese Union of Scientists and Engineers (JUSE), and Central Japan Quality Control Association (CJQCA). In 1982, the American Supplier Institute first introduced Dr. Taguchi and his methods to the United States. Since that time his methods, including techniques for engineering, business, and management, have saved American companies millions of dollars in product development and warranty costs.

Dr. Taguchi has been awarded the coveted Deming Prize on three separate occasions for his contributions to the field of quality engineering. In 1986, he received the Willard F. Rockwell Medal for combining engineering and statistical methods to achieve rapid improvements in cost and quality by optimizing product design and manufacturing processes. He received the Blue Ribbon Award from the Emperor of Japan in 1990 for his contribution to industry and the Shewhart Medal from the American Society for Quality (ASQ) in 1996. In 1997, Dr. Taguchi was elected as an Honorary Member of the ASQ, the highest honor of the ASQ, and is only the third Japanese to be inducted into the Automotive Hall of Fame in Dearborn, Michigan.

DR. SUBIR CHOWDHURY is chairman and CEO of American Supplier Institute (ASI) Consulting Group—the world leader on Six Sigma, Design For Six Sigma and Quality Leadership implementation consulting and training. A respected quality strategist, Dr. Chowdhury's clients include global *Fortune* 100 companies as well as small organizations in both the public and private sectors. Hailed by the *New York Times* as a "leading quality expert," Dr. Chowdhury is the author of eleven books, including international bestseller *The Power of Six Sigma,* which has been translated in more than 20 languages and has sold more than a million copies worldwide. Dr. Chowdhury's *Design for Six Sigma* (DFSS) is the *first* book on the topic and is credited with popularizing DFSS philosophy in the United States and around the globe. His *Management 21C* was selected as the Best Business Book of 1999 by Amazon.com in U.K. and translated into more than ten languages. His most recent book is *Next Generation Business Handbook* (Wiley, September 2004).

Dr. Chowdhury has received numerous international awards for his leadership in quality management and his major contributions to various industries worldwide. In addition to being honored by the Automotive Hall of Fame, the Society of Automotive Engineers awarded him its most prestigious recognition, the *Henry Ford II Distinguished Award for Excellence in Automotive Engineering*. He also received *Honorable U.S. Congressional Recognition* and the Society of Manufacturing Engineers' *Gold Medal*. The American Society for Quality honored him with the first *Philip Crosby Medal* for authoring the most influential business book on Six Sigma. He is also an honorary member of the World Innovation Foundation and International Technology Institute (ITI). In 2004 Dr. Chowdhury was inducted into the Hall of Fame for Engineering, Science and Technology (World Level) and the ITI honored him with its most prestigious *Rockwell Medal for Excellence in Technology*.

Dr. Chowdhury has an undergraduate degree in aerospace engineering from the Indian Institute of Technology (IIT), Kharagpur, India, a graduate degree in industrial management from Central Michigan University (CMU), and an honorary doctorate in engineering from the Michigan Technological University. In 2003, in its golden anniversary, IIT featured Dr. Chowdhury as one of its top 15 eminent alumni and CMU awarded him with its Distinguished Alumni Award (which has been bestowed upon only 22 alumni in its 100-plus year history). Most engineering schools and business schools throughout the world include his engineering and management books in undergraduate and graduate programs. Dr. Chowdhury lives with his wife and daughter in Northville, Michigan.

YUIN WU received a B.S. in chemical engineering from Cheng Kung University, taught as a professor at several institutions in Taiwan, and held senior management positions with industrial firms in Taiwan as well. Mr. Wu was a past Executive Director of ASI.

Mr. Wu was active in quality control and improvement. He became acquainted with Dr. Taguchi in 1966 while in Japan on a study sponsored by the Taiwan government. Mr. Wu made some of the first English (and Chinese) translations of Dr. Taguchi's works. He is also credited with conducting the first Taguchi Methods experiments in the United States while working with private industry in California.

He worked with the American Supplier Institute (and its predecessor, the Ford Supplier Institute) since 1982, and also provided consultation and training in many diverse Taguchi Methods applications. He was active as a consultant in North America as well as many countries in Europe, South America, and Asia. He was trained for the automotive, computer, and defense companies and also mechanical, electrical, chemical, and food industries. He wrote numerous publications on the subject of Taguchi Methods.