

**Richard C. Neuman**

# **Experimental Strategies for Polymer Scientists and Plastics Engineers**



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**Experimental Strategies for Polymer Scientists and  
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# Foreword

The Society of Plastics Engineers is pleased to sponsor and endorse *Experimental Strategies for Polymer Scientists and Plastics Engineers* by R.C. Neuman. This volume offers a comprehensive strategy unifying important concepts and methods not normally addressed in one text. This manual presents scientists and engineers with usable strategies and analytical tools for problem solving.

SPE, through its Technical Volumes Committee, has long sponsored books on various aspects of plastics. Its involvement has ranged from identification of needed volumes and recruitment of authors to peer review and approval and publication of new books.

Technical competence pervades all SPE activities, not only in the publication of books, but also in other areas such as sponsorship of technical conferences and educational programs. In addition, the Society publishes periodicals including *Plastics Engineering*, *Polymer Engineering and Science*, *Journal of Vinyl & Additive Technology*, and *Polymer Composites* as well as conference proceedings and other publications, all of which are subject to rigorous technical review procedures.

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# Preface

Success in today's fast-paced plastics industry depends on

- timely introduction of new and improved products; and
- solving problems quickly and permanently.

These tasks involve experimentation. The use of sound methodology can reduce the time and cost invested in these important activities.

Unfortunately, many of the polymer scientists and plastics engineers assigned to these tasks have not been trained in experimental design or data analysis methods. This book is dedicated to helping these workers to use good planning and sound techniques in their everyday work by:

1. outlining important planning steps that must precede experimental activities;
2. presenting experimental designs that can be used to improve their experimental efficiency without formal statistical training;
3. teaching data collection and analysis techniques that can actually improve data quality and confidence in the conclusions drawn from it; and
4. providing guidance useful in
  - defining objectives before experimental work begins; and
  - minimizing errors, testing time and project costs.

Scientists and engineers willing to learn and apply the principles presented in this book will become more productive in their work and more convincing in their communications about it.

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# I Introduction

This book presents strategies that help polymer scientists and plastics engineers to become more effective and efficient in their everyday experimental work. The author has used these techniques, and has helped others in the plastics industry to use them in formulation development and process optimization tasks. They have been refined through years of use. They do work!

Before digging in, it may be interesting to see why better techniques are needed, and how they can improve the performance and communications of those involved in experimental work.

Chapters 1 and 2 attempt to answer these questions by exploring

- the Needs of Industry, and
- the Need for Education.



# 1 The Needs of Industry

I wish I might, I wish I may  
Have the answer yesterday.

## 1.1 Time Grows Shorter

We live and work in a world of increasing technological innovation. One needs only to review any decade of recent history to observe the creation of new industries, and the rapid development of existing ones. A beautiful example is the recent rapid growth in the recycling of post-consumer plastics.

Many, if not most, of these developments are technical in nature. Computers, communications systems, process controls, and the like depend on electronic inventions and innovations. New and improved plastic materials for construction, industrial, and consumer products are developed using materials science and experimentation.

An increasingly important requirement in the plastics industry is the rapid development and introduction of new and improved products. A window of opportunity may be defined by technological development, social pressure, legislative action (as in the case of recycling) or competitive activity. When a product introduction misses such a window, the investments in marketing, product development, and manufacturing may become direct losses to the business.

Timeliness can mean everything!

Products that, until only a short time ago, needed years to develop, are being introduced in months today. In some unfortunate cases, they are introduced too soon. Product flaws may have been ignored, or may remain undiscovered because there "just wasn't time to do it right the first time." Such mistakes can be costly to companies in dollars and good will, and to the careers of those involved.



## 1.2 Product and Process Development

The risk of coming in second in the market must be weighed against the risk of premature product introduction. This dichotomy puts great pressure on product development scientists and engineers. Not only must their work be documented, and done thoroughly, correctly, and within cost targets; but with equal importance, it must be completed on time! The application of a few basic principles may help these technical personnel to achieve the objectives of timeliness and thoroughness:

1. Use a systematic, well-documented approach to promote efficiency, good communication and close coordination among the disciplines and departments involved.
2. Define objectives quantitatively before work is begun. Define project completion criteria mathematically, not emotionally! Unless this is done, there can be no understanding or agreement on project status among the departments involved.

It is likely to be a challenge to achieve consensus on a quantitatively defined product or process specification. Requirements are often difficult to define. In some cases, performance criteria are defined by industry or government standards. Replacement products can be based, in part, on the performance criteria of the products being replaced. New products may require new standards of appearance and performance to be defined, making the product development assignment even more difficult.

3. Rigorously inspect all experimental work for statistical significance, even when neither the technical nor the reviewing personnel have formal statistical training. This conundrum is solved by using appropriate software or the services of a statistician, or by applying the principles presented in this book.
4. Demonstrate that all problem solutions are effective to the degree of confidence set forth in the objectives.

### 1.2.1 Quality Assurance

Quality assurance is often done by finished goods inspection and testing. This approach may not be satisfactory for sophisticated products, complex processes, or world-class customers. Indeed, the inadequacy of this approach may not even be recognized.