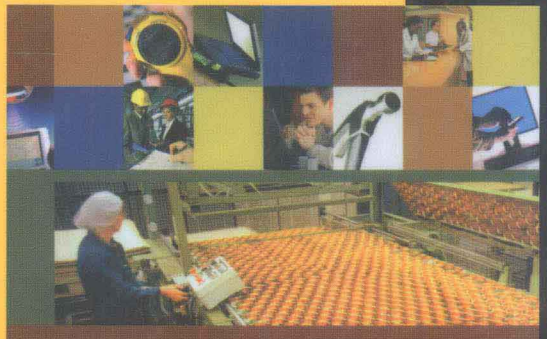
国外大学优秀教材——工业工程系列（影印版）

Andris Freivalds, Benjamin W. Niebel

李志忠 改编

方法、标准与作业设计

（第12版）



Niebel's Methods, Standards, and Work Design

Twelfth Edition

Andris Freivalds

Mc Graw Hill

清华大学出版社

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Twelfth Edition

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Forward

This textbook series is published at a very opportunity time when the discipline of industrial engineering is experiencing a phenomenal growth in China academia and with its increased interests in the utilization of the concepts, methods and tools of industrial engineering in the workplace. Effective utilization of these industrial engineering approaches in the workplace should result in increased productivity, quality of work, satisfaction and profitability to the cooperation.

The books in this series should be most suitable to junior and senior undergraduate students and first year graduate students, and to those in industry who need to solve problems on the design, operation and management of industrial systems.

Gavriel Salvendy

Department of Industrial Engineering, Tsinghua University

School of Industrial Engineering, Purdue University

April, 2002

前　言

本教材系列的出版正值中国学术界工业工程学科经历巨大发展、实际工作中对工业工程的概念、方法和工具的使用兴趣日渐浓厚之时。在实际工作中有效地应用工业工程的手段将无疑会提高生产率、工作质量、合作的满意度和效果。

该系列中的书籍对工业工程的本科生、研究生和工业界中需要解决工程系统设计、运作和管理诸方面问题的人士最为适用。

加弗瑞尔·沙尔文迪
清华大学工业工程系
普渡大学工业工程学院（美国）
2002 年 4 月

Preface

BACKGROUND

Faced with increasing competition from all parts of the world, almost every industry, business, and service organization is restructuring itself to operate more effectively. As downsizing and outsourcing become more common, these organizations must increase the intensity of cost reduction and quality improvement efforts while working with reduced labor forces. Cost-effectiveness and product reliability without excess capacity are the keys to successful activity in all areas of business, industry, and government and are the end result of methods engineering, equitable time standards, and efficient work design.

Also, as machines and equipment grow increasingly complex and semiautomated if not fully automated, it is increasingly important to study both the manual components and the cognitive aspects of work as well as the safety of the operations. The operator must perceive and interpret large amounts of information, make critical decisions, and control these machines both quickly and accurately. In recent years, jobs have shifted gradually from manufacturing to the service sector. In both sectors, there is increasingly less emphasis on gross physical activity and a greater emphasis on information processing and decision making, especially via computers and associated modern technology. The same efficiency and work design tools are the keys to productivity improvement in any industry, business, or service organization, whether in a bank, a hospital, a department store, a railroad, or the postal system. Furthermore, success in a given product line or service leads to new products and innovations. It is this accumulation of successes that drives hiring and the growth of an economy.

The reader should be careful not to be swayed or intimidated by the latest jargon offered as a cure-all for an enterprise's lack of competitiveness. Often these fads sideline the sound engineering and management procedures that, when properly utilized, represent the key to continued success. Today we hear a good deal about reengineering and use of cross-functional teams as business leaders reduce cost, inventory, cycle time, and nonvalue activities. However, experience in the past few years has proved that cutting people from the payroll just for the sake of automating their jobs is not always the wise procedure. The authors, with many years of experience in over 100 industries, strongly recommend sound methods engineering, realistic standards, and good work design as the keys to success in both manufacturing and service industries.

WHY THIS BOOK WAS WRITTEN

The objectives of the twelfth edition have remained the same as for the eleventh: to provide a practical, up-to-date college textbook describing engineering methods to measure, analyze, and design manual work. The importance of ergonomics and work design as part of methods engineering is emphasized, not only to increase productivity, but also to improve worker health and safety and thus company bottom-line costs. Far too often, industrial engineers have focused solely on increasing productivity through methods changes and job simplification, resulting in overly repetitive jobs for the operators and increased incidence rates of musculoskeletal injuries. Any cost reductions obtained are more than offset by the increased medical and worker's compensation costs, especially considering today's ever-escalating health care costs.

WHAT'S NEW IN THE TWELFTH EDITION

A new Chapter 8 on workplace and systems safety has been added that includes material on accident causation models, accident prevention, quantitative analyses, and general hazard control. This then completes the knowledge that a basic industrial engineer should have for managing a production line or a service center. Old Chapters 10 and 11 on ratings and allowances were combined as support materials to the new Chapter 10 on time study. Chapter 13 was expanded to include more material on BasicMOST.

Approximately 10 to 15 percent more examples, problems, and case studies have been added. The twelfth edition still provides a continued reliance on work design, work measurement, facilities layout, and various flow process charts for students entering the industrial engineering profession and serves as a practical, up-to-date source of reference material for the practicing engineer and manager.

HOW THIS BOOK DIFFERS FROM OTHERS

Most textbooks on the market deal strictly either with the traditional elements of motion and time study or with human factors and ergonomics. Few textbooks integrate both topics into one book or, for that matter, one course. In this day and age, the industrial engineer needs to consider both productivity issues and their effects on the health and safety of the worker simultaneously. Few of the books on the market are formatted for use in the classroom setting. This text includes additional questions, problems, and sample laboratory exercises to assist the educator. Finally, no text provides the extensive amount of online student and instructor resources, electronic forms, current information, and changes as this edition does.

ORGANIZATION OF THE TEXT AND COURSE MATERIAL

The twelfth edition is laid out to provide roughly one chapter of material per week of a semester-long introductory course. Although there are a total of 18 chapters,

Chapter 1 is short and introductory, much of Chapter 7 on cognitive work design and Chapter 8 on safety may be covered in other courses, and Chapter 15 on standards for indirect and expense work may not need to be covered in an introductory course, all of which leaves only 15 chapters to be covered in the semester.

A typical semester plan, chapter by chapter, using the first lecture number, might be as follows:

Chapter	Lectures	Coverage
1	1	Quick introduction on the importance of productivity and work design, with a bit of historical perspective.
2	3–6	A few tools from each area (Pareto analysis, job analysis/worksite guide, flow process charts, worker–machine charts) with some quantitative analysis on worker–machine interactions. Line balancing and PERT may be covered in other courses.
3	4	Operation analysis with an example for each step.
4	4	Full, but can gloss over basic muscle physiology and energy expenditure.
5	4	Full.
6	3–4	Basics on illumination, noise, temperature; other topics as desired may be covered in another course.
7	0–4	Coverage depends on instructor's interest; may be covered in another course.
8	0–5	Coverage depends on instructor's interest; may be covered in another course.
9	3–5	Three tools: value engineering, cost-benefit analysis, and crossover charts; job analysis and evaluation, and interaction with workers. Other tools may be covered in other classes.
10	3	Basics of time study.
11	3–5	One form of rating; first half of the allowances that are well established.
12	1–3	Coverage of standard data and formulas depends on instructor's interest.
13	4–7	Only one predetermined time system in depth; the second may be covered in another course.
14	2–3	Work sampling.
15	0–3	Coverage of indirect and expense labor standards depends on instructor's interest.
16	2–3	Overview and costing.
17	3–4	Day work and standard hour plan.
18	3–4	Learning curves, motivation, and people skills.

The recommended plan covers 43 lectures, with two periods for examinations. Some instructors may wish to spend more time on any given chapter, for which additional material is supplied, for example, work design (Chapters 4 to 7), and less time on traditional work measurement (Chapters 8 to 16), or vice versa. The text allows for this flexibility.

Similarly, if all the material is used (the second lecture number), there is enough material for one lecture course and one course with a lab, as is done at Penn State University. Both courses have been developed with appropriate materials such that they can be presented completely online. For an example of an online course using this text, go to *www.engr.psu.edu/cde/courses/ie327/index.html*

SUPPLEMENTARY MATERIAL AND ONLINE SUPPORT

The twelfth edition of this text continues to focus on the ubiquitous use of PCs as well as the Internet to establish standards, conceptualize possibilities, evaluate costs, and disseminate information. A website, hosted by the publisher at *www.mhhe.com/niebel-freivalds*, furthers that objective by providing the educator with various online resources, such as an updated instructor's manual. DesignTools version 4.1.1, a ready-to-use software program for ergonomics analysis and work measurement, appears on the site as well. A special new feature of DesignTools is the addition of QuikTS, a time study data collection program, and QuikSamp, a work sampling program. The program may be downloaded via hot synch to a Palm device (m105 or higher) and used to collect time study data. The data are then uploaded directly to the time study form on DesignTools for easy and accurate calculation of standard time.

The book's website also links to a website hosted by the author at *www2.ie.psu.edu/Freivalds/courses/ie327new/index.html* which provides instructors with online background material, including electronic versions of the forms used in the textbook. Student resources include practice exams and solutions. Up-to-date information on any errors found or corrections needed in this new edition appear on this site as well. Suggestions received from individuals at universities, colleges, technical institutes, industries, and labor organizations that regularly use this text have helped materially in the preparation of this twelfth edition. Further suggestions are welcome, especially if any errors are noticed. Please simply respond to the OOPS! button on the website or by email to *axf@psu.edu*

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I wish to acknowledge the late Ben Niebel for providing me with the opportunity to contribute to his well-respected textbook. I hope the additions and modifications will match his standards and continue to serve future industrial engineers as they enter their careers. Thanks to Dr. Dongjoon Kong, University of Tennessee,

for devoting so much of his time at Penn State to programming DesignTools. Thanks also to the following reviewers for their invaluable input:

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Finally, I wish to express my gratitude to Dace for her patience and support.

Andris Freivalds

FORMULAS

SYNCHRONOUS SERVICING

$$n = \frac{l + m}{l + w}$$

$$\text{TEC}_{n1} = \frac{(l + m)(K_1 + n_1K_2)}{n_1}$$

$$\text{TEC}_{n2} = (l + w)(K_1 + n_2K_2)$$

RANDOM SERVICING

$$\frac{n!}{m!(n - m)!}p^m q^{n-m}$$

$$\text{TEC} = \frac{K_1 + nK_2}{R}$$

LINE EFFICIENCY

$$E = \frac{\Sigma\text{SM}}{\Sigma\text{AM}} * 100 \qquad N = \frac{R * \Sigma\ \text{SM}}{E}$$

FITT'S LAW

$$\text{MT} = a + b \log_2 \frac{2D}{W}$$

RECOMMENDED REST

$$R = \frac{W - 5.33}{W - 1.33}$$

LIFTING GUIDELINES

$$\text{RWL (lb)} = 51(10/H)(1 - 0.0075|\text{V} - 30|)$$
$$(0.82 + 1.8/D)(1 - 0.0032A)\text{FM} \times \text{CM}$$

$$\text{LI} = \text{Load weight/RWL}$$

NOISE DOSE

$$D = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots \leq 1.0$$

HEAT STRESS

$$\text{WBGT}_{\text{IN}} = 0.7\text{WB} + 0.3\text{GT}$$
$$\text{WBGT}_{\text{OUT}} = 0.7\text{WB} + 0.1\text{DB} + 0.2\text{GT}$$

INCIDENCE RATE

$$\text{IR} = 200{,}000\frac{I}{H}$$

SECERITY RATE

$$\text{SR} = 200{,}000\frac{\text{LT}}{H}$$

INFORMATION PROCESSING

$$H = \Sigma p_i \times \log_2(1/p_i)$$
$$\log_2 n = 1.4427 \ln n$$
$$\%\ \text{redundancy} = (1 - H/H_{\max}) \times 100$$
$$\text{RT} = a + bH$$

TIME STUDY

$$n = \left(\frac{st}{k\bar{x}}\right)^2$$

$$\text{NT} = \frac{\text{OT} \times \text{Rating}}{100}$$

$$\text{ST} = \text{NT}(1 + \text{Allowance})$$

SYNTHETIC RATING

$$P = \frac{f_T}{\text{OT}}$$

MACHINE INTERFERENCE $I = 50\left[\sqrt{(1+X-N)^2+2N}-(1+X-N)\right]$

CHI-SQUARE $\chi^2 = \Sigma_{i=1}^{m}(E_i - O_i)^2/E_i$

$E_i = H_i \times O_T/H_T$

INCIDENCE AND SEVERITY RATES $\text{IR} = 200{,}000 \times I/H$

$\text{SR} = 200{,}000 \times \text{LT}/H$

PROBABILITY RELATIONSHIPS

$$P(X + Y) = P(X) + P(Y) - P(XY)$$

$$P(X + Y + Z) = 1 - [1 - P(X)]\,[1 - P(Y)]\,[1 - P(Z)]$$

$$P(XY) = P(X)P(Y)$$

$$P(Y/X) = P(Y)\,P(X/Y)/P(X) \quad \text{(Bayes' rule)}$$

DISTRIBUTIVE LAWS $(X + Y)(X + Z) = X + YZ$

$XY + XZ = X(Y + Z)$

MISCELLANEOUS SAFETY $\text{PE} = mgh$

$\text{KE} = \frac{1}{2}\,mv^2$

$V = RI$

WORK SAMPLING $n = \dfrac{3.84p(1-p)}{l^2}$

$\text{OT} = \dfrac{T}{P} \times \dfrac{n_i}{n}$

POISSON PROBABILITY $p(k) = \dfrac{a^k e^{-a}}{k!}$

LABOR EFFICIENCY $E = \dfrac{H_e}{H_c}$

MATERIAL COSTS $\text{Cost} = Q(1 + L_{sc} + L_w + L_{sh})C - S$

WAGE INCENTIVE $\text{Wages } y_w = 1 + p(x - 1)$

$\text{Unit labor costs } y_c = \dfrac{y_w}{x}$

LEARNING CURVE $y = kx^n \quad n = \dfrac{\log\ (\text{learning ratio})}{\log 2}$

$\text{Total learning time} \quad T = k\dfrac{(x_2 + \frac{1}{2})^{n+1} - (x_1 - \frac{1}{2})^{n+1}}{n+1}$

$\text{Remission line} \quad y = k + \dfrac{(k-s)(x-1)}{1 - x_s}$

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