



RE 3003

Introduction to Quality

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Spring 2025

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RE3003 @ IIT Kharagpur

Syllabus

- 1** Introduction (W#1)
- 2** Management Aspects of Quality (W#2)
- 3** Review of Probability Theory (W#3)
- 4** Descriptive Statistics (W#4)
- 5** Discrete Distributions (W#5)
- 6** Continuous Distributions (W#6)
- 7** Distribution Selection Techniques (W#7)
- 8** Six-Sigma Quality Control (W#8)
- 9** Statistical Methods for Quality Improvement (W #8)
- 10** Quality Control Tools (W#9)
- 11** Control Charts (W#10)
- 12** R Programming (W#10)
- 13** Failure Modes, Effects, and Criticality Analysis (W#11)
- 14** Product Reliability (W #12)

Grading Criteria: Final Exam (50%), Midterm Exam (30%), Assignment (20%)

Text/Reference Books

Text Book:

Douglas C. Montgomery: Introduction to Statistical Quality Control

Reference Books:

Amitava Mitra: Fundamentals of Quality Control and Improvement

M. Jeya Chandra: Statistical Quality Control

E. L. Cano, J. M. Moguerza, M. P. Corcoba: Quality Control with R

E. L. Cano, J. M. Moguerza, A. Redchuck: Six Sigma with R

1 Introduction

Definition of Quality

Traditional Definition: Quality means fitness for use.

Two general aspects of *fitness for use*:

- 1 **Quality of Design:** The product meets user needs, ensuring functionality, usability, safety, and overall user satisfaction.
- 2 **Quality of Conformance:** The product conforms to the specifications required by the design.

Modern Definition: Quality is inversely proportional to variability.

According to the modern definition, if *variability* in one or more important characteristics of a product *decreases*, the *quality* of the product *increases*.

Thus, *quality improvement* is the reduction of variability in processes and products.

Dimensions of Quality

Quality of products can be described/evaluated using several *dimensions*.

Performance: Ability of a product to perform specific functions effectively.

Reliability: Consistency and dependability of a product to perform its intended function without failure or breakdown over a period of time.

Durability: Ability of a product to withstand wear, use, or damage over time, maintaining its functionality for an extended period.

Serviceability: Ease with which a product can be repaired, maintained, or serviced when necessary.

Aesthetics: Visual appeal, design elements, and overall attractiveness, encompassing aspects such as style, form, color, texture, and visual harmony.

Dimensions of Quality (cont'd)

Features: Distinctive characteristics, functionalities, or attributes of a product that contribute to its usability and overall value.

Perceived Quality: Customer's subjective evaluation or impression of the product's excellence, reliability, and overall superiority based on brand reputation, aesthetics, features, and customer experiences.

Conformance to Standards: Extent to which a product meets or complies with established industry, regulatory, or internal standards, specifications, or benchmarks.

Customer Concern vs. Quality Dimension

Customer Concern	Quality Criteria
<i>Will the product do the intended job?</i>	Performance
<i>How often does the product fail?</i>	Reliability
<i>How long does the product last?</i>	Durability
<i>How easy is it to repair the product?</i>	Serviceability
<i>What does the product look like?</i>	Aesthetics
<i>What does the product do?</i>	Features
<i>What is the reputation of the company or its product?</i>	Perceived Quality
<i>Is the product made exactly as the designer intended?</i>	Conformance to Standards

Quality Engineering Terminologies

Quality engineering is the set of operational, managerial, and engineering activities that a company uses to ensure that

- The *quality characteristics* of a product are at the nominal or required levels.
- The *variability* around these desired levels is minimum.

Every product possesses a number of elements often called *quality* or *critical-to-quality (CTQ)* characteristics:

- *Physical*: Length, weight, voltage, viscosity
- *Sensory*: Taste, appearance, color
- *Time orientation*: Reliability, durability, serviceability

Quality Engineering Terminologies (cont'd)

In the application of statistical methods to quality engineering, data are typically classified as either *attributes* or *variables* data:

- *Variables* data are continuous measurements.
- *Attributes* data are discrete data, taking the form of counts.

Quality characteristics are evaluated relative to *specifications*, i.e., desired measurements and values, for a manufactured final product:

- *Nominal or target* value is the desired value for a quality characteristic.
- *Upper specification limit (USL)* is the largest allowable value for a quality characteristic
- *Lower specification limit (LSL)* is the smallest allowable value for a quality characteristic.

Quality Engineering Terminologies (cont'd)

Nonconforming products are those that fail to meet one or more of their specifications for quality characteristics.

A **defective product** has one or more nonconformities that are serious enough to significantly affect the **safe** or **effective** use of the product.

A nonconforming product is not necessarily unfit for use!

History of Quality

1700–1900	Quality is largely determined by the efforts of an individual craftsman. Eli Whitney introduces standardized, interchangeable parts to simplify assembly.
1875	Frederick W. Taylor introduces “Scientific Management” principles to divide work into smaller, more easily accomplished units—the first approach to dealing with more complex products and processes. The focus was on productivity. Later contributors were Frank Gilbreth and Henry Gantt.
1900–1930	Henry Ford—the assembly line—further refinement of work methods to improve productivity and quality; Ford developed mistake-proof assembly concepts, self-checking, and in-process inspection.
1901	First standards laboratories established in Great Britain.
1907–1908	AT&T begins systematic inspection and testing of products and materials.
1908	W. S. Gosset (writing as “Student”) introduces the <i>t</i> -distribution—results from his work on quality control at Guinness Brewery.
1915–1919	WWI—British government begins a supplier certification program.
1919	Technical Inspection Association is formed in England; this later becomes the Institute of Quality Assurance.
1920s	AT&T Bell Laboratories forms a quality department—emphasizing quality, inspection and test, and product reliability. B. P. Dudding at General Electric in England uses statistical methods to control the quality of electric lamps.
1922	Henry Ford writes (with Samuel Crowther) and publishes <i>My Life and Work</i> , which focused on elimination of waste and improving process efficiency. Many Ford concepts and ideas are the basis of lean principles used today.
1922–1923	R. A. Fisher publishes series of fundamental papers on designed experiments and their application to the agricultural sciences.
1924	W. A. Shewhart introduces the control chart concept in a Bell Laboratories technical memorandum.
1928	Acceptance sampling methodology is developed and refined by H. F. Dodge and H. G. Romig at Bell Labs.
1931	W. A. Shewhart publishes <i>Economic Control of Manufactured Product</i> —outlining statistical methods for use in production and control chart methods.

History of Quality (cont'd)

1932	W. A. Shewhart gives lectures on statistical methods in production and control charts at the University of London.
1932–1933	British textile and woolen industry and German chemical industry begin use of designed experiments for product/process development.
1933	The Royal Statistical Society forms the Industrial and Agricultural Research Section.
1938	W. E. Deming invites Shewhart to present seminars on control charts at the U.S. Department of Agriculture Graduate School.
1940	The U.S. War Department publishes a guide for using control charts to analyze process data.
1940–1943	Bell Labs develop the forerunners of the military standard sampling plans for the U.S. Army.
1942	In Great Britain, the Ministry of Supply Advising Service on Statistical Methods and Quality Control is formed.
1942–1946	Training courses on statistical quality control are given to industry; more than 15 quality societies are formed in North America.
1944	<i>Industrial Quality Control</i> begins publication.
1946	The American Society for Quality Control (ASQC) is formed as the merger of various quality societies. The International Standards Organization (ISO) is founded. Deming is invited to Japan by the Economic and Scientific Services Section of the U.S. War Department to help occupation forces in rebuilding Japanese industry. The Japanese Union of Scientists and Engineers (JUSE) is formed.
1946–1949	Deming is invited to give statistical quality control seminars to Japanese industry.
1948	G. Taguchi begins study and application of experimental design.
1950	Deming begins education of Japanese industrial managers; statistical quality control methods begin to be widely taught in Japan.
1950–1975	Taiichi Ohno, Shigeo Shingo, and Eiji Toyoda develops the Toyota Production System an integrated technical/social system that defined and developed many lean principles such as just-in-time production and rapid setup of tools and equipment. K. Ishikawa introduces the cause-and-effect diagram.

History of Quality (cont'd)

1950s	Classic texts on statistical quality control by Eugene Grant and A. J. Duncan appear.
1951	A. V. Feigenbaum publishes the first edition of his book <i>Total Quality Control</i> . JUSE establishes the Deming Prize for significant achievement in quality control and quality methodology.
1951+	G. E. P. Box and K. B. Wilson publish fundamental work on using designed experiments and response surface methodology for process optimization; focus is on chemical industry. Applications of designed experiments in the chemical industry grow steadily after this.
1954	Joseph M. Juran is invited by the Japanese to lecture on quality management and improvement. British statistician E. S. Page introduces the cumulative sum (CUSUM) control chart.
1957	J. M. Juran and F. M. Gryna's <i>Quality Control Handbook</i> is first published.
1959	<i>Technometrics</i> (a journal of statistics for the physical, chemical, and engineering sciences) is established; J. Stuart Hunter is the founding editor. S. Roberts introduces the exponentially weighted moving average (EWMA) control chart. The U.S. manned spaceflight program makes industry aware of the need for reliable products; the field of reliability engineering grows from this starting point.
1960	G. E. P. Box and J. S. Hunter write fundamental papers on 2^{k-p} factorial designs. The quality control circle concept is introduced in Japan by K. Ishikawa.
1961	National Council for Quality and Productivity is formed in Great Britain as part of the British Productivity Council.
1960s	Courses in statistical quality control become widespread in industrial engineering academic programs. Zero defects (ZD) programs are introduced in certain U.S. industries.
1969	<i>Industrial Quality Control</i> ceases publication, replaced by <i>Quality Progress</i> and the <i>Journal of Quality Technology</i> (Lloyd S. Nelson is the founding editor of <i>JQT</i>).
1970s	In Great Britain, the NCQP and the Institute of Quality Assurance merge to form the British Quality Association.
1975–1978	Books on designed experiments oriented toward engineers and scientists begin to appear. Interest in quality circles begins in North America—this grows into the total quality management (TQM) movement.

History of Quality (cont'd)

1980s	Experimental design methods are introduced to and adopted by a wider group of organizations, including the electronics, aerospace, semiconductor, and automotive industries. The works of Taguchi on designed experiments first appear in the United States.
1984	The American Statistical Association (ASA) establishes the Ad Hoc Committee on Quality and Productivity; this later becomes a full section of the ASA. The journal <i>Quality and Reliability Engineering International</i> appears.
1986	Box and others visit Japan, noting the extensive use of designed experiments and other statistical methods.
1987	ISO publishes the first quality systems standard. Motorola's Six Sigma initiative begins.
1988	The Malcolm Baldrige National Quality Award is established by the U.S. Congress. The European Foundation for Quality Management is founded; this organization administers the European Quality Award.
1989	The journal <i>Quality Engineering</i> appears.
1990s	ISO 9000 certification activities increase in U.S. industry; applicants for the Baldrige award grow steadily; many states sponsor quality awards based on the Baldrige criteria.
1995	Many undergraduate engineering programs require formal courses in statistical techniques, focusing on basic methods for process characterization and improvement.
1997	Motorola's Six Sigma approach spreads to other industries.
1998	The American Society for Quality Control becomes the American Society for Quality (see www.asq.org), attempting to indicate the broader aspects of the quality improvement field.
2000s	ISO 9000:2000 standard is issued. Supply-chain management and supplier quality become even more critical factors in business success. Quality improvement activities expand beyond the traditional industrial setting into many other areas, including financial services, health care, insurance, and utilities. Organizations begin to integrate lean principles into their Six Sigma initiatives, and lean Six Sigma becomes a widespread approach to business improvement.