**SIX-SIGMA QUALITY**

**286 Total Quality Management**

*Total quality management defined*

*Malcolm Baldrige National Quality Award defined*

**288 Quality Specification and Quality Costs**

Developing quality specifications *Design quality defined*

Cost of quality *Conformance quality defined*

Functions of the QC department *Quality at the source defined*

*Dimensions of quality defined*

*Cost of quality defined*

**291 Six-Sigma Quality**

Six-Sigma methodology *Six Sigma defined*

Analytical tools for Six Sigma and *DPMO defined*

continuous improvement *DMAIC defined*

Six-Sigma roles and responsibilities *PDCA cycle defined*

*Continuous improvement defined*

*Kaizen defined*

*Lean Six Sigma defined*

*Black belts, master black belts, and green belts defined*

**297 The Shingo System: Fail-Safe Design**

*Fail-safe procedures defined*

*Poka-yoke defined*

**298 ISO 9000 and ISO 14000**

*ISO 9000 defined*

**300 External Benchmarking for Quality Improvement**

*External benchmarking defined*

**300 Summary**

**302 Case: Hank Kolb, Director of Quality Assurance**

**303 Case: Appreciative Inquiry—A Different Kind**

**of Fishbone**

bchop\_tt

chapter 9

General Electric (GE) has been a major promoter of Six Sigma for more than 10 years. Jack Welch, the legendary and now retired CEO, declared that “the big myth is that Six Sigma is about quality control and statistics. It is that—but it’s much more.

Ultimately, it drives leadership to be better by providing tools to think through tough issues. At Six Sigma’s core is an idea that can turn a company inside out, focusing the organization outward on the customer.” GE’s commitment to quality centers on Six Sigma. Six Sigma is defined on the GE Web site as follows:

First, What is Six Sigma? First, what it is not. It is not a secret society, a slogan or a cliché. Six Sigma is a highly disciplined process that helps us focus on developing and delivering near-perfect products and services. Why “Sigma”? The word is

a statistical term that measures how far a given process deviates

from perfection. The central idea behind Six Sigma is that if

you can measure how many “defects” you have in a process, you

can systematically figure out how to eliminate them and get as

close to “zero defects” as possible. To achieve Six Sigma Quality,

a process must produce no more than 3.4 defects per million

opportunities. An “opportunity” is defined as a chance for nonconformance,

or not meeting the required specifications. This means

we need to be nearly flawless in executing our key processes.

At its core, Six Sigma revolves around a few key concepts.

Critical to Quality: Attributes most important to the customer

Defect: Failing to deliver what the customer wants

Process Capability: What your process can deliver

Variation: What the customer sees and feels

**After reading this chapter you will:**

1. Understand total quality management.

2. Describe how quality is measured

and be aware of the different dimensions

of quality.

3. Explain the define, measure, analyze,

improve, and control (DMAIC)

quality improvement process.

4. Understand what ISO certification

means.

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Stable Operations: Ensuring consistent, predictable processes to improve what

the customer sees and feels Design for Six Sigma: Designing to meet customer needs and process capability

In this chapter, we first review the general subject of total quality management and the quality

movement. We then develop the basic features and concepts of the Six-Sigma approach

to TQM. We then describe the Shingo system, which takes a unique approach to quality by

focusing on preventing mistakes. This is followed by a review of ISO 9000 and 14000 standards

for quality certification used by many companies throughout the world. Finally, we

provide the major steps of external benchmarking for quality improvement.

**TOTA L Q U A L I T Y MANAGEMENT**

**Total quality management** may be defined as “managing the entire organization so that it

excels on all dimensions of products and services that are important to the customer.” It has

two fundamental operational goals:

1. Careful design of the product or service.

2. Ensuring that the organization’s systems can consistently produce the design.

These two goals can only be achieved if the entire organization is oriented toward them—

hence the term *total* quality management. TQM became a national concern in the United

States in the 1980s primarily as a response to Japanese quality superiority in manufacturing

automobiles and other durable goods such as room air conditioners. A widely cited study of

Japanese and U.S. air-conditioning manufacturers showed that the best-quality American

products had *higher* average defect rates than those of the poorest Japanese manufacturers. 1

**Total quality management**

*Breakthrough* THE MALCOLM BALDRIGE NATIONAL QUALITY

AWARD

The Award is given to organizations that have demonstrated

outstanding quality in their products and processes. Three

Awards may be given annually in each of these categories:

manufacturing, service, small business, education, health care,

and nonprofit.

Applicants for the Award must submit an application of

50 pages or less that details the processes and results of their

activities under seven major categories: Leadership; Strategic

Planning; Customer and Market Focus; Measurement, Analysis

and Knowledge Management; Workforce Focus; Process

Management; and Results. The applications are scored on total

points out of 1,000 by the Baldrige Board of Examiners and

Judges. High-scoring applications are selected for site visits

and Award recipients are selected from this group. The president

of the United States traditionally presents the Awards at

a special ceremony in Washington, DC. A major benefit to all

applicants is the feedback report prepared by Examiners that

is based on their processes and practices. Many states have

used the Baldrige criteria as the basis of their quality programs.

A report, *Building on Baldrige: American Quality for the*

*21st Century,* by the private Council on Competitiveness, said,

“More than any other program, the Baldrige Quality Award is

responsible for making quality a national priority and disseminating

best practices across the United States.”

**Global**

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So severe was the quality shortfall in the United States that improving it throughout industry

became a national priority, with the Department of Commerce establishing the **Malcolm**

**Baldrige National Quality Award** in 1987 to help companies review and structure their

quality programs. Also gaining major attention at this time was the requirement that suppliers

demonstrate that they are measuring and documenting their quality practices according to

specified criteria, called ISO standards, if they wished to compete for international contracts.

We will have more to say about this later.

The philosophical leaders of the quality movement, notably Philip Crosby, W. Edwards

Deming, and Joseph M. Juran—the so-called Quality Gurus—had slightly different definitions

of what quality is and how to achieve it (see Exhibit 9.1), but they all had the same general

message: To achieve outstanding quality requires quality leadership from senior management,

a customer focus, total involvement of the workforce, and continuous improvement based

upon rigorous analysis of processes. Later in the chapter, we will discuss how these precepts

are applied in the latest approach to TQM—Six Sigma. We will now turn to some fundamental

concepts that underlie any quality effort: quality specifications and quality costs.

**Malcolm Baldrige National**

**Quality Award**

The Quality Gurus Compared **e x h i b i t 9 . 1**

CROSBY DEMING JURAN

Definition of quality Conformance to requirements A predictable degree of Fitness for use (satisfies

uniformity and dependability customer’s needs)

at low cost and suited to the

market

Degree of senior management Responsible for quality Responsible for 94% of Less than 20% of quality

responsibility quality problems problems are due to workers

Performance standard/ Zero defects Quality has many “scales”; Avoid campaigns to do

motivation use statistics to measure perfect work

performance in all areas;

critical of zero defects

General approach Prevention, not inspection Reduce variability by General management

continuous improvement; approach to quality,

cease mass inspection especially human elements

Structure 14 steps to quality 14 points for management 10 steps to quality

improvement improvement

Statistical process control Rejects statistically acceptable Statistical methods of quality Recommends SPC but warns

(SPC) levels of quality (wants 100% control must be used that it can lead to

perfect quality) tool-driven approach

Improvement basis A process, not a program; Continuous to reduce Project-by-project team

improvement goals variation; eliminate goals approach; set goals

without methods

Teamwork Quality improvement teams; Employee participation in Team and quality circle

quality councils decision making; break down approach

barriers between departments

Costs of quality Cost of nonconformance; No optimum; continuous Quality is not free; there is

quality is free improvement not an optimum

Purchasing and goods State requirements; supplier Inspection too late; sampling Problems are complex; carry

received is extension of business; most allows defects to enter system; out formal surveys

faults due to purchasers statistical evidence and control

themselves charts required

Vendor rating Yes; quality audits useless No, critical of most systems Yes, but help supplier

improve

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Fundamental to any quality program is the determination of quality specifications and the

costs of achieving (or *not* achieving) those specifications.

**D E V E L O P I N G Q U A L I T Y S P E C I F I C AT I O N S**

The quality specifications of a product or service derive from decisions and actions made

relative to the quality of its design and the quality of its conformance to that design. **Design**

**quality** refers to the inherent value of the product in the marketplace and is thus a strategic

decision for the firm. The dimensions of quality are listed in Exhibit 9.2. These dimensions

refer to features of the product or service that relate directly to design issues. A firm designs

a product or service to address the need of a particular market.

A firm designs a product or service with certain performance characteristics and features

based on what the intended market expects. Materials and manufacturing process attributes

can greatly impact the reliability and durability of a product. Here the company attempts to

design a product or service that can be produced or delivered at reasonable cost. The serviceability

of the product may have a great impact on the cost of the product or service to the

customer after the initial purchase is made. It also may impact the warranty and repair cost to

the firm. Aesthetics may greatly impact the desirability of the product or service, in particular

consumer products. Especially when a brand name is involved, the design often represents

the next generation of an ongoing stream of products or services. Consistency in the relative

performance of the product compared to the state of the art, for example, may have a great

impact on how the quality of the product is perceived. This may be very important to the

long-run success of the product or service.

**Conformance quality** refers to the degree to which the product or service design specifications

are met. The activities involved in achieving conformance are of a tactical, day-to-day

nature. It should be evident that a product or service can have high design quality but low

conformance quality, and vice versa.

**Quality at the source** is frequently discussed in the context of conformance quality. This

means that the person who does the work takes responsibility for making sure that his or her

output meets specifications. Where a product is involved, achieving the quality specifications

is typically the responsibility of manufacturing management; in a service firm, it is usually

the responsibility of the branch operations management. Exhibit 9.3 shows two examples of

the **dimensions of quality***.* One is a laser printer that meets the pages-per-minute and print

density standards; the second is a checking account transaction in a bank.

Both quality of design and quality of conformance should provide products that meet the

customer’s objectives for those products. This is often termed the product’s *fitness for use,*

and it entails identifying the dimensions of the product (or service) that the customer wants

(that is, the voice of the customer) and developing a quality control program to ensure that

these dimensions are met.

**Design quality**

**Conformance quality**

**Quality at the source**

**Dimensions of quality**

**Q U A L I T Y S P E C I F I C AT I O N A N D Q U A L I T Y COST S**

**e x h i b i t 9 . 2** The Dimensions of Design Quality

DIMENSION MEANING

Performance Primary product or service characteristics

Features Added touches, bells and whistles, secondary characteristics

Reliability/durability Consistency of performance over time, probability of failing, useful life

Serviceability Ease of repair

Aesthetics Sensory characteristics (sound, feel, look, and so on)

Perceived quality Past performance and reputation

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**C O S T O F Q U A L I T Y**

Although few can quarrel with the notion of prevention, management often needs hard numbers

to determine how much prevention activities will cost. This issue was recognized by Joseph

Juran, who wrote about it in 1951 in his *Quality Control Handbook* . Today, **cost of quality**

**(COQ)** analyses are common in industry and constitute one of the

primary functions of QC departments.

There are a number of definitions and interpretations of the

term *cost of quality* . From the purist’s point of view, it means all

of the costs attributable to the production of quality that is not

100 percent perfect. A less stringent definition considers only

those costs that are the difference between what can be expected

from excellent performance and the current costs that exist.

How significant is the cost of quality? It has been estimated

at between 15 and 20 percent of every sales dollar—the cost

of reworking, scrapping, repeated service, inspections, tests,

warranties, and other quality-related items. Philip Crosby states

that the correct cost for a well-run quality management program

should be under 2.5 percent. 2

Three basic assumptions justify an analysis of the costs of

quality: (1) failures are caused, (2) prevention is cheaper, and

(3) performance can be measured.

The costs of quality are generally classified into four types:

1. **Appraisal costs.** Costs of the inspection, testing, and other

tasks to ensure that the product or process is acceptable.

2. **Prevention costs.** The sum of all the costs to prevent

defects such as the costs to identify the cause of the defect,

to implement corrective action to eliminate the cause, to

train personnel, to redesign the product or system, and to

purchase new equipment or make modifications.

**Cost of quality**

Examples of Dimensions of Quality **e x h i b i t 9 . 3**

MEASURES

PRODUCT EXAMPLE: SERVICE EXAMPLE:

DIMENSION LASER PRINTER CHECKING ACCOUNT AT A BANK

Performance Pages per minute Time to process customer requests

Print density

Features Multiple paper trays Automatic bill paying

Color capability

Reliability/durability Mean time between failures Variability of time to process requests

Estimated time to obsolescence Keeping pace with industry trends

Expected life of major components

Serviceability Availability of authorized repair centers Online reports

Number of copies per print cartridge Ease of getting updated information

Modular design

Aesthetics Control button layout Appearance of bank lobby

Case style Courtesy of teller

Courtesy of dealer

Perceived quality Brand name recognition Endorsed by community leaders

Rating in *Consumer*

*Reports*

A GOODYEAR ASSOCIATE INSPECTS A RADIAL TIRE AT THE SAO PAULO, BRAZIL, FACTORY.

GOODYEAR PRACTICES BOTH VISUAL AND INTERNAL INSPECTIONS OF TIRES, EVEN

PULLING SOME TIRES FROM THE PRODUCTION LINE TO BE X-RAYED.

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3. **Internal failure costs.** Costs for defects incurred within the system: scrap, rework, repair.

4. **External failure costs.** Costs for defects that pass through the system: customer warranty

replacements, loss of customers or goodwill, handling complaints, and product repair.

Exhibit 9.4 illustrates the type of report that might be submitted to show the various costs by

categories. Prevention is the most important influence. A rule of thumb says that for every

dollar you spend in prevention, you can save $10 in failure and appraisal costs.

Often increases in productivity occur as a by-product of efforts to reduce the cost of quality. A

bank, for example, set out to improve quality and reduce the cost of quality and found that it had

also boosted productivity. The bank developed this productivity measure for the loan processing

area: the number of tickets processed divided by the resources required (labor cost, computer

time, ticket forms). Before the quality improvement program, the productivity index was 0.2660

[2,080/($11.23 \_ 640 hours \_ $0.05 \_ 2,600 forms \_ $500 for systems costs)]. After the quality

improvement project was completed, labor time fell to 546 hours and the number of forms

rose to 2,100, for a change in the index to 0.3088, an increase in productivity of 16 percent.

**F U N C T I O N S O F T H E Q C D E PA RT M E N T**

Although the focus of this chapter is on corporatewide quality programs, it is useful to comment

on the functions of QC departments.

The typical manufacturing QC department has a variety of functions to perform. These

include testing designs for their reliability in the lab and the field; gathering performance data

on products in the field and resolving quality problems in the field; planning and budgeting

the QC program in the plant; and, finally, designing and overseeing quality control systems

and inspection procedures, and actually carrying out inspection activities requiring special

**Service**

**e x h i b i t 9 . 4** Quality Cost Report

CURRENT MONTH’S PERCENTAGE

COST OF TOTAL

Prevention costs

Quality training $ 2,000 1.3%

Reliability consulting 10,000 6.5

Pilot production runs 5,000 3.3

Systems development 8,000 5.2

Total prevention 25,000 16.3

Appraisal costs

Materials inspection 6,000 3.9

Supplies inspection 3,000 2.0

Reliability testing 5,000 3.3

Laboratory testing 25,000 16.3

Total appraisal 39,000 25.5

Internal failure costs

Scrap 15,000 9.8

Repair 18,000 11.8

Rework 12,000 7.8

Downtime 6,000 3.9

Total internal failure 51,000 33.3

External failure costs

Warranty costs 14,000 9.2

Out-of-warranty repairs and replacement 6,000 3.9

Customer complaints 3,000 2.0

Product liability 10,000 6.5

Transportation losses 5,000 3.3

Total external failure 38,000 24.9

Total quality costs $153,000 100.0

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technical knowledge to accomplish. The tools of the QC department fall under the heading of

statistical quality control (SQC) and consist of two main sections: acceptance sampling and

process control. These topics are covered in Chapter 9A.

**S I X- S I G M A Q U A L I T Y**

**Six Sigma** refers to the philosophy and methods companies such as General Electric and

Motorola use to eliminate defects in their products and processes. A defect is simply any

component that does not fall within the customer’s specification limits. Each step or activity

in a company represents an opportunity for defects to occur, and Six-Sigma programs seek to

**Six Sigma**

The J. D. Power and Associates Initial Quality StudySM serves as

the industry benchmark for new-vehicle quality measured at

90 days of ownership. The study is used extensively by manufacturers

worldwide to help them design and build higher quality

vehicles and by consumers to help them in their purchase

decisions. Initial quality has been shown over the years to be a

good predictor of long-term durability, which can significantly

impact consumer purchase decisions. The study captures

problems experienced by owners in two distinct categories: 1)

design-related problems and 2) defects and malfunctions.

1 Exterior

a Design-related problems: front or sliding doors with

handles that are difficult to operate.

b Defects/Malfunctions: front or sliding doors that are

difficult to open or close, excessive wind noise, or paint

imperfections—including chips or scratches at delivery.

2 The Driving Experience

a Design-related problem: too much play or looseness

in the steering system, excessive brake dust, or foot

pedals that are too close together.

b Defects/Malfunctions: brakes that pull noticeably, are

noisy, or emit excessive brake dust.

3 Features/Controls/Displays

a Design-related problems: problems with the remote

keyless entry system, door locks, or cruise control

systems that are difficult to use. Controls that are

awkwardly located.

b Defects/Malfunctions: problems with remote keyless

entry systems, door locks, or cruise control systems

that are not working properly.

4 Audio/Entertainment/Navigation

a Design-related problems: audio and entertainment

systems with controls that are difficult to use or awkwardly

located, or hands-free communication systems

that don’t recognize commands.

b Defects/Malfunctions: CD players with loading problems

or radios with poor/no reception on AM/FM stations.

5 Seats

a Design-related problems: forward/backward seat adjustments

or memory seat controls that are difficult to

understand or use.

b Defects/Malfunctions: forward/backward seat adjustment

or memory seats that are broken or not working

properly.

6 Heat, Ventilation and Air Conditioning

a Design-related problems: a vehicle heater that doesn’t

get hot fast enough or windows that fog up too

often.

b Defects/Malfunctions: a fan/blower with excessive

noise or vents that emit air with a moldy or stale smell.

7 Interior

a Design-related problems: a glove box or center console

that is difficult to use.

b Defects/Malfunctions: instrument panel or dash lights

that are not working or a glove box or center console

that is broken or damaged.

8

Engine/Transmission

a Design-related problems: an engine that loses power

when the AC is on or a manual transmission that is

hard to operate.

b Defects/Malfunctions: an engine that runs and then

dies/stalls or an automatic transmission that shifts at

the wrong time.

**J. D. POWER AND ASSOCIATES INITIAL QUALITY STUDY OF NEW CARS**

SOURCE: DIRECT COMMUNICATION WITH J. D. POWER AND ASSOCIATES.

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reduce the variation in the processes that lead to these defects. Indeed, Six-Sigma advocates see

variation as the enemy of quality, and much of the theory underlying Six Sigma is devoted to

dealing with this problem. A process that is in Six-Sigma control will produce no more than two

defects out of every billion units. Often, this is stated as four defects per million units, which is

true if the process is only running somewhere within one sigma of the target specification.

One of the benefits of Six-Sigma thinking is that it allows managers to readily describe the

performance of a process in terms of its variability and to compare different processes using a

common metric. This metric is **defects per million opportunities (DPMO)** . This calculation

requires three pieces of data:

1. **Unit.** The item produced or being serviced.

2. **Defect.** Any item or event that does not meet the customer’s requirements.

3. **Opportunity.** A chance for a defect to occur.

A straightforward calculation is made using the following formula:

DPMO \_

Number of defects

\_\_\_\_\_\_\_\_\_ \_\_ \_\_\_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_\_\_ \_\_ \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_ Number of opportunities for error per unit \_ Number of units

\_ 1,000,000

**EXAMPLE 9.1**

The customers of a mortgage bank expect to have their mortgage applications processed within 10 days

of filing. This would be called a *critical customer requirement* , or CCR, in Six-Sigma terms. Suppose all

defects are counted (loans in a monthly sample taking more than 10 days to process) and it is determined

that there are 150 loans in the 1,000 applications processed last month that don’t meet this customer

requirement. Thus, the DPMO \_ 150/1,000 \_ 1,000,000, or 150,000 loans out of every million processed

that fail to meet a CCR. Put differently, it means that only 850,000 loans out of a million are approved

within time expectations. Statistically, 15 percent of the loans are defective and 85 percent are correct.

This is a case where all the loans processed in less than 10 days meet our criteria. Often there are upper

and lower customer requirements rather than just a single upper requirement as we have here. •

There are two aspects to Six-Sigma programs: the methodology side and the people side.

We will take these up in order.

**S I X - S I G M A M E T H O D O LO GY**

While Six Sigma’s methods include many of the statistical tools that were employed in other

quality movements, here they are employed in a systematic project-oriented fashion through

the define, measure, analyze, improve, and control ( **DMAIC** ) cycle. The DMAIC cycle is a

more detailed version of the Deming **PDCA cycle**, which consists of four steps—plan, do,

check, and act—that underly **continuous improvement***.* (Continuous improvement, also

called **kaizen**, seeks continual improvement of machinery, materials, labor utilization, and

production methods through applications of suggestions and ideas of company teams.) Like

Six Sigma, it also emphasizes the scientific method, particularly hypothesis testing about

the relationship between process inputs (X’s) and outputs (Y’s) using design of experiments

(DOE) methods. The availability of modern statistical software has reduced the drudgery of

analyzing and displaying data and is now part of the Six-Sigma tool kit. The overarching focus

of the methodology, however, is understanding and achieving what the customer wants, since

that is seen as the key to profitability of a production process. In fact, to get across this point,

some use the DMAIC as an acronym for “Dumb Managers Always Ignore Customers.”

The standard approach to Six-Sigma projects is the DMAIC methodology developed by

General Electric, described below: 3

1. Define (D)

• Identify customers and their priorities.

• Identify a project suitable for Six-Sigma efforts based on business objectives as

well as customer needs and feedback.

• Identify CTQs (critical-to-quality characteristics) that the customer considers to

have the most impact on quality.

**DPMO**

**DMAIC**

**PDCA cycle**

**Continuous improvement**

**kaizen**

**Service**

**Step by Step**

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2. Measure (M)

• Determine how to measure the process and how it is performing.

• Identify the key internal processes that influence CTQs and measure the defects

currently generated relative to those processes.

3. Analyze (A)

• Determine the most likely causes of defects.

• Understand why defects are generated by identifying the key variables that are

most likely to create process variation.

4. Improve (I)

• Identify means to remove the causes of defects.

• Confirm the key variables and quantify their effects on the CTQs.

• Identify the maximum acceptance ranges of the key variables and a system for

measuring deviations of the variables.

• Modify the process to stay within an acceptable range.

5. Control (C)

• Determine how to maintain the improvements.

• Put tools in place to ensure that the key variables remain within the maximum

acceptance ranges under the modified process.

**A N A LY T I C A L T O O L S F O R S I X S I G M A**

**A N D C O N T I N U O U S I M P ROV E M E N T**

The analytical tools of Six Sigma have been used for many years in traditional quality improvement

programs. What makes their application to Six Sigma unique is the integration of these

tools in a corporatewide management system. The tools common to all quality efforts, including

Six Sigma, are flowcharts, run charts, Pareto charts, histograms, checksheets, cause-and-effect

diagrams, and control charts. Examples of these, along with an opportunity flow diagram, are

shown in Exhibit 9.5 arranged according to DMAIC categories where they commonly appear.

**Flowcharts.** There are many types of flow charts. The one shown in Exhibit 9.5 depicts

the process steps as part of a SIPOC (supplier, input, process, output, customer) analysis.

SIPOC in essence is a formalized input-output model, used in the define stage of a project.

**Run charts.** They depict trends in data over time, and thereby help to understand the

magnitude of a problem at the define stage. Typically, they plot the median of a process.

**Pareto charts.** These charts help to break down a problem into the relative contributions

of its components. They are based on the common empirical finding that a large percentage

of problems are due to a small percentage of causes. In the example, 80 percent of

customer complaints are due to late deliveries, which are 20 percent of the causes listed.

**Checksheets.** These are basic forms that help standardize data collection. They are used

to create histograms such as shown on the Pareto chart.

**Cause-and-effect diagrams.** Also called *fishbone diagrams,* they show hypothesized

relationships between potential causes and the problem under study. Once the C&E diagram

is constructed, the analysis would proceed to find out which of the potential causes

were in fact contributing to the problem.

**Opportunity flow diagram.** This is used to separate value-added from non-value-added

steps in a process.

**Control charts.** These are time-sequenced charts showing plotted values of a statistic,

including a centerline average and one or more control limits. It is used here to assure that

changes introduced are in statistical control. See Chapter 9A for a discussion of the various

types and uses of charts for process control.

Other tools that have seen extensive use in Six-Sigma projects are failure mode and effect

analysis (FMEA) and design of experiments (DOE).

**Failure mode and effect analysis.** This is a structured approach to identify, estimate,

prioritize, and evaluate risk of possible failures at each stage of a process. It begins with

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**e x h i b i t 9 . 5** Analytical Tools for Six Sigma and Continuous Improvement

\*SOURCE: RATH & STRONG, *RATH & STRONG’S SIX SIGMA POCKET GUIDE*, 2001.

\*\*SOURCE: RAYTHEON SIX SIGMA, *THE MEMORY JOGGER™* II, 2001.

**Flow Chart of Major Steps in a Process\***

SUPPLIERS INPUTS PROCESSES OUTPUTS CUSTOMERS

Manufacturer

Office Supply

Company

Yourself

Power

Company

Copier

Paper

Toner

Original

Electricity

Copies You

File

Making a Others

Photocopy

Put original

on glass

Close

Lid

Adjust

Settings

Press

START

Remove

originals

and copies

PROCESS STEPS

**Define**

**Measure**

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

0

300

600

900

1200

1500

1800

2100

2400

2700

**Run Chart**\*\*

Average monthly volume of deliveries

(per shop)

Unit volume

1,951 deliveries

**Pareto Chart**\*\*

Types of customer complaints

Total \_ 2520 October–December

(across 6 shops)

Late deliveries

Wrong order

Cold food

Taste

Other

(206) (117) (87) (220)

0

500

25

50

75

100%

1000

1500

2000

2500

(1890)

**DATA COLLECTION FORMS**\*

Checksheets are basic forms that help standardize data collection

by providing specific spaces where people should record data.

Reason

Carton Transport

Lists the

characteristics

or conditions

of interest

May want to add

space for tracking

stratification factors

Includes place to

put the data

Has room for

comments

Metal Check

No Product

Sealing Unit

Barcoding

Conveyor Belt

Bad Product

Burned flakes

Low weight

Other

Frequency Comments

Operator: W\_\_e\_n\_d\_y\_\_\_ Date: M\_\_a\_y\_ 1\_9\_\_\_

**Machine Downtime**

**(Line 13)**

Defines what data

are being collected

Illustration note: Delivery time was defined

by the total time from when the order was

placed to when the customer received it.

Total # of customer complaints

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Unreliable cars No teamwork

No training

People don’t show up

No money for repairs

No capacity for Kids own junkers

peak periods

Ovens too small

High turnover

High turnover

High turnover

Lack of experience

Poor handling of

large orders

High

turnover

Poor

dispatching

Many new streets

High

turnover High turnover

Drivers get lost

Rushed

Poor training Get wrong

information

Don’t know town

Don’t know

town

Poor

training

Poor use

of space

Poor use

of space

Lack of

training

Inaccurate

ordering

Run out of ingredients

Low pay

Low pay

**Machinery/Equipment**

**C & E/Fishbone Diagram**\*\*

Reasons for late pizza deliveries

**People**

**Methods Materials**

Late pizza

deliveries on

Fridays &

Saturdays

**Analyze**

**Improve**

YES

YES

YES

Place

Original

Select

Size

Select

Orientation

Clean

Paper

Loaded?

Copier

in Use?

Glass

Dirty?

Paper? Knife?

Wait?

Take

Original Leave

Select

Number

Find

Paper

Find

Knife

YES

NO

NO

NO

YES YES

YES

Box

Open?

NO NO

Find

Help

NO

Open Box

NO

**Value-Added**

Steps that are essential

even when everything

works correctly move

down the left side

**Non-Value-Added**

Steps that would not be needed if everything worked right the first time move horizontally

across the right side

**Opportunity Flow Diagram**\*

Organized to separate value-added steps from non-value-added steps.

**Control**

J A S O N D J F M A M J J A S O N D J F M

LCL

UCL

0

10

20

30

40

50

60

70

80

90

100

Basic features same as a time plot

**Control Chart Features**\*

Control limits (calculated

from data) added to plot

Centerline usually average

instead of median

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identifying each element, assembly, or part of the process and listing the potential failure

modes, potential causes, and effects of each failure. A risk priority number (RPN) is calculated

for each failure mode. It is an index used to measure the rank importance of the

items listed in the FMEA chart. See Exhibit 9.6. These conditions include the probability

that the failure takes place (occurrence), the damage resulting from the failure (severity),

and the probability of detecting the failure in-house (detection). High RPN items should

be targeted for improvement first. The FMEA suggests a recommended action to eliminate

the failure condition by assigning a responsible person or department to resolve the failure

by redesigning the system, design, or process and recalculating the RPN.

**Design of experiments (DOE).** DOE, sometimes referred to as *multivariate testing,* is

a statistical methodology used for determining the cause-and-effect relationship between

process variables (X’s) and the output variable (Y). In contrast to standard statistical

tests, which require changing each individual variable to determine the most influential

one, DOE permits experimentation with many variables simultaneously through carefully

selecting a subset of them.

**Lean Six Sigma** combines the implementation and quality control tools of Six Sigma with

materials management concepts of *lean manufacturing* . Lean manufacturing (discussed in detail

in Chapter 13) achieves high-volume production and minimal waste through the use of just-intime

inventory methods. The term *lean* in this context is a focus on reducing cost by lowering

raw material, work-in-process, and finished goods inventory to an absolute minimum. Lowering

inventory requires a high level of quality as processes need to be predictable since extra inventory

is not available. Reducing variability is a key driver in successful lean Six-Sigma programs.

**S I X - S I G M A R O L E S A N D R E S P O N S I B I L I T I E S**

Successful implementation of Six Sigma is based on using sound personnel practices as well

as technical methodologies. The following is a brief summary of the personnel practices that

are commonly employed in Six-Sigma implementation.

1. ***Executive leaders,* who are truly committed to Six Sigma and who promote it**

**throughout the organization, and *champions,* who take ownership of the processes**

**that are to be improved.** Champions are drawn from the ranks of the executives,

and managers are expected to identify appropriate metrics early in the project

and make certain that the improvement efforts focus on business results. (See the

Breakthrough box “What Makes a Good Champion?”)

**Lean Six Sigma**

**e x h i b i t 9 . 6** FMEA Form

SOURCE: RATH & STRONG, *RATH & STRONG’S SIX SIGMA POCKET GUIDE*: 2001, P. 31.

Project: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Team: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date: \_\_\_\_\_\_\_\_(original)

\_\_\_\_\_\_\_\_\_(revised)

Item or

Process

Step

Potential

Failure

Mode

Total Risk Priority Number:

**FMEA Analysis**

“After” Risk Priority Number:

Potential

Effects of

Failure

Severity

Severity

Occurrence

Occurrence

Detection

Detection

RPN

RPN

Potential

Cause(s)

Current

Controls

Responsibility

and

Target Date

Recommended

Action

“After”

Action Taken

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2. **Corporatewide training in Six-Sigma concepts and tools.** GE spent over a billion

dollars training its professional workforce in the concepts. Now, virtually every professional

in the organization is qualified in Six-Sigma techniques. To convey the need

to vigorously attack problems, professionals are given martial arts titles reflecting their

skills and roles: **black belts** , who coach or actually lead a Six-Sigma improvement

team; **master black belts** , who receive in-depth training on statistical tools and process

improvement (they perform many of the same functions as black belts but for a larger

number of teams); and **green belts** , who are employees who have received enough Six-

Sigma training to participate in a team or, in some companies, to work individually on

a small-scale project directly related to their own job. Different companies use these

“belts” in different combinations with sponsors and champions to guide teams.

3. **Setting of stretch objectives for improvement.**

4. **Continuous reinforcement and rewards.** At GE, before any savings from a project

are declared, the black belt in charge must provide proof that the problems are fixed

permanently.

**Black belts**

**Master black belts**

**Green belts**

**T H E S H I N G O SYS T E M : FA I L - S A F E D E S I G N**

The Shingo system developed in parallel and in many ways in conflict with the statistically

based approach to quality control. This system—or, to be more precise, philosophy of production

management—is named after the codeveloper of the Toyota just-in-time system, Shigeo

Shingo. Two aspects of the Shingo system in particular have received great attention. One is

how to accomplish drastic cuts in equipment setup times by *s* ingle- *m* inute *e* xchange of *d* ie

(SMED) procedures. The other, the focus of this section, is the use of source inspection and

the poka-yoke system to achieve zero defects.

Shingo has argued that SQC methods do not prevent defects. Although they provide

information to tell us probabilistically when a defect will occur, they are after the fact.

The way to prevent defects from coming out at the end of a process is to introduce controls

within the process. Central to Shingo’s approach is the difference between errors

and defects. Defects arise because people make errors. Even though errors are inevitable,

defects can be prevented if feedback leading to corrective action takes place immediately

after the errors are made. Such feedback and action require inspection, which should be

done on 100 percent of the items produced. This inspection can be one of three types:

successive check, self-check, and source inspection. *Successive check* inspection is performed

by the next person in the process or by an objective evaluator such as a group

leader. Information on defects is immediate feedback for the worker who produced the

*Breakthrough* B R E A K T H R O U G H

SOURCE: GREG BRUE, *SIX SIGMA FOR MANAGERS* (NEW YORK: MCGRAW-HILL, 2002), P. 84.

WHAT MAKES A GOOD CHAMPION?

At a manufacturing company implementing Six Sigma, a

designated champion regularly met with his black belts. At

one report-out meeting, a black belt informed him that she

needed to purchase and install a table for sorting defects

off-line. It would cost about $17,000, but it would provide

an alternative to shutting down the entire line, which

would cost far more. The controller told her to go through

the normal requisition process and she’d have her table in

about four months. That delay would have killed the project

right then and there: to submit the project to “business as

usual” would have shown little real commitment to supporting

Six Sigma. So the champion asked for the data that

backed up her request, analyzed it, agreed with it, and then

got immediate executive sign-off on securing a table the

following week.

This is the stuff of a good champion: removing barriers and

sending a clear signal that he and upper management are

aligned and committed to Six Sigma. The champion does

whatever it takes to support the black belts.

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product, who then makes the repair. *Self-check* is done by the individual worker and is

appropriate by itself on all but items that require sensory judgment (such as existence or

severity of scratches, or correct matching of shades of paint). These require successive

checks. *Source inspection* is also performed by the individual worker, except instead

of checking for defects, the worker checks for the errors that will cause defects. This

prevents the defects from ever occurring and, hence, requiring rework. All three types

of inspection rely on controls consisting of **fail-safe procedures** or devices (called

**poka-yoke** ). Poka-yoke includes such things as checklists or special tooling that (1) prevents

the worker from making an error that leads to a defect before starting a process or (2) gives

rapid feedback of abnormalities in the process to the worker in time to correct them.

There are a wide variety of poka-yokes, ranging from kitting parts from a bin (to ensure

that the right number of parts are used in assembly) to sophisticated detection and electronic

signaling devices. An example taken from the writings of Shingo is shown in Exhibit 9.7.

There is a good deal more to say about the work of Shingo. Blasting industry’s preoccupation

with control charts, Shingo states they are nothing but a mirror reflecting current conditions.

When a chemical plant QC manager proudly stated that it had 200 charts in a plant of

150 people, Shingo asked him if “they had a control chart for control charts.” 4

**Fail-safe procedures**

**Poka-yoke**

**e x h i b i t 9 . 7** Poka-Yoke Example (Placing labels on parts coming down a conveyor)

The operation depended on the

worker’s vigilance.

**After Improvement**

**Before Improvement**

Device to ensure attachment of labels

The tape fed out by the labeler turns sharply so that the

labels detach and project out from the tape. This is

detected by a photoelectric tube and, if the label is not

removed and applied to the product within the tact time

of 20 seconds, a buzzer sounds and the conveyor stops.

Effect: Label application failures were eliminated.

Cost: 15,000 ($145)

Labeler

Blank tape

Photoelectric

tube

Label

**I S O 9 0 0 0 A N D I S O 1 4 0 0 0**

ISO 9000 and ISO 14000 are international standards for quality management and assurance.

The standards are designed to help companies document that they are maintaining an efficient

quality system. The standards were originally published in 1987 by the International

Organization for Standardization (ISO), a specialized international agency recognized by

affiliates in more than 160 countries. **ISO 9000** has become an international reference for

quality management requirements in business-to-business dealing, and ISO 14000 is primarily

concerned with environmental management.

The idea behind the standards is that defects can be prevented through the planning and

application of *best practices* at every stage of business—from design through manufacturing

and then installation and servicing. These standards focus on identifying criteria by which

any organization, regardless of whether it is manufacturing or service oriented, can ensure

that product leaving its facility meets the requirements of its customers. These standards ask

a company first to document and implement its systems for quality management and then to

verify, by means of an audit conducted by an independent accredited third party, the compliance

of those systems with the requirements of the standards.

**Global**

**ISO 9000**

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The ISO 9000 standards are based on eight quality management principles that are defined

in the ISO 9000:2000 document. These principles focus on business processes related to the

following areas in the firm: (1) customer focus, (2) leadership, (3) involvement of people,

(4) process approach, (5) system approach to management, (6) continual improvement,

(7) factual approach to decision making, and (8) mutually beneficial supplier relationships.

The ISO documents provide detailed requirements for meeting the standards and describe

standard tools that are used for improving quality in the firm. These documents are intended

to be generic and applicable to any organization producing products or services.

The ISO 14000 family of standards on environmental management addresses the need to

be environmentally responsible. The standards define a three-pronged approach for dealing

with environmental challenges. The first is the definition of more than 350 international standards

for monitoring the quality of air, water, and soil. For many countries, these standards

serve as the technical basis for environmental regulation. The second part of ISO 14000 is a

strategic approach defining the requirements of an environmental management system that

can be implemented using the monitoring tools. Finally, the environmental standard encourages

the inclusion of environment aspects in product design and encourages the development

of profitable environment-friendly products and services.

In addition to the generic ISO 9000 and ISO 14000 standards, many other specific standards

have been defined. The following are some examples:

• QS-9000 is a quality management system developed by DaimlerChrysler, Ford, and

General Motors for suppliers of production parts, materials, and services to the automotive

industry.

• ISO/TS 16949, developed by the International Automotive Task Force, aligns existing

American, German, French, and Italian automotive quality standards within the global

automotive industry.

• ISO 14001 environmental standards are applied by automobile suppliers as a requirement

from Ford and General Motors.

• ANSI/ASQ Z1.4-2003 provides methods for collecting, analyzing, and interpreting

data for inspection by attributes, while Z1.9-2003 relates to inspection by variables.

• TL 9000 defines the telecommunications quality system requirements for the design,

development, production, delivery, installation, and maintenance of products and

services in the telecommunications industry.

The ISO standards provide accepted global guidelines for quality. Although certification is not

required, many companies have found it is essential to be competitive in the global markets.

Consider the situation where you need to purchase parts for your firm and several suppliers

offer similar parts at similar prices. Assume that one of these firms has been ISO 9000–

certified and the others have not. From whom would you purchase? There is no doubt that

the ISO 9000–certified company would have the inside track in your decision making. Why?

Because ISO 9000 specifies the way the supplier firm operates as well as its quality standards,

delivery times, service levels, and so on.

There are three forms of certification:

1. First party: A firm audits itself against ISO 9000 standards.

2. Second party: A customer audits its supplier.

3. Third party: A “qualified” national or international standards or certifying agency

serves as an auditor.

The best certification of a firm is through a third party. Once passed by the third-party audit,

a firm is certified and may be registered and recorded as having achieved ISO 9000 status

and it becomes a part of a registry of certified companies. This third-party certification also

has legal advantages in the European Community. For example, a manufacturer is liable for

injury to a user of the product.

The firm, however, can free itself from any liability by showing that it has used the appropriate

standards in its production process and carefully selected its suppliers as part of its purchasing

requirements. For this reason, there is strong motivation to choose ISO 9000– certified suppliers.

**Supply**

**Chain**

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The quality improvement approaches described so far are more or less inward looking. They

seek to make improvements by analyzing in detail the current practices of the company itself.

**External benchmarking**, however, goes outside the organization to examine what industry

competitors and excellent performers outside of the industry are doing. Benchmarking typically

involves the following steps:

**Identify processes needing improvement.** Identify a firm that is the world leader in

performing the process. For many processes, this may be a company that is not in the

same industry. Examples would be Procter & Gamble using L.L Bean as the benchmark in

evaluating its order entry system, or ICL (a large British computer maker) benchmarking

Marks and Spencer (a large U.K. clothing retailer) to improve its distribution system. A

McKinsey study cited a firm that measured pit stops on a motor racing circuit as a benchmark

for worker changes on its assembly line. 5 *Contact the managers of that company and*

*make a personal visit to interview managers and workers.* Many companies select a team

of workers from that process as part of the team of visitors.

**Analyze data.** This entails looking at gaps between what your company is doing and

what the benchmarking company is doing. There are two aspects of the study: one is

comparing the actual processes; the other is comparing the performance of these processes

according to a set of measures. The processes are often described using flowcharts and

subjective evaluations of how workers relate to the process. In some cases, companies

permit videotaping, although there is a tendency now for benchmarked companies to keep

things under wraps for fear of giving away process secrets.

**External benchmarking**

**E X T E R N A L B E N C H M A R K I N G F O R**

**Q U A L I T Y I M P ROVEMENT**

**S U M M A RY**

How to achieve TQM is no secret any more. The challenge is to make certain that a quality

program really does have a customer focus and is sufficiently agile to be able to make

improvements quickly without losing sight of the real-time needs of the business. The quality

system must be analyzed for its own quality. There is also a need for sustaining a quality

culture over the long haul. Some companies (which will remain nameless) that gained a great

reputation for quality in the 1980s and 90s simply ran out of gas in their quality efforts—their

managers just couldn’t sustain the level of enthusiasm necessary for quality to remain a top

priority goal. As Tom Peters said, “Most Quality programs fail for one of two reasons: they

have system without passion, or passion without system.” 6

K E Y T E R M S

Total quality management (TQM) Managing the entire organization

so that it excels on all dimensions of products and services that are

important to the customer.

Malcolm Baldrige National Quality Award An award established by

the U.S. Department of Commerce and given annually to companies

that excel in quality.

Design quality The inherent value of the product in the marketplace.

Conformance quality The degree to which the product or service

design specifications are met.

Quality at the source The person who does the work is responsible

for ensuring that specifications are met.

Dimensions of quality Criteria by which quality is measured.

Cost of quality Expenditures related to achieving product or service

quality such as the costs of prevention, appraisal, internal failure,

and external failure.

Six Sigma A statistical term to describe the quality goal of no more

than four defects out of every million units. Also refers to a quality

improvement philosophy and program.

**Global**

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R E V I E W A N D D I S C U S S I O N Q U E S T I O N S

1 Is the goal of Six Sigma realistic for services such as Blockbuster Video stores?

2 “If line employees are required to work on quality improvement activities, their productivity

will suffer.” Discuss.

3 “You don’t inspect quality into a product; you have to build it in.” Discuss the implications of

this statement.

4 “Before you build quality in, you must think it in.” How do the implications of this statement

differ from those in question 3?

5 Business writer Tom Peters has suggested that in making process changes, we should “Try it,

test it, and get on with it.” How does this square with the DMAIC/continuous improvement

philosophy?

6 Shingo told a story of a poka-yoke he developed to make sure that the operators avoided the

mistake of putting fewer than the required four springs in a push-button device. The existing

method involved assemblers taking individual springs from a box containing several hundred

and then placing two of them behind an ON button and two more behind an OFF button. What

was the poka-yoke Shingo created?

7 A typical word processing package is loaded with poka-yokes. List three. Are there any others

you wish the packages had?

P R O B L E M S

1 A manager states that his process is really working well. Out of 1,500 parts, 1,477 were produced

free of a particular defect and passed inspection. Based upon Six-Sigma theory, how

would you rate this performance, other things being equal?

2 Professor Chase is frustrated by his inability to make a good cup of coffee in the morning. Show how

you would use a fishbone diagram to analyze the process he uses to make a cup of his evil brew.

3 Use the benchmarking process and as many DMAIC/CI analytical tools as you can to show how

you can improve your performance in your weakest course in school.

4 Prepare a SIPOC flowchart (Exhibit 9.5) of the major steps in the process of boarding a commercial

flight. Start the process with the passenger arriving curbside at your local airport.

5 Prepare an opportunity flow diagram for the same process of boarding a commercial flight.

6 The following table lists all costs of quality incurred by Sam’s Surf Shop last year. What was

Sam’s appraisal cost for quality last year?

Annual inspection costs $ 155,000

Annual cost of scrap materials $ 286,000

Annual rework cost $ 34,679

Annual cost of quality training $ 456,000

Annual warranty cost $1,546,000

Annual testing cost $ 543,000

DPMO (defects per million opportunities) A metric used to describe

the variability of a process.

DMAIC An acronym for the **D** efine, **M** easure, **A** nalyze, **I** mprove,

and **C** ontrol improvement methodology followed by companies

engaging in Six-Sigma programs.

PDCA cycle Also called the “Deming cycle or wheel”; refers to the

plan–do–check–act cycle of continuous improvement.

Continuous improvement The philosophy of continually seeking

improvements in processes through the use of team efforts.

Kaizen Japanese term for continuous improvement.

Lean Six Sigma Combines the implementation and quality control

tools of Six Sigma with the materials management concept of lean

manufacturing with a focus on reducing cost by lowering inventory

to an absolute minimum.

Black belts, master black belts, green belts Terms used to describe

different levels of personal skills and responsibilities in Six-Sigma

programs.

Fail-safe or poka-yoke procedures Simple practices that prevent

errors or provide feedback in time for the worker to correct errors.

ISO 9000 Formal standards used for quality certification, developed

by the International Organization for Standardization.

External benchmarking Looking outside the company to examine

what excellent performers inside and outside the company’s

industry are doing in the way of quality.

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7 Below is a table of data collected over a six-month period in a local grocery store. Construct a

Pareto analysis of the data and determine the percentage of total complaints represented by the

two most common categories.

All Other 71

Checker 59

General 58

Service Level 55

Policy/Procedures 40

Price Marking 45

Product Quality 87

Product Request 105

Checkout Queue 33

Stock Condition 170

8 A common problem that many drivers encounter is a car that will not start. Create a fishbone

diagram to assist in the diagnosis of the potential causes of this problem.

I N T E R N E T E N R I C H M E N T E X E R C I S E S

1 Visit the Baldrige Award Web site and see who won this year. What quality ideas did the winner

demonstrate? What did the winner do that was particularly creative?

2 Visit the Six-Sigma Web site to see how companies are applying the concept.

C A S E : H A N K K O L B , D I R E C T O R O F Q U A L I T Y A S S U R A N C E

Hank Kolb was whistling as he walked toward his office, still feeling

a bit like a stranger since he had been hired four weeks before as

director of quality assurance. All that week he had been away from

the plant at a seminar given for quality managers of manufacturing

plants by the corporate training department. He was now looking

forward to digging into the quality problems at this industrial products

plant employing 1,200 people.

Kolb poked his head into Mark Hamler’s office, his immediate

subordinate as the quality control manager, and asked him how

things had gone during the past week. Hamler’s muted smile and an

“Oh, fine,” stopped Kolb in his tracks. He didn’t know Hamler very

well and was unsure about pursuing this reply any further. Kolb

was still uncertain of how to start building a relationship with him

since Hamler had been passed over for the promotion to Kolb’s job;

Hamler’s evaluation form had stated “superb technical knowledge;

managerial skills lacking.” Kolb decided to inquire a little further

and asked Hamler what had happened; he replied, “Oh, just another

typical quality snafu. We had a little problem on the Greasex line

last week [a specialized degreasing solvent packed in a spray can

for the high-technology sector]. A little high pressure was found in

some cans on the second shift, but a supervisor vented them so that

we could ship them out. We met our delivery schedule!” Because

Kolb was still relatively unfamiliar with the plant and its products,

he asked Hamler to elaborate; painfully, Hamler continued:

We’ve been having some trouble with the new filling

equipment and some of the cans were pressurized beyond

the upper specification limit.

The production rate is still 50 percent of standard,

about 14 cases per shift, and we caught it halfway into

the shift. Mac Evans [the inspector for that line] picked it

up, tagged the cases “hold,” and went on about his duties.

When he returned at the end of the shift to write up the

rejects, Wayne Simmons, first-line supervisor, was by a

pallet of finished goods finishing sealing up a carton of the

rejected Greasex; the reject “hold” tags had been removed.

He told Mac that he had heard about the high pressure

from another inspector at coffee break, had come back,

taken off the tags, individually turned the cans upside

down and vented every one of them in the eight rejected

cartons. He told Mac that production planning was really

pushing for the stuff and they couldn’t delay by having it

sent through the rework area. He told Mac that he would

get on the operator to run the equipment right next time.

Mac didn’t write it up but came in about three days ago

to tell me about it. Oh, it happens every once in a while

and I told him to make sure to check with maintenance

to make sure the filling machine was adjusted; and I saw

Wayne in the hall and told him that he ought to send the

stuff through rework next time.

Kolb was a bit dumbfounded at this and didn’t say much—he

didn’t know if this was a big deal or not. When he got to his office,

he thought again what Morganthal, general manager, had said when

he had hired him. He warned Kolb about the “lack of quality attitude”

in the plant and said that Kolb “should try and do something

about this.” Morganthal further emphasized the quality problems in

the plant: “We have to improve our quality; it’s costing us a lot of

money, I’m sure of it, but I can’t prove it! Hank, you have my full

support in this matter; you’re in charge of these quality problems.

This downward quality–productivity–turnover spiral has to end!”

The incident had happened a week before; the goods were

probably out in the customers’ hands by now, and everyone had

forgotten about it (or wanted to). There seemed to be more pressing

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problems than this for Kolb to spend his time on, but this continued

to nag him. He felt that the quality department was being treated as

a joke, and he also felt that this was a personal slap from manufacturing.

He didn’t want to start a war with the production people, but

what could he do? Kolb was troubled enough to cancel his appointments

and spend the morning talking to a few people. After a long

and very tactful morning, he learned the following information:

1 **From personnel.** The operator for the filling equipment

had just been transferred from shipping two weeks ago. He

had no formal training in this job but was being trained by

Wayne, on the job, to run the equipment. When Mac had

tested the high-pressure cans, the operator was nowhere to

be found and had only learned of the rejected material from

Wayne after the shift was over.

2 **From plant maintenance.** This particular piece of automated

filling equipment had been purchased two years

ago for use on another product. It had been switched to the

Greasex line six months ago and maintenance completed

12 work orders during the last month for repairs or adjustments

on it. The equipment had been adapted by plant maintenance

for handling the lower viscosity of Greasex, which

it had not originally been designed for. This included designing

a special filling head. There was no scheduled preventive

maintenance for this equipment and the parts for the sensitive

filling head, replaced three times in the last six months,

had to be made at a nearby machine shop. Nonstandard

downtime was 15 percent of actual running time.

3 **From purchasing.** The plastic nozzle heads for the Greasex

can, designed by a vendor for this new product on a rush order,

were often found to have slight burrs on the inside rim, and this

caused some trouble in fitting the top to the can. An increase in

application pressure at the filling head by maintenance adjustment

had solved the burr application problem or had at least

forced the nozzle heads on despite burrs. Purchasing agents

said that they were going to talk to the sales representative of

the nozzle head supplier about this the next time he came in.

4 **From product design and packaging.** The can, designed

especially for Greasex, had been contoured to allow better

gripping by the user. This change, instigated by marketing

research, set Greasex apart from the appearance of its competitors

and was seen as significant by the designers. There

had been no test of the effects of the contoured can on filling

speed or filling hydrodynamics from a high-pressured filling

head. Kolb had a hunch that the new design was acting as a

venturi (carrier creating suction) when being filled, but the

packaging designer thought that was unlikely.

5 **From the manufacturing manager.** He had heard about

the problem; in fact, Simmons had made a joke about it,

bragging about how he beat his production quota to the other

foremen and shift supervisors. The manufacturing manager

thought Simmons was one of the “best foremen we have . . .

he always got his production out.” His promotion papers

were actually on the manufacturing manager’s desk when

Kolb dropped by. Simmons was being strongly considered

for promotion to shift supervisor. The manufacturing manager,

under pressure from Morganthal for cost improvements

and reduced delivery times, sympathetized with Kolb but

said that the rework area would have vented with their pressure

gauges what Wayne had done by hand. “But I’ll speak

with Wayne about the incident,” he said.

6 **From marketing.** The introduction of Greasex had been

rushed to market to beat competitors, and a major promotional

advertising campaign was under way to increase consumer

awareness. A deluge of orders was swamping the order-taking

department and putting Greasex high on the back-order list.

Production had to turn the stuff out; even being a little off

spec was tolerable because “it would be better to have it on

the shelf than not there at all. Who cares if the label is a little

crooked or the stuff comes out with a little too much pressure?

We need market share now in that high-tech segment.”

What bothered Kolb most was the safety issue of the high pressure

in the cans. He had no way of knowing how much of a hazard the

high pressure was or if Simmons had vented them enough to effectively

reduce the hazard. The data from the can manufacturer, which

Hamler had showed him, indicated that the high pressure found by

the inspector was not in the danger area. But, again, the inspector had

used only a sample testing procedure to reject the eight cases. Even

if he could morally accept that there was no product safety hazard,

could Kolb make sure that this would never happen again?

Skipping lunch, Kolb sat in his office and thought about the

morning’s events. The past week’s seminar had talked about the

role of quality, productivity and quality, creating a new attitude, and

the quality challenge; but where had they told him what to do when

this happened? He had left a very good job to come here because he

thought the company was serious about the importance of quality,

and he wanted a challenge. Kolb had demanded and received a salary

equal to the manufacturing, marketing, and R&D directors, and

he was one of the direct reports to the general manager. Yet he still

didn’t know exactly what he should or shouldn’t do, or even what

he could or couldn’t do under these circumstances.

Q U E S T I O N S

1 What are the causes of the quality problems on the Greasex

line? Display your answer on a fishbone diagram.

2 What general steps should Hank follow in setting up a

continuous improvement program for the company? What

problems will he have to overcome to make it work?

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DISCUSSION RATHER THAN TO ILLUSTRATE EITHER EFFECTIVE OR INEFFECTIVE HANDLING OF AN ADMINISTRATIVE SITUATION. REPRINTED BY PERMISSION OF THE HARVARD BUSINESS SCHOOL.

C A S E : A P P R E C I A T I V E I N Q U I RY — A D I F F E R E N T K I N D O F F I S H B O N E

The standard cause-and-effect, or fishbone, diagram approach

focuses on identifying the root cause of a problem. Finding this

cause then becomes an input into developing a solution. On the

other hand, improvements aren’t always about finding out what went

wrong; rather, they may be about identifying what was done right.

This is what the AI approach is designed to do. The way it works is

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**e x h i b i t 9 . 8** Identifying Excellence