Introduction to Quality Assurance

L-27

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Quality control systems in the larger production system

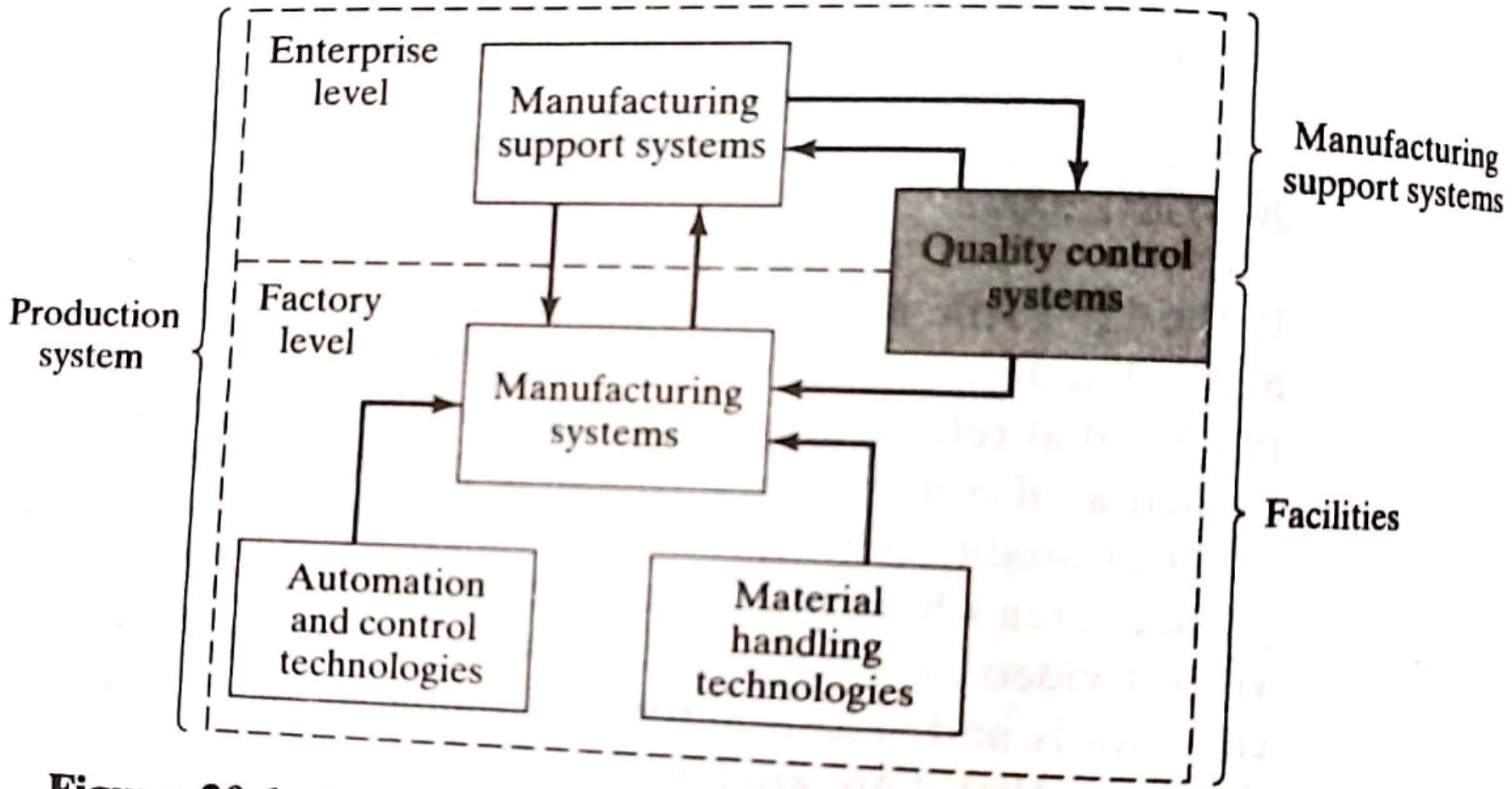


Figure 20.1 Quality control systems in the larger production system.

1. Quality Definition

- The dictionary defines quality as the degree of excellence which a thing possesses or the features that make something what it is-its characteristics elements and attributes.
- Crosby defines quality as conformance to requirements.
- Juran summarizes it as fitness for use and quality is customer satisfaction.
- The American Society for Quality Control (ASQC) defines quality as the totality of features and characteristics of the product or service that bear on its ability to satisfy given needs.

a) Dimensions of Quality

Garvin defines eight dimensions of quality that are applicable in particular to a manufactured product

(i) Performance
(ii) Features
(iii) Aesthetic appeal
(iv) Conformance
(v) Reliability
(vi) Durability
(vii) Serviceability
(viii) Perceived quality

b) Quality in Design and Manufacturing

Juran and Gryna distinguish two aspects of quality in a manufactured product.

(i) Product features (ii) freedom from deficiencies

Product features: They are the characteristics of product that result from design.

- They are the functional and aesthetic features of the product intended to appeal to and provide satisfaction to the customer.
- In an automobile, these features include the size of the car, the arrangement of the dashboard, the fit and finish of the body and similar aspects

Freedom from deficiencies: It means that the product does what it is supposed to do and that it is absent of defects and out of tolerance conditions.

Aspects of Quality

Quality Aspect	*Examples*
Product features	Design configuration, size, weight Function and ***performance*** Distinguishing ***features*** of the model ***Aesthetic appeal*** Ease of use Availability of options ***Reliability*** and dependability ***Durability*** and long service life ***Serviceability*** Reputation of product and producer.
Freedom from deficiencies	Absence of defects ***Conformance*** to specifications Components within tolerance No missing parts No early failures

* Terms in ital

2) Traditional and Modern Quality Control

a) Traditional Quality Control:

- Traditional quality control focused on inspection.
- Much attention was given to sampling and statistical methods. The statistical quality control was used to describe these methods.
- Two statistical sampling methods dominate the field of SQC (i) control charts (ii) acceptance sampling
- Acceptance sampling is traditionally used for various purposes (i) receiving inspection of raw materials from a vendor (ii) deciding whether or not to ship a batch parts or products to a customer (iii) inspection of parts between steps in the manufacturing sequence.

Contd.

The management principles and practices that characterize traditional QC included the following.

(i) Customers are external to the organization. The sales and marketing department is responsible for relations with customers.

(ii) The company is organized by functional departments. There is little appreciation of the interdependence of the departments in the larger enterprise. The loyalty and view point of each departments tends to be centered in itself rather than on the corporation

(iii) Quality is the responsibility of the inspection department. The quality function in the organization emphasizes inspection and conformance to specifications. Its objective is simple:elimination of defects

(iv) Inspection follows production. The objectives of production often clash with the objectives of QC

(v) Knowledge of SQC techniques resides only in the minds of the QC experts in the organization. Workers responsibilities are limited. Managers and technical staff do all the planning. Workers follow instructions

(vi) There is an emphasis on maintaining the status quo.

b) The Modern view of Quality Control

- High quality is achieved by a combination of good management and good technology. The management factor is captured in the frequently used term total quality management.
- Total quality management (TQM) denotes a management approach that pursues three main objectives

(i) Achieving customer satisfaction

(ii) continuous improvement

(iii) encouraging involvement of the entire work force.

Contd.

Compare the following factors, which reflect the modern view of quality management with the preceding list that characterizes the traditional approach to quality management.

(i) Quality is focused on customer satisfaction

(ii) The quality goals of an organization are driven by top management, which determines the overall attitude toward quality in a company. The quality goals of a company are not established in manufacturing; they are defined at the highest levels of the organization.

(iii) Quality control is pervasive in the organization, not just the job of the inspection department. It extends from top of the organization through all levels

(iv) In manufacturing, the viewpoint is that inspecting the product after it is made is not good enough. Quality must be built into the product. Production workers must inspect their own work and not rely on the inspection department to find their mistakes.

(v) Quality is the job of everyone in the organization. It even extends outside the immediate organization to the suppliers

(vi) High product quality is a process of continuous improvement. It is never ending chase to design better products and then to manufacture them better

Quality Control Technologies

Good technology also plays an important role in achieving high quality. Modern technologies in QC include.

(i) Quality engineering
(ii) Quality function deployment
(iii) Statistical process control
(iv) 100% automated inspection
(v) On-line inspection
(vi) Coordinate measurement machines for dimensional measurement
(vii) Non-contact sensors such as machine vision for inspection

3) Taguchi Methods in Quality Engineering

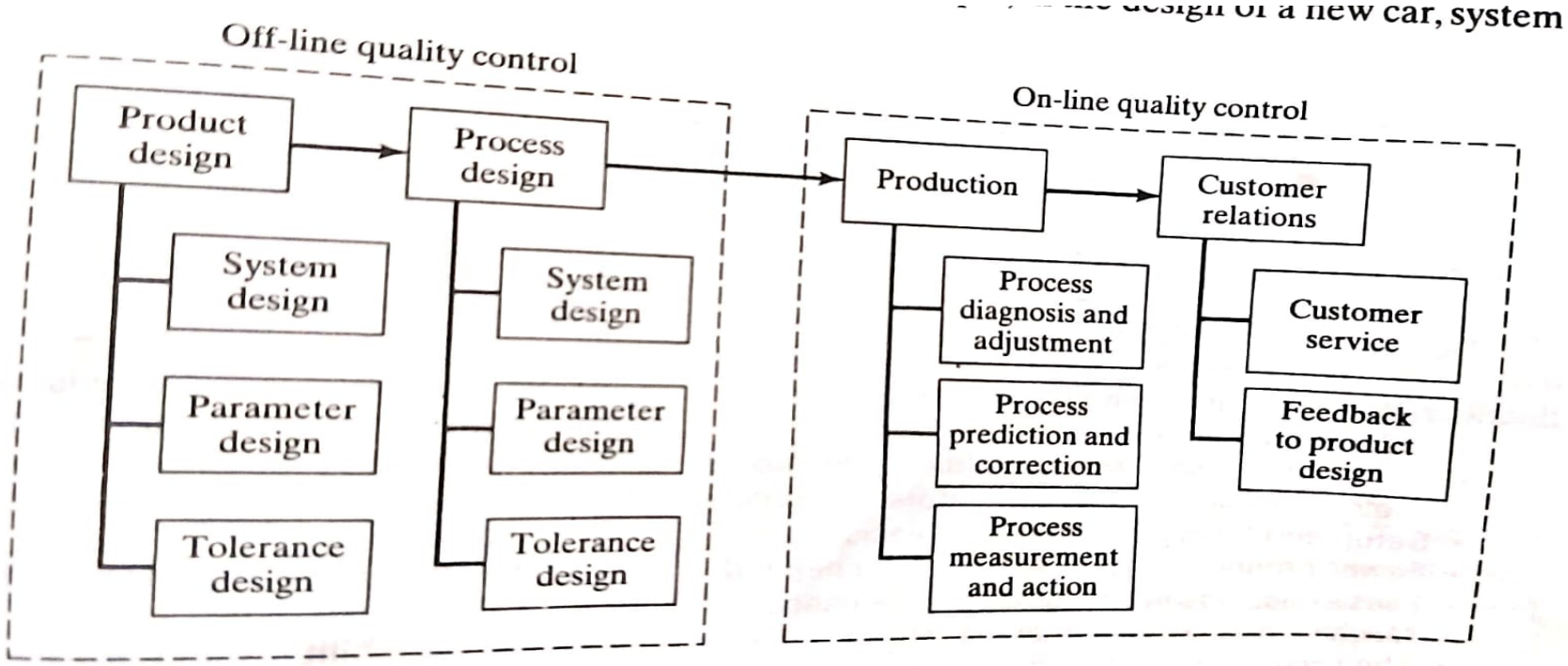
- The term quality engineering encompasses a broad range of engineering and operational activities whose aim is to ensure that a product's quality characteristics are at their nominal or target values
- The field of quality engineering owes much to G. Taguchi, who has had an important influence on its development, especially in the design area-both product design and process design.

a) Off-line and on-line quality Control

(i) off-line quality control- This function is concerned with design issues, both product and process design. It is applicable prior to production and shipment of the product. In the sequence of the two functions, off-line control preceds on-line control

(ii) On-line quality control- This is concerned with production operations and relations with the customer after shipment. Its objective is to manufacture products within the specifications defined in product design, utilizing the technologies and methods developed in process design.

Block diagram of Taguchi's off-line and on-line quality control



b) Robust Design

- The objective of parameter design in Taguchi's off-line/on-line quality control is to set specifications on product and process parameters to create a design that resists failure or reduced performance in the face of variations.
- Taguchi calls the variation noise factors. A noise factor is a source of variation that is impossible or difficult to control and that affects the functional characteristics of the product. Three types of noise factors can be distinguished

(i) Unit-to-unit noise factors-variability in raw materials, machinery and human participation

(ii) Internal noise factors- They include time dependent factors such as wear mechanical components, spoilage of raw materials and fatigue of metal parts, operational errors such as improper settings on the product or machine tool.

(iii) External noise factors- temperature, humidity, raw material supply, input voltage.

Some Examples of Robust Designs in Products and Processes

Product design:

- An airplane that flies as well in stormy weather as in clear weather
- A car that starts in Minneapolis, Minnesota in January as well as Phoenix, Arizona in July
- A tennis racket that returns the ball just as well when hit near the rim as when hit in dead center
- A hospital operating room that maintains lighting and other life support systems when the electric power to the hospital is interrupted

Process design:

- A turning operation that produces a good surface finish throughout a wide range of cutting speeds
- A plastic injection molding operation that molds a good part despite variations in ambient temperature and humidity in the factory
- A metal forging operation that presses good parts in spite of variations in starting temperature of the raw billet

Other:

- A biological species that survives unchanged for millions of years despite significant climatic changes in the world in which it lives

C) Taguchi Loss Function

- The Taguchi loss function is a useful concept in tolerance design. Taguchi defines quality as the loss a product costs society from the time the product is released for shipment
- Loss includes costs to operate, failure to function, maintenance and repair costs, customer dissatisfaction, injuries caused by poor design and similar costs.

$L(x) = K(x-N)^2$, where L(x) = loss function; K= constant of proportionality; and x and N are as defined. At some level of deviation $(x_2 - N) = -(x_1 - N)$, the loss will be prohibitive, and it is necessary to scrap or rework the product.

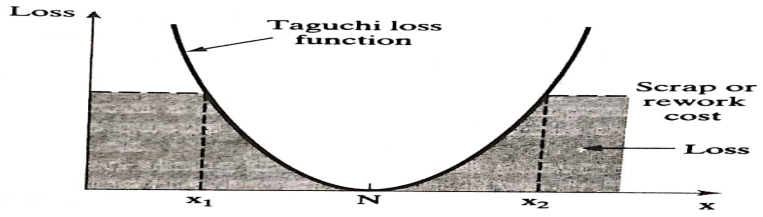


Figure 20.3 The quadratic quality loss function.

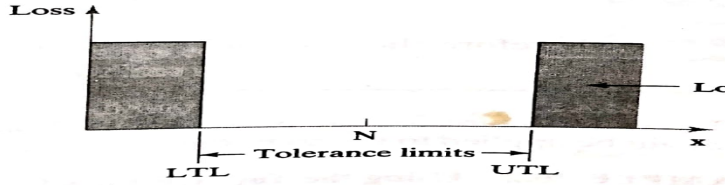


Figure 20.4 Loss function implicit in traditional tolerance specification.

Example

Suppose that a certain part dimension is specified as 100.0 ± 0.20 mm. To investigate the impact of this tolerance on product performance, the company

has studied its repair records to discover that if the ±0.20 mm tolerance is exceeded, there is a 60% chance that the product will be returned for repairs at a cost of $100 to the company (during the warranty period) or to the customer (beyond the warranty period). Estimate the Taguchi loss function constant k for these data.

Solution: In Eq. (20.1) for the loss function, the value of $(x - N)$ is the tolerance value 0.20. The loss is the expected cost of the repair, which can be calculated as follows:

$$E\{L(x)\} = 0.60(\$100) + 0.40(0) = \$60$$

Using this cost in Eq. (20.1), we have

$$60 = k(0.20)^2 = k(0.04)$$

$$k = \frac{60}{0.04} = \$1500$$

Therefore, the Taguchi loss function for this case is the following:

$$L(x) = 1500(x - N)^2 \tag{20.2}$$

The Taguchi loss function can be used to evaluate the relative costs of alternative tolerances that might be applied to the component in question, as illustrated in the following example.

EXAMPLE 20.2 Using the Taguchi Loss Function to Estimate the Cost of Alternative Tolerances

Let us use the Taguchi quadratic loss function, Eq. (20.2), to evaluate the cost of several alternative tolerances for the same data given in Example 20.1. Specifically, given the nominal dimension of 100, as before, determine the cost (value of the loss function) for tolerances of (a) ±0.10 mm and (b) ±0.05 mm.

Solution: (a) For a tolerance of ±0.10 mm, the value of the loss function is:

$$L(x) = 1500(0.10)^2 = 1500(0.01) = \$15.00$$

(b) For a tolerance of ±0.05 mm, the value of the loss function is:

$$L(x) = 1500(0.05)^2 = 1500(0.0025) = \$3.75$$

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4) ISO 9000

- ISO 9000 is a set of international standards on quality developed by the International Organization for Standardization (ISO) based in Geneva, Switzerland and representing virtually all industrialized nations.
- Implementation of ISO 9000 requires that all of a facility's activities affecting quality be carried out in a three phase cycle that continues indefinitely. The three phases are:

(i) Planning

(ii) Control

(iii) Documentation

ISO 9000 and other ISO Quality Standards, 1994 Update

Standard	Description
ISO 8402	Vocabulary for quality management and quality assurance
ISO 9000-1	Quality management and quality assurance, Part 1: Guidelines for selection and use
ISO 9000-2	Quality management and quality assurance, Part 2: Generic guidelines for application of ISO 9001, ISO 9002, and ISO 9003
ISO 9000-3	Quality management and quality assurance, Part 3: Guidelines for application of ISO 9001 to the development, supply, and maintenance of software
ISO 9000-4	Quality management and quality assurance, Part 4: Application for dependability program management
ISO 9001	Quality system models for facilities whose operations include design and/or development, production, inspection and testing, installation, and servicing of products
ISO 9002	Quality system models for facilities that manufacture products that are designed and serviced by others
ISO 9003	Quality system models for facilities that only perform inspection and testing
ISO 9004-1	Quality management and quality system elements: Guidelines
ISO 9004-2	Quality management and quality system elements: Guidelines for services
ISO 9004-3	Quality management and quality system elements: Guidelines for processed materials
ISO 9004-4	Quality management and quality system elements: Guidelines for quality improvement
ISO 10011-1	Guidelines for auditing quality systems, Part 1: Auditing
ISO 10011-2	Guidelines for auditing quality systems, Part 2: Qualification criteria for quality system auditors
ISO 10011-3	Guidelines for auditing quality systems, Part 3: Management of audit programs
ISO 10012-1	Metrological qualification system for measuring equipment
ISO 10013	Guidelines for developing quality manuals
ISO/TR 13425	Guidelines for the selection of statistical methods in standardization and specification

Source: ISO Easy, http://www.exit109.com.

Topics Areas Covered by ISO 9001, ISO 9002 and IS) 9003

TABLE 20.5 Topic Areas Covered by ISO 9001, ISO 9002, and ISO 9003

Section Number	Topic Area and Brief Description	ISO 9001	ISO 9002	ISO 9003
1.	***Management responsibility***. Management shall define and document its policy and objectives for quality and ensure understanding and implementation at all levels of the organization.	×	×	×
2.	***Quality system***. The facility shall establish and maintain a quality system that ensures conformance of the product or service to specified requirements.	×	×	×
3.	***Contract review***. Procedures shall be established and maintained for review and coordination of contracts to ensure that requirements are adequately defined and documented.	×	×	
4.	***Design control***. The facility shall establish and maintain procedures to control the product design to ensure that specifications are satisfied.	×		
5.	***Document control***. Procedures shall be established and maintained to control all documents pertaining to the requirements of this standard.	×	×	×
6.	***Purchasing***. The facility shall ensure that all purchased products conform to specified requirements.	×	×	
	Purchaser-supplied product. Procedures shall be established and maintained for verification, storage, and maintenance of purchaser-supplied items that will be incorporated into the final product sent to the ultimate customer.	×	×	
	Product identification and traceability. Where appropriate, procedures shall be established and maintained for identifying the product from drawings, specifications, and other documents during all stages of production, delivery, and installation.	×	×	×
	Process control. The facility shall plan the production and install processes that directly affect quality and shall ensure that these processes are performed under controlled conditions. Controlled conditions include, e.g., documented work instructions, process monitoring and control, and specified criteria for workmanship.	×	×	
	Inspection and testing. The facility shall (1) ensure that incoming materials are not further processed or used until verified as conforming to specification; (2) inspect, test, and identify product during processing as specified in the quality plan; and (3) carry out all final inspection and testing of the product to ensure conformance of the finished product to specified requirements.	×	×	×
	Inspection, measuring, and test equipment. The facility shall calibrate and maintain inspection, measurement, and test equipment used to demonstrate that product conforms to specified requirements.	×	×	×
	Inspection and test status. The facility shall identify the inspection and test status of the product through the use of markings, labels, stamps, inspection records, or other suitable means that indicate conformance or nonconformance of the product to specification. In addition, records shall identify the authority responsible for release of conforming product.	×	×	×
	Control of nonconforming product. The facility shall establish and maintain procedures to ensure that nonconforming product is prevented from being used or installed.	×	×	×
	Corrective action. Procedures shall be established, documented, and maintained to (1) investigate the cause of nonconforming product and the corrective action to prevent recurrence, (2) perform analysis to detect and eliminate causes of nonconforming product, (3) apply controls to ensure that corrective actions are effective, and (4) implement and record changes in procedures resulting from corrective actions.	×	×	

(continued on next page)

TABLE 20.5 (continued)

Section Number	Topic Area and Brief Description	ISO 9001	ISO 9002	ISO 9003
15.	***Handling, storage, packaging, and delivery***. The facility shall establish and maintain procedures to (1) prevent damage during product handling; (2) avoid damage and deterioration during product storage; (3) control packaging and related operations; and (4) protect the product after final inspection and testing, including delivery when contractually required.	X	X	X
16.	***Quality records***. The facility shall establish and maintain procedures for the identification, collection, indexing, filing, storage, maintenance, and disposition of quality records.	X	X	X
17.	***Internal quality audits***. The facility shall perform planned and documented internal audits to verify that quality activities are effective and comply with its own procedures.	X	X	
18.	***Training***. The facility shall establish and maintain procedures to (1) identify training needs and (2) provide training as needed for employees who affect quality.	X	X	X
19.	***Servicing***. When servicing is contractually specified, the facility shall establish and maintain procedures for performing and verifying that servicing meets the requirements specified in the contract.	X		
20.	***Statistical techniques***. As appropriate, the facility shall establish procedures to identify adequate statistical techniques for verifying that process capabilities and product characteristics are acceptable.	X	X	X

Source: Paraphrased and/or quoted from ISO 9001 [1].