The Requirements on statistical techniques in QS-9000

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Abstract

QS-9000 was established by Chrysler, Ford, General Motors and some Truck Manufactures to solve problems of efforts to prepare original standards for each company. When we compare the requirements in QS-9000 with those in ISO 9000, we may observe that those of QS-9000 are more specific, since the user of the standard is limited to the automobile industry. In particular, the requirements on statistical techniques are described in more detail. In this paper, we present the requirements on statistical techniques in QS-9000. Specifically, we review the contents of QS-9000 and explore the philosophy and the minimum requirement on statistical techniques behind the description.

1. Introduction

The number of books related to ISO 9000 sold in book stores is enough to recognize the huge impact of ISO 9000 to the world. It is also evident from the citation of Zuckerman (1996) that ISO 9000 business market in worldwide is reputed to be 10 billion US$ per a-year. One of the reasons of the popularity of ISO 9000 is that it is not a standard for a specific industry but a generic standard for all industries. This aspect sometimes causes a problem in terms of quality systems, since the description of the standard is sometimes vague. One of the measures which can be taken may be the independent preparation by purchasers of an original standard on quality systems. However, the preparation and the effort to meet the original standard require a large amount of work.

Under these circumstances, QS-9000 was established by Chrysler, Ford, General Motors, (sometimes called "The Big Three"), and some Truck Manufactures to solve such problems of efforts to prepare original standards for each company. The work on the establishment began in 1988 by harmonizing Chrysler's Supplier Quality Assurance Manual, Ford's Q-101 Quality System Standard and General Motors' NAO Targets for Excellence, with input from the Truck Manufactures.

The requirements in ISO 9000 were also included, since it was beginning to catch attention. The first edition of QS-9000 was established in August 1994 and revised in February 1995 as the second edition and March 1998 as the third edition.

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Specifically, we review the contents of QS-9000 and explore the philosophy and the minimum requirement on statistical techniques behind the description.

2. Overview of the requirements in QS-9000

2.1 Outline

The requirements of QS-9000 are described in *Quality System Requirements*, which consists of the following two sections.

Section I: ISO 9000-Based Requirements

Section II: Customer-specific Requirements

Section I involves the requirements in ISO-9001 with some additions. Section II describes the requirements for each of Chrysler, Ford and General Motors. The following manuals are prepared as references.

QS-9000 Quality System Assessment (*QSA*),

Production Part Approval Process (*PPAP*),

Advanced Product Quality Planning and control plan (*APQP*),

Potential Failure Mode and Effect Analysis (*FMEA*),

Measurement Systems Analysis (*MSA*),

Statistical Process Control (*SPC*).

QSA is prepared as a checklist for all kinds of quality assessments, for example internal assessment. Other manuals are prepared as references to meet the requirement. For example, SPC is used to determine the process control by statistical methods. In this paper, we will review section I in order to consider the common concept among the Big Three behind QS-9000.

2.2 Additional requirements to ISO 9000

Since the Section I consists of the requirements in ISO 9001 with some additional ones, we will evaluate these additional requirements in order to clarify the features and the philosophy behind the description. Table 1 shows the list of the additional requirements from the ISO 9001 requirements.

(1) QS-9000 describes more details on requirements compared with ISO 9000. For example, QS-9000 states in sub-section *4.9.1 Process Monitoring and Operator*

Instructions that "These instructions should be derived from the source listed in the Advanced Product Quality Planning and Control Plan reference manual." Regarding the detailed description in QS-9000, Ukai (1997) made a statement to the effect that we can determine the quality system related HOW to meet the requirements in ISO 9000, since only *WHAT* is determined in ISO 9000.

On the other hand, QS-9000 specifies not only *WHAT* but also *HOW* in order to assure the level of implementation of quality system. In other words, QS-9000 specifies more details since the users are limited to Automobile industries.

(2) It is very interesting that the new subsection *4.1.5 Analysis and Use of Company level data* was added into the section *4.1 Management responsibility* in ISO 9000. In the history of Quality Management, automobile industries have played important roles, in particular, application of statistical techniques and implementation of the concept of *Management by Fact*. The addition of

Table 1 Examples of the additional requirements in QS-9000 from ISO 9000

ISO 9001 clause Additional requirements	
4.1 Management Responsibility	
4.1.2.4 Organizational Interfaces	4.1.3.1 Management Review
4.1.4 Business Plan	
4.1.5 Analysis and Use of Company Level data	
4.1.6 Customer satisfaction	
4.2 Quality System	
4.2.3.1 Advanced Product Quality Planning	4.2.3.2 Special Characteristics
4.2.3.3 Feasibility Reviews	4.2.3.4 Product Safety
4.2.3.5 Process Failure Mode and Effect Analysis (Process FMEAs)	
4.2.3.6 Mistake Proofing.	4.2.3.7 The Control Plan
4.2.4 Product Approval Process	4.2.5 Continuous Improvement
4.2.6 Facilities and Tooling Management	
4.4 Design Control	
4.4.1.1 Use of Design Data	
4.4.2.1 Required Skills	
4.4.8.1 Design Validation -Supplemental-	
4.4.9.2 Design Change Impact	
4.9 Process Control	
4.9.b.1 Cleanliness of Premises	4.9.b.2 Contingency Plans
4.9.d.1 Designation of Special Characteristics	
4.9.1 Process Monitoring and Operator Instructions	
4.9.2 Maintaining Process Control	
4.9.4 Verification of Job Setups	
4.9.6 Appearance Items	
4.20 Statistical Techniques	
4.20.3 Selection of Statistical Tools	
4.20.4 Knowledge of Basic Statistical Concepts	

subsection *4.1.5* can be regarded as a will to keep this good tradition in the future.

3. The requirements on statistical techniques

(1) As regarding the statistical techniques, *4.2.5 Continuous Improvement* states that "The following list shows examples of possible techniques that might be used. There may be many other methods which meet specific supplier needs more appropriately.

Control Charts (variable, attribute, CUSUM), Design of Experiments (DOE),..."

The above is an example of the appearance of relatively advanced techniques, such as CUSUM chart and design of experiments.

Suppliers may have a question on whether application of relatively advanced techniques is necessary or not. This paper describes this aspect in the next section.

(2) In *4.20 Statistical Quality Element*, two new subsections *4.20.3 Selection of Statistical Tools* and *4.20.4 Knowledge of Basic Statistical Concepts* have been added on to Section *4.20 Statistical Techniques*.

The standard spends only one page to describe the requirements on statistical techniques, and for further reference, *Statistical Process Control(SPC)* manual needs to be consulted. In order to consider the essence of requirements on statistical techniques in QS-9000, we review the contents of the *SPC* manual. This manual consists of four chapters, and Table 2 shows the contents. Chapter I is an introduction chapter of this manual, such as what is SPC, how to use this manual, etc. Chapter II and III specify the usage of control charts for variables and attributes, respectively. Chapter IV describes measurement systems.

One of the interesting things is that the joint usage of control charts and process capability/performance indices is specified in Chapters II and III. Table 2 also shows the contents of Section 1 in Chapter II. In this table, "C" and "D" are mainly related to interpretation of control charts and process capability/performance indices, respectively.

4. Discussions

(1) Is application of advanced techniques compulsory ?

The supplier may wonder whether application of advanced statistical techniques is compulsory or not, since such advanced techniques, such as design of experiments, are listed in the standards described in Section 2 of this paper. I believe that the answer should be "NO," by the following three reasons. The first one is the contents of the reports on certification QS-9000. There are two reports (Ukai (1997) and Yamada and Asai (1997)) which describe the process to obtain certification, where the authors have worked in parts suppliers.

According to the reports, there were many difficulties to keep contingency on documents.

However, there is no description on the difficulty on application of advanced techniques. The fact of no description on application of advanced techniques suggests that the assessors did not require the application excessively. If such an application was required, the authors would probably describe the requirements statistical techniques in their report, although they belong to the promotion departments of QS-9000, not in the departments to be assessed, such as design departments and process control departments.

The second reason is the description of the standard related to the application. In QS-9000, the word "shall" implies a mandatory requirement and "should" implies a mandatory requirement with some flexibility. Regarding the should-requirements, the suppliers can determine the approach to satisfy the requirements. Almost all description on the application of the advanced statistical techniques are should-requirements. It implies that supplier should apply the techniques if necessary.

The third reason is the contents of the revision of QS-9000. The second edition of QS-9000 listed relatively more statistical techniques compared to the third. This fact implies that the revision from second to third edition may have been done to reduce excessive emphasis on advanced statistical techniques. These advanced techniques sometimes look good and can cause confusion of the objective of using the techniques, *i.e.* the use of such techniques becomes a goal in itself. The application of advanced techniques is not the goal, the goal is to assure the high quality.

(2) Background on *SPC* Manual

In the *SPC* manual, the application of process capability/performance indices is described in details with many examples. By combining this with the arguments in (1), we would find that QS-9000 requires the application of control charts and process capability/performance indices in an appropriate way, although application of advanced techniques beyond the charts and indices are not mandatory. Control charts and process capability/performance indices are minimum requirements on statistical techniques, although there are no specified requirements on statistical techniques in ISO 9000.

(3) Contents of *SPC* manual

The following would be worthy of special mention. (i) The order of evaluation $\bar{x}$-R chart is specified as R chart first and $\bar{x}$ chart second. (ii) Combined usage of control charts and process capability/performance indices is emphasized. (iii) Both process capability and performance are defined. The first point:(i) is important but sometimes forgotten in practice. I agree with the philosophy behind the second point:(ii) since the combined usage brings important information. For example, we may derive the degree of improvement by reducing the variation between sub-groups. However, the third point:(iii) seems to be doubtful. According to the QS-9000 definition, in process capability index, the dispersion of data is measured by information of R, while in process performance index, the dispersion is

Table 2 Contents of *SPC* manual

- **Chapter I: Introduction to continual improvement and statistical process control**
  - Section 1: Prevention versus detection
  - Section 2: A process control system
  - Section 3: Variation: Common and special causes
  - Section 4: Local actions and actions on the system
  - Section 5: Process control and process capability
  - Section 6: The process improvement cycle and process control
  - Section 7: Control charts: Tools for process control
  - Section 8: Benefits of control charts
- **Chapter II: Control chart for variables**
  - Section 1: Average and range chart (and R)
    - A: Gather data
    - B: Calculate control limits
    - C: Interpret for process control
      - C1: Analyze the data plots on the Range chart (Beyond the limit, runs, Obviously non random patterns)
      - C2: Find and address special causes (Range chart)
      - C3: Recalculate control limits (Range chart)
      - C4: Analyze the data plots on the Average chart (and R)
      - C5: Find and Address Special Causes (Average chart) (Beyond the limit, runs, Obviously non random patterns)
      - C6: Recalculate control limits (Average chart)
      - C7: Extend control limits for ongoing control
    - D: Interpret for process capability
      - D1: Calculate the process standard deviation
      - D2: Calculate the process capability
      - D3: Evaluate the process capability
      - D4: Improve the process capability
      - D5: Chart and analyze the revised process
  - Section 2: Average and standard deviation charts (and R)
  - Section 3: Median charts (and R)
  - Section 4: Charts for individuals and moving range (X-MR)
  - Section 5: Understanding process capability and process performance for variables data
- **Chapter III: Control chart for attributes**
  - Section 1: The p chart for proportion nonconforming
  - Section 2: The np chart for number of nonconforming
  - Section 3: The c chart for number of nonconformities
  - Section 4: The u chart for number of nonconformities per unit
- **Chapter IV: Process measurement systems analysis**
  - Section 1: Introduction
  - Section 2: Average and range method

measured by total variation, without strong consideration on variation between sub-groups and within a sub-group. If both the $\bar{x}$ and the R charts are stable, these indices are essentially the same. When at least one of the $\bar{x}$ and R charts are unstable, the data is not appropriate to measure the process since the process is unstable and reappearance of the data would not be assured. I believe that we should use the process capability index for stable processes only. For unstable processes, process performance index should not be used as an index for evaluation, it should be used merely as a guideline for improvement.

(4) Revision from the second to the third edition

The third edition was published in 1998 after the publishing of second edition 1995.

One of the major features of the revision is the requirement on statistical techniques.

The second specifies the highly advanced techniques, such as design of experiments, CUSUM chart, Taguchi method and so on, in the main body of standard. On the other hand, the third edition does not include the advanced techniques in the main body of the standard and the advanced techniques moved in the reference statements in the standard or reference manual. Thus, it can be regarded as the tone down of the requirements of advanced statistical techniques. On the other hand, the basic tools such as control chart and process capability index seems to be emphasized in the third edition more in the second edition.

One of the evidence is that the statements on the basic tools are appeared more in main body than the second edition. This fact implies that QS-9000 aim to ascertain of application on the basic tools, while the advanced techniques are not required so much.

(5) Some comments in view of statistical techniques in Japanese automobile companies

It is widely recognized that the Japanese automobile companies, such as Toyota, Nissan, and so on, have been promoted application of statistical techniques as well as the activities in Big Three. For example, we can easily find the application of some advanced statistical techniques in the abstract of the research meeting of Japanese Society for Quality Control, the abstract of Quality and Standard annual meeting and so on. Of course, the advanced techniques are also applied in the US industry. When we compare the application in companies in USA and Japan, it may be very difficult to find the difference in the activities, expect the promotion style on the basic tools, such as control chart and process capability index. The big three have implemented the standardization of the basic techniques while the Japanese companies have implemented the basic techniques in each company. As regard the advanced techniques, companies in both USA and Japan had implemented in each company and it seems to be no essential difference between companies in USA and Japan.

5. Concluding remarks

In this paper, we considered the requirements on statistical requirements in QS-9000 since the requirements are harder than the requirements in ISO 9000. The contents review on QS-9000 tells us the fundamental philosophy as follows: The basic tools, such as control chart and process capability index should be applied in an appropriate way, while the requirements on the advanced technique depend on the situation, such as the contract between the Big three and suppliers. The revision from the second to the third edition can be regarded as an evidence of the philosophy. In general, the essential role of standards is specification of the minimum level to achieve minimum level of quality. ISO 9000 works better in an initial stage to achieve minimum level of quality. On the other hand, these standards may not bring a way to achieve world-level quality (Yamada and Kano (1992), Kano and Yamada (1995)). From this viewpoint, the revision from the second to the third edition in QS-9000 may be favorable, since the requirements on the advanced statistical techniques are reduced and the requirements on the basic tools, that are helpful to achieve the minimum level, are enhanced.

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