SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE AS9103

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Variation Management of Key Characteristics

FOREWORD

In December 1998, the Aerospace Industry had established the International Aerospace Quality Group (IAQG) with the purpose of achieving significant improvements in quality and reductions in cost throughout the value stream.

This organization, with representation from Aerospace companies in Americas, Asia and Europe and sponsored by SAE, SJAC, and AECMA has agreed to take responsibility for the technical contents of this standard.

INTRODUCTION

This Aerospace Standard establishes variation management requirements for Key Characteristics. The Standard also specifies general requirements and provides a process to achieve those requirements.

The Standard requires a thorough assessment of the part production process with the primary goals being to control and minimize variation in characteristics being produced by this process.

Specifically, the Standard mandates:

- Understanding process elements that affect Key Characteristics
- Disciplined determination of process Key Characteristics using appropriate analysis tools for variation control and reduction to satisfy Customer requirements
- Control and capability assessment to ensure variation is well understood
- Process Control Documentation that defines specific control of Key Characteristics and manufacturing process parameters

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This standard does not:

- Mandate rejection of any part that conforms to engineering specification.
- Inhibit shipment or use of product during production process capability assessment.

Although Aerospace Standard AS9103 is focused on production and variation control of Key Characteristics, this process can also be used as a model for other characteristics, such as those that affect cost and delivery.

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1. SCOPE:

This Standard is primarily intended to apply to new parts, but can also be applied to parts currently in production. The Standard shall be applicable to all production processes that influence the variation of Key Characteristics.

1.1 Purpose:

This Aerospace Standard is designed to drive the improvement of manufacturing processes through adequate planning and effective management of Key Characteristic variation. The Key Characteristic focus is intended to improve confidence for part features whose variation has a significant influence on to end-product form, fit, performance, service life and manufacturability.

1.2 Convention:

The following conventions are used in this standard:

- The words shall, will or must indicate mandatory requirements.
- The word “should” indicates a requirement with some flexibility allowed in compliance methodology. Producers choosing other methods to satisfy a “should” must be able to show that their approach meets the intent of the requirements of this standard.
- Words “typical”, ”example”, “for reference” or “e.g.” indicate suggestions given for guidance only.
- “Notes” are used for additional clarifications.
- Words or phrases with specific meaning pertaining to this document are capitalized and defined in Section 3, Definitions.

2. REFERENCES:

2.1 Aerospace Standard AS9100 “Quality Systems- Aerospace- Model for Quality Assurance in Design, Development, Production, Installation and Servicing”, Published by SAE, Warrendale, PA, USA, 1999.

2.2 International Standard EN 9100 “Quality Systems- Aerospace- Model for Quality Assurance in Design, Development, Production, Installation and Servicing”, Published by AECMA-STAN, 1999.

2.3 Aerospace Standard SJAC 9100 “Quality Systems- Aerospace- Model for Quality Assurance in Design, Development, Production, Installation and Servicing”, Published by JSA, Tokyo, Japan, 1999.

2.4 Aerospace Standard AS9102: “Aerospace Standard for First Article Inspection Requirements”, Published by SAE, Warrendale, PA, USA, 2000.

2.5 International Standard EN9102: “Aerospace Standard for First Article Inspection Requirements”, Published by AECMA-STAN, 2000

2.6 Aerospace Standard SJAC 9102: “Aerospace Standard for First Article Inspection Requirements”, Published by JSA, Tokyo, Japan2000

3. DEFINITIONS:

3.1 Key Characteristic (KC):

AS9100/EN-9100/JISQ 9100 definition: The features of a material or part whose variation has a significant influence on product fit, performance, service life, or manufacturability.

This definition is further explained as follows:

- Key Characteristics for a part, subassembly or system are those selected geometrical, material properties, functional and/or cosmetic features, which are measurable, whose variation control is necessary in meeting Customer requirements and enhancing Customer Satisfaction.
- Key Characteristics for a process are those selected measurable parameters of a process whose control is essential to manage variation of part or system Key Characteristics.
- Substitute Key Characteristics may be identified when a Customer-defined Key Characteristic is not readily measurable within the production setting and other characteristics may need to be controlled to ensure conformance.

3.2 Producer:

An organization that performs any process affecting the manufacture of the part.

3.3 Customer:

The organization which provides Part or System Key Characteristics via engineering drawings, specifications or purchase order/contract requirements. For example, a Customer may be an internal engineering department for a company which has design authority, in addition to the external Customer who specifies system Key Characteristics.

3.4 Key Characteristic Owner:

Key characteristic owner is the person or function who defines the Key Characteristics and recognizes the reasons for the selection of the Key Characteristic. Typically, these responsibilities are held by Internal or External Customer Design, Quality or Manufacturing Engineering, and should be identified by a cross-functional team.

3.5 Key Characteristic Process Owner:

The Key Characteristic Process Owner is the person or function who uses Key Characteristic data to maintain and improve the process.

3.6 Process Control Document (PCD):

A Process Control Document (PCD) is a written description of manufacturing plan developed to control variation in Key Characteristics. It is a living document and is updated to reflect the addition / deletion of Key Characteristics.

3.7 Special Cause:

The term 'special cause' in this standard can be substituted by 'assignable cause.' The terms have their usual meanings relative to Statistical Process Control methodology.

4. APPLICABILITY:

This Aerospace Standard applies to assemblies and all levels of parts within an assembly, including castings and forgings, and to organizations that are responsible for producing the design characteristics of the product. Producers and their Subcontractors shall be responsible for flow down of the requirements of the applicable revision of this Aerospace Standard to Subcontractors who produce design characteristics, and for ensuring that Key Characteristics conform to Customer requirements.

5. GENERAL REQUIREMENTS:

Section 5 provides the following general requirements which must be met regardless of the variation management methodology applied.

5.1 Variation management activities must be performed on identified Key Characteristics and processes until they are in control and process capability has been established. Appropriate monitoring methodology should then be implemented to ensure continued performance.

5.2 The Producer shall maintain appropriate documentation of Key Characteristics and manufacturing process elements that influence variation in Key Characteristics as well as their control techniques and measurement methods. This documentation shall be developed when any of the following occurs:

a. Customer defines a Key Characteristic or a key process parameter.

b. Lower level or Substitute Key Characteristics are required to control variation of higher level Key Characteristics.

c. Analysis performed as part of a process improvement activity to meet quality objectives required by AS9100 results in the identification of a key characteristic or process.

5.3 If statistical process control is chosen as the method of control for the Key Characteristic, the following requirements must be met:

a. Process capability shall be established for Key Characteristics. The process capability index (e.g., Cp and Cpk) shall be calculated only when the process is shown to be stable and in statistical control, using sound statistical methods and/or appropriate control charts

b. The process shall be capable, with Cpk $\geq$ 1.33, or as specified by the Customer.

Note: A Key Characteristic is considered capable if its Cpk exceeds 1.33. Other comparable measures of process capability may be used. If the process does not meet capability requirements, the Producer may have several options as described in this section.

c. When similar Key Characteristics from different products are combined on the same control chart (a part or product family, or process output control approach), the characteristics shall have similar variability and be traceable to the specific part or product.

d. If process capability is used to justify reduced frequency of inspection, the process capability or equivalent fallout rate shall be calculated using industry standard statistical methods.

e. Processes that cease to be in control and/or capable and the product feature is under a reduced inspection plan, normal end-item inspection shall resume for acceptance of the product feature until the cause has been identified, corrected and process capability and control are re-established.

5.4 Other variation control methods such as tooling, control of process settings, standard processes and mistake proofing may be used to ensure process stability and capability. However, measurable evidence must demonstrate that the controls are effective.

5.5 Focusing on Key Characteristics does not relieve the Producer from meeting all drawing characteristics, specifications and other customer requirements and/or invoked standards.

5.6 In some cases, it may be impossible or prohibitively expensive to meet the stability and capability requirements of Section 5. These exceptions must be documented by the Producer and may require customer approval.

6. PROCESS MODEL AND OUTPUTS:

Appendix A describes a model that may be used in fulfilling the requirements of this Standard and is presented for illustration and clarity.

The model consists of several stages, starting with the definition of Key Characteristics and ending with the monitoring of product manufacturing process performance. Other methods or processes may be employed to achieve compliance. The Producer in either case must show that compliance with the requirements in Section 5 has been achieved and the method by which compliance was obtained.

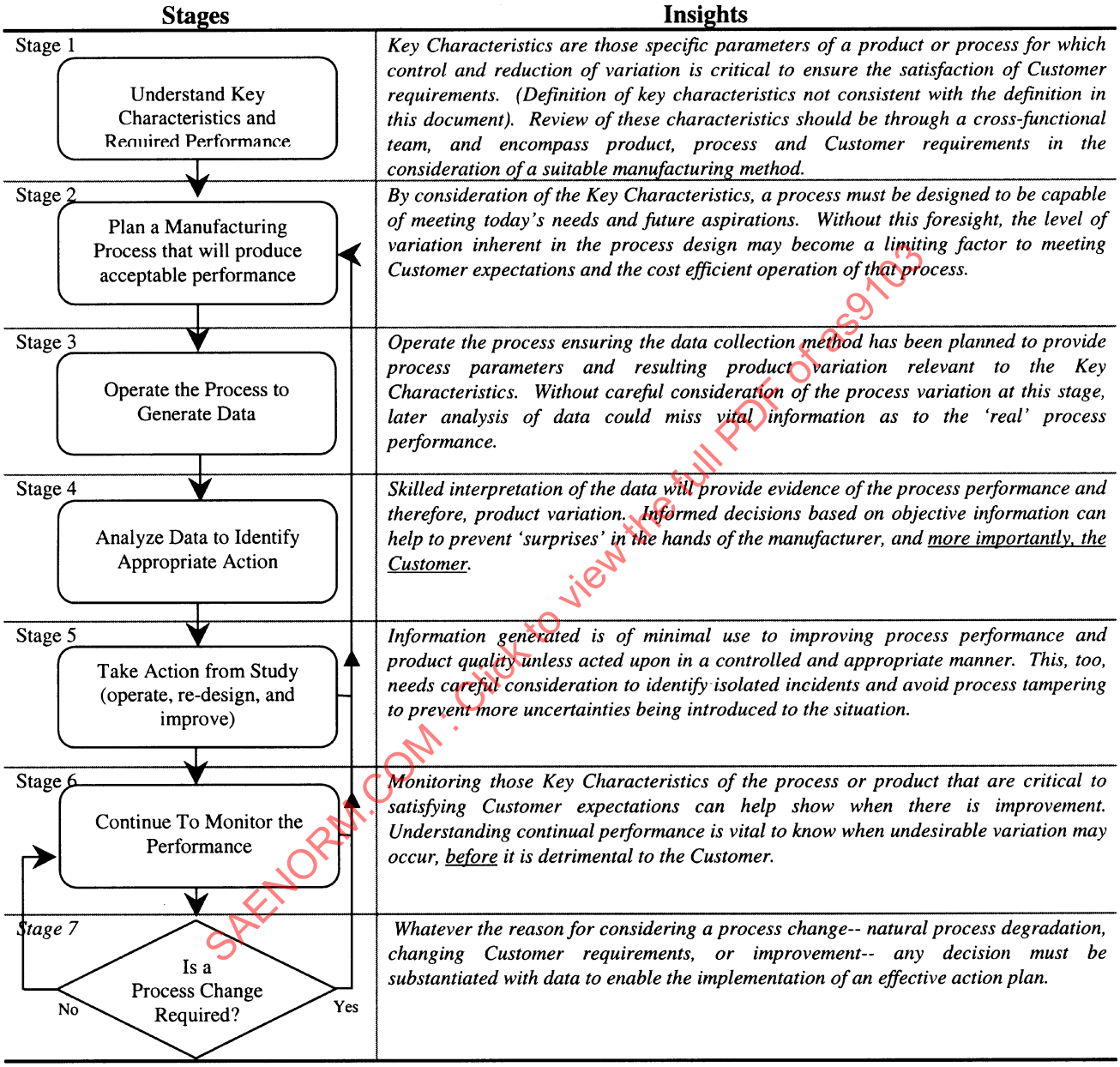

FIGURE 1 - Preferred Model for Key Characteristic Variation Management

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APPENDIX A
GUIDELINES TO MEETING REQUIREMENTS FOR VARIATION MANAGEMENT OF KEY CHARACTERISTICS

A.1 STAGE 1: REVIEW KEY CHARACTERISTICS AND REQUIRED PERFORMANCE:

A.1.1 Producer establishes an appropriate cross-functional team, which has an understanding of customer requirements and the producer's manufacturing processes. The cross-functional team reviews customer requirements - specifically the Key Characteristics on the product (if any).

A.1.2 Key Characteristics and the required performance are documented on the Process Control Document or equivalent.

A.1.3 Stage 1 Outputs:

- Documentation of customer Key Characteristics

A.2 STAGE 2: PLANNING A MANUFACTURING PROCESS:

A.2.1 The producer defines a manufacturing process by developing a new or by reviewing an existing manufacturing process flowchart. This includes the identification of key elements that influence variation of Key Characteristics. Knowledge of existing process capability and customer capability requirements is considered.

A.2.2 The producer performs cause effect analysis to identify any process Key Characteristics. If substitute Key Characteristics are used, the producer demonstrates association of substitute Key Characteristics with customer defined Key Characteristics. The producer establishes a minimum acceptable capability ratio for each Key Characteristic.

A.2.3 The producer identifies a Process Owner for each Key Characteristic. The Process Owner is responsible to maintain and improve the process performance that generates the Key Characteristic.

A.2.4 A disciplined review of each process generating Key Characteristics is conducted to identify sources of variation and potential risks. Plans are developed to manage those risks.

A.2.5 Detailed work instructions and measurement instructions are developed to manage sources of variation.

A.2.6 The producer updates the Process Control Document (PCD) after completing activities of this stage (see PCD Example, Appendix B).

A.2.7 Stage 2 Outputs:

- Flow chart of the manufacturing process or equivalent documentation
- Cause/Effect Analysis
- Key process elements and their reference to Key Characteristics
- Process Key Characteristics
- Substitute Key Characteristics and association with Customer defined KCs
- Identification of the Process Owner
- Potential sources of variation
- Work instructions
- Measurement instructions
- Updated PCD or equivalent

A.3 STAGE 3: OPERATE THE PROCESS ON TRIAL BASIS TO GENERATE DATA:

A.3.1 The producer creates a data collection plan(s) for all Key Characteristics that reflects the sources of variations. The plan specifies who, what, where, frequency and how many parts will be included and under what conditions the data will be collected. The producer determines the type of control chart to be used.

A.3.2 The producer manufactures parts according to previously defined work instructions. The trial parts are manufactured in a representative production environment.

A.3.3 The producer collects data on control charts according to the data collection plan. Any deviation to this plan is documented.

A.3.4 A first article inspection (FAI) may be performed at this stage (Reference AS/EN/ SJAC 9102).

A.3.5 The producer updates the Process Control Document as required.

A.3.6 Stage 3 Outputs:

- Data collection plan
- Control chart
- Updated PCD or equivalent

A.4 STAGE 4: ANALYZE DATA FOR ACTION:

A.4.1 The producer reviews control charts to determine if the process is stable. The producer calculates process capability and provides evidence to demonstrate statistical reasoning and justification, in addition to the calculation method. The process capability index (e.g., Cp. and Cpk.) is calculated only when the process is stable.

A.4.2 If the process is not stable, the producer investigates to determine the root cause using suitable problem resolution tools. Investigation results are documented.

A.4.3 If the process is stable, but the capability does not meet the customer requirements, the producer prioritizes common cause sources of variation, to identify the most influential source(s). Subsequent investigation determines root cause(s) of this variability. If the capability meets customer requirements, take no further action on the process, and finalize the PCD.

A.4.4 Process Key Characteristics are re-evaluated based on understanding of the observed process behavior to determine if any need to be added or do not apply.

A.4.5 The producer updates the Process Control Document. Reference to associated documentation is included.

A.4.6 Stage 4 Outputs:

- Process capability, including calculation method
- Investigation results of out-of-control points
- Investigation results of sources of variation
- New or revised Key Characteristics identified
- Updated PCD or equivalent

A.5 STAGE 5: TAKE ACTION FROM STUDY OF KEY-CHARACTERISTIC PERFORMANCE:

A.5.1 When a process is not stable, and the special cause is known, corrective action is taken to remove permanently or minimize the cause. Effectiveness of corrective action is verified.

A.5.2 When a process is not capable or the special cause continues to be evident, the producer investigates gage variation. If a Measurement Systems Analysis (MSA) has already been performed, the producer verifies the results.

A.5.3 If a process is stable but still not capable, the producer investigates centering of the process.

A.5.4 If a process continues to be stable but not capable, the producer takes appropriate actions on sources of variation that influence the process performance.

A.5.5 If after performing the previous actions, the process is not stable or not capable, the producer implements a Product/Process protection plan until such time that the process is proven capable and stable.

A.5.6 A first article inspection (FAI) may be performed (Reference: AS/EN/SJAC 9102), unless it has been performed previously in Stage 3 and the process is unchanged.

A.5.7 Whenever actions are taken that change the manufacturing process, the producer will take appropriate action in Stage 2 through Stage 5.

A.5.8 The Process Control Document is finalized as soon as the process is stable and capable.

A.5.9 Stage 5 Outputs:

- Corrective action documentation for out of control points
- Measurement Systems Analysis
- Corrective action documentation for sources of variation
- Product/process protection plan
- Updated PCD or equivalent

A.6 STAGE 6: CONTINUE TO MONITOR THE PROCESS:

A.6.1 When a Key Characteristic is meeting capability requirements, then the producer will periodically verify that the process remains in control and capable. The producer should continue to measure process performance to identify opportunities for process improvement through variation reduction. If learning from monitoring the process results in a change in the method of production, the producer will operate to Stage 7.

A.6.2 To ensure that valid producer Key Characteristics have been identified the producer should continually review business indicators as appropriate. This may result in eliminating some producer Key Characteristics and adding others. All additional producer Key Characteristics will follow the requirements of this standard from Stage 2 and beyond.

A.6.3 Stage 6 Outputs:

- Ongoing controls on Key Characteristics
- Ongoing analysis of business indicators
- Updated PCD or equivalent

A.7 STAGE 7: PROCESS CHANGE MANAGEMENT:

A.7.1 The producer documents any planned change to the manufacturing process.

A.7.2 The producer follows the requirements of A.1 to A.5 prior to implementing any planned change to the approved manufacturing process, as related to the affected Key Characteristics.

A.7.3 Stage 7 Outputs:

- Process change documentation
- Updated PCD or equivalent

APPENDIX B
PROCESS CONTROL DOCUMENT EXAMPLE

Process Control Document (PCD) shown in Appendix B is the preferred method of fulfilling the documentation requirements of this Section, any other equivalent method of documentation may be accepted.

1. Process Control Document (PCD) Number - Enter the process control document number used for tracking. It may be made of any combination of letters and/or numbers.

2. Part Number / Part Family / Latest Change Level - Enter the number of the assembly, or part number being controlled. The process designation / specification number and part family can be entered into this block if applicable. Enter the latest engineering change level.

3. Part Name / Description - Enter the name and description of the part / process being controlled.

4. Producer / Plant - Enter the name of the company and appropriate division / plant / department preparing the Process Control Document.

5. Manufacturing Code - Enter the identification number as requested by the procuring organization. For example this could be Producer Code, vendor identification code, Mfg. Id Number, etc.

6. Process Owner - Enter the name of the person who uses Key Characteristic data to maintain and improve the process.

7. Is Flow Chart Created? Answer yes or no.

8. Producer Approval and Date - Enter the person(s) name that is responsible for producing and approval of the manufacturing plan and date signed.

9. Customer Approval and Date - Obtain the approvals from customer organizations (such as Engineering, SQA, etc.) if required.

10. Date (original) - Enter the date that the original Process Control Document was compiled. Usually the end of Stage 1.

11. Date (Rev) - Date that the Process Control Document was revised.

12. Key Characteristic No. - Enter the KC number that would uniquely identify that KC.

13. KC Name - Enter name of the key characteristics, e.g. Diameter, Temperature, etc.

14. Process ID - Identify type of manufacturing process by its unique producer specific number (or name).

15. Operation Number - Enter the Operation number from the work instruction.