



ENGINE PRODUCTION QUALITY SPECIFICATION

**SUPPLIER REQUIREMENTS FOR  
CHARACTERISTIC ACCOUNTABILITY,  
VERIFICATION, AND QUALITY PLANNING**

*This specification is in addition to and in no way limiting,  
superseding, or abrogating any contractual obligation as  
required by the applicable procurement document.*

**COLUMBIA HELICOPTERS, INC.  
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<b>ENGINE PRODUCTION QUALITY SPECIFICATION SUPPLIER REQUIREMENTS FOR CHARACTERISTIC ACCOUNTABILITY, VERIFICATION, AND QUALITY PLANNING</b>	<b>CHI-SQS-03</b>
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#### RECORD OF REVISIONS

With each revision the following content is always updated:

Title Page – Updated revision number and date

Record of Revision – Revision changes listed

List of Effective Pages – Updated page dates and revised pages marked with change bars

Page Footer – Updated to reflect new revision date.

REVISION	DATE	CHANGES
0	Dec 05/19	Initial Release

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## SPECIFICATION

### 1. Purpose

- A. To make sure that all Columbia Helicopters Inc. (CHI) accountable characteristics of a product are addressed by the supplier in the manufacturing and quality plans, and that planning includes controls adequate to make sure of continued conformance of these characteristics.
- B. To provide requirements for documenting the results of First Article Inspection (FAI) and evaluations of changes subsequent to FAI documentation.

### 2. Reference Documents

Document Number	Title
CHI-SQS-01	<i>Quality System Requirements for Suppliers</i>
CHI-SQS-02	<i>Supplier Verification Process</i>
CHI-SQS-03A	<i>Operator Acceptance Plan</i>
CHI-SQS-03B	<i>OAP Workstation Audit</i>
CHI-SQS-03C	<i>Supplier Verification List T58/CT58 Part Number accountability</i>
CHI-SQS-03D	<i>T58/CT58 Product Accountability: Raw Material, Special Process, Functional Testing</i>
CHI-SQS-03E	<i>T58/CT58 Characteristic Accountability, Verification and Compatibility Evaluation</i>
CHI-SQS-03F	<i>T58/CT58 Product Audit Part Family Designation</i>
CHI-SQS-03G	<i>T58/CT58 Product Audit Proposal/Completion</i>
CHI-SQS-03H	<i>T58/CT58 Product Validation Checklist</i>

#### GE AVIATION SPECIFICATIONS

P1TF3	<i>Interpretation of Drawings</i>
P1TF9	<i>Machined Features – Shop-Run Tolerances</i>
P1TF10	<i>Sheet Metal Parts and Fabricated Assemblies – Shop-Run Tolerances</i>
P1TF11	<i>Cast and Forged Parts – Shop Run Tolerances</i>
P1TF108	<i>Interpretation of Drawing</i>
P23TF3	<i>Identification Marking</i>
P23TF10	<i>Identification Marking Wizard</i>
M50TF9	<i>Vendor Designed Parts</i>

#### SOCIETY OF AUTOMOTIVE ENGINEERS AEROSPACE STANDARDS

AS13002	<i>Requirements for Developing and Qualifying Alternate Inspection Frequency Plans</i>
AS13003	<i>Measurement Systems Analysis Requirements for the Aero Engine Supply Chain</i>
AS13004	<i>Process Failure Mode and Effects Analysis (PFMEA) and Control Plans</i>

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### 3. Acronyms

Acronym	Full Description
AS	Aerospace Standard
CHI	Columbia Helicopters, Inc.
CHIQR	Columbia Helicopters, Inc. Quality Representative
CID	Change In Design
CMM	Coordinate Measurement Machine
CPD	Concurrent Product Development
DPD	Design Procurement Drawing
FAI	First Article Inspection
IEC	International Electrotechnical Commission
MED	Master Envelope Drawing
MT&E	Measurement & Test Equipment)
OAP	Operator Acceptance Plan
PDCN	Process Drawing Change Notice
PFMEA	Process Failure Mode and Effects Analysis
PO	Purchase Order
PQE	Product Quality Engineer
SSP	Source Substantiation Process
SSPCT	Small Sample Process Capability Tool
SPS	Significant Process Substantiation
SVP	Supplier Verification Process
VSE	GE Aviation Vendor Substantiation Engineering

### 4. Special Instructions

A. In the event of conflict in CHI quality system requirements, order of precedence must be:

- 1st – Applicable GE-A drawing (including specifications referenced on drawing)
- 2nd – Procurement Document (excluding this document)
- 3rd – CHI-SQS-01, *Quality System Requirements for Suppliers*
- 4th – This Document
- 5th – All specifications referenced in this document



**NOTE:**

This order of precedence applies to the purchase order (PO) holder to make sure the PO does not take exception to a drawing requirement for a finished part.

B. For all applicable references to GE Aviation Vendor Substantiation Engineering (VSE), Source Substantiation Process (SSP) or Significant Process Substantiation (SPS), refer to CHI-SQS-02, *Supplier Verification Process*.

### 5. Applicability and Use

A. This specification defines characteristic accountability, verification, and quality planning for initial approval and ongoing production. This applies to product supplied to CHI by CHI Suppliers.

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- B. The Supplier is responsible for performing characteristic accountability, verification, and development of the quality plan in accordance with this specification. This must be completed and CHI approval obtained before initial shipment of production hardware. CHI reserves the right to witness the Supplier's inspections and/or tests to determine the degree of conformance.
- C. This document applies to applicable GE-A drawings for all levels of parts within an assembly, including castings and forgings, and to all Suppliers who are responsible for producing the accountable characteristics of the product. Suppliers who receive the Purchase Order from CHI are responsible for flow down of the requirements of the latest issue of this specification to their Sub-tier Suppliers.
- D. When a CHI production facility is used to produce product or provide processing, a Certificate of Conformance must be provided as evidence of the work performed. For product that is used by the supplier and was purchased by CHI, evidence of receipt of material from CHI must be provided.
- E. When a supplier has developed an internal process/system that addresses all requirements of this specification, supplemented by effective auditing to assure compliance, the supplier can request CHIQR approval of that alternate internal process/system.
- F. An approved Product Acceptance Package by the CHIQR is a sufficient means of indicating approval for alternate documentation or methods permitted (e.g. "unless otherwise approved by the CHIQR").
- G. All data and related records are required to be documented in the English language and data must be recorded in US Customary Units (US Units), unless the drawing or PO specifies International System of Metric Units (SI Units) as prime. Conversion of dimensional measurements from SI Units to US Units is covered by GE-A specifications P1TF3 and P1TF108. The Drawing Revision entry on form CHI-SQS-03C is the revision applicable to the First Article part shipped. Drawing revision entries on form CHI-SQS-03D are to be kept current as required to reflect any changes in required characteristics.
  - (1) Drawings may reflect both units of measure (US units and SI units), with one unit designated as prime and the other unit designated as the alternate. In these cases, the manufacturer may use either unit of measure, but must consistently apply the same unit measuring system to all drawing characteristics.
- H. CHI approvals on CHI-SQS-03C for all task types and copies of all other related data and documentation must be maintained as part of the product acceptance record requirements of CHI-SQS-01. The Supplier's quality function maintains these records under their control, or specifically delegate this responsibility, to make sure of retrieval when required.
- I. Alternate materials, processes, and configurations that are permitted by drawing must be ballooned and annotated. With CHIQR approval, annotate on form CHI-SQS-03E and document applicability.
- J. For any part that has a lapse in manufacturing of 24 months or more (between the completion of the manufacturing cycle of the last part produced and the start of a new part), the product acceptance records must be submitted for approval if requested by the CHIQR.
- K. Process Failure Mode and Effects Analysis (PFMEA) requirements are incorporated during the FAI process. PFMEA forms must be available for review by the CHIQR for product acceptance records and attached to the documents at the time of submittal. If there is a need for PFMEA activity after FAI approval, this must be coordinated through the responsible CHIQR. Appropriate PFMEA forms can be attached to a new FAI document (full or partial FAI, as appropriate). Refer to AS13004 for requirements.
- L. Statistical methods to support alternate inspection frequency plans must meet AS13002 *Requirements for Developing and Qualifying Alternate Inspection Frequency Plans* except,

where appropriate, the Small Sample Process Capability Tool (SSPCT) may be used to analyze initial, short term capability.

6. Establishment of Accountable Characteristics

- A. Suppliers are responsible for all accountable characteristics, including those generated by their Sub-tier Suppliers. Sub-tier Suppliers must route characteristics that they are responsible for and provide evidence of completion of those accountable characteristics to the Supplier
- B. A ballooned drawing should be provided using CHI controlled balloons. If no CHI controlled balloon drawing exists, a ballooned drawing must be generated and accountable characteristics numbered for the manufactured part using the ballooning principles stated in [Appendix C](#).



**NOTE:**

All balloon drawings generated by the Supplier must be approved by CHIQR before implementation.


- C. When working to an issued drawing plus CID(s), the CID number(s) must be listed on CHI-SQS-03C.

7. First Article Inspection

First Article Inspection is required to be a complete, independent, and documented physical and functional inspection procedure after all part processing, unless the drawing or processing dictates that the characteristic be inspected before all processing is completed. The FAI part must be representative of a production run.

- A. The first article inspection must be performed using an independent gaging method rather than the normal product acceptance plan, unless otherwise approved by the CHIQR. Production gaging may be used for first article inspection in cases where it is the only method of accurately checking a characteristic.
- B. Inaccessible Characteristics: A characteristic inaccessible at final inspection may receive first article inspection when accessible during the process in lieu of disassembly/destruction. The Supplier must make sure that subsequent processing does not cause the characteristic to become nonconforming or unintentionally alter the characteristic.
- C. Characteristics that cannot be evaluated non-destructively on a finished part may be re-evaluated using component parts before final assembly or by using hardware not usable because of reasons unrelated to the characteristic under re-evaluation.
- D. Non-Measurable Characteristics: Result such as "Acknowledge" or "Conform" or "Not Reportable" must be entered.
- E. Dimensional Specifications (e.g., Shop Run Tolerance specifications P1TF9, P1TF10, P1TF11): Measure all occurrences of every characteristic and provide a summary of results using minimum/maximum values, unless additional data is required by the CHIQR.
- F. Multiple Characteristics (e.g., bolt circle, dovetail slots): Provide variable data for all occurrences of every characteristic or minimum/maximum readings along with the number of measurements taken, unless additional data is required by the CHIQR.
- G. Continuous Characteristics (e.g. radius along circumference, weld seams, edge breaks, surface finish, slot dimension, wall thickness and continuous features invoked by specifications): Measure a sufficient number of locations over the total extent of the characteristic to make sure of total conformity. Provide variable data for all measurements or minimum/maximum readings, along with the number of measurements taken. Provide additional data as required by the CHIQR

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- H. Nonconformance: Characteristics that are identified as nonconforming during first article inspection must be documented appropriately and sent to the CHIQR. Additionally, the NC number must be linked to the characteristic results or referred to in the CHI-SQS-03E results.
- (1) Any nonconforming characteristic found on the FAI requires 100% characteristic evaluation until justification for an alternate acceptance plan per AS13002 *Requirements for Developing and Qualifying Alternate Inspection Frequency Plans* is approved by the CHIQR.
  - (2) The FAI may be approved with an approved NC record. At least a partial FAI must be performed and approved on the next manufacturing lot to evaluate the original nonconformance, before shipment of parts related to that manufacturing lot.
8. Supporting Elements of Product Acceptance Records
- Items listed in this paragraph are required supporting elements for the Product Acceptance Record Data Package (for FAI and product audit.)
- A. Part marking wizard (for specifications that have available wizards – P23TF3, P23TF10, and M50TF9), planning/operation sheets for the marking operations, and a photo of all marking required unless otherwise directed by the CHIQR.
  - B. Manufacturing routing sheets unless otherwise directed by the CHIQR.
  - C. Applicable inspection reports (Final, In-Process, etc.) unless otherwise directed by CHIQR.
  - D. Certificates of Conformance for all material, testing and sub-tier special processes, unless otherwise directed by the CHIQR. Certificates must be traceable to the documented information in the CHI-SQS-03E form results column.
  - E. Ballooned drawing (drawing with characteristic numbers assigned).
  - F. Special process Tech plans.
- 

For initial FAI of SVP parts, items other than 1 and 6 may be attached to the SVP in lieu of attaching them to the Product Acceptance Package, and noted as such unless otherwise specified by the CHIQR.
- NOTE:**
9. Quality Planning and Acceptance Plans
- A. Manufacturing and quality planning must be in place before final acceptance of deliverable hardware to make sure that all accountable characteristics are included in the plans. Refer to [Appendix A](#) for a recommended quality planning process map. The FAI must be completed for the GE-A drawing and the supplier MED (Master Envelope Drawing) where applicable. Where Supplier/Sub-tier product and process drawings exist that contain GE-A design characteristics, the Supplier must complete a compatibility assessment.
  - B. Inspection equipment selected for first article inspection and ongoing production must meet the requirements of AS13003, *Measurement Systems Analysis Requirements for the Aero Engine Supply Chain* unless otherwise authorized by the responsible CHIQR. It is recommended that equipment used for measurement purposes be of sufficient capability to measure one decimal point beyond engineering requirements (i.e., if the drawing requires 3 decimal points – 0.000, the equipment should be capable of reading to 4 decimal points – 0.0000). All significant digits past one decimal point beyond engineering requirements should be truncated.
  - C. If standard gages are not used, the functional or single-purpose gage number must be noted.
  - D. The required acceptance plan is 100% inspection of each characteristic on every piece manufactured, except when implementing an Alternate Inspection Frequency Plan per AS13002, *Requirements for Developing and Qualifying Alternate Inspection Frequency Plans*.

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- E. Data used for process capability calculations must be representative of the planned process and must not include rework or work outside the normal process.
- F. The operation where each characteristic is verified must be recorded on form CHI-SQS-03E. Consideration must be given as to whether subsequent operations could have an effect on the final characteristic.
- G. Measurement of characteristics for product acceptance, whether completed during manufacturing or at final inspection, must be performed by qualified inspectors or certified operators. Certification must be achieved through a supplier certification program that meets the requirements of [Appendix B](#).

#### 10. Change Management

The following paragraphs provide both requirements and options to consider when “Change” occurs. Special attention is required.

- A. All requirements of this specification apply to accountable characteristics impacted by any of the changes listed below, including those invoked by drawing specifications. The CHIQR may require additional characteristic accountability as deemed necessary. When CHI approval is not required, changes must be documented and documentation must be sent to the CHIQR before shipment. Changes must be documented on the current CHI-SQS-03C/ D/E forms, or equivalent, and be available for review upon request.

- (1) Changes to a configuration of a previously approved part (i.e., P01 to P02, G01 to G02).



All changes, additions, deletions, and modifications of characteristics must be accounted for and submitted to CHI for approval.

- (2) Drawing or specification changes that do not change the part or assembly number (P# or G#).



All changes, additions, deletions, and modifications of characteristics must be accounted for. Updated documentation does not require submission to CHI for approval unless the frequency is changing to anything less than 100%.

- (3) Process changes (including change in manufacturing Supplier and Sub-tier owned changes): Inspection method and/or frequency for affected characteristics of any process change must be evaluated for impact. Updated documentation does not require submission to CHI for approval unless the frequency is changing to anything less than 100%. This does not override CHI-SQS-02 requirements.
- (4) Product acceptance change: Updated documentation does not require submission to CHI for approval unless the frequency is changing to anything less than 100%, except as required by AS13002, *Requirements for Developing and Qualifying Alternate Inspection Frequency Plans*.
  - (a) Change in product acceptance plan: Refer to AS13002, *Requirements for Developing and Qualifying Alternate Inspection Frequency Plans* for required documentation and approval process.
  - (b) Change in production inspection equipment (e.g., from micrometer to functional gage).
  - (c) Changes to the point of inspection relative to the manufacturing process. (e.g., move from final inspection to in-process)

- (5) A repeat (full or partial, as appropriate) first article inspection must be performed when any of the following events occur: (This paragraph highlights some repeat FAI scenarios, but is not intended to be an all-encompassing list.)

- (a) A change in inspection methods or measurement equipment.



Refer to AS 13003, *Measurement Systems Analysis Requirements for the Aero Engine Supply Chain*.

**NOTE:**

- (b) Relocation of a process and equipment within a Supplier (examples: moving a machine operation from one broach to another broach or from a Haas NC Mill to a Monarch Mill or reducing the number of mill passes to a machine feature, moving equipment from one building to another, or within a building).



SVP product may require additional requirements to be met, refer to CHI-SQS-02.

**NOTE:**

- (c) A change to numerical control programs.



Refer to CHI-SQS-01, *Requirements for Suppliers Software Quality Assurance Programs*.

**NOTE:**

- (d) A natural or man-made event that adversely affects characteristics.
- (e) Any change in the process or process sequence (examples: tooling, fixtures, material, material coolant type) that could potentially have an effect on part characteristics.
- (f) Any change to Characteristic Classification, including Key, Critical, Major or Minor characteristics. Make sure the Acceptance Plan is correct, as outlined in [Appendix A: Quality Planning and Acceptance Plans](#).

- B. The most current quality plan (locked or approved by the CHIQR) must match the inspection method and frequency used at the Supplier and/or Sub-tier Suppliers. The Supplier must develop a plan to update and notify the CHIQR when manufacturing plans or inspection plans are revised.
- C. If a given part number is changed or an FAI of any type is performed, the most current quality plan (locked or approved by the CHIQR) must match the inspection method and frequency used and the obsoleted record must no longer be used. When a Partial FAI is done for the first time and the FAI (full or previous partials) resides on file at CHI, you must attach a PDF or Excel document of the previous FAIs (at least the characteristic number and quality plan) record. The attachment(s), as well as the quality plan record, must match what is used during manufacturing.
- D. The Supplier must have a process to make sure all engineering and manufacturing changes to the manufacturing planning are reviewed against the current quality plan. Changes must be submitted as required.

#### 11. Product/Process Audit

Supplier Product/Process Audit: This paragraph defines the minimum requirements for product audits. These requirements must be incorporated into the Supplier Product Audit procedure.

- A. The purpose of this audit is to make sure that the established process controls and product acceptance plans continue to provide conforming material.
- B. The audit plan is initiated at the beginning of the calendar year by the Supplier. The Supplier must document their proposed part family/part audit plan for the calendar year in a timely manner.

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- C. Family designations and selected part(s) must be documented and submitted to the CHIQR for review and approval. When approved, the Supplier is notified.
- D. Any changes to the approved plan must be requested and approved by the CHIQR.
- E. The product audit includes all accountable characteristics on a completed production part. It is also an evaluation of the Supplier's planning and procedures to make sure of compliance with the requirements of this specification. Evaluation must include variable results, inspection equipment, and the current acceptance plan—100% or alternate inspection plans as specified in AS13002, *Requirements for Developing and Qualifying Alternate Inspection Frequency Plans*.
- F. The Supplier documents completion of the product audit and the evaluation results, using form CHI-SQS-03G (Product Audit Proposal/Completion), unless an alternate form is approved by the CHIQR.
- G. Each part identified for product audit must have a Product Validation Review (PVR) completed by the Supplier. Form CHI-SQS-03H (Product Validation Checklist) must be completed and sent to the CHIQR.
- H. Family designations and parts assigned must be submitted to the CHIQR for review and approval using form CHI-SQS-03F (Product Audit Part Family Designation). This should be accomplished on an annual basis before developing the audit plan for the year.



Families defined either too broadly or too restrictively can defeat the purpose of a product audit, which is to evaluate the effectiveness of the processes used to manufacture parts.

- I. A minimum of one part per part family must be audited annually. The Supplier part selection for audits must be reviewed and approved by the CHIQR using form CHI-SQS-03G (T58/CT58 Product Audit Proposal/Completion). Any changes to the plan must be submitted and approved by the CHIQR. Once the audits are complete, the CHIQR must approve the form as an acknowledgment of completion.
- J. Parts that are audited must not be re-audited until all parts in the family are completed. An exception may be made for parts with quality issues, high volume parts, or for parts not in production when the audit is performed.
- K. Whenever possible, the product audit re-evaluation must be performed using a method of acceptance measurement independent of the planned acceptance measurement method. In cases where the production method of acceptance is the most accurate (e.g., CMM), it may be used as long as program verification or an independent check is completed. Characteristics that cannot be evaluated non-destructively on a finished part may be re-evaluated using component parts before final assembly or hardware that is not usable because of reasons unrelated to the characteristic being re-evaluated.
- L. Development hardware does not require a product audit unless specified in the Purchase Order.
- M. The Supplier must address any Product Audit non-conforming findings per CHI-SQS-01, *Quality Systems Requirements for Suppliers*.
- N. Any finding during product audit may subject the Supplier to additional audits at the discretion of the CHIQR.
- O. A plan must contain, at a minimum, forms CHI-SQS-03F, CHI-SQS-03G, CHI-SQS-03H, and approval by the CHIQR.
- P. Exception to Product/Process Audit Requirements: 100% lot-by-lot testing performed by a GE-certified Test Laboratory may satisfy the requirements of the product audit. This applies to raw material and to processes that generate a Certificate of Conformance for every

manufacturing lot. Processes that are verified by a certified GE Test Laboratory, but do not get a certification for every manufacturing lot (e.g. EDM, Laser, Heat Treat), require re-certification and must meet the requirements of this specification.

12. Supplier Designed Products

- A. All requirements of this specification apply to the characteristics defined by the GE-A drawings unless specifically noted below. For the purposes of this specification, all characteristics on DPD and MED drawings are considered to be GE-A drawing requirements (DPD plus MED equals GE-A Source Control drawing).
- B. Where the Supplier/Sub-tier product and process drawings exist that contain CHI accountable characteristics, the supplier must complete a compatibility evaluation.
- C. Component design specification documentation must be completed only on the following:
  - (1) Acceptance/Inspection Tests defined in the Quality Assurance Provisions section of the design specification.
  - (2) Identification and Part Marking requirements of the design specification or specifications referenced therein.
- D. As a minimum, the Supplier's system must make sure that characteristics defined by the Supplier/Sub-tier drawings are accounted for, documented, and controlled. The format(s) must be defined by the Supplier and are subject to review and disapproval by the CHIQR. The system must include the following:
  - (1) The documented format(s), defined by the Supplier, must include the same elements as shown on form CHI-SQS-03E under the headings Characteristic Accountability, Inspection/Test Results, and Product Acceptance.
  - (2) Changes to the Supplier's or Sub-tier's drawing, manufacturing, or quality plan must be documented and approved under requirements defined by the Supplier system for their characteristics.
- E. First Article Inspection Package (FAI) Requirements for characteristics defined by CHI Supplier/Sub-tier drawing(s).
  - (1) GE-A Drawing(s) and Characteristics: The FAI package must include all items required by CHI-SQS-03C, CHI-SQS-03D, CHI-SQS-03E and the following items:
    - (a) Results from component acceptance test and inspection requirements.
    - (b) Evidence of CHI engineering approval of applicable Acceptance Test Procedures (ATPs).
- F. Supplier/Sub-tier Drawing(s) and Characteristics: First Article Inspection (FAI) package must include the following items that must be retained at the Supplier facility unless otherwise directed by the procurement document:
  - (1) First Article Inspection results.
  - (2) Nonconformance document(s) referenced for accepting nonconforming characteristic(s).
  - (3) Referenced exhibits (e.g., functional test reports, evidence of part marking, certifications, etc.)



**NOTE:**

A copy of all CHI approved Acceptance Test Procedures (ATPs) must accompany first article data.

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13. Life Controlled Parts

- A. When the engineering drawing for a part specifies “Life Controlled Part”, or a periodic cut-up note appears on the drawing such as “first, fiftieth, and every two hundredth thereafter”, refer to all applicable purchase order requirements. In the event of conflict contact your CHIQR for guidance.

14. Definitions

**ACCOUNTABLE CHARACTERISTICS** (equivalent to Design Characteristic as defined in AS9102): Those dimensional, visual, functional, mechanical, and material features or properties, which describe and constitute the engineering definition of the article and can be measured, inspected, tested, or verified to determine conformance to the engineering definition. Dimensional features must include those features defined by the engineering definition, such as target-machined (or forged/ cast) dimensions on forgings, castings, and weld/braze joint preparation necessary for acceptance of finished joint. Material features or properties must include processing variables and sequences that are specified by the engineering definition (e.g., heat treat temperature, fluorescent penetrant class, ultrasonic scans, sequence of welding, heat treat, etc.).

**ACCURACY RATIO:** The ratio between the total M&TE (Measurement & Test Equipment) Accuracy and the total part tolerance.

**CALIBRATION TOLERANCE:** Total permitted variation or limits allowed for calibration of M&TE (Measuring and Test Equipment).

**CERTIFIED OPERATOR:** An operator who has fulfilled all the qualifications, training, and testing requirements for their assigned job description per the supplier OAP (Operator Acceptance Plan). Certified operators may verify characteristics that are inspected at the point of generation. Refer to [Appendix B](#).

**CHARACTERISTIC TOLERANCE:** Difference between upper and lower limits of a part characteristic.

**COMPATIBILITY EVALUATION:** An evaluation of Supplier/Sub-tier product and process drawings containing CHI engineering definition, to make sure that they specify the same engineering definition as the CHI engineering definition.

**CORRELATION:**

- 1) A characteristic that is verified by an operator and is reverified by a different operator/ inspector using the same gage type and results are equivalent within acceptable tolerance band.
- 2) Use of independent or secondary method of inspection or test to make sure of consistent and expected results (i.e., use of CMM to make sure of the manual inspection method result or use of test samples to make sure of the processes.)
- 3) A statistical relation between two or more variables, such that systematic changes in the value of one variable are accompanied by systematic changes in the other (i.e., quality escape data indicates a strong correlation to changes within the manufacturing process.)

**CUSTOMER:** The term customer, as used in this procedure, can mean external end users or internal customers.

**DESIGN PROCUREMENT DRAWING (DPD):** A CHI prepared drawing to control supplier-designed items and to serve as the procurement identity. The DPD provides all the design control functions of a source control drawing and uses the Supplier-furnished Master Envelope Drawing (MED) to specify envelope features.

**ENGINEERING DEFINITION:** Design engineering requirements as documented within the drawing, drawing notes, specifications on the drawing, or referenced specifications the include digital design requirements, if applicable.

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**FEASIBLE:** Capable of being performed, within constraints (e.g., delivery, cost, technical) as agreed between CHI and the Supplier.

**FIRST ARTICLE INSPECTION (FAI):** A complete, independent, and documented physical and functional inspection process to make sure that prescribed production methods have produced an acceptable item, as specified by engineering drawings, planning, purchase order, engineering specifications, and/or other applicable design documents.

**CHI QUALITY REPRESENTATIVE (CHIQR):** A CHI employee or authorized representative with the authority to represent CHI Supplier Quality.

**INSPECTOR:** An individual who inspects and makes sure of characteristics, but does not generate the characteristics.

**KEY CHARACTERISTIC (KC):** The select few, measurable features of a specific part/drawing/specification/process where variation can significantly impact customer satisfaction, manufacturability, durability, or performance.

**LIFE CONTROLLED PART:** Those commercial and military parts, and the forgings or castings from which they are made, for which periodic monitoring of certain material properties is an engineering requirement.

**MASTER ENVELOPE DRAWING (MED):** A Supplier prepared and maintained drawing that controls the external envelope boundaries and details of the physical interface for the project.

**MEASURING AND TEST EQUIPMENT (M&TE):** All devices used to measure, gage, test, inspect, or otherwise examine items to determine compliance with drawing or specification requirements.

**MEASUREMENT SYSTEM ANALYSIS (MSA):** The method used to define and document the amount of variation in the process due to the measurement system. It is a tool that evaluates the measurement system's performance on specific characteristics in the process and under conditions that occur in the process.

**NONCONFORMANCE DOCUMENT:** A material review document used for disposition of nonconforming characteristics.

**OAP (OPERATOR ACCEPTANCE PLAN):** The Supplier plan that defines the requirements, procedures, and individual responsibilities for the certification of operators. Refer to CHI-SQS-03A.

**OPERATOR:** The individuals who physically perform the process. These individuals can be referred to as "Individual Process Owners", "Technicians", "Process Team Members", or by other terminology suitable for the organization's program focus, cultural, and customer environment.

**PART FAMILY:** A group of parts with similar processes, materials, complex form, and tolerances, which are produced by similar manufacturing methods.

**PARTIAL FAI (also referred to as PFAI):** An FAI on a partial portion of a drawing to account for a new part number on an existing drawing that already has a Part Number Approved FAI or to incorporate a change to an existing Approved FAI within the same part number (refer to [Para 10. Change Management](#)).

**PART NUMBER:** For GE-A drawings, this comprises the basic Drawing Number plus Part or Group designation (e.g., Pxx or Gxx).

**PROCESS CAPABILITY:** The performance of which a process is capable, with all the effects of assignable cause variation removed. Process capability is typically quantified as + or - 3 standard deviations about the process mean.

**PROCESS FAILURE MODE AND EFFECTS ANALYSIS (PFMEA):** A process for analysis of potential failure modes within a system for classification by severity or determination of the effect of failures on the system and related risk abatement actions.

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**PROCESS STABILITY:** A process that is operating with only chance causes of variation present is said to be statistically stable.

**PRODUCT ACCEPTANCE:** Verification that characteristics of a part meet the engineering definition.

**PRODUCT/PROCESS AUDIT:** Evaluation of any or all accountable characteristics for conformance, independent of Product Acceptance evaluation. Also includes an appraisal of the Supplier's system to make sure stable processes are in place that continually generate conforming characteristics.

**REPORTABLE CHARACTERISTIC:** An accountable characteristic that requires a result reported.

For example, a basic dimension that is ballooned on the drawing is an accountable characteristic, but not reportable.

**SIGMA VALUE:** A statistical measurement, indicating the probability of producing a part characteristic within the drawing limits. The sigma value represents "Z:", the number of process standard deviations between the process mean and the nearest specification limit.

**SINGLE PURPOSE M&TE/GAGE:** A gage that is designed to accommodate specific part configurations (e.g. airfoil guillotine gages).

**SUPPLIER CHANGE:** A change in manufacturing Supplier or the addition of an alternate manufacturing Supplier for a complete part.

**SPECIAL PROCESS TECH PLANS:** A technical plan is a part-specific, process-specific document required by a Drawing Specification, used to demonstrate source capability to meet the technical requirements of the special process, with CHI Certifying Agent approval required.

**STANDARD M&TE/GAGE:** M&TE that is not controlled by a tool drawing (i.e., commercially available).

**STATISTICAL CONTROL:** A quantitative condition that describes a process that is free of assignable/special causes of variation (e.g., variation in the central tendency and variance). Such a condition is most often evidenced on a control chart.

**SUPPLIER:** Sources (including distributors, warehouses, revenue share participants, and supplier participants) other than CHI, who supply material, parts, processes, or services for incorporation into CHI products.

**TRUNCATE:** A method of approximating a decimal number by dropping all decimal places past a certain point without rounding.

For example, 3.14159265... can be truncated to 3.1415. Note: If 3.14159265... were rounded to the same decimal place, the approximation would be 3.1416.

**VERIFICATION:** Confirmation through objective evidence that specified requirements are fulfilled.

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## APPENDIX A

### QUALITY PLANNING AND ACCEPTANCE PLANS

#### 1. General Guidelines

- A. Supplier's engineering and manufacturing functions should be involved in quality planning. Collaboration of quality, engineering, and manufacturing is expected at the following times:
  - PO review
  - Initial product development
  - Initial quality plan development
  - Supplier engineering, inspection, process and/or manufacturing changes (including sub-tier changes)
  - A change of inspection frequency is being substantiated
  - Drawing revision
  - 24-month lapse in production
- B. AS13002, *Requirements for Developing and Qualifying Alternate Inspection Frequency Plans* must be followed when selecting acceptance plans other than 100% inspection with the following exceptions and requirements:
  - (1) Critical characteristics must be 100% inspected and must have variable results recorded when inspection is performed using a measuring device capable of obtaining a variable result, unless otherwise approved by the responsible CHIQR.
  - (2) Major characteristics must have variable results recorded when inspection is performed using a measuring device capable of obtaining a variable result, unless otherwise approved by responsible CHIQR.
- C. It is recommended that accountable characteristics be inspected at the earliest possible step in the manufacturing process, if subsequent process steps do not alter the characteristic.
- D. The Quality Planning Process Map ([Figure 1](#)) is the recommended map for the Quality Planning process, followed by the recommended checklist items for each step.
- E. Throughout this document, any reference to Cp and Cpk implies long-term capability. It should be noted that some statistical software programs (e.g., Minitab) or statistical publications might refer to Pp and Ppk as long-term capability and Cp and Cpk as short-term capability.

Cpk Calculations for Attribute Data: Use one of the following methods depending on the criteria listed below.

Method 1 – Inspect each characteristic in the sample and identify as defective or non-defective. Then calculate  $p(\text{defective}) = (\text{number defective})/(\text{number in sample})$ . Use a standard normal table to find Z and divide by 3 to find Cpk or use the abridged Z/Cpk in the following table to define the Cpk.

Method 2 – Used if no defects are observed in the sample for methods 1 above. Calculate the estimated proportion defective,  $p(d) = 1/(n+2)$  where n is the number of characteristics inspected, convert this number to a Z score using the one sided Z table and divide by 3 to obtain Cpk or use the abridged Z/Cpk in [Table 1](#).

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Probability of Defective = p(d)	Estimated Z	Cpk
Greater than 0.16 or > 16%	< 1	< 0.33
0.16 to 0.023 or 16 to 2.3%	1 to 2	< 0.67
0.023 to 0.00135	2 to 3	< 1.0
0.00135 to 0.000032	3 to 4	> 1.0 but < 1.33
Less than 0.00032	> 4.0	> 1.33

Process Capability Table  
Table 1

Method 3 – Used to estimate if Cpk > 1.0 with small samples. Cannot provide Cpk > 1.33 estimates. Given a very small sample (3 to 6 points) assessing process capability via direct calculation is not feasible. The approach outlined here makes sure that the process is well centered and has acceptable variation.

Variation test, calculate range of your sample of characteristics measurements

– Provide assurance that the standard deviation of process is < = 16.6% of tolerance (that is, Z = 3)

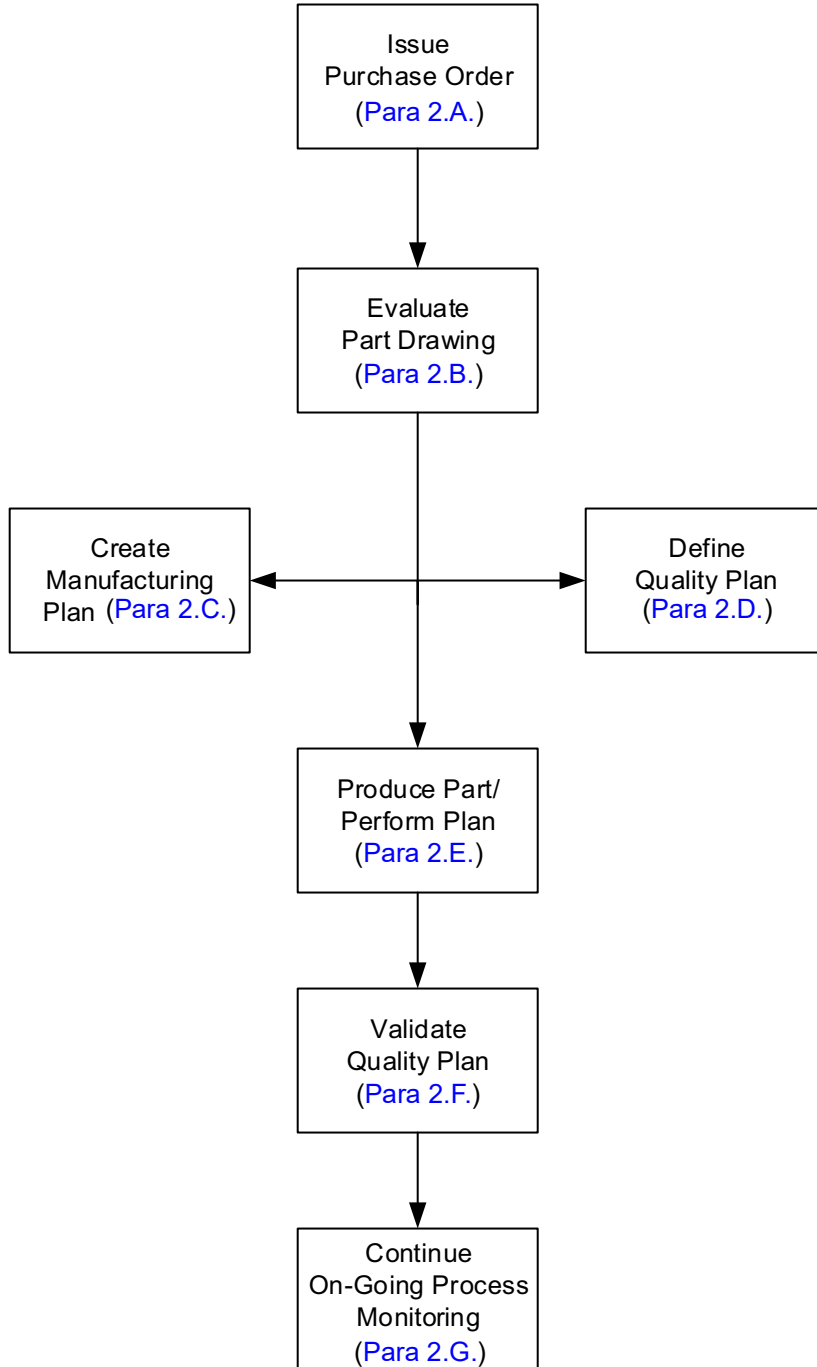
Centering test, calculate the mean of the sample

– Make sure that X Bar is at least one standard deviation away from either tolerance limit with 99% assurance.

– If the data satisfies both the mean and the range test as detailed in [Table 2](#), estimate Cpk as > 1.0 (but not as high as 1.33).

# of Pieces	X Bar vs. Target	Range vs. Tolerance
2	±3%	31%
3	±9%	42%
4	±12%	49%
5	±14%	54%
6	±16%	57%

Acceptance Criteria  
Table 2



Quality Planning Process Map  
Figure 1

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2. Checklist Related to Each Quality Planning Process

A. Issue Purchase Order

- Make sure the PO matches the quote.
- Review the PO, quality requirements, engineering requirements, standard and non-standard remarks.
- Make sure if the part is new or previously manufactured.
- Identify if any CIDs or PDCNs are issued, but not on the drawing.
- Obtain the engineering parts list.
- Make sure the SVP is initiated as necessary, including sub components.
- For engineering class hardware other than production class, document in the system that special marking required.
- Request a ballooned drawing (if one does not exist).

B. Evaluate Part Drawing

- Review the engineering parts list.
- Review the latest revision of drawings, CIDs, and PDCNs, as applicable.
- Identify required specifications and make sure they are current revisions.
- Identify any drawing or manufacturing issues.
- Identify stack-up concerns.
- Review the part quality history and discuss with CHIQR (MRB and escape history).
- Review GE-A Quality Alerts for applicability.
- For an existing PN, review internal and Sub-tier quality history.
- Review lessons learned for similar parts with similar manufacturing processes.
- Request engineering models, Mylar, etc. as necessary.
- Identify education and training needs for applicable Supplier personnel.

C. Create Manufacturing Plan

- Identify risk abatement plans for open issues and discuss with CHIQR.
- Initiate FAI on internal forms.
- Manually balloon the drawing.
- Make sure the ballooned drawing includes all accountable characteristics.
- Generate a Master Specification or its equivalent.
- Request permission to specifications as necessary.
- Review datum/transfer datum system.
  - Does the datum system control movement?
  - Is the datum system repeatable?
  - Is order of precedence maintained?
- Identify key manufacturing characteristics.
- Develop proposed manufacturing plan sequence and make sure the operation sequence complies with engineering drawing

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- Develop sequence of steps within each operation.
- Identify operation step where each characteristic is generated.
- Make sure the current CHI-SQS-02B exists for special processes, whether performed in house or at a Sub-tier.
- Make sure the fixture has the necessary controls, fixture height, size, tolerances, etc. Error proofing must be considered.
- Make sure the fixture set-up has the necessary controls. Error proofing must be considered.

**D. Define Quality Plan**

- Determine where verification is for each accountable characteristic. If an accountable characteristic verification is “in process”, evaluate the effect of subsequent processing, including manual benching.
- Select the appropriate acceptance plan for each accountable characteristic: 100% evaluation, special process, process parameter, variable data charting, die/mold, fixture/tool, software/numeric, and component/accountable characteristic stack-up. Refer to AS13002, *Requirements for Developing and Qualifying Alternate Inspection Frequency Plans*.
- Enter the acceptance plan for each characteristic on the FAI form AS9102 or equivalent, if authorized by the CHIQR.
- Evaluate the need for MSA on new gaging techniques. Refer to AS13003, *Measurement Systems Analysis Requirements for the Aero Engine Supply Chain*.
- For single purpose gages or functional gages, error-proof the gage and make sure the gage meets the engineering requirements.
- Develop detailed inspection process sheets, including visual cell techniques.
- Make sure an Operator Acceptance Plan exists, if applicable. Refer to CHI-SQS-03A-OAP Evaluation Form.
- Define and execute the necessary training for operators.

**E. Produce Part/Perform Plan**

- Make sure raw material, processes, equipment, and operators are production ready.
- Make sure the gaging method meets the minimum requirements of AS13003, *Measurement Systems Analysis Requirements for the Aero Engine Supply Chain*.
- Make sure the selected gage can be used with the geometry/fixture combination.
- Make sure the gaging method is understood by those performing the inspection.
- Make sure of verification of each accountable characteristic by an inspector or certified operator ([Appendix B](#)).
- For accountable characteristics requiring CMM inspection, make sure of the CMM set-up and routines/programs satisfy engineering requirements.
- Where single purpose or functional gages are used, perform independent inspections of accountable characteristics. Make sure that the gage correlates to the independent inspection.
- Apply statistical analysis, if applicable.

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- F. Validate Quality Plan
  - Make sure all accountable characteristics are included in the quality plan.
  - Make sure the FAI part is representative of the defined production process.
  - Complete the FAI and quality plan.
  - For CPD parts, make sure the quality plan is reconciled to the final engineering drawing.
  - Complete the SVP package, if required.
  - Evaluate the manufacturing/inspection process for improvements (evaluation to be done by product engineering, manufacturing, and quality).
  - Select the appropriate acceptance plan for each accountable characteristic: 100% evaluation, special process, process parameter, variable data charting, die/mold, fixture/tool, software/numeric, and component/accountable characteristic stack-up. Refer to AS13002, *Requirements for Developing and Qualifying Alternate Inspection Frequency Plans*.
- G. Continue On-Going Process Monitoring
  - Maintain on-going monitoring for reduced inspection, as specified in AS13002, *Requirements for Developing and Qualifying Alternate Inspection Frequency Plans*.
  - Evaluate the quality plan periodically. Correct/update the quality plan as necessary.
  - Update the CHIQR if there are any process or quality plan changes, including Sub-tier changes.
  - Execute the product audit plan as specified in CHI-SQS-03G.

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## APPENDIX B

### OPERATOR ACCEPTANCE PLAN

#### 1. Purpose

To establish the minimum requirements for an Operator Acceptance Plan (CHI-SQS-03A), hereafter referred to as the OAP. This plan allows verification of characteristics by certified operators at the point of generation. All elements of the plan are subject to CHI disapproval.

#### 2. Minimum Requirements

- A. The Supplier's OAP must identify provisions for training, certification, work station audits, disqualification, records, and retention.
- B. Only certified operators or inspectors are permitted to perform final verification of product characteristics.
- C. Verification of characteristics generated by non-certified operators must be done by a certified operator or inspector.
- D. Traceability of measured characteristics to the inspector/certified operator must be maintained to the part/lot.
- E. Recertification requirements must be identified.

#### 3. Training

- A. The Supplier's OAP must provide a process for training all operators on the procedures and work instructions that pertain to their immediate job function. Each operator must be trained on the following, as applicable:
  - (1) Measurement and test equipment
  - (2) Engineering drawings
  - (3) Router/Op sheets/Work Instructions, usage, and documentation
  - (4) Non-conforming hardware/MRB
  - (5) Safety and part handling
  - (6) Visual inspection techniques (e.g., tin solder inspection)
  - (7) Geometric tolerancing
- B. Consideration must be given to the following when developing training for individual operators.
  - (1) Previous related experience
  - (2) Performance reviews
  - (3) Job safety analysis results
  - (4) Non-conformance data
  - (5) Customer complaints/returns
  - (6) Internal workstation audit results
  - (7) Difficulty and criticality of the operation

#### 4. Certification

- A. Each candidate must be evaluated to make sure of their understanding of the training material and their ability to perform and document the required measurements. Refer to CHI-SQS-03A, *Operator Acceptance Plan* as an example.

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5. OAP Workstation Audits
  - A. Each certified operator must be re-evaluated to an established audit plan. Audits must be performed at least once per year, using a workstation audit form (CHI-SQS-03B).
  - B. Satisfactory workstation audit completion must result in continued certification. The records must be updated and the next audit date must be established.
  - C. If an operator fails the workstation audit, the Supplier determines if re-training and/or increased audit frequency is necessary.
  - D. Upon a failed audit, the Supplier must have a process to determine root cause, recommend a corrective action, and investigate whether non-conforming material was shipped to CHI.
6. Operator Disqualification
  - A. The Supplier must develop a system for operator disqualification and consideration must be given to the following:
    - (1) Failure to follow documented work instructions
    - (2) Failure to pass an OAP workstation audit
    - (3) Inability to repeat/correlate measurements
    - (4) Change in job function or classification
7. Record Retention
  - A. Records related to the Operator Acceptance Planning must include, but are not limited to:
    - (1) Evaluation and training (initial training and any re-training) ([Para 3.](#))
    - (2) Certification test results ([Para 4.](#))
    - (3) Audit results ([Para 5.](#))
  - B. Certification records must be maintained for the entire duration of the operator's employment, and audit results for 5 years.

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## APPENDIX C

### ESTABLISHMENT OF BALLOONING PRINCIPLES

1. Purpose

This appendix gives the recommended methodology for identification of engineering definition, CHI product creating a standard baseline for identification, and tagging of GE-A engineering requirements, as communicated via 2-dimensional drawings, model-based definition, or specifications.

2. Sources for Ballooning

- A. Characteristic lists with related drawings can be obtained from your CHIQR.
- B. Drawings are ballooned by suppliers.

3. Ballooning Rules

- A. Balloon the text notes in their current numerical order, making sure to adhere to the following:
  - (1) Every note must be ballooned with a unique CN.
    - (a) Applicable documents as well as new bullet points must be ballooned separately.
    - (b) Accountable characteristics within specifications must be broken out.

4. General Ballooning Notes

- A. The numbering scheme does not matter as long as all accountable characteristics are identified.
- B. In the case of changes to the part:
  - (1) Never reuse CNs.
    - (a) If a dimension is removed, the balloon must be removed as well, and the CN must not be reused.
    - (b) If the type of dimension changes, a new CN is assigned and the original balloon must not be reused.
  - (2) CNs must remain the same during changes only when:
    - (a) The value of the dimension is the only change.
    - (b) The number of places the dimension is found changes.
- C. Balloon CNs must remain the same from revision to revision, except in those cases noted above.

5. Supplementary Views, Tabulated Features, and Alternate Methods of Manufacture

- A. When required for the part number being reported, all accountable characteristics must be ballooned.
- B. When not required for the part number being reported, a single CN may be used.