Applies to: Aerojet Rocketdyne ADMS Documents **Doc Owner:** Gordon, Dale

Aerojet Quality Note	Rev #	Date
QN-C24	**2**	**05/30/2014**

Scope: Any process or characteristic-related data collected at the supplier or the supplier's subcontractor's facilities for the purpose of variation management of special characteristics.

Application: Where Special Characteristics, as noted in the design disclosure, are established and/or Process Variation Management (PVM) is required by the purchase order and/or referenced drawing.

A special characteristic is an attribute or feature whose variation has a significant influence on product fit, performance, service life, or producibility and requires specific action for the purpose of controlling variation.

Process Variation Management is comprised of five phases, Selection, Baseline, Problem Solving, Improvement /Optimization and Sustainment. This Quality Note will cover how to implement and comply with all five phases.

Implementation:

1. Selection

1.1 Identify and Prioritize Key Process(es) and associated characteristics:

1.1.1 In the selection phase, identify and prioritize the important processes. An assessment should be performed to determine a prioritized list of processes and/or features which are most likely to impact expectations for producibility and product performance.

1.1.2 If Special Characteristics are indicated on the design disclosure no other Special Characteristics are required to be identified. However, the identification of additional Special Characteristics by the supplier is encouraged.

1.1.3 If Special Characteristics are not identified in the design disclosure, the supplier shall identify a sufficient number of Special Characteristics based upon their processes that will ensure a product that consistently meets or exceeds design/performance requirements.

2 Baseline

2.1 Identify the Key Process Output (KPO) characteristics and the Key Process Input (KPI) characteristics that drive the KPO characteristics.

2.2 Baseline the measurement system for the KPO characteristics and KPI characteristics by identifying and initiating Measurement System Analyses (MSA). MSA shall consist of at least one of the following four industry standard studies. Aerojet Rocketdyne can provide documentation and/or forms to help facilitate the completion of the MSA.

2.2.1 Gage Linearity and Bias Study

A. This study will determine the bias (accuracy) of the gage and any associated linearity.
B. This study is recommended to be performed at least once for each gage type.
C. This study may apply to either a CMM or SMI type gage.
D. This study is typically required for process certification.

2.2.2 Gage Short Term Variation Study

A. This study will determine the variation that is typically attributed to random machine variation.
B. This study is optional, but recommended for each gage.
C. This study is typically performed multiple times over the life of the gage.
D. This study may apply to a CMM type gage.

2.2.3 Gage Long Term Variation (Capability) Study

A. This study will determine the variation that is typically attributed to non-random variation.
B. This study is optional, but recommended for each gage.
C. This study is typically performed continuously over the life of the gage.
D. This study may apply to a CMM type gage.

2.2.4 Gage Repeatability and Reproducibility (Gage R&R) Study

A. This study will determine the repeatability and reproducibility of the measurement system to measure the desired feature.
B. This study is recommended to be performed at least once for each measured part.
C. This study may apply to either a CMM or SMI type gage.
D. This study is typically required for process certification.

2.3 Define the current state of the process(es) that affect the special characteristics and develop an understanding of how the process currently performs. Analyze and interpret the data to assess the current state of the process and how it relates to the product requirements.

2.3.1 To determine if the process is stable, in control, and capable, an evaluation of statistical process control and capability for each of the identified characteristics using historical data should be complete. This may, or may not include a statistically based sample size or evidence of control. The evaluation is intended to establish both a baseline for reporting and a priority for improvements.

2.4 Create the Process Control Plan (PCP) and begin to collect relevant data and information. The PCP shall consist of the following sections at a minimum. Appendix A provides an example of a PCP to help illustrate the minimum contents, which are ten heading fields and ten data fields. They are as follows:

2.4.1 PCP heading information: PCP document number, a description of the process covered such as program, product line, process line, and/or applicable part number(s), core team members including lead personnel, and revision date.

2.4.2 A unique identification number for each KPO/KPI for tracking internal and external to the PCP

2.4.3 A description for each item and whether it is a KPO or KPI

2.4.4 The source for each KPO and KPI. KPO sources will be identified as either a result of being identified during the selection phase, by manufacturing as a manufacturing control, or as a KPI from a downstream PCP. Enter the source document number and unique identifier from within the source document. If a source document doesn't exist, state why the KPO was deemed important such as a manufacturing control to enhance downstream yield. The source of KPIs is the KPO which the KPI is responsible for controlling.

2.4.5 The specific KPO/KPI requirements that need to be maintained, such as minimum and maximum limits. The requirements may be either a design or manufacturing requirement as applicable. Manufacturing requirements may be modified based upon analysis of data gathered through the PCP. Manufacturing requirements are required to be equal to or more limiting than design requirements.

2.4.6 The KPO/KPI Controls. For KPOs, the controls are all of the KPIs associated with the KPO as determined by the PCP team; record the KPIs for each KPO. For KPIs, enter the control method as appropriate. KPI controls can vary widely, from an administrative buy off in the work instructions, to a strong engineering control such as a well-documented

mistake-proofed design, or even a KPO identified in an upstream PCP. The appropriateness of KPI controls will be determined by the team, and ultimately validated through the control and capability of the KPO. Controls may be added or deleted from the PCP based upon analysis of data obtained through the PCP.

2.4.7 The work instruction location - For KPOs, where possible, document the location from the work instruction that the KPO data is collected and monitored to ensure the KPO meets its requirements. For a KPI, enter the location from the work instruction where the KPI control is defined. When feasible, the work instruction should include an identifier referencing the applicable PCP item to ensure changes are not arbitrarily made without updating the PCP. It is best practice to choose work instruction location identifiers independent of step numbers to ensure the PCP will not require revision should the step number change.

2.4.8 The Inspection Plan details - Enter how the process or feature is to be inspected. Include such things as gage identification, the sample size and frequency. Sample size and frequency will vary from 100% for a special characteristic to a one time process proof for a simple planning instruction. For a process control that is cyclic such as by calibration or certification, enter the calibration/re-certification frequency. All controls should have some form of verification even if it is only one time.

2.4.9 The Statistical Monitoring Methods - Enter the appropriate statistical capability and control evaluation details such as chart type, subgroup size, control limits, and capability target.

A. KPOs not derived from key or significant characteristics and their associated KPIs shall have statistical monitoring methods chosen with the goal of developing and maintaining cost effective processes whose outputs are sufficiently defect free.

2.4.10 Evaluation Methods and Reaction Plan - Enter the appropriate statistical run rules (such as Nelson Rules) and what action is to be taken during monitoring if a rule is violated such as the name, extension, and email of the person to contact.

2.4.11 Analysis/Review Plan - Enter who will be responsible for collating the data and reviewing it. This person is usually the process owner but other PCP team members may take on this task. Enter the maximum time between reviews.

3 Problem Solving Phase

3.1 In the problem solving phase, investigate and analyze the process to determine the process control and/or capability issues and identify improvement opportunities. This can be completed by developing a plan using the requirements outlined in Sections A.4 of SAE AS9103.

4 Improvement and Optimization Phase

4.1 In the improvement and optimization phase, the process issues are addressed and the process control and capability is improved. As good variation management practice, processes should be centered around the target value and variation reduced as needed. Section A.5 of SAE AS9103 can be used as a guideline for developing a plan to satisfy the requirements of this phase.

5 Sustainment Phase

5.1 In the sustainment phase, maintain process control and capability and address process issues by deploying and maintaining the PCP to monitor and control the process health and permanently incorporate all of the process improvements made in the improvement phase.

5.2 While it is the goal to achieve process certification for all parts and processes, the implications will vary for each process and part. The following requirements shall be met and documented to achieve process certification:

5.2.1 A valid data set has been produced. A valid data set is typically indicated by the MSA.

5.2.2 KPI characteristics are identified and controlled per the PCP.

5.2.3 KPO characteristics are in statistical control as evidenced by the applicable control chart.

5.2.4 KPO characteristics are capable per the PCP.

A. For variable data, the process shall have either the estimated C_{pk} (or P_{pk}) greater than or equal to 1.33 or the lower bound of a two-sided 95% confidence interval on C_{pk} (or P_{pk}) shall be greater than 1.0.

B. For attribute data, the process has greater than or equal to 45 successive observations with no nonconformances or turnbacks detected with 90% confidence or greater than 6 consecutive

months of 100% compliance to continuously monitored customer and downstream process requirements.

5.2.5 PCP is in place and maintained.

5.2.6 A plan developed that will audit all other certification requirements for continued compliance.

Deliverables: When PVM is required, PVM methodology (plan) shall be submitted to Aerojet Rocketdyne for approval prior to manufacture via a Supplier Submittal Request (SSR), which can be found on Supplier Net: http://www.rocket.com/files/aerojet/documents/SupplierNet/forms/SupplierNRform.doc

PVM data shall be in a standard electronic format specified by the buyer. Transmission of data shall occur after each phase, where applicable, based upon the activities in those phases outlined in the preceding paragraphs, with the final data being submitted no later than with the shipment of hardware. The specific submittal requirements shall be detailed in the approved PVM methodology, but at a minimum the supplier shall be responsible for demonstrating that all five PVM phases were complied with.

Appendix A – Sample Process Control Plan Referenced in Paragraphs 2.4.1 – 2.4.11

Process Control Plan																		
(1) Process Control Plan No. / Rev.							(6) Date (Origination)				(9) Core Team Members					(10) Special Approvals		
(2) Process Name / Description							(7) Date (Revision)											
(3) Part Number / Rev. (if available)							(8) Team File Location											
(4) Part Name (if available)																		
(5) Affected Product Line or Program(s)																		
		Feature Definition						Inspection and Monitoring Plan										
ID (11)	KPO/KPI, Description (12)	KPO/KPI Source (13)	KPO/KPI Requirement (14)	KPO/KPI Control Method(s) (15)	Work Instruction Location (16)	Inspection plan, sample size and frequency (17)	Statistical Monitoring Method(s) chart type, subgroup size, Control Limits, Capability (18)	Evaluation Methods (Run Rules) and Reaction Plan (19)	Analysis/Review Plan (20)									
1.00	KPO, Description of KPO#1.00	*Drawing #, Special Characteristics Identification*	*Min, Max etc*	*See KPIs 1.01 through 1.05*	*W.I. #, Control ID #*	*Min, Max, 100% Inspection*	*I-MR, Subgroup size 1, LCL=X, UCL=Y, Cpk*	*Nelson RR, Notify Process Owner Name and extension*	*Update files and review control chart once per week*									
1.01	KPI, Description of KPI#1.01	KPO#1.00	Mfg Min, Max etc	*Pass/Fail Lab test*	*W.I. #, Control ID #*	*Min,Max APU sample use within 3 days*	NA	*Notify Process Owner if APU fails*	NA									
1.02	KPI, Description of KPI#1.02	KPO#1.00	*thing installed properly*	*Buy off, operator training*	*W.I. #, Control ID #*	*100% verification*	NA	NA	NA									
1.03	KPI, Description of KPI#1.03	KPO#1.00	*Min, Max etc*	*KPO #X from PCP Y*	*W.I. #, Control ID #*	*See PCP #*	*See PCP #*	*See PCP #*	*See PCP #*									
1.04	KPI, Description of KPI#1.04	KPO#1.00	*Min, Max etc*	*Mistake proof and calibration*	*W.I. #, Control ID #*	*Tooling #, one time operational checkout 4/2/2011, calibration every 6 months*	NA	NA	NA									
1.05	KPI, Description of KPI#1.05	KPO#1.00	Mfg Min, Max etc	*SPC*	*W.I. #, Control ID #*	NA	*I-MR, LCL=X, UCL=Y Subgroup size 1 Cpk*	*Nelson RR, Notify Process Owner Name and extension*	*Update files and review control chart once per year*									
2.00	KPO, Description of KPO#2.00	Other PCP Document # and KPI#, required for control of description	Mfg Min, Max etc	Pass/Fail inspection	*W.I. #, Control ID #*	100%	NA	NA	NA									

Table 1: Sample PCP With Section Examples