Manufacturing Process Excellence

The Roadmap to Customer Impact

Turning Process Excellence into a Competitive Advantage

Developed By: John Bero 1/07
Manufacturing Process Excellence

Training Scope

To teach the following Six Sigma methodologies using the D.M.A.I.C process:

- Characteristic Matrix
- Process Map
- Process FMEA
  - Ishikawa (Fishbone) Diagram
  - 5 Why’s
- Control Plan
- Manufacturing Instructions
Manufacturing Process Excellence

Training Objective

To implement Six Sigma methodologies to:

• Reduce overall escapes to customers (DPPM)
  
  Reduce Scrap and Rework.

  Improve Internal Yield.

  Reduce Final Inspection Rejects.

• Encourage Relentless Root Cause Analysis & Mistake-Proofing.

• Reduce variation in critical to quality features.

• Proactively control cost of poor quality.

• Turn actions into systemic process improvements.
Manufacturing Process Excellence

**MPE Project Flow**

1. **DEFINE SCOPE**
   - Part/Product Family/Process, Critical and Key Characteristics

2. **MEASURE**
   - Process Map - Key process variables: Inputs, Output Characteristics (C and K), Warranty Data, Scrap, DPPM/Sigma

3. **ANALYZE**
   - Characteristic Matrix
   - Process FMEA
   - Ishikawa diagram
   - Process Capability Studies
   - 5 Why's
   - MSA Studies
   - Process Improvement Log

4. **IMPROVE**
   - Process Control Plan: (Characteristic Accountability)
   - Standardized Manufacturing Instructions: Eliminate process variation by implementing process control across a family of products

5. **CONTROL**
   - Output
Key Outputs

The key outputs of the Manufacturing Process Excellence project will include the following per product family or Process:

Characteristic Matrix

Process Map

Process FMEA

Control Plan

Standardized Manufacturing Instructions.
The purpose of a characteristic matrix is to display the relationship between the product characteristics, parameters and the manufacturing operation

**Key Inputs:**
DFMEA, Process Map, Router

<table>
<thead>
<tr>
<th>Ref. No.</th>
<th>Characteristic</th>
<th>Char. Class</th>
<th>Supplier</th>
<th>Receiving Inspection</th>
<th>Valve Assembly</th>
<th>Valve Testing</th>
<th>Valve Final Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Valve</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Overall Length (AOL)</td>
<td>K</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Land Length</td>
<td>K</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>Distance Between Lands</td>
<td>K</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Surface Finish</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>Pressure Relief</td>
<td>K</td>
<td>2</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td>Relief spring length</td>
<td>K</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Purpose:

Used to get an overall understanding of the process flow and interactions.

Is the basic tool used in the analysis of a process by looking at each step’s Key Process Output Variables and determining which Inputs can be controlled and which ones we have to /choose to live with.

Minimum Requirements:
Software - Microsoft Visio (Basic Flow Chart Shapes).
Complete Process Flow.
Key process variables
  - Process Inputs.
  - Process Outputs.
Most commonly used basic flow chart shapes, symbols and connectors:

- Processing function
- Decision
- Document
- Data
- Predefined Process
- Manual Input
- Manual Operation
- Preparation
- Terminator
- Dynamic Connector
- Annotation
- Control Transfer
Process Maps

Example for a product family

**INPUT:**
- material (casting)
- Tooling
- Program
- Machine
- Coolant

**OUTPUT:**
- Datum Aligned per Print
- Conforming Part

**1) MILLING (Mounting Pads)**

**2) NEXT OPERATION**

**Input Definitions**
- **C-Controllable:** Those inputs that we can change - Speed, feeds, thickness, machine, ...
- **N-Noise:** Those inputs that we cannot control or too costly too. Humidity, temperature, nonstandard thickness, ....
Example for a part number
CNC Lathe Operation

1. Previous Operation
   INPUT:
   Operators - C/N
   Training - C
   4340 AMS 6410 -
   Tooling - NC
   Tooling Condition - C
   Maintenance - C
   Work Instruction - C
   Measurement Error – C
   Program - C

2. CNC Lathe Operation
   OUTPUT:
   .760/.758 Dia
   Runout .005
   .44 00/.4390 Dia
   Runout .005

3. Next Operation
   INPUT:
   XXXXXXXX
   XXXX
   XXXXXX
   XX

   OUTPUT:
   .XXX/.XXX AOL
Top Level Process Example

CIRCUIT BOARD
TOP LEVEL PROCESS MAP

1. KITTING
   - Input (X): Kit list
   - Output (Y): Correct Material pulled for Job, Traveler

2. SMT KIT PREP.
   - Input (X): Kit list
   - Output (Y): Correctly loaded kit, Machine set-up

3. PRINTING
   - Input (X): Traveler, Stencil, Process set-up sheet, Blades, Paste
   - Output (Y): Correctly loaded kit, Machine set-up, Printed Board

4. POST PRINT INSPECTION
   - Input (X): Traveler, Printed Board, Process Instructions
   - Output (Y): Fully populated approved board

5. SMT AUTO PLACEMENT
   - Input (X): Traveler, Correctly loaded kit, Process set-up sheet, Qualified printed board
   - Output (Y): Populated Board

6. POST PLACEMENT INSPECTION (Hand placement)
   - Input (X): Traveler, Process Instructions, Completed board, Final assembly kit
   - Output (Y): PopulatedBoard

7. OVEN
   - Input (X): Populated approved board

8. WASH
   - Input (X): Populated wave soldered brd. with active flux residue
   - Output (Y): Populated wave soldered brd. without active flux residue

9. INSPECTION
   - Input (X): Traveler, IP 610 Certified Inspector, Flat Piece/Populated brds.
   - Output (Y): Populated reflowed brd., with IPC 610 TH compliant brd.

10. TOUCH-UP
   - Input (X): Traveler, TH Kit, Process Instructions, SMT Populated brd.
   - Output (Y): Soldered brd.

11. THROUGH-HOLE INSERTION
    - Input (X): Traveler, TH populated brd (IPC 610)
    - Output (Y): Populated TH, IP 610 TH compliant brd.

12. WAVE SOLDER
    - Input (X): Traveler, Process Instructions, Completed brd, Final assembly kit
    - Output (Y): TH Populated brd.

13. WASH
    - Input (X): Populated wave soldered brd.
    - Output (Y): Populated wave soldered brd. with active flux residue

14. FINAL ASSEMBLY
    - Input (X): Traveler, Process Instructions, Completed brd, Final assembly kit
    - Output (Y): Completed brd.

15. FINAL INSPECTION
    - Input (X): Traveler, Process Instructions, Completed brd, Final assembly kit
    - Output (Y): IPC 610 compliant brd. (TH, SMT)

16. TOUCH-UP REPAIR
    - Input (X): Traveler, Process Instructions, Completed brd, Final assembly kit
    - Output (Y): IPC 610 compliant brd. (TH, SMT)

17. FUNCTIONAL TEST
    - Input (X): Traveler, Process Instructions, Completed brd, Final assembly kit
    - Output (Y): IPC 610 compliant brd. (TH, SMT)

18. TOUCH-UP
    - Input (X): Traveler, Process Instructions, Completed brd, Final assembly kit
    - Output (Y): IPC 610 compliant brd. (TH, SMT)

19. FUNCTIONAL TEST
    - Input (X): Traveler, Process Instructions, Completed brd, Final assembly kit
    - Output (Y): Tested brd. compliant to customer functional test.

20. SHIPMENT
    - Input (X): Traveler, Process Instructions, Completed brd, Final assembly kit
    - Output (Y): Customer Compliant Product
Creating a Process FMEA:

Use a cross functional Team; Typically Manufacturing, Manufacturing Engineering, Quality Assurance and Design Engineering.

Follow the flow of the process map.

Include the entire process flow in the FMEA.

Do not overlook any characteristic. Remember a product is nonconforming if it fails to meet any requirement.
Process FMEA

**Purpose:**

Track down and remove special causes of variation.

Verify that controls for key and critical product characteristics are addressed in the process.

To identify the unacceptable process outputs that can be created at each process step, the causes, the severity and the method of control to prevent or detect the potential unacceptable process outputs.

To identify the possible ways in which non-conformities can occur in a manufacturing process, and recommend actions to prevent the non-conformities and/or detect them before the non-conforming parts are shipped to the customer.

**Process FMEA Inputs:**

- DFMEA (If available)
- Customer Returns, Complaints, Corrective Actions
- Internal NR Data
- Characteristic Matrix
- Process Map
- Final Inspection Reject Data
- Process Capability Studies (Cpk)
- MSA Studies
Process FMEA

**Key Analysis Considerations**
- Characteristic Accountability
- Self QC
- Product Handling
- Administrative Errors
- Assembly Errors
- Part Marking Errors
- F.O.D.
- Packing
- Shipping Damage
- Customer Perception

**Brainstorming tools that will assist with developing a process FMEA:**
- Ishikawa Diagrams (Fish Bone)
- Five Why’s
Ishikawa (Fish Bone) Diagram

Simple steps allow you to identify, analyze, and graphically depict with increasing detail, all potential causes related to a problem or current condition in order to discover its root causes.

<table>
<thead>
<tr>
<th>Fishbone Suggested Categories</th>
<th>Service Industries (The 4 Ps)</th>
<th>Manufacturing Industries (The 6 Ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policies</td>
<td></td>
<td>Machines</td>
</tr>
<tr>
<td>Procedures</td>
<td></td>
<td>Methods</td>
</tr>
<tr>
<td>People</td>
<td></td>
<td>Materials</td>
</tr>
<tr>
<td>Plant/Technology</td>
<td></td>
<td>Measurements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mother Nature (Environment)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manpower (People)</td>
</tr>
</tbody>
</table>
How To Complete The 5 Whys:

1. Write down the specific problem. Writing the issue helps you formalize the problem and describe it completely. It also helps a team focus on the same problem.

2. Ask Why the problem happens and write the answer.

3. If the answer you just provided doesn't identify the root cause of the problem that you wrote down in step 1, ask Why again and write that answer down.

4. Loop back to step 3 until the team is in agreement that the problem's root cause is identified. Again, this may take fewer or more times than five Whys.

5 Why Example:

Problem Statement: You are on your way home from work and your car stops in the middle of the road.

1. Why did your car stop?
   - Because it ran out of gas.

2. Why did it run out of gas?
   - Because I didn't buy any gas on my way to work.

3. Why didn't you buy any gas this morning?
   - Because I didn't have any money.

4. Why didn't you have any money?
   - Because I lost it all last night in a poker game.

5. Why did you lose your money in last night's poker game?
   - Because I'm not very good at "bluffing" when I don't have a good hand.
How to complete an FMEA?
Process FMEA

Process Step/Name

What is the process Name / Function?

Enter the specific process or workstation name that is being evaluated, multiple workstations should be reflected as separate PFMEA line items.

Example:
- TESTING (Air Decay)
- ASSEMBLY (Press Fit)

Potential Failure Mode

How could this process/product fail to meet it's intended function?

- Over/Under sized
- Rough
- Eccentric
- Deformed
- Cracked
- Open
- Shorted
- Leaking

NOTE: The numbering sequence must match the Process Map numbering for each process.

NOTE: A Failure mode at one operation can be an effect of a failure mode in a previous (upstream) operation.
Potential Failure Effects

What are the effects / results of the Failure Mode?

Typical effects may include, but are not limited to:
- Intermittent operation
- Erratic operation
- Inoperative
- Unstable
- Control impaired

NOTE: Describe the effects in terms of what the internal or external customer would experience.

Severity Number

How bad are the effects?

The severity number is estimated on a 1 to 10 scale that represents the severity of the effect.

The PFMEA Severity Matrix is used to determine the severity ranking number in correspondence with the effect listed.
### Severity Matrix

<table>
<thead>
<tr>
<th>EFFECT</th>
<th>CRITERIA: SEVERITY OF EFFECT</th>
<th>RANKING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous - without warning</td>
<td>• Very high severity ranking when a potential failure mode affects safety and/or involves noncompliance with governmental or customer regulation without warning.</td>
<td>10</td>
</tr>
<tr>
<td>Hazardous - with warning</td>
<td>• Very high severity ranking when a potential failure mode affects safety and/or involves noncompliance with governmental or customer regulation with warning.</td>
<td>9</td>
</tr>
<tr>
<td>Very High</td>
<td>• Item inoperable, loss of primary function. Customer very dissatisfied.</td>
<td>8</td>
</tr>
<tr>
<td>High</td>
<td>• Item operable, but at reduced level of performance. Customer dissatisfied.</td>
<td>7</td>
</tr>
<tr>
<td>Moderate</td>
<td>• Item operable, but some Comfort/Convenience item(s) inoperable. Customer experiences discomfort.</td>
<td>6</td>
</tr>
<tr>
<td>Low</td>
<td>• Item operable, but some Comfort/Convenience item(s) operable at reduced level of performance. Customer experiences some dissatisfaction.</td>
<td>5</td>
</tr>
<tr>
<td>Very Low</td>
<td>• Fit &amp; Finish/Squeak &amp; Rattle item does not conform. Defect noticed by most customers (greater than 75%).</td>
<td>4</td>
</tr>
<tr>
<td>Minor</td>
<td>• Fit &amp; Finish/Squeak &amp; Rattle item does not conform. Defect noticed by 50% of customers.</td>
<td>3</td>
</tr>
<tr>
<td>Very Minor</td>
<td>• Fit &amp; Finish/Squeak &amp; Rattle item does not conform. Defect noticed by discriminating customers (less than 25%).</td>
<td>2</td>
</tr>
<tr>
<td>None</td>
<td>• No discernible effect.</td>
<td>1</td>
</tr>
</tbody>
</table>

**FLIGHT SAFETY RISK PRODUCT**

**NON FLIGHT SAFETY RISK PRODUCT**
**Characteristic Class**

**Critical (C)** The letter C indicates a Critical characteristic. A product or process characteristic for which reasonably anticipated variation could significantly affect the product’s safety or its compliance with governmental regulations. Such as Hazardous without warning, flammability, occupant or operator protection, loss of control etc.

**NOTE:** A Critical Characteristic (C) would be considered a [Flight Safety](#) Risk and would be associated with severity rankings of 8, 9 and 10.

**Key (K)** The letter K indicates a Key characteristic. A product or process characteristic for which reasonably anticipated variation is likely to significantly affect customer satisfaction with a product (other than safety considerations) such as its fit, partial function, mounting, or the ability to process or build the product.

**Standard (""")** Leaving the column blank/empty indicates a standard characteristic. A product or process characteristic for which reasonably anticipated variation would not affect a product’s safety, fit/function or compliance with governmental regulations. Would include minor issues such as appearance, marking, administrative errors.
Potential Causes

What are the causes?
What conditions can bring about the failure mode?

List, to the extent possible, every conceivable failure cause assignable to each potential failure mode.
Be specific
If a cause is exclusive to the failure mode, i.e., if correcting the cause has a direct impact on the failure mode, then this portion of the FMEA thought process is completed.

Consider using Ishikawa (Fishbone) Diagrams and the 5 Why’s to help identify the real root cause.

NOTE: Do not include contributing causes:
• Operator Error
• Missed at final Inspection
Process FMEA

Occurrence Number

How often does it happen?

Occurrence is how frequently the specific failure cause/mechanism is projected to occur.

A number from 1 to 10 that represents the likelihood of each cause listed.

The PFMEA Occurrence Matrix is used to determine the likelihood that the cause list could occur.

Process Capability Study

A capability study is an excellent method for determining the rate of failure and stability on measurable processes. (Reference the occurrence matrix)

The capability of the system refers to the ability of the system to perform in comparison to its specification limits.

NOTE:

The Cpk tells how well a system can meet specification limits while accounting for the location of the average.

The higher the Cpk, the more stable the process is.

Cpk:

1.33 Good
1.67 very Good
>2.00 Excellent

Minitab is the preferred software for statistical analysis. Additional training is available in Minitab and Eaton University
## PFMEA Occurrence Matrix

<table>
<thead>
<tr>
<th>Probability of Failure</th>
<th>Possible Failure Rates</th>
<th>Cpk</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very High: Persistent Failures</strong></td>
<td>=/&gt; 51 %</td>
<td>&lt; 0.33</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>33 % to 50 %</td>
<td>=/&gt; 0.33</td>
<td>9</td>
</tr>
<tr>
<td><strong>High: Frequent Failures</strong></td>
<td>12.5 % to 33 %</td>
<td>=/&gt; 0.51</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>5 % to 12.5 %</td>
<td>=/&gt; 0.67</td>
<td>7</td>
</tr>
<tr>
<td><strong>Moderate: Occasional Failures</strong></td>
<td>1.25 % to 5 %</td>
<td>=/&gt; 0.83</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>.25 % to 1.25 %</td>
<td>=/&gt; 1.00</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>.05 % to .25 %</td>
<td>=/&gt; 1.17</td>
<td>4</td>
</tr>
<tr>
<td><strong>Low: Relatively Few Failures</strong></td>
<td>.01 % to .05 %</td>
<td>=/&gt; 1.33</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>.002 % to .01 %</td>
<td>=/&gt; 1.50</td>
<td>2</td>
</tr>
<tr>
<td><strong>Remote: Failure is Unlikely</strong></td>
<td>&lt; .002 %</td>
<td>=/&gt; 1.67</td>
<td>1</td>
</tr>
</tbody>
</table>
Current Controls

How can the cause be prevented?

Description of prevention and detection controls:

(D) SPC
(D) Gauging
(D) Automated inspection
(D) Visual Inspection
(P) Mistake-proofing
(D) Testing
(P) First Piece Inspection
(P) Calibration / Preventive Maintenance

NOTE: Be specific, do not state: see work instruction etc.

Think mistake proofing!

The methodology is used either to:
1. Prevent the special causes that result in defects.
2. To inexpensively inspect each characteristic (Self QC) as it is produced to determine whether it is acceptable or defective. One error occurs, not a batch.

Example:
Sometimes a worker will forget to put the spring under the button and a defect occurs. A simple poka-yoke device to eliminate this problem was developed. The worker counts out two springs from a bin and places them in a small dish. After assembly is complete, if a spring remains in the dish, an error has occurred.
Process FMEA

Detection Number

How good is this method of detecting?

A number from 1 to 10 that represents the effectiveness of the current process controls to prevent or detect the cause.

Detection values are associated with Current Controls.

The PFMEA Detection Matrix is used to determine the detection number

Detection Matrix

<table>
<thead>
<tr>
<th>Detection</th>
<th>Criteria</th>
<th>Inspection Type</th>
<th>Detection Methods</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>C - Manual Inspection</td>
<td>Almost impossible Absolute certainty of non-detection</td>
<td>X</td>
<td>Cannot detect or is not checked.</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Very Remote Control will probably not detect</td>
<td>X</td>
<td>Control is achieved with indirect or random checks only.</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Remote Controls have poor chance of detection.</td>
<td>X</td>
<td>Control is achieved with visual inspection only.</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Very Low Controls have poor chance of detection.</td>
<td>X</td>
<td>Control is achieved with double visual inspection only.</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Low Controls may detect.</td>
<td>X X</td>
<td>Control is achieved with charting methods, such as SPC (Statistical Process Control)</td>
<td>6</td>
</tr>
<tr>
<td>B - Gauging</td>
<td>Moderate Controls may detect.</td>
<td>X</td>
<td>Control is based on variable gauging after parts have left the station, or Go/No Go gauging performed on 100% of the parts after the parts have left the station.</td>
<td>5</td>
</tr>
<tr>
<td>A - Error-proofed</td>
<td>Moderately High Controls have a good chance to detect.</td>
<td>X X</td>
<td>Error detection in subsequent operations, OR gauging performed on setup and first-piece check (for set-up causes only).</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>High Controls have a good chance to detect.</td>
<td>X X</td>
<td>Error detection in station, or error detection in subsequent operations by multiple layers of acceptance: supply, select, install, verify. Cannot accept discrepant part.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Very High Controls almost certain to detect.</td>
<td>X X</td>
<td>Error detection in-station (automatic gauging with automatic stop feature). Cannot accept discrepant part.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Certain Controls certain to detect.</td>
<td>X</td>
<td>Discrepant parts cannot be made because item has been error-proofed by product/process design.</td>
<td>1</td>
</tr>
</tbody>
</table>
Risk Priority Number (RPN)

What is the risk?

The product of Occurrence X Severity X Detection = RPN

The higher the RPN, the higher the calculated risk is for producing undesirable process outcomes.

For higher RPN’s the team should undertake efforts to reduce the calculated risk through corrective actions.

Required Actions:

Any process step with an RPN of 125 or greater, or a severity rating of 8 or higher will require an MSA and process capability study (if applicable/capable) for all key and critical characteristics.
Corrective Action

Recommended Actions:

Intent is to reduce Severity, Occurrence, and/or Detection Rankings.

If the effect could be a hazard to manufacturing personnel, cause must be eliminated or controlled OR operator protection specified.

To reduce Occurrence ranking, process and/or design revisions are required.

Only a design revision can reduce the Severity ranking.

Remember: If action is not taken to improve, the effectiveness of the PFMEA is limited!

<table>
<thead>
<tr>
<th>Recommended Actions</th>
<th>Person Responsible Target Date</th>
<th>Actions Taken</th>
<th>Severity</th>
<th>Occurrence</th>
<th>Detection</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add Precision Dedicated alignment Fixture per P/N. Add fixture to calibration schedule</td>
<td>Joe Godoit ASAP</td>
<td>Precision alignment Fixtures created per P/N. Fixtures added to calibration schedule</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>20</td>
</tr>
</tbody>
</table>

Improvement actions must be taken for processes having capability indices (Cpk), for critical and key characteristics, less than 1.67 Cpk and/or an RPN greater than 175.

The intent of the recommended corrective action is to reduce any one or all of the occurrence, severity, and/or detection rankings.
Process FMEA Map
### PROCESS CONTROL PLAN

|-------------------------------------|-------------------------------------|-----|---------|---------|--------------------|------------------------------------------|-----------------------------------|-------------|-------------|----------------|---------------|

**Process Control Plan**

- **Category:** Prototype
- **Key Contact Name:**
- **Date (Orig):**
- **Date (Rev):**
- **Revision:**

**Control Plan Number:**

**Core Team:**

- **Customer Engineering Approval (If Req’d):**
- **Date (If Req’d):**

**Manufacturing Engineering Manager Approval:**

**Customer Quality Approval (If Req’d):**

**Date (If Req’d):**

**Quality Assurance Manager Approval:**

**Other Approval (If Req’d):**

**Date (If Req’d):**

**Part Name / Description:**

**Quality Assurance Manager Approval:**

**Other Approval (If Req’d):**

**Date (If Req’d):**

**Plant:**

**Other Approval Date (If Req’d):**

**Other Approval (If Req’d):**

**Date (If Req’d):**
Process Control Plan

**Purpose;**

To aid in the manufacturing of products according to customer and design requirements.

To focus resources on controlling special product and process characteristics.

Control plans are developed to create part number or product family specific and systemic controls of product/process characteristics to aid in the development of robust documentation.

The Control Plan describes the actions that are required at each phase of the process to assure that all process outputs will be in a state of control.

**Creating a Control Plan:**

Use a cross functional team.

Key Inputs: Design FMEA, Characteristic Matrix, Process Map, Process FMEA.

Control Plans are a living document; the control plan must reflect the current process documentation.
How to complete a control plan
Process Control Plan

Process Number and Name

What is the process number?
The sequence of the process should line up with the process map and PFMEA

What is the process name?
The process name should line up with the process map and PFMEA

<table>
<thead>
<tr>
<th>Proc #</th>
<th>Process Name / Operation description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MILLING (Mounting Pads)</td>
</tr>
</tbody>
</table>

Machine, Device, Jig, Tools for Mfg.

What significant machines or tools are used?
List the processing equipment, e.g., machine, device, jig, or other tools for manufacturing, as appropriate

<table>
<thead>
<tr>
<th>Machine, Device, Jig, Tools For Mfg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNC Alignment Fixture per Part Number</td>
</tr>
</tbody>
</table>
## Characteristics

<table>
<thead>
<tr>
<th>No.</th>
<th>Product</th>
<th>Process</th>
<th>Special Char. Class.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>Datum</td>
<td></td>
<td>K</td>
</tr>
</tbody>
</table>

### What is the Characteristic Number (No.)?

A reference number for the characteristic on the corresponding matrix or print (if available).

### Product

#### What is the Product Characteristic?

A product characteristic is a feature such as dimension, size etc.

### Process

#### What is the Process Characteristic?

Process characteristics are the process variables such as machine pressure, flow, speed etc.

### Special Characteristic Class

#### What is the Special Characteristic Classification?

Assign the appropriate characteristic classification to the identified product or process characteristic.

- **Critical (C)** The letter C indicates a Critical characteristic.
- **Key (K)** The letter K indicates a Key characteristic.
- **Standard (‘ ‘)** Leaving the column blank/empty indicates a standard characteristic.

### NOTE:

Product and process characteristics should be separate line items. They will often have a different characteristic class, specification and control methods.
## Process Control Plan

### Methods

<table>
<thead>
<tr>
<th>Part One: what are the characteristic requirements?</th>
</tr>
</thead>
<tbody>
<tr>
<td>List the specifications that are required for the characteristic to be in compliance. 2.± .005, Ra 16, finish acceptance per per print xyz etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluation / Measurement Technique</th>
<th>Sample Size</th>
<th>Sample Freq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual, Alignment Fixture per P/N</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Control Method

**How is the characteristic controlled?**

SPC, inspection, attribute data, automated, sampling plans, mistake proof process etc.
### Reaction plan

<table>
<thead>
<tr>
<th>Reaction Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact Cell Leader.</td>
</tr>
<tr>
<td>Repeat Set-up.</td>
</tr>
<tr>
<td>Scrap per NCM Process.</td>
</tr>
</tbody>
</table>

**What does the operator do if the characteristic does not meet specifications?**

Example: reject, scrap, repair process/print number referenced, rework, readjust device/machine, reevaluate process, segregate, tag nonconforming product and notify leader for disposition.
Process Control Plan Map

**Process Control Plan Map**

**PROCESS CONTROL PLAN**

- **Vendor:** Eaton Aerospace, Glenolden PA
- **Plant:** Glenolden, PA
- **Vendor Number:** N/A

**Characteristics**

- **What is the process number?**
  - The sequence of the process should line up with the process map and PFMEA.
- **What is the process name?**
  - The process name should line up with the process map and PFMEA.
- **What are the characteristics and class?**
  - Product and process characteristics should be separate line items because they will often have a different characteristic class, specification, and control methods.
- **Special Characteristic Classification:**
  - Assign the appropriate characteristic classification to the identified product or process characteristic. Reference this procedure for the classifications.
- **What are the characteristic requirements?**
  - List the specifications that are required for the characteristic to be in compliance. E.g., +/- .005, Ra 16, finish acceptance per print, etc.
- **What methods are used to measure the characteristic?**
  - List the measurement system being used. It could be gages, fixture, visual, special inspection techniques, and/or test equipment.
- **How many pieces are checked to verify the characteristic meets specifications and how often?**
- **How is the characteristic controlled?**
  - SPC, inspection, attribute data, automated, sampling plans, etc.
- **What does the operator do if the characteristic does not meet specifications?**
  - Example: Reject, scrap, repair, process/print number referenced, rescript, rework, device/machine, reevaluate process, segregate, tag, nonconforming product and notify leader for disposition.

**Machine/Device/Jig/Tool for Op:**

- **What is the machine used?**
  - List the processing equipment, e.g., machine, device, jig, or other tools for manufacturing, as appropriate.
Manufacturing Instructions

Purpose:
To define the requirements for developing comprehensive and supplemental Manufacturing Instructions (MI) for product, process, or activity to be produced which is to be applied at each operation or workstation.

Staking Process

- Insert specified mandrel.
- Orient staking tool.
- Insert fixture into staker.
- Check pressure setting. (Usually 15 psi)
- Put part on fixture.
- Hold part in place.
- Pull arm down on part and hold. Depress foot pedal. *Never press pedal without a part on mandrel.*
- Inspect for sufficient swedge. Repeat process if required.

*Staking: The process that moves sufficient material over a stud pin to insure it is captured.*