

***Advanced Product Quality Planning
and Control Plan***

APQP
Second Edition





**ADVANCED
PRODUCT QUALITY PLANNING
(APQP)
AND CONTROL PLAN**

Reference Manual
Second Edition

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FOREWORD

Second Edition

Effective November 1, 2008, APQP and Control Plan Second Edition replaces APQP and Control Plan First Edition unless otherwise specified by your customer.

APQP and Control Plan Second Edition includes:

- incorporation of the customer focused process approach
- updated terminology and concepts consistent with ISO/TS 16949 and other Chrysler, Ford and General Motors core tool manuals
- appropriate references to customer specifics provided without the full text

This manual continues to provide general guidelines for ensuring that Advanced Product Quality Planning is implemented in accordance with the requirements of the customer. It does not give specific instructions on how to arrive at each APQP or Control Plan entry, a task best left to each organization.

While these guidelines are intended to cover most situations normally occurring either in the early planning, design phase, or process analysis, there will be questions that arise. These questions should be directed to your authorized customer representative.

The Supplier Quality Requirements Task Force gratefully acknowledges the contributions of the following individuals and their respective companies that participated in the revision process.

Bryan Book, Chrysler LLC, Chair
Russ Hopkins, Ford Motor Company
William Fick, General Motors Corporation
Robert Minkler, Delphi Corporation
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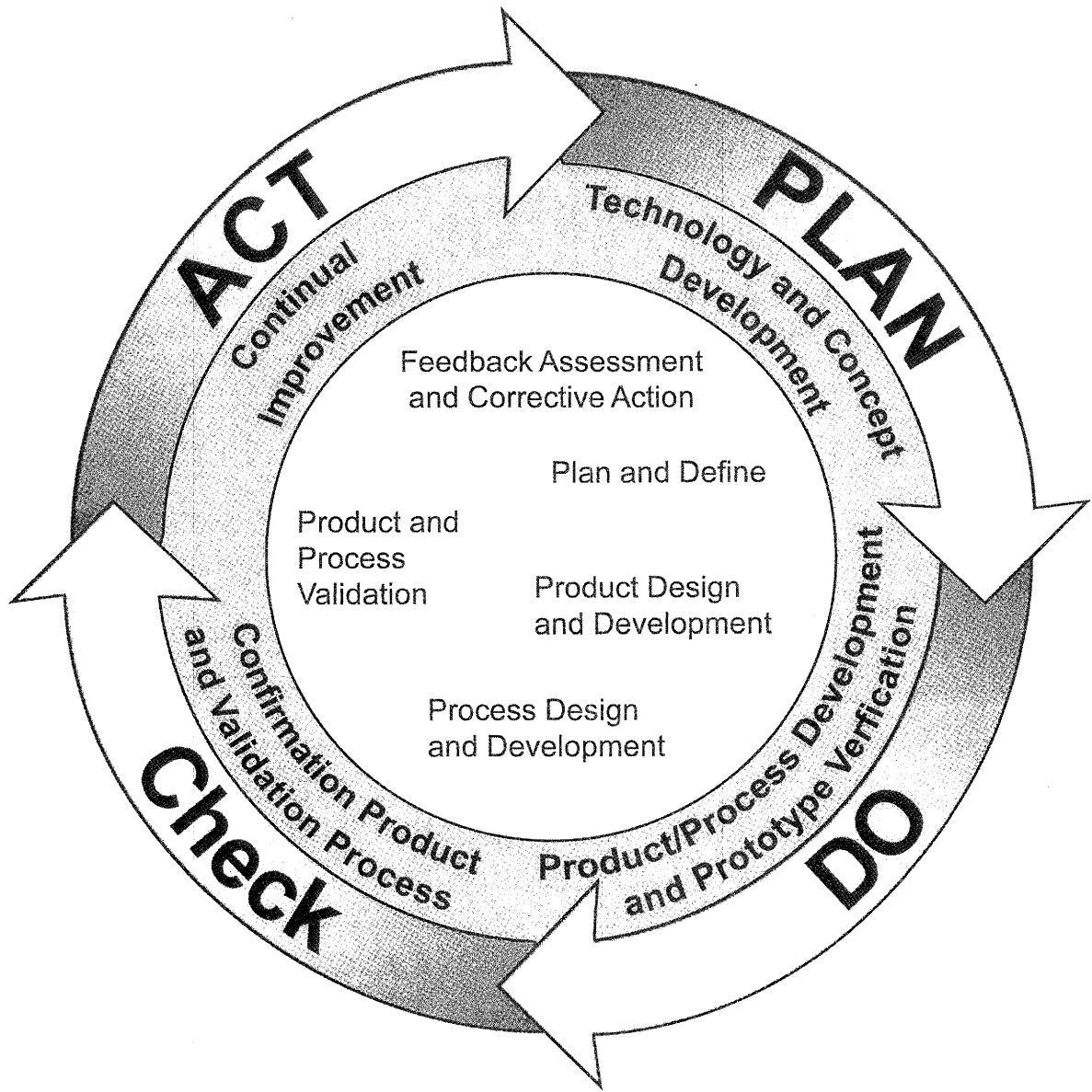
July 2008

TABLE OF CONTENTS

| | |
|---|-----------|
| FOREWORD..... | III |
| TABLE OF CONTENTS..... | V |
| INTRODUCTION..... | 1 |
| FUNDAMENTALS OF PRODUCT QUALITY PLANNING..... | 3 |
| <i>Organize the Team</i> | 3 |
| <i>Define the Scope</i> | 3 |
| <i>Team-to-Team</i> | 4 |
| <i>Training</i> | 4 |
| <i>Customer and Organization Involvement</i> | 4 |
| <i>Simultaneous Engineering</i> | 4 |
| <i>Control Plans</i> | 4 |
| <i>Concern Resolution</i> | 5 |
| <i>Product Quality Timing Plan</i> | 5 |
| <i>Plans Relative to the Timing Chart</i> | 5 |
| CHAPTER I PLAN AND DEFINE PROGRAM..... | 7 |
| INTRODUCTION..... | 9 |
| 1.1 <i>Voice of the Customer</i> | 9 |
| 1.2 <i>Business Plan and Marketing Strategy</i> | 11 |
| 1.3 <i>Product/Process Benchmark Data</i> | 11 |
| 1.4 <i>Product/Process Assumptions</i> | 12 |
| 1.5 <i>Product Reliability Studies</i> | 12 |
| 1.6 <i>Customer Inputs</i> | 12 |
| 1.7 <i>Design Goals</i> | 12 |
| 1.8 <i>Reliability and Quality Goals</i> | 12 |
| 1.9 <i>Preliminary Bill of Material</i> | 12 |
| 1.10 <i>Preliminary Process Flow Chart</i> | 13 |
| 1.11 <i>Preliminary Identification of Special Product and Process Characteristics</i> | 13 |
| 1.12 <i>Product Assurance Plan</i> | 13 |
| 1.13 <i>Management Support</i> | 14 |
| CHAPTER 2 PRODUCT DESIGN AND DEVELOPMENT | 15 |
| INTRODUCTION..... | 17 |
| 2.1 <i>Design Failure Mode and Effects Analysis (DFMEA)</i> | 18 |
| 2.2 <i>Design for Manufacturability and Assembly</i> | 18 |
| 2.3 <i>Design Verification</i> | 19 |
| 2.4 <i>Design Reviews</i> | 19 |
| 2.5 <i>Prototype Build - Control Plan</i> | 20 |
| 2.6 <i>Engineering Drawings (Including Math Data)</i> | 20 |
| 2.7 <i>Engineering Specifications</i> | 21 |
| 2.8 <i>Material Specifications</i> | 21 |
| 2.9 <i>Drawing and Specification Changes</i> | 21 |
| 2.10 <i>New Equipment, Tooling and Facilities Requirements</i> | 21 |
| 2.11 <i>Special Product and Process Characteristics</i> | 21 |
| 2.12 <i>Gages/Testing Equipment Requirements</i> | 22 |
| 2.13 <i>Team Feasibility Commitment and Management Support</i> | 22 |
| CHAPTER 3 PROCESS DESIGN AND DEVELOPMENT..... | 23 |
| INTRODUCTION..... | 25 |
| 3.1 <i>Packaging Standards and Specifications</i> | 26 |

| | |
|---|------------|
| 3.2 Product/Process Quality System Review..... | 26 |
| 3.3 Process Flow Chart..... | 26 |
| 3.4 Floor Plan Layout..... | 26 |
| 3.5 Characteristics Matrix..... | 27 |
| 3.6 Process Failure Mode and Effects Analysis (PFMEA)..... | 27 |
| 3.7 Pre-Launch Control Plan..... | 27 |
| 3.8 Process Instructions..... | 28 |
| 3.9 Measurement Systems Analysis Plan..... | 28 |
| 3.10 Preliminary Process Capability Study Plan..... | 29 |
| 3.11 Management Support..... | 29 |
| CHAPTER 4 PRODUCT AND PROCESS VALIDATION..... | 31 |
| INTRODUCTION..... | 33 |
| 4.1 Significant Production Run..... | 34 |
| 4.2 Measurement Systems Analysis..... | 34 |
| 4.3 Preliminary Process Capability Study..... | 34 |
| 4.4 Production Part Approval..... | 35 |
| 4.5 Production Validation Testing..... | 35 |
| 4.6 Packaging Evaluation..... | 35 |
| 4.7 Production Control Plan..... | 35 |
| 4.8 Quality Planning Sign-Off and Management Support..... | 35 |
| CHAPTER 5 FEEDBACK, ASSESSMENT AND CORRECTIVE ACTION..... | 37 |
| INTRODUCTION..... | 39 |
| 5.1 Reduced Variation..... | 39 |
| 5.2 Improved Customer Satisfaction..... | 40 |
| 5.3 Improved Delivery and Service..... | 40 |
| 5.4 Effective Use of Lessons Learned/Best Practices..... | 40 |
| CHAPTER 6 CONTROL PLAN METHODOLOGY..... | 41 |
| INTRODUCTION..... | 43 |
| 6.1 Control Plan Column Descriptions..... | 47 |
| 6.2 Process Analysis..... | 56 |
| APPENDIX A PRODUCT QUALITY PLANNING CHECKLISTS..... | 71 |
| APPENDIX B ANALYTICAL TECHNIQUES..... | 88 |
| Assembly Build Variation Analysis..... | 89 |
| Benchmarking..... | 89 |
| Cause and Effect Diagram..... | 89 |
| Characteristics Matrix..... | 90 |
| Critical Path Method..... | 91 |
| Design of Experiments (DOE)..... | 91 |
| Design for Manufacturability and Assembly..... | 92 |
| Design Verification Plan and Report (DVP&R)..... | 92 |
| Mistake Proofing/Error-Proofing..... | 92 |
| Process Flow Charting..... | 93 |
| Quality Function Deployment (QFD)..... | 93 |
| APPENDIX C REFERENCE MATERIAL..... | 95 |
| APPENDIX D TEAM FEASIBILITY COMMITMENT..... | 97 |
| APPENDIX E PRODUCT QUALITY PLANNING SUMMARY AND APPROVALS..... | 99 |
| APPENDIX F GLOSSARY..... | 102 |
| APPENDIX G INDEX..... | 105 |

PRODUCT QUALITY PLANNING CYCLE



Introduction

The purpose of this manual is to communicate to organizations (internal and external) and suppliers, common Product Quality Planning and Control Plan guidelines developed jointly by Chrysler, Ford and General Motors. This manual provides guidelines designed to produce a product quality plan, which will support the development of a product or service that will satisfy the customer (see Section 1.6). The following terms, used in this edition are used to describe the supply chain. The term "organization" refers to the unit to which these guidelines apply. The term "supplier" replaces the term subcontractor that was used in the First Edition. Some of the expected benefits in using these guidelines are:

- A reduction in the complexity of product quality planning for the customers and organizations.
- A means for organizations to easily communicate product quality planning requirements to suppliers.

This reference manual contains guidelines that support the requirements as described in ISO/TS 16949 and applicable customer-specific requirements. All forms in this manual are provided as examples only. The purpose is to assist the organization's product quality planning team in developing the appropriate communication forms to support meeting customer requirements, needs, and expectations.

The Product Quality Planning Cycle shown on the facing page is a graphic depiction of a typical program. The various phases are sequenced to represent planned timing to execute the functions described. The purpose of the Product Quality Planning Cycle is to emphasize:

- Up-front planning. The first three quarters of the cycle are devoted to up-front product quality planning through product/process validation.
- The act of implementation. The fourth quarter is the stage where the importance of evaluating the output serves two functions: to determine if customers are satisfied, and to support the pursuit of continual improvement.

Depicting product quality planning as a cycle illustrates the never-ending pursuit of continual improvement that can only be achieved by taking the experience in one program and applying that acquired knowledge to the next program.

PRODUCT QUALITY PLANNING RESPONSIBILITY MATRIX

The matrix shown below depicts the Product Quality Planning Functions for three types of organizations. It is to assist organizations in defining the scope of their planning responsibilities. Refer to Fundamentals of Product Quality Planning on the next page. The matrix does not depict all the different types of product quality planning relationships that could exist among organizations, suppliers, and customers.

| | *Design Responsible | *Manufacturing Only | *Service Organization i.e. Heat Treat, Warehousing, Transportation, etc. |
|---|--------------------------------|--------------------------------|---|
| Define the Scope | X | X | X |
| Plan and Define Chapter 1.0 | X | | |
| Product Design and Development Chapter 2.0 | X | | |
| Feasibility Section 2.13 | X | X | X |
| Process Design and Development Chapter 3.0 | X | X | X |
| Product and Process Validation Chapter 4.0 | X | X | X |
| Feedback, Assessment and Corrective Action Chapter 5.0 | X | X | X |
| Control Plan Methodology Chapter 6.0 | X | X | X |

* Refer to Section 1 "Scope" of ISO/TS 16949.

Fundamentals of Product Quality Planning

Product Quality Planning is a structured method of defining and establishing the steps necessary to assure that a product satisfies the customer. The goal of product quality planning is to facilitate communication with everyone involved to assure that all required steps are completed on time. Effective product quality planning depends on a company's top management commitment to the effort required in achieving customer satisfaction. Some of the benefits of product quality planning are:

- To direct resources to satisfy the customer.
- To promote early identification of required changes.
- To avoid late changes.
- To provide a quality product on time at the lowest cost.

The work practices, tools, and analytical techniques described in this manual are listed in a logical sequence to make it easy to follow. Each Product Quality Plan is unique. The actual timing and sequence of execution is dependent on customer needs and expectations and/or other practical matters. The earlier a work practice, tool, and/or analytical technique can be implemented in the Product Quality Planning Cycle, the better.

Organize the Team

The organization's first step in product quality planning is to assign a process owner for the APQP project. In addition, a cross functional team should be established to assure effective product quality planning. The team should include representatives from multiple functions such as engineering, manufacturing, material control, purchasing, quality, human resources, sales, field service, suppliers, and customers, as appropriate.

Define the Scope

It is important for the organization's product quality planning team in the earliest stage of the product program to identify customer needs, expectations, and requirements. At a minimum, the team must meet to:

- Select a project team leader responsible for overseeing the planning process. (In some cases it may be advantageous to rotate the team leader during the planning cycle.)
- Define the roles and responsibilities of each area represented.
- Identify the customers - internal and external.
- Define customer requirements. (Use QFD if applicable, as referenced in Appendix B.)
- Select the disciplines, individuals, and/or suppliers that must be added to the team, and those not required.

Introduction

- Understand customer expectations, i.e., design, number of tests.
- Assess the feasibility of the proposed design, performance requirements and manufacturing process.
- Identify costs, timing, and constraints that must be considered.
- Determine assistance required from the customer.
- Identify documentation process or method.

Team-to-Team

The organization's product quality planning team must establish lines of communication with other customer and organization teams. This may include regular meetings with other teams. The extent of team-to-team contact is dependent upon the number of issues requiring resolution.

Training

The success of a Product Quality Plan is dependent upon an effective training program that communicates all the requirements and development skills to fulfill customer needs and expectations.

Customer and Organization Involvement

The primary customer may initiate the quality planning process with an organization. However, the organization has an obligation to establish a cross functional team to manage the product quality planning process. Organizations must expect the same performance from their suppliers.

Simultaneous Engineering

Simultaneous Engineering is a process where cross functional teams strive for a common goal. It replaces the sequential series of phases where results are transmitted to the next area for execution. The purpose is to expedite the introduction of quality products sooner. The organization's product quality planning team assures that other areas/teams plan and execute activities that support the common goal or goals.

Control Plans

Control plans are written descriptions of the systems for controlling parts and processes. Separate control plans cover three distinct phases:

- Prototype - A description of the dimensional measurements and material and performance tests that will occur during Prototype build.

Introduction

- Pre-launch - A description of the dimensional measurements and material and performance tests that will occur after Prototype and before full Production.
- Production - A comprehensive documentation of product/process characteristics, process controls, tests, and measurement systems that will occur during mass production.

Concern Resolution

During the planning process, the team will encounter product design and/or processing concerns. These concerns should be documented on a matrix with assigned responsibility and timing. Disciplined problem-solving methods are recommended in difficult situations. Analytical techniques described in Appendix B should be used as appropriate.

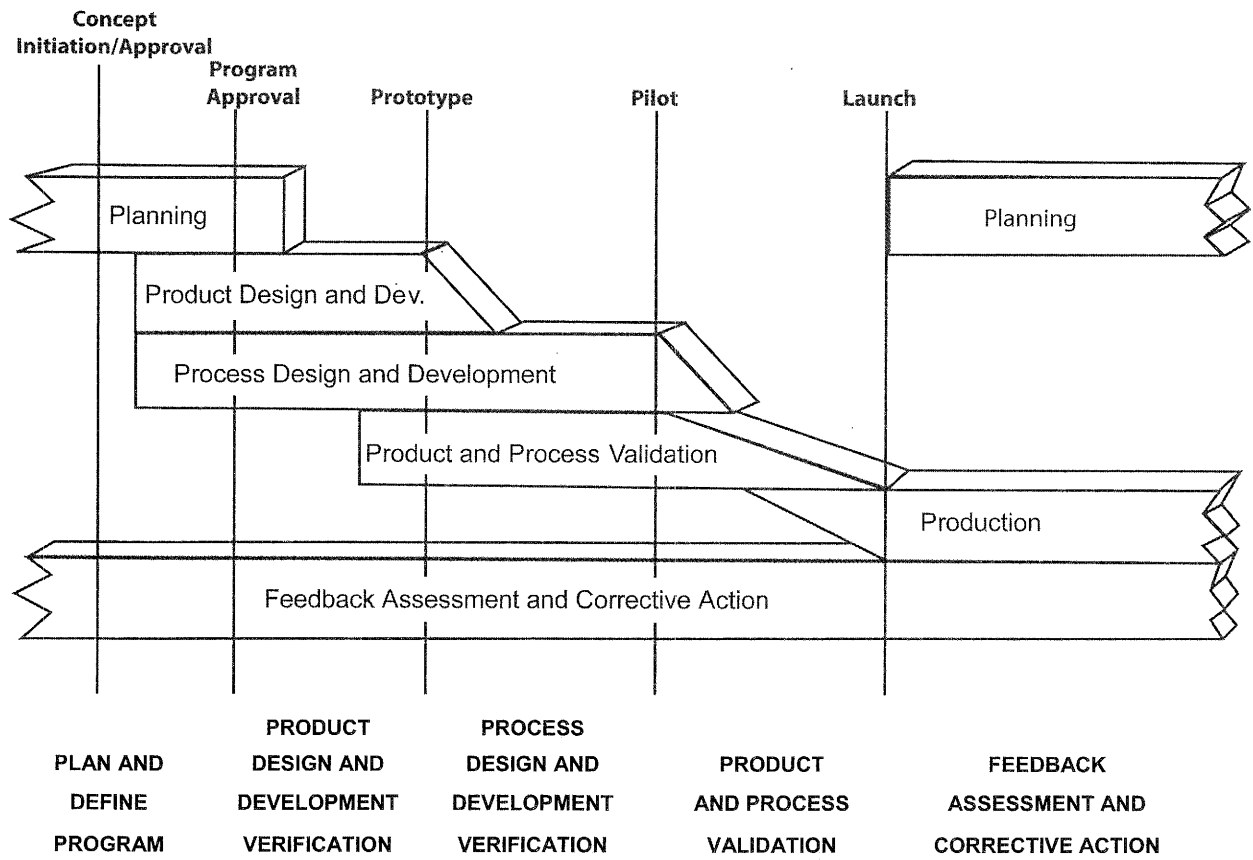
Product Quality Timing Plan

The organization's product quality planning team's first order of business following organizational activities should be the development of a Timing Plan. The type of product, complexity and customer expectations should be considered in selecting the timing elements that must be planned and charted. All team members should agree with each event, action, and timing. A well-organized timing chart should list tasks, assignments, and/or other events. (The Critical Path Method may be appropriate; reference Appendix B.) Also, the chart provides the planning team with a consistent format for tracking progress and setting meeting agendas. To facilitate status reporting, each event must have a "start" and a "completion" date with the actual point of progress recorded. Effective status reporting supports program monitoring with a focus on identifying items that require special attention.

Plans Relative to the Timing Chart

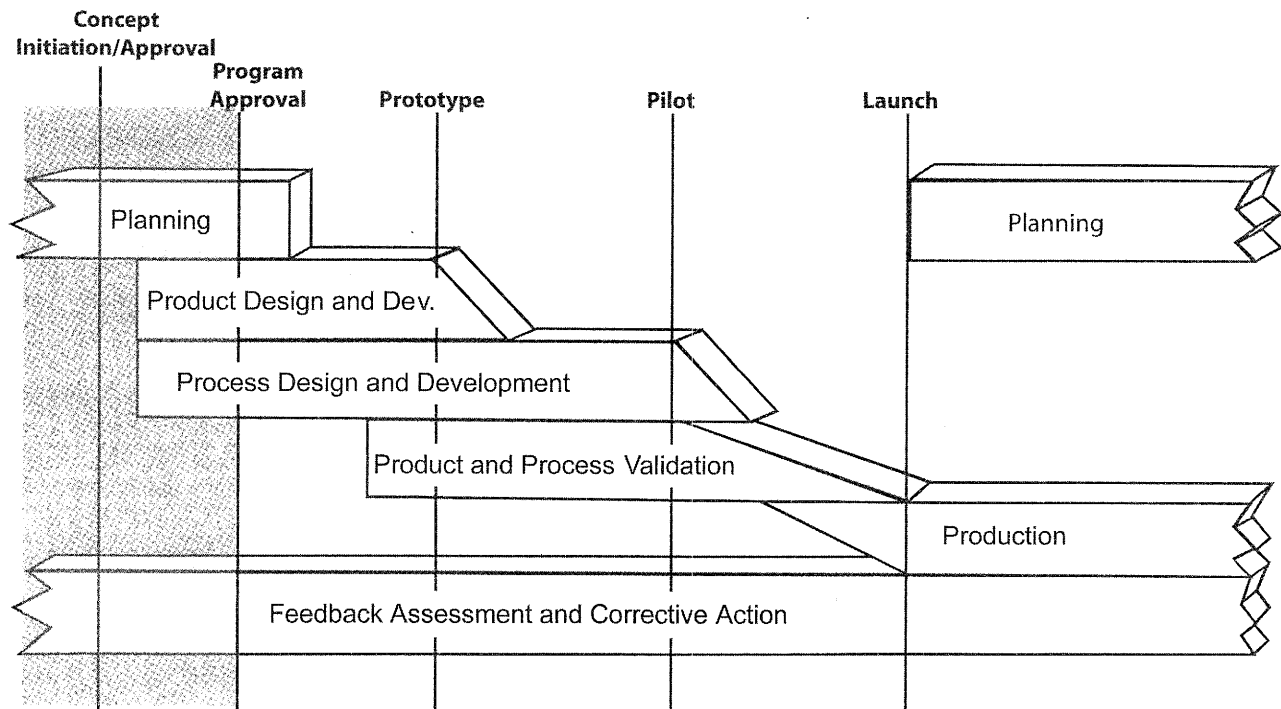
The success of any program depends on meeting customer needs and expectations in a timely manner at a cost that represents value. The Product Quality Planning Timing Chart below and the Product Quality Planning Cycle described previously require a planning team to concentrate its efforts on problem prevention. Problem prevention is driven by Simultaneous Engineering performed by product and manufacturing engineering activities working concurrently. Planning teams must be prepared to modify product quality plans to meet customer expectations. The organization's product quality planning team is responsible for assuring that timing meets or exceeds the customer timing plan.

PRODUCT QUALITY PLANNING TIMING CHART



**Chapter I
Plan and Define Program**

PRODUCT QUALITY PLANNING TIMING CHART



OUTPUTS:

- **Design Goals**
- **Reliability and Quality Goals**
- **Preliminary Bill of Material**
- **Preliminary Process Flow Chart**
- **Preliminary Listing of Special Product and Process Characteristics**
- **Product Assurance Plan**
- **Management Support**

Introduction

This chapter describes how customer needs and expectations are linked to planning and defining a quality program. The goal of any product program is meeting customer needs while providing competitive value. The initial step of the product quality planning process is to ensure that customer needs and expectations are clearly understood.

The inputs and outputs applicable to the planning process may vary according to the product development process, and customer needs and expectations. Some recommendations discussed in this chapter are as follows:

INPUTS

- Voice of the Customer
 - Market Research (including OEM Vehicle Build Timing and OEM Volume Expectations)
 - Historical Warranty and Quality Information
 - Team Experience
- Business Plan/Marketing Strategy
- Product/Process Benchmark Data
- Product/Process Assumptions
- Product Reliability Studies
- Customer Inputs

OUTPUTS (Become inputs for Chapter 2)

- Design Goals
- Reliability and Quality Goals
- Preliminary Bill of Material
- Preliminary Process Flow Chart
- Preliminary Listing of Special Product and Process Characteristics
- Product Assurance Plan
- Management Support (including program timing and planning for resources and staffing to support required capacity)

1.1 Voice of the Customer

The "Voice of the Customer" encompasses complaints, recommendations, data and information obtained from internal and/or external customers. Some methods for gathering this information appear in the following paragraphs.

1.1.1 Market Research

The organization's product quality planning team may need to obtain market research data and information reflecting the Voice of the Customer. The following sources can assist in identifying customer concerns and wants and translating those concerns into product and process characteristics:

- Customer interviews
- Customer questionnaires and surveys
- Market test and positioning reports
- New product quality and reliability studies
- Competitive product quality studies
- Best Practices
- Lessons Learned

1.1.2 Historical Warranty and Quality Information

A list of historical customer concerns and wants should be prepared to assess the potential for recurrence during the design, manufacture, installation and use of the product. These should be considered as an extension of the other design requirements and included in the analysis of customer needs.

Many of the following items can assist the team in identifying customer concerns and wants and prioritizing appropriate resolutions.

- Best Practices
- Lessons Learned
- Warranty reports
- Capability indicators
- Supplier plant internal quality reports
- Problem resolution reports
- Customer plant returns and rejections
- Field return product analysis

1.1.3 Team Experience

The team may use any source of any information as appropriate, including the following:

- Input from higher system level or past Quality Function Deployment (QFD) projects
- Media commentary and analysis: magazine and newspaper reports, etc.

- Customer letters and suggestions
- Best Practices
- Lessons Learned
- Dealer comments
- Fleet Operator's comments
- Field service reports
- Internal evaluations using surrogate customers
- Road trips
- Management comments or direction
- Problems and issues reported from internal customers
- Government requirements and regulations
- Contract review

1.2 Business Plan and Marketing Strategy

The customer business plan and marketing strategy will set the framework for the product quality plan. The business plan may place constraints (e.g., timing, cost, investment, product positioning, research and development (R&D) resources) on the team that affect the direction taken. The marketing strategy will define the target customer, the key sales points, and key competitors.

1.3 Product/Process Benchmark Data

The use of benchmarking (referenced in Appendix B) will provide input to establishing product/process performance targets. Research and development may also provide benchmarks and concept ideas. One method to successful benchmarking is:

- Identify the appropriate benchmarks.
- Understand the reason for the gap between your current status and the benchmark.
- Develop a plan to close the gap, match the benchmark, or exceed the benchmark.

1.4 Product/Process Assumptions

There will be assumptions that the product has certain features, design, or process concepts. These include technical innovations, advanced materials, reliability assessments, and new technology. All should be utilized as inputs.

1.5 Product Reliability Studies

This type of data considers frequency of repair or replacement of components within designated periods of time and the results of long-term reliability/durability tests.

1.6 Customer Inputs

The next users of the product can provide valuable information relating to their needs and expectations. In addition, the next product users may have already conducted some or all of the aforementioned reviews and studies. These inputs should be used by the customer and/or organization to develop agreed upon measures of customer satisfaction.

1.7 Design Goals

Design goals are a translation of the Voice of the Customer into measurable design objectives. The proper selection of design goals assures that the Voice of the Customer is not lost in subsequent design activity. The Voice of the Customer also includes regulatory requirements such as materials composition reporting and polymeric part marking.

1.8 Reliability and Quality Goals

Reliability goals are established based on customer wants and expectations, program objectives, and reliability benchmarks. An example of customer wants and expectations could include no safety failures. Some reliability benchmarks could be competitor product reliability, warranty data, or frequency of repair over a set time period. Quality goals should be based on metrics such as parts per million, problem levels, or scrap reduction.

1.9 Preliminary Bill of Material

The team should establish a preliminary bill of material based on product/process assumptions and include a potential supplier list. In order to identify the preliminary special product/process characteristics it is necessary to have selected the appropriate design and manufacturing process.

1.10 Preliminary Process Flow Chart

The anticipated manufacturing process should be described using a process flow chart developed from the preliminary bill of material and product/process assumptions.

1.11 Preliminary Identification of Special Product and Process Characteristics

Special product and process characteristics are identified by the customer in addition to those selected by the organization through knowledge of the product and process. Examples of input to identification of special characteristics include:

- Product assumptions based on the analysis of customer needs and expectations.
- Identification of reliability goals and requirements.
- Identification of special process characteristics from the anticipated manufacturing process.
- Similar part FMEAs.

1.12 Product Assurance Plan

The Product Assurance Plan translates design goals into design requirements and is based on customer needs and expectations. This manual does not require a specific method for preparing a Product Assurance Plan. The Product Assurance Plan can be developed in any format understood by the organization and should include:

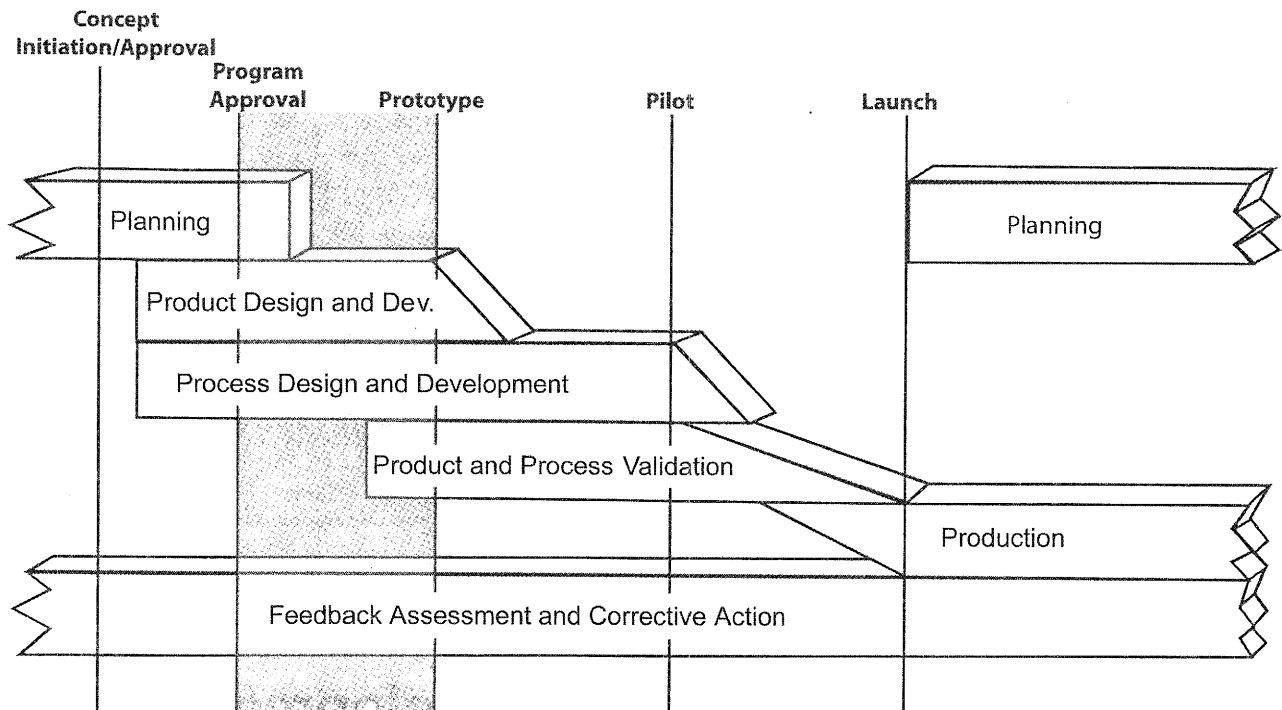
- Outlining of program requirements.
- Identification of reliability, durability, and apportionment/allocation goals and/or requirements.
- Assessment of new technology, complexity, materials, application, environment, packaging, service, and manufacturing requirements, or any other factor that may place the program at risk.
- Use of Failure Mode and Effects Analysis (FMEA).
- Development of preliminary engineering requirements.

1.13 Management Support

One of the keys to the success of Advanced Product Quality Planning is the interest, commitment and support of upper management. Participation by management in product quality planning meetings is vital to ensuring the success of the program. Management should be updated at the conclusion of every product quality planning phase to reinforce their commitment and support. Updates and/or requests for assistance can occur more frequently as required. A primary goal of Advanced Product Quality Planning is to maintain management support by demonstrating that all planning requirements have been met and/or concerns documented and scheduled for resolution, including program timing and planning for resources and staffing to support required capacity.

Chapter 2
Product Design and Development

PRODUCT QUALITY PLANNING TIMING CHART



DESIGN OUTPUTS

- Design Failure Mode and Effects Analysis (DFMEA)
- Design For Manufacturability and Assembly
- Design Verification
- Design Reviews
- Prototype Build – Control Plan
- Engineering Drawings (Including Math Data)
- Engineering Specifications
- Material Specifications
- Drawing and Specification Changes

APQP OUTPUTS

- New Equipment, Tooling and Facilities Requirements
- Special Product and Process Characteristics
- Gages/Testing Equipment Requirements
- Team Feasibility Commitment & Management Support

Introduction

This chapter discusses the elements of the planning process during which design features and characteristics are developed into a near final form. All design factors should be considered by the organization in the Advanced Product Quality Planning process even if the design is owned by the customer or shared. The steps include prototype build to verify that the product or service meets the objectives of the Voice of the Customer. A feasible design must permit meeting production volumes and schedules, and be consistent with the ability to meet engineering requirements, along with quality, reliability, investment cost, weight, unit cost and timing objectives. Although feasibility studies and control plans are primarily based on engineering drawings and specification requirements, valuable information can be derived from the analytical tools described in this chapter to further define and prioritize the characteristics that may need special product and process controls.

In this chapter, the Product Quality Planning Process is designed to assure a comprehensive and critical review of engineering requirements and other related technical information. At this stage of the process, a preliminary feasibility analysis will be made to assess the potential problems that could occur during manufacturing.

The inputs and outputs applicable to this chapter are as follows:

INPUTS (Derived from the outputs of Chapter 1)

- Design Goals
- Reliability and Quality Goals
- Preliminary Bill of Material
- Preliminary Process Flow Chart
- Preliminary Listing of Special Product and Process Characteristics
- Product Assurance Plan
- Management Support

DESIGN OUTPUTS (Become inputs for Chapter 3)

- Design Failure Mode and Effects Analysis (DFMEA)
- Design for Manufacturability and Assembly
- Design Verification
- Design Reviews
- Prototype Build - Control Plan
- Engineering Drawings (Including Math Data)
- Engineering Specifications
- Material Specifications
- Drawing and Specification Changes

APQP OUTPUTS (Becomes Inputs for Chapter 3)

- New Equipment, Tooling and Facilities Requirements
- Special Product and Process Characteristics
- Gages/Testing Equipment Requirements
- Team Feasibility Commitment and Management Support

2.1 Design Failure Mode and Effects Analysis (DFMEA)

The DFMEA is a disciplined analytical technique that assesses the probability of failure as well as the effect of such failure. A DFMEA is a living document continually updated as customer needs and expectations require. The DFMEA is an important input to the APQP process that may include previously selected product and process characteristics. The Chrysler, Ford and General Motors Potential Failure Mode and Effects Analysis (FMEA) reference manual provides guidance for the preparation of a DFMEA. The Design FMEA Checklist in Appendix A-1 should also be reviewed to assure that the appropriate design characteristics have been considered.

2.2 Design for Manufacturability and Assembly

Design for Manufacturability and Assembly is a Simultaneous Engineering process designed to optimize the relationship between design function, manufacturability, and ease of assembly. The scope of customer needs and expectations defined in Chapter 1 will determine the extent of the organization's product quality planning team involvement in this activity. This manual does not include or refer to a formal method of preparing a Design for Manufacturability and Assembly Plan. At a minimum, the items listed here should be considered by the organization's product quality planning team:

- Design, concept, function, and sensitivity to manufacturing variation
- Manufacturing and/or assembly process
- Dimensional tolerances
- Performance requirements
- Number of components
- Process adjustments
- Material handling

The above list may be augmented based on the organization's product quality planning team's knowledge, experience, the product/process, government regulations, and service requirements.

2.3 Design Verification

Design verification verifies that the product design meets the customer requirements derived from the activities described in Chapter 1.

2.4 Design Reviews

Design reviews are regularly scheduled meetings led by the organization's design engineering activity and must include other affected areas. The design review is an effective method to prevent problems and misunderstandings; it also provides a mechanism to monitor progress, report to management, and obtain customer approval as required.

Design reviews are a series of verification activities that are more than an engineering inspection. At a minimum, design reviews should include evaluation of:

- Design/Functional requirement(s) considerations
- Formal reliability and confidence goals
- Component/subsystem/system duty cycles
- Computer simulation and bench test results
- DFMEA(s)
- Review of the Design for Manufacturability and Assembly effort
- Design of Experiments (DOE) and assembly build variation results (Refer to Appendix B.)
- Test failures
- Design verification progress

A major function of design reviews is the tracking of design verification progress. The organization should track design verification progress through the use of a plan and report format, referred to as Design Verification Plan and Report (DVP&R) by some customers. The plan and report is a formal method to assure:

- Design verification
- Product and process validation of components and assemblies through the application of a comprehensive test plan and report.

The organization's product quality planning team is not limited to the items listed. The team should consider and use as appropriate, the analytical techniques listed in Appendix B.

2.5 Prototype Build - Control Plan

Prototype control plans are a description of the dimensional measurements and material and functional tests that will occur during prototype build. The organization's product quality planning team should ensure that a prototype control plan is prepared. Control plan methodology is described in Chapter 6. A Control Plan Checklist is provided in both Section 6 and Appendix A-8 to assist in the preparation of the prototype control plan.

The manufacture of prototype parts provides an excellent opportunity for the team and the customer to evaluate how well the product or service meets the Voice of the Customer objectives. It is the organization's product quality planning team's responsibility to review prototypes for the following:

- Assure that the product or service meets specification and report data as required.
- Ensure that particular attention has been given to special product and process characteristics.
- Use data and experience to establish preliminary process parameters and packaging requirements.
- Communicate any concerns, deviations, and/or cost impact to the customer.

2.6 Engineering Drawings (Including Math Data)

Customer designs do not preclude the organization's product quality planning team's responsibility to review engineering drawings in the following manner. Engineering drawings may include special (governmental regulatory and safety) characteristics that must be shown on the control plan. When customer engineering drawings are nonexistent, the controlling drawings should be reviewed by the team to determine which characteristics affect fit, function, durability and/or governmental regulatory safety requirements.

Drawings should be reviewed to determine if there is sufficient information for a dimensional layout of the individual parts. Control or datum surfaces/locators should be clearly identified so that appropriate functional gages and equipment can be designed for ongoing controls. Dimensions should be evaluated to assure feasibility and compatibility with industry manufacturing and measuring standards. If appropriate, the team should assure that math data is compatible with the customer's system for effective two-way communications.

2.7 Engineering Specifications

A detailed review and understanding of the controlling specifications will help the organization's product quality planning team to identify the functional, durability and appearance requirements of the subject component or assembly. Sample size, frequency, and acceptance criteria of these parameters are generally defined in the in-process test section of the Engineering Specification. Otherwise, the sample size and frequency are to be determined by the organization and listed in the control plan. In either case, the organization should determine which characteristics affect meeting functional, durability, and appearance requirements.

2.8 Material Specifications

In addition to drawings and performance specifications, material specifications should be reviewed for special characteristics relating to physical properties, performance, environmental, handling, and storage requirements. These characteristics should also be included in the control plan.

2.9 Drawing and Specification Changes

Where drawing and specification changes are required, the team must ensure that the changes are promptly communicated and properly documented to all affected areas.

2.10 New Equipment, Tooling and Facilities Requirements

The DFMEA, Product Assurance Plan and/or design reviews may identify new equipment and facilities including meeting capacity requirements. The organization's product quality planning team should address these requirements by adding the items to the Timing Chart. The team should assure that there is a process to determine that new equipment and tooling is capable and delivered on time. Facilities progress should be monitored to assure completion prior to planned production tryout. Refer to the New Equipment, Tooling and Test Equipment Checklist in Appendix A-3.

2.11 Special Product and Process Characteristics

In the Plan and Define Program stage (Chapter 1), the team identified preliminary special product and process characteristics. The organization's product quality planning team should build on this listing and reach consensus through the evaluation of the technical information. The organization should refer to the appropriate customer-specific requirements

for additional details on the use of special product and process characteristics. The consensus is to be documented on the appropriate control plan. The Control Plan Special Characteristics and Data Point Coordinates forms referenced in Chapter 6, Supplements K and L, are recommended methods to document and update special characteristics. The organization can use any form that meets the documentation requirements. Refer to customer-specific requirements for unique approval requirements

2.12 Gages/Testing Equipment Requirements

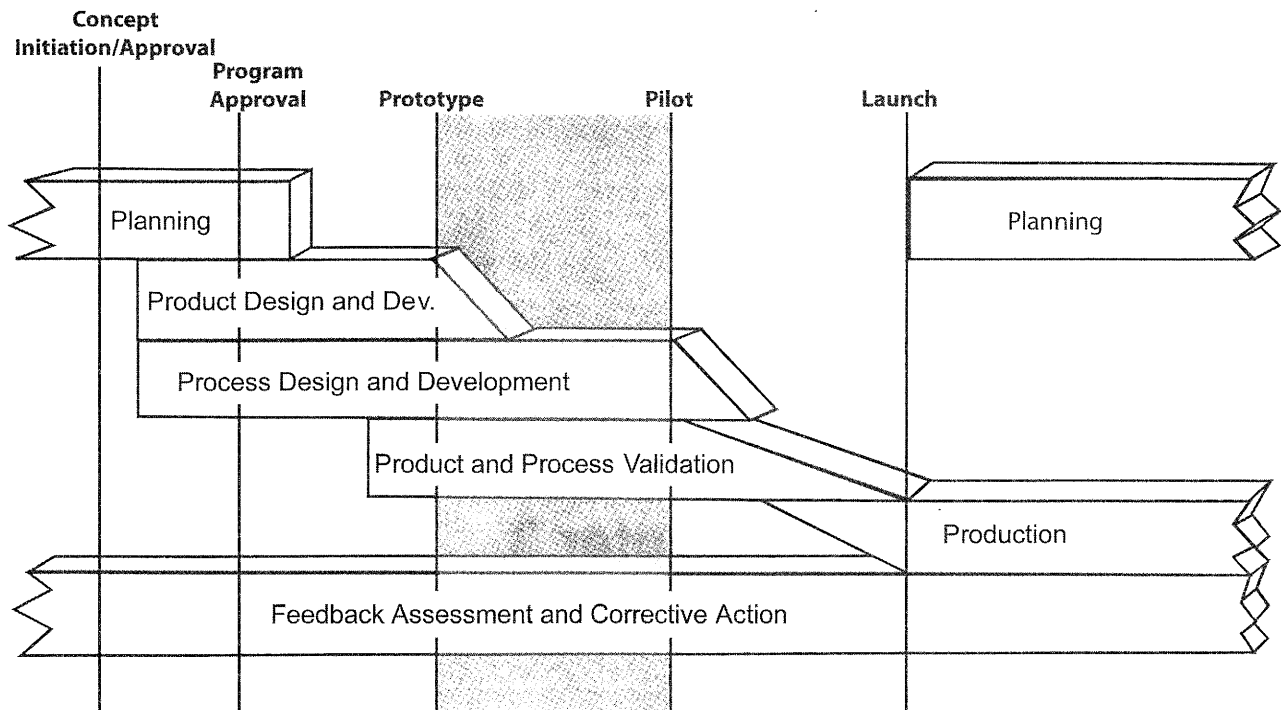
Gages/testing equipment requirements may also be identified at this time. The organization's product quality planning team should add these requirements to the Timing Chart. Progress should be monitored to assure that required timing is met.

2.13 Team Feasibility Commitment and Management Support

The organization's product quality planning team must assess the feasibility of the proposed design at this time. Customer design ownership does not preclude the organization's obligation to assess design feasibility. The team must be satisfied that the proposed design can be manufactured, assembled, tested, packaged, and delivered in sufficient quantity on schedule at an acceptable cost to the customer. The Design Information Checklist in Appendix A-2 allows the team to review its efforts in this section and make an evaluation of effectiveness. This checklist will also serve as a basis for the open issues discussed in the Team Feasibility Commitment, Appendix D. The team consensus that the proposed design is feasible should be documented along with all open issues that require resolution and presented to management for their support. The Team Feasibility Commitment form shown in Appendix D is an example of the type of written record recommended.

Chapter 3
Process Design and Development

PRODUCT QUALITY PLANNING TIMING CHART



OUTPUTS:

- Packaging Standards and Specifications
- Product/Process Quality System Review
- Process Flow Chart
- Floor Plan Layout
- Characteristics Matrix
- Process Failure Mode and Effects Analysis (PFMEA)
- Pre-Launch Control Plan
- Process Instructions
- Measurement Systems Analysis Plan
- Preliminary Process Capability Study Plan
- Management Support

Introduction

This chapter discusses the major features of developing a manufacturing system and its related control plans to achieve quality products. The tasks to be accomplished at this step of the product quality planning process depend upon the successful completion of the prior stages contained in the first two sections. This next step is designed to ensure the comprehensive development of an effective manufacturing system. The manufacturing system must assure that customer requirements, needs and expectations are met. The inputs and outputs applicable to the process step in this chapter are as follows:

INPUTS (Derived from the outputs of Chapter 2)

- Design Failure Mode and Effects Analysis (DFMEA)
- Design for Manufacturability and Assembly
- Design Verification
- Design Reviews
- Prototype Build - Control Plan
- Engineering Drawings (Including Math Data)
- Engineering Specifications
- Material Specifications
- Drawing and Specification Changes
- New Equipment, Tooling and Facilities Requirements
- Special Product and Process Characteristics
- Gages/Testing Equipment Requirements
- Team Feasibility Commitment and Management Support

OUTPUTS (Become inputs for Chapter 4)

- Packaging Standards & Specifications
- Product/Process Quality System Review
- Process Flow Chart
- Floor Plan Layout
- Characteristics Matrix
- Process Failure Mode and Effects Analysis (PFMEA)
- Pre-Launch Control Plan (including Error-Proofing Devices)
- Process Instructions
- Measurement Systems Analysis Plan
- Preliminary Process Capability Study Plan
- Management Support (including operator staffing and training plan)

3.1 Packaging Standards and Specifications

The customer will usually have packaging requirements that should be incorporated into any packaging specifications for the product. If none are provided, the packaging design should ensure product integrity at point of use. The organization's product quality planning team should ensure that individual product packaging (including interior partitions) is designed and developed. Customer packaging standards or generic packaging requirements should be used when appropriate. In all cases the packaging design should assure that the product performance and characteristics will remain unchanged during packing, transit, and unpacking. The packaging should have compatibility with all identified material handling equipment including robots.

3.2 Product/Process Quality System Review

The organization's product quality planning team should review the manufacturing site(s) Quality Management System. Any additional controls and/or procedural changes required to produce the product should be updated, documented and included in the manufacturing control plan. This is an opportunity for the organization's product quality planning team to improve the existing quality system based on customer input, team expertise, and previous experience. The Product/Process Quality Checklist provided in Appendix A-4 can be used by the organization's product quality planning team to verify completeness.

3.3 Process Flow Chart

The process flow chart is a schematic representation of the current or proposed process flow. It can be used to analyze sources of variations of machines, materials, methods, and manpower from the beginning to end of a manufacturing or assembly process. It is used to emphasize the impact of sources of variation on the process. The flow chart helps to analyze the total process rather than individual steps in the process. The flow chart assists the organization's product quality planning team to focus on the process when conducting the PFMEA and designing the Control Plan. The Process Flow Chart Checklist in Appendix A-6 can be used by the organization's product quality planning team to verify completeness.

3.4 Floor Plan Layout

The floor plan should be developed and reviewed to determine the acceptability of important control items, such as inspection points, control chart location, applicability of visual aids, interim repair stations, and

storage areas to contain non-conforming material. All material flow should be keyed to the process flow chart and control plan. The Floor Plan Checklist in Appendix A-5 can be used by the organization's product quality planning team to verify completeness. The floor plan layout should be developed in such a manner to optimize the material travel, handling and value-added use of floor space and should facilitate the synchronous flow of materials through the process.

3.5 Characteristics Matrix

A characteristics matrix is a recommended analytical technique for displaying the relationship between process parameters and manufacturing stations. See Analytical Techniques in Appendix B for further detail.

3.6 Process Failure Mode and Effects Analysis (PFMEA)

A PFMEA should be conducted during product quality planning and before beginning production. It is a disciplined review and analysis of a new or revised process and is conducted to anticipate, resolve, or monitor potential process problems for a new or revised product program. For further information on the creation and maintenance of PFMEAs refer to Chrysler, Ford and General Motors Potential Failure Mode and Effects Analysis (FMEA) reference manual. The Process FMEA Checklist in Appendix A-7 can be used by the organization's product quality planning team to verify completeness.

3.7 Pre-Launch Control Plan

Pre-launch control plans are a description of the dimensional measurements and material and functional tests that will occur after prototype and before full production. The pre-launch control plan should include additional product/process controls to be implemented until the production process is validated. The purpose of the pre-launch control plan is to contain potential non-conformities during or prior to initial production runs. Examples of enhancements in the pre-launch control plan are:

- More frequent inspection
- More in-process and final check points
- Robust statistical evaluations
- Enhanced audits
- Identification of error-proofing devices

For further information on the creation and maintenance of control plans refer to Chapter 6. The Control Plan Checklist in Appendix A-8 can be

used by the organization's product quality planning team to verify completeness.

3.8 Process Instructions

The organization's product quality planning team should ensure that process instructions provide sufficient understanding and detail for all personnel who have direct responsibility for the operation of the processes. These instructions should be developed from the following sources:

- FMEAs
- Control plan(s)
- Engineering drawings, performance specifications, material specifications, visual standards and industry standards
- Process flow chart
- Floor plan layout
- Characteristics matrix
- Packaging Standards and Specifications
- Process parameters
- Organization expertise and knowledge of the processes and products
- Handling requirements
- Operators of the process

The process instructions for standard operating procedures should be posted and should include set-up parameters such as: machine speeds, feeds, cycle times, and tooling, and should be accessible to the operators and supervisors. Additional information for process instruction preparation may be found in appropriate customer-specific requirements.

3.9 Measurement Systems Analysis Plan

The organization's product quality planning team should ensure that a plan to accomplish the required measurement systems analysis is developed, including checking aids. This plan should include, at a minimum, a laboratory scope appropriate for the required measurements and tests, the responsibility to ensure gage linearity, accuracy, repeatability, reproducibility, and correlation for duplicate gages. Refer to the Chrysler, Ford, and General Motors Measurement Systems Analysis (MSA) reference manual.

3.10 Preliminary Process Capability Study Plan

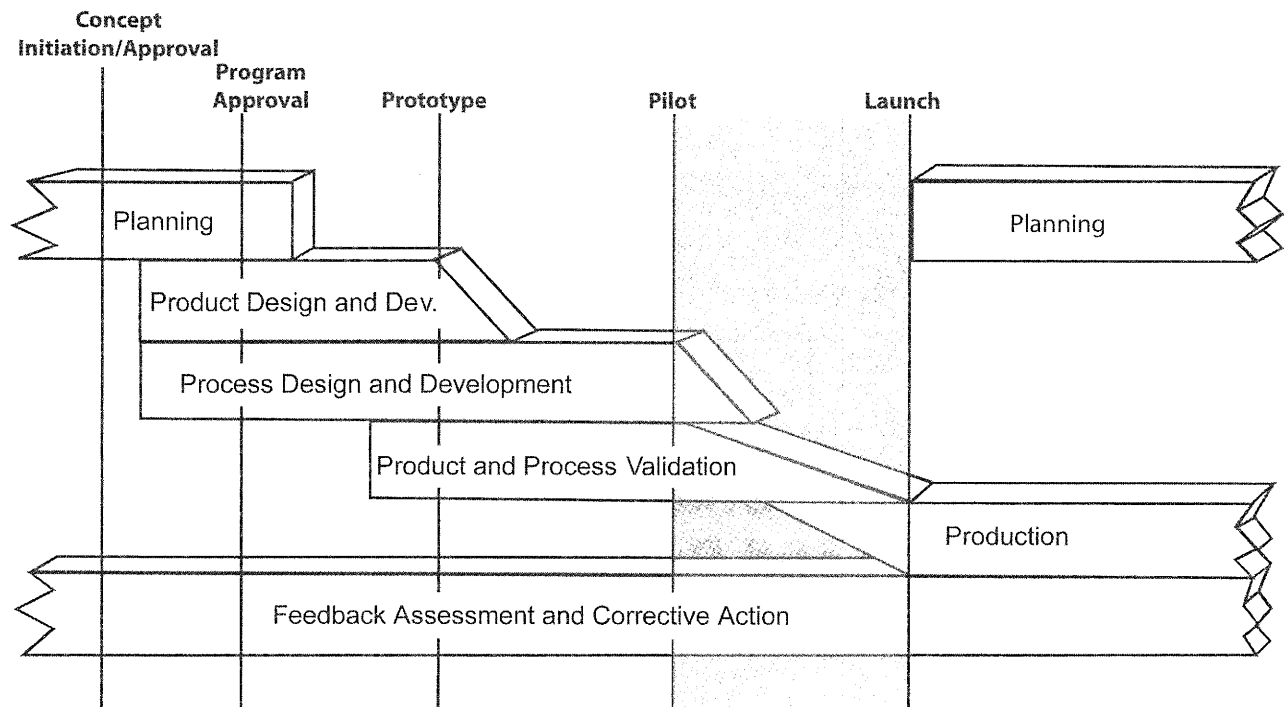
The organization's product quality planning team should ensure the development of a preliminary process capability plan. The characteristics identified in the control plan will serve as the basis for the preliminary process capability study plan. Reference the Chrysler, Ford, and General Motors Production Part Approval Process (PPAP) manual and Chrysler, Ford, and General Motors Statistical Process Control (SPC) reference manual for further definition.

3.11 Management Support

The organization's product quality planning team should schedule a formal review designed to reinforce management commitment at the conclusion of the process design and development phase. This review is critical to keeping upper management informed as well as gaining assistance to assist in resolution of any open issues. Management support includes the confirmation of the planning and providing the resources and staffing to meet the required capacity.

**Chapter 4
Product and Process Validation**

PRODUCT QUALITY PLANNING TIMING CHART



OUTPUTS:

- **Significant Production Run**
- **Measurement Systems Evaluation**
- **Preliminary Process Capability Study**
- **Production Part Approval**
- **Production Validation Testing**
- **Packaging Evaluation**
- **Production Control Plan**
- **Quality Planning Sign-Off and Management Support**

Introduction

This chapter discusses the major features of validating the manufacturing process through an evaluation of a significant production run. During a significant production run, the organization's product quality planning team should validate that the control plan and process flow chart are being followed and the products meet customer requirements. Additional concerns should be identified for investigation and resolution prior to regular production runs.

The inputs and outputs applicable to the process steps in this chapter are as follows:

INPUTS (Derived from the outputs of Chapter 3)

- Packaging Standards & Specifications
- Product/Process Quality System Review
- Process Flow Chart
- Floor Plan Layout
- Characteristics Matrix
- Process Failure Mode and Effects Analysis (PFMEA)
- Pre-Launch Control Plan
- Process Instructions
- Measurement Systems Analysis Plan
- Preliminary Process Capability Study Plan
- Management Support

OUTPUTS (Become inputs for Chapter 5)

- Significant Production Run
- Measurement Systems Evaluation
- Preliminary Process Capability Study
- Production Part Approval
- Production Validation Testing
- Packaging Evaluation
- Production Control Plan
- Quality Planning Sign-Off and Management Support

4.1 Significant Production Run

The significant production run must be conducted using production tooling, production equipment, production environment (including production operators), facility, production gages and production rate. The validation of the effectiveness of the manufacturing process begins with the significant production run (refer to the Chrysler, Ford, and General Motors Production Part Approval Process (PPAP) manual or the appropriate customer-specific requirements for additional details). The minimum quantity for a significant production run is usually set by the customer, but can be exceeded by the organization's product quality planning team. Output of the significant production run (product) is used for:

- Preliminary process capability study
- Measurement systems analysis
- Production rate demonstration
- Process review
- Production validation testing
- Production part approval
- Packaging evaluation
- First time capability (FTC)
- Quality planning sign-off
- Sample production parts
- Master sample (as required)

4.2 Measurement Systems Analysis

The specified monitoring and measuring devices and methods should be used to check the control plan identified characteristics to engineering specification and be subjected to measurement system evaluation during or prior to the significant production run. Refer to the Chrysler, Ford, and General Motors Measurement Systems Analysis (MSA) reference manual.

4.3 Preliminary Process Capability Study

The preliminary process capability study should be performed on characteristics identified in the control plan. The study provides an assessment of the readiness of the process for production. Refer to the Chrysler, Ford, and General Motors Production Part Approval Process (PPAP) manual and Chrysler, Ford, and General Motors Statistical Process Control (SPC) reference manual for details concerning the preliminary

process capability study. Refer to customer-specific requirements for unique requirements.

4.4 Production Part Approval

PPAP's purpose is to provide the evidence that all customer engineering design record and specification requirements are properly understood by the organization and that the manufacturing process has the potential to produce product consistently meeting these requirements during an actual production run at the quoted production rate. Refer to the Chrysler, Ford, and General Motors Production Part Approval Process (PPAP) manual.

4.5 Production Validation Testing

Production validation testing refers to engineering tests that validate that products made from production tools and processes meet customer engineering standards including appearance requirements.

4.6 Packaging Evaluation

All test shipments (when required) and test methods must assess the protection of the product from normal transportation damage and adverse environmental factors. Customer-specified packaging does not preclude the organization's product quality planning team involvement in evaluating the effectiveness of the packaging.

4.7 Production Control Plan

The production control plan is a written description of the systems for controlling production parts and processes. The production control plan is a living document and should be updated to reflect the addition or deletion of controls based on experience gained by producing parts. (Approval of the authorized customer representative may be required.) The production control plan is a logical extension of the pre-launch control plan. Mass production provides the organization the opportunity to evaluate output, review the control plan and make appropriate changes. Chapter 6 and Appendix A-8 present Control Plan Methodology and a checklist to verify completeness.

4.8 Quality Planning Sign-Off and Management Support

The organization's product quality planning team should perform a review at the manufacturing location(s) and coordinate a formal sign-off. The product quality sign-off indicates to management that the appropriate APQP

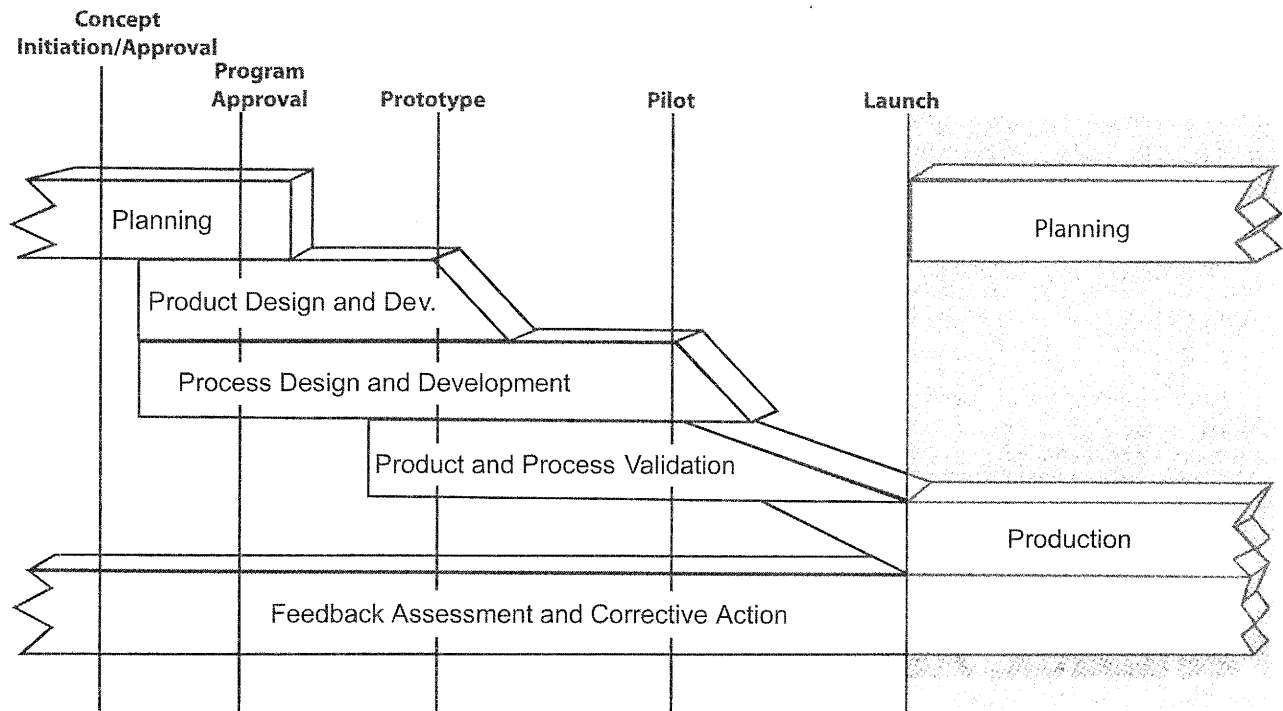
activities have been completed. The sign-off occurs prior to first product shipment and includes a review of the following:

- **Process Flow Charts.** Verify that process flow charts exist and are being followed.
- **Control Plans.** Verify that control plans exist, are available and are followed at all times for all affected operations.
- **Process Instructions.** Verify that these documents contain all the special characteristics specified in the control plan and that all PFMEA recommendations have been addressed. Compare the process instructions, PFMEA and process flow chart to the control plan.
- **Monitoring and Measuring Devices.** Where special gages, fixtures, test equipment or devices are required per the control plan, verify gage repeatability and reproducibility (GR&R) and proper usage. (Refer to the Chrysler, Ford, and General Motors Measurement Systems Analysis (MSA) reference manual for more information.)
- **Demonstration of Required Capacity.** Using production processes, equipment, and personnel.

Upon completion of the sign-off, a review with management should be scheduled to inform management of the program status and gain their support with any open issues. The Product Quality Planning Summary and Approval report shown in Appendix E is an example of the documentation required to support an effective quality planning sign-off.

Chapter 5
Feedback, Assessment and Corrective Action

PRODUCT QUALITY PLANNING TIMING CHART



OUTPUTS:

- **Reduced Variation**
- **Improved Customer Satisfaction**
- **Improved Delivery and Service**
- **Effective Use of Lessons Learn / Best Practices**

Introduction

Quality planning does not end with process validation and installation. It is the component manufacturing stage where output can be evaluated when all special and common causes of variation are present. This is also the time to evaluate the effectiveness of the product quality planning effort. The production control plan is the basis for evaluating product or service at this stage. Variable and attribute data must be evaluated. Appropriate actions as described in the Chrysler, Ford, and General Motors Statistical Process Control (SPC) reference manual must be taken. Organizations that fully implement an effective APQP process will be in a better position to meet customer requirements including any special characteristics specified by the customer.

The inputs and outputs applicable to the process step in this chapter are as follows:

INPUTS (Derived from the outputs of Chapter 4)

- Significant Production Run
- Measurement Systems Evaluation
- Preliminary Process Capability Study
- Production Part Approval
- Production Validation Testing
- Packaging Evaluation
- Production Control Plan
- Quality Planning Sign-Off and Management Support

OUTPUTS

- Reduced Variation
- Improved Customer Satisfaction
- Improved Delivery and Service
- Effective use of Lessons Learned/Best Practices

5.1 Reduced Variation

Control charts and other statistical techniques should be used as tools to identify process variation. Analysis and corrective actions should be used to reduce variation. Continual improvement requires attention not only to the special causes of variation but understanding common causes and seeking ways to reduce these sources of variation. Proposals should be developed including costs, timing, and anticipated improvement for customer review.

The reduction or elimination of a common cause may provide the additional benefit of lower costs. Organizations should be using tools such as value analysis and reduction of variation to improve quality and reduce cost. Refer to the Chrysler, Ford, and General Motors Statistical Process Control

(SPC) reference manual for details on long-term capability, special and common causes of variation.

5.2 Improved Customer Satisfaction

Detailed planning activities and demonstrated process capability of a product or service are important components to customer satisfaction. However, the product or service still has to perform in the customer environment. This product usage stage requires organization participation. In this stage much can be learned by the organization and customer. The effectiveness of the product quality planning efforts can also be evaluated at this stage.

The organization and customer become partners in making the changes necessary to correct any deficiencies and to improve customer satisfaction.

5.3 Improved Delivery and Service

The delivery and service stage of quality planning continues the organization and customer partnership in solving problems and continual improvement. The customer's replacement parts and service operations must also meet requirements for quality, cost, and delivery. The goal is first time quality. However, where problems or deficiencies occur in the field it is essential that the organization and customer form an effective partnership to correct the problem and satisfy the end-user customer.

The experience gained in this stage provides the customer and organization with the necessary knowledge to reduce process, inventory, and quality costs and to provide the right component or system for the next product.

5.4 Effective Use of Lessons Learned/Best Practices

A Lessons Learned or Best Practices portfolio is beneficial for capturing, retaining and applying knowledge. Input to Lessons Learned and Best Practices can be obtained through a variety of methods including:

- Review of Things Gone Right/Things Gone Wrong (TGR/TGW)
- Data from warranty and other performance metrics
- Corrective action plans
- "Read-across" with similar products and processes
- DFMEA and PFMEA studies

Chapter 6
Control Plan Methodology

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Introduction

The purpose of this control plan methodology is to aid in the manufacture of quality products according to customer requirements. It does this by providing a structured approach for the design, selection and implementation of value-added control methods for the total system. Control plans provide a written summary description of the systems used in minimizing process and product variation. The intent of the control plan form displayed in this chapter is to provide an example of how this information can be documented. An alternate format may be used as long as it contains the same information, as a minimum. The control plan does not replace the information contained in detailed operator instructions. This methodology is applicable to a wide range of manufacturing processes and technologies. The control plan is an integral part of an overall quality process and is to be utilized as a living document. Therefore this chapter should be used in conjunction with other related documents.

An important phase of the process for quality planning is the development of a control plan. A control plan is a written description of the system for controlling parts and processes. A single control plan may apply to a group or family of products that are produced by the same process at the same source. Drawings and visual standards, as necessary, may be attached to the control plan for illustration purposes. In support of a control plan, operator and process monitoring instructions should be defined and used continually.

In effect, the control plan describes the actions that are required at each phase of the process including receiving, in-process, out-going, and periodic requirements to assure that all process outputs will be in a state of control. During regular production runs, the control plan provides the process monitoring and control methods that will be used to control characteristics. Since processes are expected to be continually updated and improved, the control plan reflects a strategy that is responsive to these changing process conditions.

The control plan is maintained and used throughout the product life cycle. Early in the product life cycle its primary purpose is to document and communicate the initial plan for process control. Subsequently, it guides manufacturing in how to control the process and ensure product quality. Ultimately, the control plan remains a living document, reflecting the current methods of control, and measurement systems used. The control plan is updated as measurement systems and control methods are evaluated and improved.

For process control and improvement to be effective, a basic understanding of the process must be obtained. A multi-disciplined team is established to develop the control plan by utilizing all the available information to gain a better understanding of the process, such as:

- Process Flow Diagram
- System/Design/Process Failure Mode and Effects Analysis
- Special Characteristics
- Lessons Learned from Similar Parts
- Team's Knowledge of the Process
- Design Reviews
- Optimization Methods (e.g., QFD, DOE, etc.)

The benefits of developing and implementing a control plan include:

Quality:

The control plan methodology reduces waste and improves the quality of products during design, manufacturing, and assembly. This structured discipline provides a thorough evaluation of the product and process. Control plans identify process characteristics and identify the control methods for the sources of variation (input variables), which cause variation in product characteristics (output variables).

Customer Satisfaction:

Control plans focus resources on processes and products related to characteristics that are important to the customer. The proper allocation of resources on these major items helps to reduce costs without sacrificing quality.

Communication:

As a living document the control plan identifies and communicates changes in the product/process characteristics, control method, and characteristic measurement.

CONTROL PLAN

1 Prototype Pre-Launch Production
 Control Plan Number (2) Key Contact/Phone (7) Date (Orig.) (10) Date (Rev.) (11)

| PART/ PROCESS NUMBER (15) | PROCESS NAME/ OPERATION DESCRIPTION (16) | MACHINE, DEVICE, JIG, TOOLS FOR MFG. (17) | NO. (18) | CHARACTERISTICS | | SPECIAL CHAR. CLASS (21) | METHODS | | | REACTION PLAN (26) | | |
|------------------------------------|---|---|-------------|-----------------|-----------------|-----------------------------------|--|---|------------------------|--------------------------|---------------|---------------------------|
| | | | | PRODUCT (19) | PROCESS (20) | | PRODUCT/PROCESS SPECIFICATION/ TOLERANCE (22) | EVALUATION/ MEASUREMENT TECHNIQUE (23) | SAMPLE SIZE (24) | | FREQ. (25) | CONTROL METHOD (25) |
| | | | | | | | | | | | | |
| | Part Number/Latest Change Level (3) | Core Team (8) | | | | | | | | | | |
| | Part Name/Description (4) | Organization/Plant Approval/Date (9) | | | | | | | | | | |
| | Organization/Plant (5) | Organization Code (6) | | | | | | | | | | |
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6.1 Control Plan Column Descriptions

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| 1) PROTOTYPE, PRE-LAUNCH, PRODUCTION | <p>Indicate the appropriate category.</p> <ul style="list-style-type: none"> • Prototype - A description of the dimensional measurements material and performance tests occurring during Prototype build. • Pre-Launch - A description of the dimensional measurements, material and performance tests that will occur after Prototype and before normal Production. • Production - A comprehensive documentation of product/process characteristics, process controls, tests, and measurement systems occurring during normal production. |
| 2) CONTROL PLAN NUMBER | Enter the control plan document number used for tracking, if applicable. For multiple control pages, enter page number (page ___ of ___). |
| 3) PART NUMBER/LATEST CHANGE LEVEL | Enter the number of the system, subsystem or component being controlled. When applicable, enter the latest engineering change level and/or issue date from the drawing specification. |
| 4) PART NAME/DESCRIPTION | Enter the name and description of the product/process being controlled. |
| 5) ORGANIZATION/PLANT | Enter the name of the company and the appropriate division/plant/department preparing the control plan. |
| 6) ORGANIZATION CODE (SUPPLIER CODE) | Enter the identification number (For example: DUNS, Customer Supplier Code) as requested by the customer. |
| 7) KEY CONTACT/PHONE AND OTHER CONTACT INFORMATION | Enter the name, telephone number and other contact information, e.g., email of the primary contact responsible for the control plan. |
| 8) CORE TEAM | Enter the name(s), telephone number(s), and other contact information, e.g., email of the individual(s) responsible for preparing the control plan to the latest revision. It is recommended that all of the team members' names, phone numbers, and locations be included on an attached distribution list. |
| 9) ORGANIZATION/PLANT APPROVAL/DATE | Obtain the responsible manufacturing plant approval of the organization (if required - see appropriate customer-specific requirements). |

| | |
|---|---|
| 10) DATE (ORIG.) | Enter the date that the original control plan was compiled. |
| 11) DATE (REV.) | Enter the date of the latest control plan updates. |
| 12) CUSTOMER ENGINEERING APPROVAL/DATE | Obtain the responsible customer engineering approval (if required - see appropriate customer-specific requirements). |
| 13) CUSTOMER QUALITY APPROVAL/DATE | Obtain the responsible customer supplier quality representative approval (if required - see appropriate customer-specific requirements). |
| 14) OTHER APPROVAL/DATE | Obtain any other agreed upon approval (if required). |
| 15) PART/PROCESS NUMBER | This item number is usually referenced from the Process Flow Chart. If multiple part numbers exist (assembly), list the individual part numbers and their processes accordingly. |
| 16) PROCESS NAME/ OPERATION DESCRIPTION | All steps in the manufacturing of a system, subsystem, or component are described in a process flow diagram. Identify the process/operation name from the flow diagram that best describes the activity being addressed. |
| 17) MACHINE, DEVICE, JIG, TOOLS FOR MANUFACTURING | For each operation that is described, identify the processing equipment, e.g., machine, device, jig, or other tools for manufacturing, as appropriate. |
| CHARACTERISTICS (Includes items 18, 19 and 20) | A distinguishing feature, dimension or property of a process or its output (product) on which variable or attribute data can be collected. Use visual aids where applicable. |
| 18) NUMBER | Assign a cross reference number to all applicable documents such as, but not limited to, process flow diagram, numbered blue print, FMEAs, and drawings or other visual standards, if required. Optional example work sheets and explanation of these work sheets are located in Supplements K and L. |

CONTROL PLAN

1 Prototype Pre-Launch Production

| Control Plan Number (2) | | Key Contact/Phone (7) | | Date (Orig.) (10) | Date (Rev.) (11) | | | | | | |
|-------------------------------------|--|---|----------|---|------------------|--------------------------|---------------------------------------|--|------------------|---------------|------------|
| Part Number/Latest Change Level (3) | | Core Team (8) | | Customer Engineering Approval/Date (if Req'd.) (12) | | | | | | | |
| Part Name/Description (4) | | Organization/Plant Approval/Date (9) | | Customer Quality Approval/Date (if Req'd.) (13) | | | | | | | |
| Organization/Plant (5) | | Organization Code (6) | | Other Approval/Date (if Req'd.) (14) | | | | | | | |
| PART/ PROCESS NUMBER (15) | PROCESS NAME/ OPERATION DESCRIPTION (16) | MACHINE, DEVICE, JIG, TOOLS FOR MFG. (17) | NO. (18) | CHARACTERISTICS | | SPECIAL CHAR. CLASS (21) | METHODS | | | REACTION PLAN | |
| | | | | PRODUCT (19) | PROCESS (20) | | PRODUCT/SPECIFICATION/ TOLERANCE (22) | EVALUATION/ MEASUREMENT TECHNIQUE (23) | SAMPLE SIZE (24) | | FREQ. (25) |
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| <p>19) PRODUCT</p> | <p>Product Characteristics are the features or properties of a part, component or assembly that are described on drawings or other primary engineering information. The Core Team should identify the special product characteristics that are a compilation of important Product Characteristics from all sources. All special characteristics must be listed on the control plan. In addition, the organization may list other Product Characteristics for which process controls are routinely tracked during normal operations.</p> |
| <p>20) PROCESS</p> | <p>Process Characteristics are the process variables (input variables) that have a cause and effect relationship with the identified Product Characteristic. A Process Characteristic can only be measured at the time it occurs. The Core Team should identify Process Characteristics for which variation must be controlled to minimize product variation. There could be one or more Process Characteristics listed for each Product Characteristic. In some processes one Process Characteristic may affect several Product Characteristics.</p> |
| <p>21) SPECIAL CHARACTERISTIC CLASSIFICATION</p> | <p>Use the appropriate classification as required by the customer (see the appropriate customer-specific requirements), to designate the type of special characteristic or this field can be left blank for other undesignated characteristics. Customers may use unique symbols to identify important characteristics, such as those that affect customer safety, compliance with regulations, function, fit, or appearance.</p> |

CONTROL PLAN

Prototype Pre-Launch Production

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|-------------------------------------|---|---|------------------------|---|------------------|-----------------------------------|---|---|------------------|
| Control Plan Number (2) | | Key Contact/Phone (7) | | Date (Orig.) (10) | Date (Rev.) (11) | | | | |
| Part Number/Latest Change Level (3) | | Core Team (8) | | Customer Engineering Approval/Date (If Req'd.) (12) | | | | | |
| Part Name/Description (4) | | Organization/Plant Approval/Date (9) | | Customer Quality Approval/Date (If Req'd.) (13) | | | | | |
| Organization/Plant (5) | | Other Approval/Date (If Req'd.) (14) | | Other Approval/Date (If Req'd.) (14) | | | | | |
| PART/ PROCESS NUMBER (15) | PROCESS NAME/ OPERATION DESCRIPTION (16) | MACHINE, DEVICE, JIG, TOOLS FOR MFG. (17) | MACHINE NO. (18) | CHARACTERISTICS | | SPECIAL CHAR. CLASS (21) | METHODS | | REACTION PLAN |
| | | | | PRODUCT | PROCESS | | PRODUCT/SPECIFICATION/ TOLERANCE (22) | EVALUATION/ MEASUREMENT TECHNIQUE (23) | |
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| <p>METHODS (INCLUDES ITEMS 22-25)</p> | <p>A systematic plan using procedures and other tools to control a process.</p> |
| <p>22) PRODUCT/PROCESS SPECIFICATION/ TOLERANCE</p> | <p>Specifications/tolerance may be obtained from various engineering documents, such as, but not limited to, drawings, design reviews, material standard, computer-aided design data, manufacturing, and/or assembly requirements.</p> |
| <p>23) EVALUATION/ MEASUREMENT TECHNIQUE</p> | <p>This column identifies the measurement system being used. This could include gages, fixtures, tools, and/or test equipment required to measure the part/process/manufacturing equipment. A measurement systems analysis should be done to ensure control of monitoring and measuring devices prior to relying on a measurement system. For example, an analysis of the linearity, reproducibility, repeatability, stability and accuracy of the measurement system should be performed. Improvements to the measurement systems should be made accordingly. Refer to the Chrysler, Ford, and General Motors Measurement Systems Analysis (MSA) reference manual for additional details.</p> |
| <p>24) SAMPLE SIZE/ FREQUENCY</p> | <p>When sampling is required list the corresponding sample size and frequency.</p> |
| <p>25) CONTROL METHOD</p> | <p>This is one of the critical elements to an effective control plan. This column contains a brief description of how the operation will be controlled, including procedure numbers where applicable. The control method utilized should be based on effective analysis of the process. The control method is determined by the type of process and the risks identified during quality planning (e.g. FMEA). Operations may be controlled by, but are not limited to, statistical process control, inspection, attribute data, mistake-proofing, (automated/non-automated), and sampling plans. The control plan descriptions should reflect the planning and strategy being implemented in the manufacturing process. If elaborate control procedures are used, the plan will typically reference the procedure document by a specific identification name and/or number. Refer to the examples for how typical processes are controlled.</p> <p>The method of control should be continually evaluated for effectiveness of process control. For example, significant changes in the process or process capability should lead to an evaluation of the control method.</p> |

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| <p>26) REACTION PLAN</p> | <p>The reaction plan specifies the corrective actions necessary to avoid producing nonconforming products or operating out of control. The actions should normally be the responsibility of the people closest to the process, the operator, job-setter, or supervisor, and be clearly designated in the plan. Provisions should be made for documenting actions taken.</p> <p>In all cases, suspect and nonconforming products must be clearly identified and quarantined, and disposition made by the responsible person designated in the reaction plan. This column may also refer to a specific reaction plan number and identify the person responsible for the reaction plan.</p> |
|--------------------------|--|

6.2 Process Analysis

Different types of processes present challenges and opportunities for control and reduction of variation. The process types can be related to their most common sources of variation or the dominant factors in determining the quality of the product. There are many effective methods of performing process analysis. It is up to the organization to determine the best method to analyze the process. Examples are:

- Fault Tree Analysis
- Design of Experiments
- Cause and Effect (see Appendix B)

Supplement A

- EQUIPMENT: SET-UP DOMINANT PROCESS:** The process is highly capable and stable, therefore set-up is major variable impacting product variation.
- Automotive grills are produced on plastic injection molding machines. After set-up of the mold, the machine must be adjusted to produce a dimensionally-correct part. Parts must also be free of blemishes, flow lines and sink marks on the surface. The molding machine is highly repeatable because all parameters are computer controlled. A set-up card provides specifications for setting all controls on the machine. After setting the machine to the specifications a sample part is produced. This part is checked for the key control dimensions for mounting holes and perimeter fit, and visually inspected.
- The set-up is the critical variable in this type of process. Capability studies on the product characteristics show that when properly set-up, the operation is highly capable and stable. The set-up specifications become the process characteristics that affect the product characteristic.
 - Types of controls for the process characteristic include first piece check procedures, and verification that machine settings are correct to authorized set-up cards.
 - Product characteristics are measured to insure the set-up is correct and that no unusual special cause has occurred. In some cases lot control may be appropriate between checks.

CONTROL PLAN

| <input type="checkbox"/> Prototype <input type="checkbox"/> Pre-Launch <input checked="" type="checkbox"/> Production Control Plan Number: 001 | | Key Contact/Phone: J. Davis /313-555-5555 Date (Orig.): 1/26/2008 Date (Rev.): 2/2/2008 | | | | | | | | | |
|---|------------------------------------|---|-----------------|----------------------------|---------------------|--|---|------------|-----------------|--|---|
| Part Number/Latest Change Level: 22521211/G 11-2-92 Organization/Plant: Plastic Injection Molded Grill | | Customer Engineering Approval/Date (if Req'd): Customer Quality Approval/Date (if Req'd): Other Approval/Date (if Req'd): | | | | | | | | | |
| Organization/Plant: 4-B Grill Co. Plant #3 Organization Code: 0123 | | Product Development Team (E01) - See List Organization/Plant Approval/Date: Other Approval/Date (if Req'd.): | | | | | | | | | |
| PART/PROCESS NUMBER | PROCESS NAME/OPERATION DESCRIPTION | MACHINE, DEVICE, JIG, TOOLS FOR MFG. | CHARACTERISTICS | | SPECIAL CHAR. CLASS | PRODUCT/SPECIFICATION/TOLERANCE | EVALUATION/MEASUREMENT TECHNIQUE | METHODS | | REACTION PLAN | |
| | | | NO. | PRODUCT | | | | PROCESS | SIZE | | SAMPLE FREQ. |
| 3 | Plastic Injection Molding | Machine No. 1-5 | 18 | Appearance No blemishes | * | Free of blemishes flowlines sink marks | Visual inspection 1st piece buy-off 1st piece buy-off | 100% | Continuous | 100% inspection Check Sheet Check Sheet Check Sheet x-R chart Check Sheet | Notify Inspector Adjust-re-check Adjust-re-check Adjust-re-check Quarantine and adjust Adjust and re-check |
| | | Machine No. 1-5 | 19 | Mounting hole loc. | * | Hole "X" location 2.5 ± 1mm | Fixture #10 | 1st piece | buy-off per run | Check Sheet | Adjust-re-check |
| | | Machine No. 1-5 | 20 | Dimension | * | Gap 3 ± .5mm | Fixture #10 | 5 pcs | buy-off per run | Check Sheet | Quarantine and adjust |
| | | Fixture #10 | 21 | Perimeter fit | * | Gap 1 ± .5mm | Check gap to fixture 4 locations | 5 pcs | hr | x-R chart | Quarantine and adjust |
| | | Machine No. 1-5 | 22 | Set-up of mold machine | | See attached set-up card | Review of set-up card and machine settings | Each setup | Each setup | 1st piece buy-off | Adjust and re-check |
| | | | | | | | | | | Inspector verifies settings | |

* Reference Customer Specific Requirements. EXAMPLES ARE FOR REFERENCE ONLY. REFER TO SPECIFIC CUSTOMER REQUIREMENTS.

Supplement B

- EQUIPMENT: MACHINE DOMINANT PROCESS:** Machine parameters are the variables affecting the process output.
- A supplier manufactures a circuit board with electronic components soldered on the board. Properly soldered connections are the major product characteristics. Two major process characteristics for the wave solder machine, are solder level and flux concentration. An automated feeder controls the solder level by sensing the level of solder and feeding in additional solder as the level is reduced. The flux must be sampled and tested for the concentration level. The Special Product Characteristic is measured 100% by checking electrically for continuity.
- Machine settings are the variables that have the major effect on the output for this type of process. These process characteristics are the variables that need to be controlled and measured to ensure that all products meet the customer's requirements.
 - Types of controls include self-adjusting devices on the parameters and statistical measurements taken on the process parameters and recorded on control charts (i.e. x-bar R charts).
 - Product characteristics are measured using error proofing methods or statistical sampling to insure that all products meet the customer's requirements.

CONTROL PLAN

Page 2 of 4

| <input type="checkbox"/> Prototype <input type="checkbox"/> Pre-Launch <input checked="" type="checkbox"/> Production | | Key Contact/Phone T. Smith /313-555-5555 | | Date (Orig.) 1/1/2008 | Date (Rev.) 2/20/2008 | | | | | | | |
|---|------------------------------------|--|--------------------|--|--------------------------|---------------------|---|----------------------------------|---------------|-------------|---------------------------------------|----------------------|
| Control Plan Number 002 | | Core Team | | Customer Engineering Approval/Date (if Req'd.) | | | | | | | | |
| Part Number/Latest Change Level Circuit 10/8 | | See attached Organization/Plant Approval/Date | | Customer Quality Approval/Date (if Req'd.) | | | | | | | | |
| Part Name/Description Electronic Circuit Board | | Other Approval/Date (if Req'd.) | | Other Approval/Date (if Req'd.) | | | | | | | | |
| Organization/Plant ACR Control | | Organization Code 439412 | | Other Approval/Date (if Req'd.) | | | | | | | | |
| PART/PROCESS NUMBER | PROCESS NAME/OPERATION DESCRIPTION | MACHINE, DEVICE, JIG, TOOLS FOR MFG. | CHARACTERISTICS | | | METHODS | | | REACTION PLAN | | | |
| | | | NO. | PRODUCT | PROCESS | SPECIAL CHAR. CLASS | PRODUCT/PROCESS SPECIFICATION/TOLERANCE | EVALUATION/MEASUREMENT TECHNIQUE | | SAMPLE SIZE | FREQ. | CONTROL METHOD |
| 2 | Soldering connections | Wave solder machine | Wave solder height | | | * | 2.0 ± 0.25mc | Sensor continuity check | 100% | Continuous | Automated inspection (error proofing) | Adjust and retest |
| | | | Flux concentration | | | | Standard #302B | Test sampling lab environment | 1 pc | 4 hours | x-MR chart | Segregate and retest |
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* Reference Customer Specific Requirements
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Supplement C

CONTROL PLAN

Page 1 of 10

| <input type="checkbox"/> Prototype <input type="checkbox"/> Pre-Launch <input checked="" type="checkbox"/> Production | | Control Plan Number: 12345M Key Contact/Phone: A. B. Casting 813-123-4567 | | Date (Orig): 9/9/2007 Date (Rev): 2/20/2008 | | | | | | | |
|---|------------------------------------|--|-------------------|--|---------------------|---|----------------------------------|---------|----------------------|---------------|-----------------------------|
| Part Number/Latest Change Level: 3432123 I/D Core Team | | Customer Engineering Approval/Date (If Req'd): | | | | | | | | | |
| Part Name/Description: Engine Block Organization/Plant: ABC Company/Plant #2 | | Customer Quality Approval/Date (If Req'd): | | | | | | | | | |
| Organization/Plant: Engine Block Organization Code: 12345M Machine, Device, Jig, Tools for Mfg.: | | Other Approval/Date (If Req'd): | | | | | | | | | |
| PART/PROCESS NUMBER | PROCESS NAME/OPERATION DESCRIPTION | NO. | CHARACTERISTICS | | SPECIAL CHAR. CLASS | PRODUCT/PROCESS SPECIFICATION/TOLERANCE | EVALUATION/MEASUREMENT TECHNIQUE | METHODS | | REACTION PLAN | |
| | | | PRODUCT | PROCESS | | | | SIZE | SAMPLE FREQ. | | CONTROL METHOD |
| 3 | Machine surface "A" | 51 | Depth of cut | | * | 2.0 ± 0.25" | Depth gage | 5 | per hour per fixture | x-R chart | Quarantine adjust and reset |
| | Holding fixture #10 | 52 | Perpendicular out | | * | 90° ± 1° | Gage 050 | 1 pc | every 4 hrs | x-MR chart | Quarantine adjust and reset |
| | Holding fixture #10 | 53 | | Hold casting in fixture for proper orientation | | Fixture free from debris | Visual inspection | 1 pc | After each cycle | Air blow-off | Re-adjust air blow-off |
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EQUIPMENT: FIXTURE/PALLET DOMINANT PROCESS: Fixture-to-fixture variation causes product variation.

Metal castings are loaded on a seven-stage rotary machine with several fixtures which rotary machine rotates under a cutting head. Each part has a machined surface on which perpendicularity and depth of cut are critical. The depth of cut and perpendicularity are major product characteristics. Besides the cutting tool, the removal of debris and proper adjustment of the fixtures can significantly affect the special product characteristic.

- The process characteristic includes variation between fixtures or pallets. The dimensional differences between fixtures or pallets and part location contribute to product variation. In addition, debris accumulated on the fixture can cause fixture-to-fixture variation of part location.
- Types of controls for fixture/pallet process characteristics are driven by loading procedures, fixture/pallet adjustments and maintenance (i.e. cleaning).
- Product characteristics are often difficult to measure in fixture/pallet dominant processes. Therefore, frequent statistical product sampling may be required for Special Product Characteristics.

* Reference Customer Specific Requirements
 EXAMPLES ARE FOR REFERENCE ONLY. REFER TO SPECIFIC CUSTOMER REQUIREMENTS.

Supplement D1

- EQUIPMENT: TOOLING DOMINANT PROCESS: Tool life and design characteristics are the variables affecting the process output.
- A sheet metal stamping die is used to form a steel bracket that has several angles and a pierced hole. The pierced hole diameter will not vary significantly; therefore it is not marked as a Special Characteristic. The presence of the hole is critical to the part. The angles on the part are critical and two angles are marked as Special Characteristics. Historically, broken hole punches are a problem with this type of tooling. Further, moving parts in the tool can vary when forming the angles in the bracket.
- The process characteristic is the tooling. Tools can have details that break or moving parts that intermittently/permanently fail to move. Tools can also wear or be repaired incorrectly. The product characteristics are affected by these tooling problems.
 - Types of controls for tooling dominant processes are mainly seen in the product. First piece check can verify that a tool has been properly repaired. When in operation a tool failure may go unnoticed except in the part, therefore lot control is appropriate. Error proofing techniques that check for holes or a dimension are also needed.
 - Product characteristics are a very important measure of proper tool life performance.

CONTROL PLAN

Page 3 of 8

| <input type="checkbox"/> Prototype <input type="checkbox"/> Pre-Launch <input checked="" type="checkbox"/> Production | | Control Plan Number 004 | Date (Orig.) 9/9/2007 | Date (Rev.) 2/4/2008 | | | | | | | |
|---|------------------------------------|---|--|-------------------------|---------------------|---|----------------------------------|---------|---------|---------------------------------------|----------------------------------|
| Part Number/Latest Change Level 4321234/E | | Key Contact/Phone A. C. Brown/206-555-1234 | Customer Engineering Approval/Date (if Req'd.) | | | | | | | | |
| Part Name/Description Seat Bracket | | Organization/Plant Approval/Date See attached list | Customer Quality Approval/Date (if Req'd.) | | | | | | | | |
| Organization/Plant Ace Stamping | | Organization Code 23456N | Other Approval/Date (if Req'd.) | | | | | | | | |
| PART/PROCESS NUMBER | PROCESS NAME/OPERATION DESCRIPTION | MACHINE, DEVICE, JIG, TOOLS FOR MFG. | CHARACTERISTICS | | SPECIAL CHAR. CLASS | PRODUCT/PROCESS SPECIFICATION/TOLERANCE | EVALUATION/MEASUREMENT TECHNIQUE | METHODS | | REACTION PLAN | |
| | | | NO. | PRODUCT | | | | PROCESS | SIZE | | SAMPLE FREQ. |
| 4 | Form metal bracket | Stamping die (13-19) | 6 | Hole | | Presence of hole | Light beam/light sensor | 100% | ongoing | Automated inspection (error proofing) | Segregate and replace hole punch |
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EXAMPLES ARE FOR REFERENCE ONLY. REFER TO SPECIFIC CUSTOMER REQUIREMENTS.

Supplement D2

EQUIPMENT: TOOLING DOMINANT PROCESS: Tool life and design characteristics are the variables affecting the process output.
 A broach is used to form the internal spline teeth on a steel propshaft yoke. The pitch diameter of internal spline teeth is the Special Product Characteristic.
 * The sharpened tool is checked on a visual comparator for correct pitch diameter and relief angle prior to being approved for production.
 * First piece of a production run is checked for sharpness of cut and correct pitch diameter.

CONTROL PLAN

Page 1 of 1

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|---|---|---|--|-----------------|---|---------|------------------|-----------------------------|--|
| <input type="checkbox"/> Prototype <input type="checkbox"/> Pre-Launch <input checked="" type="checkbox"/> Production | | Control Plan Number 002 | Date (Orig) 3/7/2008 | Date (Rev) | | | | | |
| Part Number/Latest Change Level 9873245/A | | Key Contact/Phone T. Thomas 313-555-1234 | Customer Engineering Approval/Date (If Req'd.) Customer Quality Approval/Date (If Req'd.) | | | | | | |
| Part Name/Description Yoke Propshaft | | Organization/Plant Approval/Date See attached list | Other Approval/Date (If Req'd.) | | | | | | |
| Organization/Plant Key Machine | | Organization Code 17532B | Other Approval/Date (If Req'd.) | | | | | | |
| PART/ PROCESS NUMBER | PROCESS NAME/ OPERATION DESCRIPTION | MACHINE/ DEVICE JIG/TOOLS FOR MFG. | SPECIAL CHAR. CLASS | CHARACTERISTICS | EVALUATION/ MEASUREMENT TECHNIQUE | METHODS | REACTION PLAN | | |
| | | | | | | | | PRODUCT NO. | PROCESS |
| 30 | Broach internal spline | Acme Broach B-752 | | Yoke | Visual comparator | 1st pc | buy-off per run | Set-up sheet | Repair tool and recheck |
| | | | | | Special dial Indicator T-0375 | 2 pcs | each shift | Tool control check sheet | Contain parts, replace tool and recheck |
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EXAMPLES ARE FOR REFERENCE ONLY. REFER TO SPECIFIC CUSTOMER REQUIREMENTS.

Supplement F

CONTROL PLAN

Page 1 of 1

| <input type="checkbox"/> Prototype <input type="checkbox"/> Pre-Launch <input checked="" type="checkbox"/> Production | | Date (Orig.) 11/20/2007 Date (Rev.) 1/25/2008 | | | | | | | | |
|---|------------------------------------|--|------------------|---------------------|---|----------------------------------|---------|------------|--|-----------------------------------|
| Control Plan Number: | | Key Contact/Phone: S. Specs 555-8888 | | | | | | | | |
| Part Number/Latest Change Level: | | Customer Engineering Approval/Date (if Req'd.): | | | | | | | | |
| 54312345 C 10/31/02 | | Customer Quality Approval/Date (if Req'd.): | | | | | | | | |
| Part Name/Description: | | Other Approval/Date (if Req'd.): | | | | | | | | |
| Automobile Hood | | Other Approval/Date (if Req'd.): | | | | | | | | |
| Organization/Plant: | | Other Approval/Date (if Req'd.): | | | | | | | | |
| Q.C./Suppco Organization Code 4000-1 | | Other Approval/Date (if Req'd.): | | | | | | | | |
| MACHINE, DEVICE, JIG, TOOLS FOR MFG. | | Other Approval/Date (if Req'd.): | | | | | | | | |
| PART/PROCESS NUMBER | PROCESS NAME/OPERATION DESCRIPTION | CHARACTERISTICS | | SPECIAL CHAR. CLASS | PRODUCT/PROCESS SPECIFICATION/TOLERANCE | EVALUATION/MEASUREMENT TECHNIQUE | METHODS | | REACTION PLAN | |
| | | NO. | PRODUCT | | | | PROCESS | SIZE | | SAMPLE FREQ. |
| 1 | Mold part | | Force | * | Must withstand 10N vertical force | Izod Impact test | 1st 5 | per hour | Failure reliability chart test to 11N | Segregate, analyze material |
| 2 | Material receiving | | Material content | | | Incoming Inspection | 1 pc | lot | Lab report #G 9441 | Return to supplier |
| 3 | Mixing operation | | Mix ratio | | 3:1:2 | Lab equip #11 Lab equip #22 | 1 pc | lot | Lab report #G 9442 | Segregate and adjust ratio |
| 4 | Store material | | Storage | | Shelf life | 1st place visual control | 1 pc | lot | Document "last use" of each mix | Dispose and/or return to supplier |
| | | | Temperature | | 65-72 °F | Temperature sensor | 100% | Continuous | Error proof by using an auto-adjust back-up alarm for temp. limits | Adjust and re-check |

MATERIAL: MATERIAL OR COMPONENT DOMINANT PROCESS: Characteristics of materials/components are the variables affecting the process output. An automobile hood is made of SMC. SMC is a molding compound that is temperature sensitive, has a specific shelf life, and for which mixing is critical. The parts produced from this material can become brittle when the material is improperly mixed, handled, or rotated. A force specification on one end of the bracket is a Special Product Characteristic. The Special Process Characteristics are the proper formulation, storage, and use of material date control. The customer requires a laboratory report on each lot of compound and the lots of material are dated for proper rotation.

- The materials or components are the process characteristics for this process. The variation found in the materials or components will affect the output of the process.
- Types of controls for the process characteristics include the various ways of testing and controlling the specification on the material or component being used (i.e. control charts, lab reports and error proofing).

* Reference Customer Specific Requirements
EXAMPLES ARE FOR REFERENCE ONLY. REFER TO SPECIFIC CUSTOMER REQUIREMENTS.

Supplement G

- METHODS: PREVENTIVE MAINTENANCE DOMINANT PROCESS: Equipment maintenance is the main variable that affects the process output.
- A painting operation for decorative parts requires clean equipment and a dirt-free work area. Dirt-free paint is a Special Product Characteristic. Periodic cleaning of the paint equipment and paint room prevents the problem of dirt in the paint. The process characteristic is a scheduled routine cleaning, repair, and replacement.
- Periodic maintenance is the process characteristic. Where input variables exist, replacing worn out parts, cleaning, calibration, tool adjustments, and other maintenance activities have an effect on the product characteristics, and must be controlled.
 - Types of controls for these process characteristics include scheduled maintenance programs and warning devices for monitoring.
 - Product characteristics are checked after each maintenance to verify the process is properly performed.

CONTROL PLAN

Page 2 of 5

Prototype Pre-Launch Production

Control Plan Number: 007 Key Contact/Phone: F. Mercury 123-456-78910 Date (Orig.): 6/3/2008 Date (Rev.): 8/4/2008

Part Number/Latest Change Level: 1234/B Core Team: Erin Hope, Alan Burt Customer Engineering Approval/Date (If Req'd.)

Part Name/Description: Grille Organization/Plant Approval/Date: Customer Quality Approval/Date (If Req'd.)

Organization/Plant: Lynch Inc. Organization Code: 0010 Other Approval/Date (If Req'd.):

| PART/PROCESS NUMBER | PROCESS NAME/OPERATION DESCRIPTION | MACHINE, DEVICE, JIG, TOOLS FOR MFG. | CHARACTERISTICS | | SPECIAL CHAR. CLASS | PRODUCT SPECIFICATION/TOLERANCE | EVALUATION/MEASUREMENT TECHNIQUE | METHODS | | | REACTION PLAN |
|---------------------|------------------------------------|--------------------------------------|-----------------|----------------|---------------------|---------------------------------------|----------------------------------|---------|--------------|---|------------------------|
| | | | PRODUCT NO. | PROCESS | | | | SIZE | SAMPLE FREQ. | CONTROL METHOD | |
| 1 | Spray paint | Electrostatic Bell #110 | | Spray painting | | Less than 6 particles per square inch | Visual | 100% | Inspection | Check sheet | Clean guns and recheck |
| | | Fluid controller | | Fluid control | | Per J2154 | Fluid meter and controller | | Continuous | Automatic fluid meter prevents film build | Recalibrate and adjust |
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EXAMPLES ARE FOR REFERENCE ONLY. REFER TO SPECIFIC CUSTOMER REQUIREMENTS.

Supplement H

- ENVIRONMENT: CLIMATE DOMINANT PROCESS: Climate variables such as temperature, humidity, noise, vibrations, have major impact on the process outputs. Humidity adversely affects the function of plastic injection molding machines. Plastic material absorbs dampness from the air, causing defects in the molded part. Material dryers are installed on the molding machines to eliminate the problem.
- The proper functioning of the dryer is the process characteristic in having the process perform properly.
 - Type of control for this process characteristic is a planned, periodic check to make sure the dryer is turned on and performing properly.
 - Product characteristics are checked by visual examination during first piece check and by subsequent periodic checks.

CONTROL PLAN

Page 1 of 1

| <input type="checkbox"/> Prototype <input type="checkbox"/> Pre-Launch <input checked="" type="checkbox"/> Production | | Control Plan Number 1240 | Key Contact/Phone A. P. Smith 313-472-0001 | Date (Orig.) 9/9/2007 | Date (Rev.) 2/4/2008 | | | | | | |
|---|------------------------------------|--------------------------------------|--|-----------------------------|-------------------------|---|----------------------------------|-------------|---------------|--------------|--|
| Part Number/Latest Change Level 32123345 F | | Core Team See attached list | Customer Engineering Approval/Date (if Req'd.) | | | | | | | | |
| Part Name/Description I/P Clip (Plastic) | | Organization/Plant Approval/Date | Customer Quality Approval/Date (if Req'd.) | | | | | | | | |
| Organization/Plant Aim Plastic Co., Iowa Plant | | Organization Code 34567J | Other Approval/Date (if Req'd.) | | | | | | | | |
| PART/PROCESS NUMBER | PROCESS NAME/OPERATION DESCRIPTION | MACHINE, DEVICE, JIG, TOOLS FOR MFG. | CHARACTERISTICS | | | METHODS | | | REACTION PLAN | | |
| | | | SPECIAL CHAR. CLASS | PRODUCT | PROCESS | PRODUCT/PROCESS SPECIFICATION/TOLERANCE | EVALUATION/MEASUREMENT TECHNIQUE | SAMPLE SIZE | | FREQ. | CONTROL METHOD |
| 8 | Injected mold plastic parts | Injection mold machine #22 | | Raw material (pellet dryer) | | .1% max. rel. humidity | Humidity gage on dryer | 1 | hour | Record sheet | Adjust dryer, dry material and requalify |
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EXAMPLES ARE FOR REFERENCE ONLY. REFER TO SPECIFIC CUSTOMER REQUIREMENTS.

Supplement J

CONTROL PLAN CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|--|-----|----|-----|---------------------------|--------------------|----------|
| 1 Was the control plan developed according to the methodology described in Chapter 6 of this APQP manual? | | | | | | |
| 2 Have all the controls identified in the PFMEA been included in the control plan? | | | | | | |
| 3 Are all special product/process characteristics included in the control plan? | | | | | | |
| 4 Were DFMEA and PFMEA used to prepare the control plan? | | | | | | |
| 5 Are material specifications requiring inspection identified? | | | | | | |
| 6 Does the control plan address incoming (material/components) through processing/assembly including packaging? | | | | | | |
| 7 Are engineering performance testing and dimensional requirements identified? | | | | | | |
| 8 Are gages and test equipment available as required by the control plan? | | | | | | |
| 9 If required, has the customer approved the control plan? | | | | | | |
| 10 Are the gage methodology and compatibility appropriate to meet customer requirements? | | | | | | |
| 11 Have measurement systems analysis been completed in accordance with customer requirements? | | | | | | |
| 12 Are sample sizes based upon industry standards, statistical sampling plan tables, or other statistical process control methods or techniques? | | | | | | |

Revision Date _____

Prepared By: _____

SUPPLEMENT K**Special Characteristics Worksheet**

The Description/Rationale column includes all special process and product characteristics agreed upon by the cross functional team. A sequential number (No.) is assigned to each characteristics listed to ensure none are overlooked by the supplier when the control plan (Part Two) is completed. Develop a rationale for each special characteristic and add this information to the list for clarification. When considered necessary, a Supplemental Form (Supplement L) will depict measurement points and coordinates. This form, when used, will be considered an extension of the control plan.

**APPENDIX A
PRODUCT QUALITY PLANNING CHECKLISTS**

Purpose of the Checklists

The following checklists are provided to assist the organization's product quality planning team in order to verify that the APQP process is both complete and accurate. These checklists are not intended to fully define or represent all elements of the APQP process. The use of the checklists is one of the last steps of the process and not intended as a "check the box" activity or exercise to circumvent full application of the APQP process.

In reviewing the questions in the checklist, where "No" is identified as the appropriate response, the column "Comment/Action Required" is used to identify the action required to close the gap, including the impact on the APQP process. The follow up action should include identification of an individual responsible and schedule. Use the "Person Responsible" and "Due Date" columns.

A-1 DESIGN FMEA CHECKLIST

| Customer or Internal Part No _____ | | Revision Level _____ | | | | | | | |
|------------------------------------|--|----------------------|-----------|------------|----------------------------------|---------------------------|-----------------|--|--|
| | Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date | | |
| 1 | Was the DFMEA prepared using the <i>Chrysler, Ford, and General Motors Potential Failure Mode and Effects Analysis (FMEA)</i> reference manual, and applicable customer specific requirements? | | | | | | | | |
| 2 | Have historical campaign and warranty data been reviewed? | | | | | | | | |
| 3 | Have best practices and lessons learned from similar part DFMEAs been considered? | | | | | | | | |
| 4 | Does the DFMEA identify Special Characteristics? | | | | | | | | |
| 5 | Have pass-through characteristics (glossary) been identified and reviewed with affected suppliers for FMEA alignment and appropriate controls in the supply base? | | | | | | | | |
| 6 | Have special characteristics designated by the customer or organization been reviewed with affected suppliers to assure FMEA alignment? | | | | | | | | |
| 7 | Have design characteristics that affect high risk priority failure modes been identified? | | | | | | | | |
| 8 | Have appropriate corrective actions been assigned to high risk priority numbers? | | | | | | | | |
| 9 | Have appropriate corrective actions been assigned to high severity numbers? | | | | | | | | |
| 10 | Have risk priorities been revised when corrective actions have been completed and verified? | | | | | | | | |

Revision Date: _____

Prepared By: _____

A-2 DESIGN INFORMATION CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| | Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|-------------------|---|-----|----|-----|---------------------------|--------------------|----------|
| A. General | | | | | | | |
| 1 | Does the design require: | | | | | | |
| a | • New materials? | | | | | | |
| b | • Special tooling? | | | | | | |
| c | • New technology or process? | | | | | | |
| 2 | Has assembly build variation analysis been considered? | | | | | | |
| 3 | Has Design of Experiments been considered? | | | | | | |
| 4 | Is there a plan for prototypes in place? | | | | | | |
| 5 | Has a DFMEA been completed? | | | | | | |
| 6 | Has a DFMA (Design For Manufacturability and Assembly) been completed? | | | | | | |
| 7 | Have service and maintenance issues been considered? | | | | | | |
| 8 | Has the Design Verification Plan been considered? | | | | | | |
| 9 | If yes, was it completed by a cross functional team? | | | | | | |
| 10 | Are all specified tests, methods, equipment and acceptance criteria clearly defined and understood? | | | | | | |
| 11 | Have Special Characteristics been selected? | | | | | | |
| 12 | Is bill of material complete? | | | | | | |
| 13 | Are Special Characteristics properly documented? | | | | | | |

A-2 Design Information Checklist (Continued)

A-2 DESIGN INFORMATION CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|---|-----|----|-----|---------------------------|--------------------|----------|
| B. Engineering Drawings | | | | | | |
| 14 Are reference dimensions identified to minimize inspection layout time? | | | | | | |
| 15 Are sufficient control points and datum surfaces identified to design functional gages? | | | | | | |
| 16 Are tolerances compatible with accepted manufacturing standards? | | | | | | |
| 17 Can existing and available inspection technology measure all design requirements? | | | | | | |
| 18 Is the customer designated engineering change management process used to manage engineering changes? | | | | | | |
| C. Engineering Performance Specifications | | | | | | |
| 19 Have special characteristics been identified? | | | | | | |
| 20 Are test parameters sufficient to address required use conditions, i.e., production validation and end use? | | | | | | |
| 21 Have parts manufactured at minimum and maximum specifications been tested as required? | | | | | | |
| 22 Will all product testing be done in-house? | | | | | | |
| 23 If not, is it done by an approved supplier? | | | | | | |
| 24 Is the specified in-process performance test sampling size and/or frequency consistent with manufacturing volumes? | | | | | | |
| 25 Has customer approval been obtained, e.g., for testing and documentation, as required? | | | | | | |

A-2 Design Information Checklist (Continued)

A-2 DESIGN INFORMATION CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|--|-----|----|-----|---------------------------|--------------------|----------|
| D. Material Specification | | | | | | |
| 26 Are special material characteristics identified? Where the organization is design responsible, are specified materials, heat treat and surface treatments compatible with the durability requirements in the identified environment? | | | | | | |
| 27 Where required, are the material suppliers on the customer approved list? | | | | | | |
| 28 Has the organization developed and implemented a process to control incoming material quality? | | | | | | |
| 29 Have material characteristics requiring inspection been identified? If so, | | | | | | |
| a ● Will characteristics be checked in-house? | | | | | | |
| b ● If checked in-house, is test equipment available? | | | | | | |
| c ● If checked in-house, are competent people available to assure accurate testing? | | | | | | |

A-2 Design Information Checklist (Continued)

A-2 DESIGN INFORMATION CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|--|-----|----|-----|---------------------------|--------------------|----------|
| 31 Will outside laboratories be used? <ul style="list-style-type: none"> • Does the organization have a process in place to assure laboratory competency such as accreditation? NOTE: Competency needs to be assured, regardless of the organization's relationship with the laboratory. | | | | | | |
| 32 Have the following material requirements been considered: <ul style="list-style-type: none"> a • Handling, including environmental aspects? b • Storage, including environmental aspects? c • Have the materials/substance composition been reported in accordance with customer requirements e.g., IMDS? d • Have polymeric parts been identified/marked per customer requirements? | | | | | | |

Revision Date _____
 Prepared By: _____

A-3 NEW EQUIPMENT, TOOLING, AND TEST EQUIPMENT CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|--|-----|----|-----|---------------------------|--------------------|----------|
| 1 Does the design require: | | | | | | |
| a • New materials? | | | | | | |
| b • Quick change? | | | | | | |
| c • Volume fluctuations? | | | | | | |
| d • Mistake proofing? | | | | | | |
| 2 Have lists been prepared identifying: (Include all suppliers) | | | | | | |
| a • New equipment? | | | | | | |
| b • New tooling? | | | | | | |
| c • New test equipment (including checking aids)? | | | | | | |
| 3 Have acceptance criteria been agreed upon for: (Include all suppliers) | | | | | | |
| a • New equipment? | | | | | | |
| b • New tooling? | | | | | | |
| c • New test equipment (including checking aids)? | | | | | | |
| 4 Will a preliminary capability study be conducted at the tooling and/or equipment manufacturer? | | | | | | |
| 5 Has test equipment feasibility and accuracy been established? | | | | | | |
| 6 Is a preventive maintenance plan complete for equipment and tooling? | | | | | | |

A-3 New Equipment, Tooling, and Test Equipment Checklist (continued)

A-3 NEW EQUIPMENT, TOOLING, AND TEST EQUIPMENT CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| | Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|----|---|-----|----|-----|---------------------------|--------------------|----------|
| 7 | Are setup instructions for new equipment and tooling complete and understandable? | | | | | | |
| 8 | Will capable gages be available to run preliminary process capability studies at the equipment supplier's facility? | | | | | | |
| 9 | Will preliminary process capability studies be run at the processing plant? | | | | | | |
| 10 | Have process characteristics that affect special product characteristics been identified? | | | | | | |
| 11 | Were special product characteristics used in determining acceptance criteria? | | | | | | |
| 12 | Does the manufacturing equipment have sufficient capacity to handle forecasted production and service volumes? | | | | | | |
| 13 | Is testing capacity sufficient to provide adequate testing? | | | | | | |
| 14 | Has the measurement equipment been verified and documented showing qualification for the required scope of measurement and testing? | | | | | | |

Revision Date _____

Prepared By: _____

A-4 PRODUCT/PROCESS QUALITY CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| | Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|---|--|-----|----|-----|---------------------------|--------------------|----------|
| 1 | Is customer assistance or approval required for the development of the control plan? | | | | | | |
| 2 | Has the organization identified who will be the quality liaison with the customer? | | | | | | |
| 3 | Has the organization identified who will be the quality liaison with its suppliers? | | | | | | |
| 4 | Has the quality management system been reviewed and approved per customer specific requirements? | | | | | | |
| 5 | Are there sufficient personnel identified to cover: | | | | | | |
| a | • Control plan requirements? | | | | | | |
| b | • Layout inspection? | | | | | | |
| c | • Engineering performance testing? | | | | | | |
| d | • Problem reaction and resolution analysis? | | | | | | |
| 6 | Is there a documented training program that: | | | | | | |
| a | • includes all employees? | | | | | | |
| b | • Lists those who have been trained? | | | | | | |
| c | • Provides a training schedule? | | | | | | |
| 7 | Has training been completed for: | | | | | | |
| a | • Statistical process control? | | | | | | |
| b | • Capability studies? | | | | | | |
| c | • Problem solving? | | | | | | |
| d | • Mistake proofing? | | | | | | |
| e | • Reaction Plans? | | | | | | |
| f | • Other topics as identified? | | | | | | |
| 8 | Is each operation provided with process instructions that are keyed to the control plan? | | | | | | |

A-4 Product/Process Quality Checklist (continued)

A-4 PRODUCT/PROCESS QUALITY CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| | Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|----|---|-----|----|-----|---------------------------|--------------------|----------|
| 9 | Are standard operator instructions accessible at each work station? | | | | | | |
| 10 | Do operator instructions include pictures and diagrams? | | | | | | |
| 11 | Were operator/team leaders involved in developing standard operator instructions? | | | | | | |
| 12 | Do inspection instructions include: <ul style="list-style-type: none"> • Easily understood engineering performance specifications? | | | | | | |
| a | | | | | | | |
| b | • Test frequencies? | | | | | | |
| c | • Sample sizes? | | | | | | |
| d | • Reaction plans? | | | | | | |
| e | • Documentation requirements? | | | | | | |
| 13 | Are visual aids: <ul style="list-style-type: none"> • Appropriate, easily understood and legible? • Available? • Accessible? • Approved? • Dated and current? | | | | | | |
| a | | | | | | | |
| b | | | | | | | |
| c | | | | | | | |
| d | | | | | | | |
| e | | | | | | | |
| 14 | Is there a procedure to implement, maintain, and establish reaction plans, for issues such as out of control conditions based on statistical process control? | | | | | | |
| 15 | Is there an identified problem solving process that includes root cause analysis? | | | | | | |
| 16 | Are the latest drawings and specifications available for the operator, in particular at the points of the inspection? <ul style="list-style-type: none"> • Have engineering tests (dimensional, material, appearance, and performance) been completed and documented as required in accordance with customer requirements? | | | | | | |
| a | | | | | | | |

A-4 Product/Process Quality Checklist (continued)

A-4 PRODUCT/PROCESS QUALITY CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| | Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|----|--|-----|----|-----|---------------------------|--------------------|----------|
| 25 | Is there a procedure to identify, segregate, and control nonconforming products to prevent shipment? | | | | | | |
| 26 | Are rework/repair procedures available to assure conforming product? | | | | | | |
| 27 | Is there a procedure to requalify repaired/reworked material? | | | | | | |
| 28 | Has a master sample, if required, been retained as part of the part approval process? | | | | | | |
| 29 | Is there an appropriate lot traceability procedure? | | | | | | |
| 30 | Are periodic audits of outgoing products planned and implemented? | | | | | | |
| 31 | Are periodic assessments of the quality system planned and implemented? | | | | | | |
| 32 | Has the customer approved the packaging and the packaging specification? | | | | | | |

Revision Date _____

Prepared By: _____

A-5 FLOOR PLAN CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|---|-----|----|-----|---------------------------|--------------------|----------|
| 1 Have lean concepts been applied in considering material flow? | | | | | | |
| 2 Does the floor plan identify all required process and inspection points? | | | | | | |
| 3 Have clearly marked areas for all material, tools, and equipment at each operation been considered? | | | | | | |
| 4 Has sufficient space been allocated for all equipment? | | | | | | |
| 5 Are process and inspection areas: | | | | | | |
| a • Of adequate size? | | | | | | |
| b • Properly lighted? | | | | | | |
| 6 Do inspection areas contain necessary equipment and record storage? | | | | | | |
| 7 Are there adequate: | | | | | | |
| a • Staging areas? | | | | | | |
| b • Impound areas? | | | | | | |
| 8 Are inspection points located to prevent shipment of nonconforming products? | | | | | | |
| 9 Are there controls for each process to eliminate contamination or inappropriate mixing of product? | | | | | | |
| 10 Is material protected from overhead or air handling systems contamination? | | | | | | |
| 11 Have facilities been provided for final product audit? | | | | | | |
| 12 Are facilities adequate to control movement of nonconforming incoming material? | | | | | | |

Revision Date _____

Prepared By: _____

A-6 PROCESS FLOW CHART CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| | Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|---|--|-----|----|-----|---------------------------|--------------------|----------|
| 1 | Does the flow chart illustrate the entire process from receiving through shipping, including outside processes and services? | | | | | | |
| 2 | In the development of the process flow chart, was the DFMEA used, if available, to identify specific characteristics that may be critical? | | | | | | |
| 3 | Is the flow chart keyed to product and process checks in the control plan and PFMEA? | | | | | | |
| 4 | Does the flow chart describe how the product will move, i.e., roller conveyor, slide containers, etc.? | | | | | | |
| 5 | Has the pull system/optimization been considered for this process? | | | | | | |
| 6 | Have provisions been made to identify and inspect reworked product before being used? | | | | | | |
| 7 | Are material controls for movement and staging of product including appropriate identification properly defined and implemented? The controls should address incoming supplier product as well as subcontracted processes. | | | | | | |

Revision Date _____

Prepared By: _____

A-7 PROCESS FMEA CHECKLIST

| Customer or Internal Part No _____ | | Revision Level _____ | | | | | |
|---|----|----------------------|---------------------------|--------------------|----------|--|--|
| Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date | | |
| <p>Question</p> <p>Was the Process FMEA prepared by a cross functional team? Has the team taken into account all customer specific requirements, including FMEA methodologies as shown in the current edition of FMEA?</p> | | | | | | | |
| 1 | | | | | | | |
| <p>Have all operations including subcontracted, or outsourced processes and services been considered?</p> | | | | | | | |
| 2 | | | | | | | |
| <p>Have all operations affecting customer requirements including fit, function, durability, governmental regulations and safety been identified and listed sequentially?</p> | | | | | | | |
| 3 | | | | | | | |
| <p>Were similar part/process FMEA's considered?</p> | | | | | | | |
| 4 | | | | | | | |
| <p>Have historical campaign and warranty data been reviewed and used in the analysis?</p> | | | | | | | |
| 5 | | | | | | | |
| <p>Have you applied the appropriate controls to address all of the identified failure modes?</p> | | | | | | | |
| 6 | | | | | | | |
| <p>Were severity, detection and occurrence revised when corrective action was completed?</p> | | | | | | | |
| 7 | | | | | | | |
| <p>Do the effects consider the customer in terms of the subsequent operation, assembly, and product?</p> | | | | | | | |
| 8 | | | | | | | |
| <p>Were customer plant problems used as an aid in developing the PFMEA?</p> | | | | | | | |
| 9 | | | | | | | |
| <p>Have the causes been described in terms of something that can be corrected or controlled?</p> | | | | | | | |
| 10 | | | | | | | |
| <p>Have provisions been made to control the cause of the failure mode prior to subsequent or the next operation?</p> | | | | | | | |
| 11 | | | | | | | |

Revision Date _____

Prepared By: _____

A-8 CONTROL PLAN CHECKLIST

Customer or Internal Part No _____ Revision Level _____

| | Question | Yes | No | N/A | Comment / Action Required | Person Responsible | Due Date |
|----|---|-----|----|-----|---------------------------|--------------------|----------|
| 1 | Was the control plan developed according to the methodology described in Chapter 6 of this APQP manual? | | | | | | |
| 2 | Have all the controls identified in the PFMEA been included in the control plan? | | | | | | |
| 3 | Are all special product/process characteristics included in the control plan? | | | | | | |
| 4 | Were DFMEA and PFMEA used to prepare the control plan? | | | | | | |
| 5 | Are material specifications requiring inspection identified? | | | | | | |
| 6 | Does the control plan address incoming (material/components) through processing/assembly including packaging? | | | | | | |
| 7 | Are engineering performance testing and dimensional requirements identified? | | | | | | |
| 8 | Are gages and test equipment available as required by the control plan? | | | | | | |
| 9 | If required, has the customer approved the control plan? | | | | | | |
| 10 | Are the gage methodology and compatibility appropriate to meet customer requirements? | | | | | | |
| 11 | Have measurement systems analysis been completed in accordance with customer requirements? | | | | | | |
| 12 | Are sample sizes based upon industry standards, statistical sampling plan tables, or other statistical process control methods or techniques? | | | | | | |

Revision Date _____
Prepared By: _____

APPENDIX B ANALYTICAL TECHNIQUES

Assembly Build Variation Analysis

An assembly build variation analysis is an analysis that simulates the buildup of an assembly and examines tolerance accumulation, statistical parameters, sensitivity, and "what if" investigation.

Benchmarking

Benchmarking is a systematic approach to identifying standards for comparison. It provides input to the establishment of measurable performance targets, as well as ideas for product design and process design. It can also provide ideas for improving business processes and work procedures.

Product and process benchmarking should include the identification of world class or best-in-class based on customer and internal objective performance measures and research into how this performance was achieved. Benchmarking should provide a stepping stone for developing new designs and processes that exceed the capabilities of the benchmark companies.

Cause and Effect Diagram

The "cause and effect" diagram is an analytical tool to indicate the relationship between an "effect" and all possible "causes" influencing it. This is sometimes referred to as fishbone diagram, Ishikawa diagram, or feather diagram.

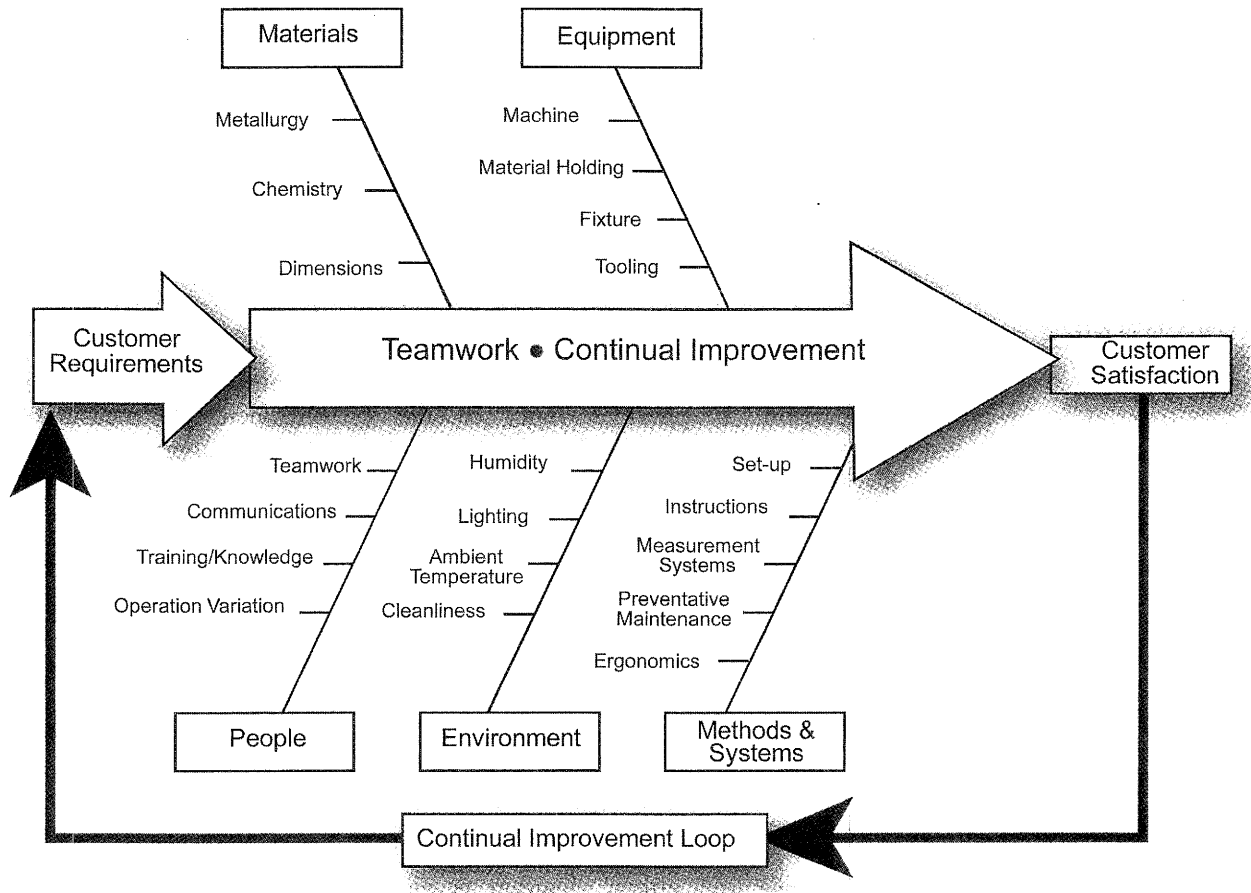


Figure 1 Cause and Effect Diagram

Figure 1 organizes the types of process inputs into a cause and effect model, where the primary groupings are: People, Materials, Equipment, Methods and Systems, Environment and Customer Requirements.

The key to successful development of cost effective processes is identification of the sources of variation and appropriate control methods.

Characteristics Matrix

A characteristics matrix is a display of the relationship between process parameters and manufacturing stations. A method of developing the characteristics matrix is to number the dimensions and/or features on the part print and each manufacturing operation. All manufacturing operations and stations appear across the top, and the process parameters are listed down the left-hand column. The more manufacturing relationships there are, the more important the control of a characteristic becomes. Regardless of matrix size, the upstream relationships of characteristics are evident. A typical matrix is shown below.

CHARACTERISTICS MATRIX

(EXAMPLE)

| DIM. NO. | DESCRIPTION | TOLERANCE | OPERATION NOS. | | | |
|-------------|-------------|-----------|-------------------|----|----|----|
| | | | 05 | 10 | 20 | 30 |
| 1 | ID | | X | C | | X |
| 2 | FACE | | | X | C | C |
| 3 | | | | X | L | L |
| 4 | | | | | X | |
| 5 | | | | | X | |
| 6 | OD | | | | X | |

C = Characteristic at an operation used for clamping

L = Characteristic at an operation used for locating

x = Characteristic created or changed by this operation should match the process flow diagram form

Critical Path Method

The critical path method can be a Pert or Gantt Chart that shows the chronological sequence of tasks that require the greatest expected time to accomplish. It can provide valuable information as to:

- Interrelationships
- Early Forecast of Problems
- Identification of Responsibility
- Resource Identification, Allocation and Leveling

Design of Experiments (DOE)

A design experiment is a test or sequence of tests where potential influential process variables are systematically changed according to a prescribed design matrix. The response of interest is evaluated under the various conditions to: (1) identify the influential variables among the ones tested, (2) quantify the effects across the range represented by the levels of the variables, (3) gain a better understanding of the nature of the causal system at work in the process, and (4) compare the effects and interactions. Application early in the product/process development cycle can result in: (1) improved process yields, (2) reduced variability around a nominal or target value, (3) reduced development time, and (4) reduced overall costs.

Design for Manufacturability and Assembly

Design for Manufacturability and Assembly is a Simultaneous Engineering process designed to optimize the relationship between design function, manufacturability, and ease of assembly. The enhancement of designs for assembly and manufacturing is an important step. Plant representatives should be consulted early in the design process to review components or systems and provide input on specific assembly and manufacturing requirements. Specific dimensional tolerances should be determined based on the like process. This will assist in identifying the equipment required and any process changes necessary.

Design Verification Plan and Report (DVP&R)

The Design Verification Plan and Report (DVP&R) is a method to plan and document testing activity through each phase of product/process development from inception to ongoing refinement. An effective DVP&R provides a concise working document that aids engineering personnel in the following areas:

- Facilitates the development of a logical testing sequence by requiring the responsible areas to thoroughly plan the tests needed to assure that the component or system meets all engineering requirements.
- Assures product reliability meets customer-driven objectives.
- Highlights situations where customer timing requires an accelerated test plan.
- Serves as a working tool for responsible area(s) by:
 - Summarizing functional, durability, and reliability testing requirements and results in one document for ease of reference.
 - Providing the ability to easily prepare test status and progress reports for design reviews.

Detailed instructions can be obtained from the appropriate Chrysler and Ford Quality or Engineering areas.

Mistake Proofing/Error-Proofing

Mistake proofing is a technique to identify errors after they occur. Mistake proofing should be used as a technique to control repetitive tasks or actions and prevent non-conformances from being passed on to the subsequent operation and ultimately the customer. Error-proofing is a technique used to identify potential process errors and either design them out of the product

or process, or eliminate the possibility that the error could produce a non-conformance.

Process Flow Charting

Process flow charting is a visual approach to describing and developing sequential or related work activities. It provides both a means of communication and analysis for planning, development activities, and manufacturing processes.

Since one goal of quality assurance is to eliminate non-conformities and improve the efficiency of manufacturing and assembly processes, advanced product quality plans should include illustrations of the controls and resources involved. These process flow charts should be used to identify improvements and to locate significant or critical product and process characteristics that will be addressed in control plans to be developed later.

Quality Function Deployment (QFD)

QFD is a systematic procedure for translating customer requirements into technical and operational terms, displaying and documenting the translated information in matrix form. QFD focuses on the most important items and provides the mechanism to target selected areas to enhance competitive advantages.

Depending upon the specific product, the technique of QFD may be used as a structure for the quality planning process. In particular, QFD Phase I - Product Planning translates customer requirements into counterpart control characteristics or design requirements. QFD provides a means of converting general customer requirements into specified final product and process control characteristics.

A. ASPECTS OF QFD

The two dimensions of QFD are:

- Quality Deployment: Translation of Customer Requirements into Product Design Requirements.
- Function Deployment: Translation of Design Requirements into appropriate Part, Process and Production Requirements.

B. BENEFITS OF QFD

- Increases the assurance of meeting the customer requirements.
- Reduces number of changes due to increased engineering understanding of customer requirements.
- Identifies potentially conflicting design requirements.

- Focuses various company activities on customer-oriented objectives.
- Reduces product development cycle time.
- Reduces costs of engineering, manufacturing, and service.
- Improves quality of product and services.¹

¹ Appendix B developed based on the following references:

Duncan, A. J. (1974). *Quality Control and Industrial Statistics* (4th Ed.). Homewood, IL: Richard D. Irwin, Inc.

Feigenbaum, A. V. (1991). *Total Quality Control* (3rd Ed. Revised). New York: McGraw - Hill.

Grant, E. L. & Leavenworth, R. S. (1980). *Statistical Quality Control*, New York: McGraw - Hill.

Ishikawa, K. (1971). *Guide to Quality Control*, White Plains, NY: Asian Productivity Organization.

Juran, J. M. (1988). *Juran's Quality Control Handbook*, New York: McGraw - Hill.

Kane, V. E. (1989). *Defect Prevention: Use of Simple Statistical Tools*, New York: Marcel Dekker, Inc.

Shewhart, W. A. (1931). *Economic Control of Quality of Manufactured Product*, New York: D. Van Nostrand Company.

Western Electric Company (1956). *Statistical Quality Control Handbook*. Indianapolis: Author

**APPENDIX C
REFERENCE MATERIAL**

The following manuals can be obtained from AIAG at www.aiag.org.

Measurement Systems Analysis (MSA) Reference Manual

This is a reference manual that describes common methods of evaluating measurement system variation and gives general guidance in the application of techniques.

Potential Failure Mode and Effects Analysis (FMEA) Reference Manual

This is a reference manual that potential Failure Mode and Effects Analysis (FMEA) and gives general guidance in the application of techniques.

Production Part Approval Process (PPAP)

This requirements document covers generic requirements for production part approval for all production and service commodities.

Statistical Process Control (SPC) Reference Manual

This is a reference manual that provides a unified reference for statistical process control and gives general guidance in the application of techniques.

**APPENDIX D
TEAM FEASIBILITY COMMITMENT**

TEAM FEASIBILITY COMMITMENT

Customer: _____ Date: _____

Part Number: _____ Part Name: _____

Revision Level _____

Feasibility Considerations

Our product quality planning team has considered the following questions. The drawings and/or specifications provided have been used as a basis for analyzing the organizations ability to meet all specified requirements. All "no" answers are supported with attached comments identifying our concerns and/or proposed changes to enable the organization to meet the specified requirements.

| YES | NO | CONSIDERATION |
|-----|----|--|
| | | Is product adequately defined (application requirements, etc. to enable feasibility evaluation?) |
| | | Can Engineering Performance Specifications be met as written? |
| | | Can product be manufactured to tolerances specified on drawing? |
| | | Can product be manufactured with process capability that meet requirements? |
| | | Is there adequate capacity to produce product? |
| | | Does the design allow the use of efficient material handling techniques? |
| | | Can the product be manufactured within normal cost parameters? Abnormal cost considerations may include: |
| | | - Costs for capital equipment? |
| | | - Costs for tooling? |
| | | - Alternative manufacturing methods? |
| | | Is statistical process control required on the product? |
| | | Is statistical process control presently used on similar products? |
| | | Where statistical process control is used on similar products: |
| | | - Are the processes in control and stable? |
| | | - Does process capability meet customer requirements? |

Conclusion

- Feasible Product can be produced as specified with no revisions.
- Feasible Changes recommended (see attached).
- Not Feasible Design revision required to produce product within the specified requirements.

Approval

Team Member/Title/Date

Team Member/Title/Date

Team Member/Title/Date

Team Member/Title/Date

Team Member/Title/Date

Team Member/Title/Date

**APPENDIX E
PRODUCT QUALITY PLANNING SUMMARY
AND APPROVALS**

PRODUCT QUALITY PLANNING SUMMARY AND APPROVALS

DATE: _____

PRODUCT NAME: _____ PART NUMBER / REV: _____

CUSTOMER: _____ MANUFACTURING PLANT: _____

1. PRELIMINARY PROCESS CAPABILITY STUDY

Ppk - SPECIAL CHARACTERISTICS

| QUANTITY | | |
|----------|------------|----------|
| REQUIRED | ACCEPTABLE | PENDING* |
| | | |

2. CONTROL PLAN APPROVAL (If Required)

APPROVED: YES / NO* _____ DATE APPROVED _____

3. INITIAL PRODUCTION SAMPLES CHARACTERISTIC CATEGORY

DIMENSIONAL
VISUAL
LABORATORY
PERFORMANCE

| SAMPLES | CHARACTERISTICS PER SAMPLE | QUANTITY | |
|---------|----------------------------|------------|----------|
| | | ACCEPTABLE | PENDING* |
| | | | |
| | | | |
| | | | |

4. GAGE AND TEST EQUIPMENT MEASUREMENT SYSTEM ANALYSIS

SPECIAL CHARACTERISTIC

| QUANTITY | | |
|----------|------------|----------|
| REQUIRED | ACCEPTABLE | PENDING* |
| | | |

5. PROCESS MONITORING

PROCESS MONITORING INSTRUCTIONS
PROCESS SHEETS
VISUAL AIDS

| QUANTITY | | |
|----------|------------|----------|
| REQUIRED | ACCEPTABLE | PENDING* |
| | | |
| | | |

6. PACKAGING/SHIPPING

PACKAGING APPROVAL
SHIPPING TRIALS

| QUANTITY | | |
|----------|------------|----------|
| REQUIRED | ACCEPTABLE | PENDING* |
| | | |
| | | |

7. Approvals

TEAM MEMBER/TITLE/DATE

TEAM MEMBER/TITLE/DATE

TEAM MEMBER/TITLE/DATE

TEAM MEMBER/TITLE/DATE

TEAM MEMBER/TITLE/DATE

TEAM MEMBER/TITLE/DATE

* REQUIRES PREPARATION OF AN ACTION PLAN TO TRACK PROGRESS.

PRODUCT QUALITY PLANNING SUMMARY AND APPROVAL - INSTRUCTIONS

SECTION

- 1 Under "required," for each item indicate the number of characteristics required.
Under "acceptable," for each item, indicate the quantity that was accepted per Chrysler, Ford, and General Motors Production Part Approval Process manual or customer requirements.
Under "pending," for each item, indicate the quantity not accepted. Attach action plan for each item.
- 2 Indicate if control plan has been approved by the customer (if required) by circling yes or no. If yes, indicate date approved. If no, attach action plan.
- 3 Under "samples," indicate the quantity of samples inspected for each item.
Under "characteristics per sample," for each item indicate the number of characteristics inspected on each sample for each category.
Under "acceptable," for each item indicate the quantity of characteristics acceptable on all samples.
Under "pending," for each item indicate the quantity of characteristics not accepted. Attach action plan for each item.
- 4 Under "required," for each item indicate the number of characteristics required.
Under "acceptable," for each item indicate the quantity acceptable per Chrysler, Ford and General Motors Measurement Systems Analysis Reference Manual.
Under "pending," for each item, indicate quantity not accepted. Attach action plan for each item.
- 5 Under "required," for each item indicate the quantity required.
Under "acceptable," for each item, indicate the quantity accepted.
Under "pending," for each time, indicate quantity not accepted. Attach action plan for each item.
- 6 Under "required," for each item indicate yes or no to indicate if item is required.
Under "acceptable," for each item indicate yes or no to indicate acceptance.
Under "pending," if answer under "acceptable" is no - attach action plan.
- 7 Each team member should sign form and indicate title and date of signature.

**APPENDIX F
GLOSSARY**

Glossary

- Apportionment:** Referred to in this manual as a part of Reliability Engineering. Synonymous with the term Reliability Apportionment, which is the assignment of reliability goals from system to subsystem in such a way that the whole system will have the required reliability?
- Benchmark Data:** The results of an investigation to determine how competitors and/or best-in-class companies achieved their level of performance.
- Bill of Material:** Total list of all components and materials required to manufacture the product.
- Characteristics Matrix:** An analytical technique for displaying the relationship between process parameters and manufacturing stations.
- Design Failure Mode and Effects Analysis (DFMEA):** An analytical technique used by a design responsible organization as a means to assure, to the extent possible, that potential failure modes and their associated causes/mechanisms have been considered and addressed. See current edition of FMEA.
- Design for Manufacturability and Assembly:** A simultaneous engineering process designed to optimize the relationship between design function, manufacturability, and ease of assembly.
- Design Information Checklist:** A mistake proofing checklist designed to assure that all important items were considered in establishing design requirements.
- Design Reviews:** Milestone checkpoints to review progress of the design process, a proactive process.
- (Design) Validation:** Confirmation through objective evidence, that the requirements for a specific intended use or application have been fulfilled. Testing to ensure that product conforms to defined user needs and/or requirements. Design validation follows successful design verification and is normally performed on the final product under defined operating conditions. Multiple validations may be performed if there are different intended uses.
- (Design) Verification:** Confirmation through objective evidence, that specified requirements have been fulfilled. Testing to ensure that all design outputs meet requirements may include activities such as:
- Design Review
 - Performing Alternate Calculations
 - Understanding Tests and Demonstrations
 - Review of Design Stage Documents Before Release
- Durability:** The probability that an item will continue to function at customer expectation levels, at the useful life without requiring overhaul or rebuild due to wear-out.
- Failure Modes Effects Analysis (FMEA):** See current edition of FMEA
- Feasibility:** A determination that a process, design, procedure, or plan can be successfully accomplished in the required time frame.
- Packaging:** A unit that provides protection and containment of items plus ease of handling by manual or mechanical means.
- Pass-through Characteristics:** Characteristics manufactured within the supplier process and used in the organization's process without modification or further validation.

Preliminary Bill of Material: An initial Bill of Material completed prior to design and print release.

Preliminary Process Flow Chart: An early depiction of the anticipated manufacturing process for a product.

Process Failure Mode and Effects Analysis (PFMEA): An analytical technique used by a manufacturing responsible engineer/team as a means to assure that, to the extent possible, potential failure modes and their associated causes/mechanisms have been considered and addressed. See current edition of FMEA.

Product Assurance Plan: A part of the Product Quality Plan. It is a prevention-oriented management tool that addresses product design, process design, and when applicable software design.

Quality Planning Approval: A review and verification by the organization's product quality planning team that all planned controls and processes are being followed.

Reliability: The probability that an item will continue to function at customer expectation levels at a measurement point, under specified environmental and duty cycle conditions.

Reliability Apportionment: See Apportionment.

Significant Production Run: Product made using all production tools, processes, equipment, environment, facility, and cycle time.

Simulation: The practice of imitating some or all of the behavior of one system with a different, dissimilar system.

Special Characteristics: Product and process characteristics designated by the customer, including governmental regulatory and safety, and/or selected by the organization through knowledge of the product and process.

Subsystem: A major part of a system which itself has the characteristics of a system, usually consisting of several components, or processes.

System: A combination of several components, processes or pieces of equipment integrated to perform a specific function.

Team Feasibility Commitment: A commitment by the organization's product quality planning team that the design can be manufactured, assembled, tested, packaged, and shipped in sufficient quantity at an acceptable cost, and on schedule.

Timing Plan: A plan that lists tasks, assignments, events, and timing required to provide a product that meets customer needs and expectations.

Voice of the Customer: Customer feedback both positive and negative including likes, dislikes, problems and suggestions.

**APPENDIX G
INDEX**

Index

A

assembly build variation 19, 89

B

benchmarking 11, 89
 bill of material 8, 9, 12, 17, 103, 104
 business plan/marketing strategy 9

C

cause and effect diagram 89, 90
 characteristics matrix 24, 25, 27, 28, 33, 90, 91, 103
 concern resolution 5
 control plan iii, 1, 2, 4, 17, 20, 21, 25, 26, 27, 28, 29, 32,
 33, 34, 35, 36, 39, 43, 45, 47, 49, 53, 68, 93, 101
 critical path method 5, 91
 customer inputs 9, 12
 customer satisfaction 3, 12, 38, 39, 40, 45
 customers 1, 2, 3, 9, 11, 19
 Customers 51

D

define the scope 2, 3
 delivery 38, 39, 40
 Design Failure Mode and Effects Analysis (DFMEA)
 16, 17, 18, 25, 103
 design for manufacturability and assembly... 16, 17, 18,
 19, 25, 92, 103
 design goals 8, 9, 12, 13, 17
 design information checklist 22, 103
 design of experiments 19, 56, 91
 design responsible 2, 103
 design reviews 16, 17, 19, 21, 25, 45, 53, 92, 103
 design verification 16, 17, 19, 25, 103
 design verification plan and report 19, 92
 drawing and specification changes 16, 17, 21, 25
 durability 12, 13, 20, 21, 92, 103

E

engineering drawings 16, 17, 20, 25, 28
 engineering specifications 16, 17, 25

F

facilities requirements 16, 18, 21, 25
 Failure Mode and Effects Analysis (FMEA) 13, 18
 feasibility 2, 4, 16, 18, 20, 22, 25, 103, 104
 floor plan 24, 25, 26, 28, 33

G

gages/testing equipment requirements 16, 18, 22, 25

H

historical warranty and quality information 9, 10

M

management support 8, 9, 14, 16, 18, 24, 25, 29, 32, 33,
 35, 39
 manufacturing only 2
 market research 9, 10
 marketing strategy 11
 material specifications 16, 17, 21, 25, 28
 measurement systems analysis plan 24, 25, 28, 33
 measurement systems evaluation 32, 33, 39
 mistake proofing 92, 103

N

new equipment, tooling and facilities requirements . 16,
 18, 25

O

organize the team 3

P

packaging specification 26
 packaging standards 24, 25, 26, 28, 33
 plans relative to the timing chart 5
 pre-launch control plan 24, 25, 27, 33, 35
 preliminary bill of material 8, 9, 12, 17, 104
 preliminary listing of special product and process 9, 17
 preliminary process capability plan 29
 preliminary process capability study 24, 25, 29, 32, 33,
 34, 39
 preliminary process flow chart 8, 9, 13, 17, 104
 process capability 24, 25, 29, 32, 33, 34, 39, 40, 53
 Process Failure Mode and Effects Analysis (PFMEA)
 25, 27, 33, 45, 104
 process flow chart. 8, 13, 24, 25, 26, 28, 33, 36, 49, 93,
 104
 process instructions 24, 25, 28, 33, 36
 product assurance plan 8, 9, 13, 17, 21, 104
 product quality planning cycle viii, 1, 3, 5
 product quality planning summary 101
 product quality sign-off 35
 product quality timing plan 5
 product reliability studies 9, 12
 product/process assumptions 9, 12, 13
 product/process benchmark data 9, 11
 product/process quality checklist 26
 product/process quality system review 24, 25, 26, 33
 production part approval 29, 32, 33, 34, 35, 39, 101
 production validation testing 32, 33, 34, 35, 39
 prototype 4, 16, 17, 20, 27, 47

Appendix G

Index

prototype build - control plan.....25

Q

quality function deployment10, 93

quality planning iii, 1

quality planning sign-off.....32, 34, 39

R

reduced variation.....38, 39

reliability goals.....12, 13, 103

S

service 1, 2, 3, 11, 13, 17, 19, 20, 38, 39, 40, 94

significant production run32, 33, 34, 39, 104

similar part FMEA13

simulation.....19, 104

simultaneous engineering.....4, 5, 18, 92, 103

special product and process characteristics... 13, 16, 18,
20, 21, 25

T

team experience 9, 10

team feasibility commitment 22

team-to-team 4

testing equipment requirements 18, 22, 25

timing chart..... 5, 6, 8, 21, 24, 32, 38

training..... 4

V

validation 1, 2, 6, 19, 32, 34, 35, 39, 103

variation 18, 19, 26, 38, 39, 43, 45, 51, 56, 89, 90

voice of the customer..... 9, 10, 12, 17, 20

W

warranty 9, 10, 12, 40

