APQP 4 Wind®

APQP4Wind Manual

Advanced Product Quality Planning Manual for the Wind Industry

VERSION 1.3 - MARCH 2024

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Introduction to APQP4Wind

At the beginning of 2014, the Danish Wind Industry Association (now Green Power Denmark) started a network group consisting of suppliers interested in quality assurance. To strengthen the network, wind turbine manufacturers and utility companies were invited to participate on equal footing with the suppliers.

In February 2014, the first meeting in the Danish Wind Industry Association's Quality Assurance network took place. This marked the very beginning of quality assurance cooperation between wind turbine manufacturers and suppliers within the Danish wind industry, and subsequently, the idea of APQP4Wind was born.

With facilitation from the Danish Wind Industry Association and support from the Danish Industry Foundation, Siemens Gamesa Renewable Energy and Vestas Wind Systems shared the leadership of the APQP4Wind project running from 2015 to 2018 in cooperation with KK Wind Solutions and LM Wind Power.

In August 2018, APQP4Wind was established as an independent organization with global reach and a board of directors that currently includes GE Vernova, GRI Renewable Industries, Goldwind, KK Wind Solutions, LM Wind Power, Siemens Gamesa Renewable Energy, Vattenfall, Vestas Wind Systems, ZF Wind Power, and Ørsted.

In 2024, in connection with utility companies joining APQP4Wind, the Manual was updated to cover the entire wind industry, changing focus from Customer - OEM - Supplier relationship to describing a Customer - Supplier relationship.

The Purpose of APQP4Wind

APQP4Wind is a common quality assurance methodology for the global wind industry. The background for the APQP4Wind Manual is the continuous quality improvement that is needed to improve performance, reduce risk, lower the costs of poor quality, and keep pace with the ongoing trend towards decreases in the Levelized Cost of Energy (LCoE) within the wind industry.

Advanced Product Quality Planning (APQP) is a well-known concept within the automotive industry and has been the backbone for maturing quality performance at Customers and Suppliers for decades. In the context of APQP4Wind, the concept of APQP in this Manual is adapted to the business areas and special conditions differentiating wind from automotive.

The APQP4Wind Manual aims to make the process of product quality assurance demands and the Production Part Approval Process (PPAP) as clear as possible. The Manual is made to fit the entire wind industry and set a common standard and best practice for planning and executing quality assurance in the whole value chain.

The standards made available in this Manual are made to substitute company-specific procedures and set aligned methods and procedures for all parties to reduce time to market and increase efficiency within the global wind industry.

The APQP4Wind Manual has been subjected to multiple reviews involving subject matter experts from the APQP4Wind Working Group, Board of Directors, and a certifying body.

All future activities, documents and references can be found at:
www.apqp4wind.org

The APQP4Wind Manual will refer several times to the APQP4Wind Toolbox consisting of a Workbook and Analysis Tool which can be found at:
www.apqp4wind.org

Table of Contents

Introduction

The purpose of this document is to describe the relationship between a Customer and a Supplier in a common Advanced Product Quality Planning (APQP) Manual developed by the APQP4Wind organization. The Manual provides the information and requirements to develop a Product Quality Plan (PQP) that should enable the development and production of products or services that will fulfill the wind industry's requirements.

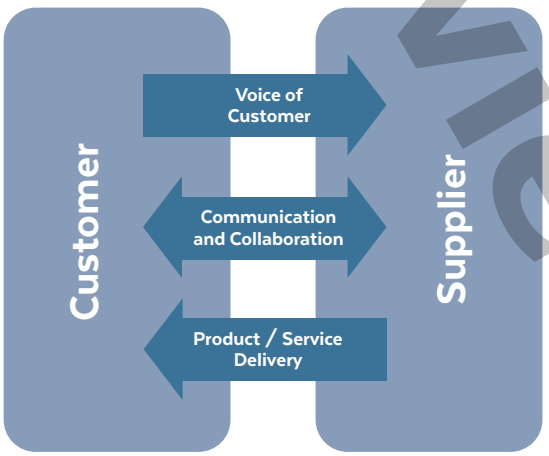
The main objective of the approach outlined in this Manual is to:

- Reduce variation to ensure stable and capable processes.
- Reduce the risk of defects and the costs of quality when introducing new products and services, thereby bringing down the costs of energy.
- Reduce complexity.
- Improve alignment of Product Quality Planning in the wind industry value chain.
- Provide an effective way of communicating quality requirements to Suppliers and Sub-Suppliers.
- Avoid problem/failure repetition.

By applying the approach described in this Manual, the wind industry will:

- Gain a preventive approach to quality.
- Shift from quality control to quality assurance.
- Enable the Supplier base to mature globally.
- Support standardization and simplification of processes to reduce time to market and increase efficiency.
- Support profitable growth.

This Manual aims to guide all parties on the quality requirements and enable organizations to develop appropriate communication forms. This Manual supports the quality requirements in the wind power industry by providing recommended formats and templates such as the Product Quality Plan (PQP). The Supplier shall comply with Customer-specific quality requirements specified in addition to this Manual.
The term 'product' used throughout this Manual should be interpreted as the system, subsystem, project, component, or service provided.

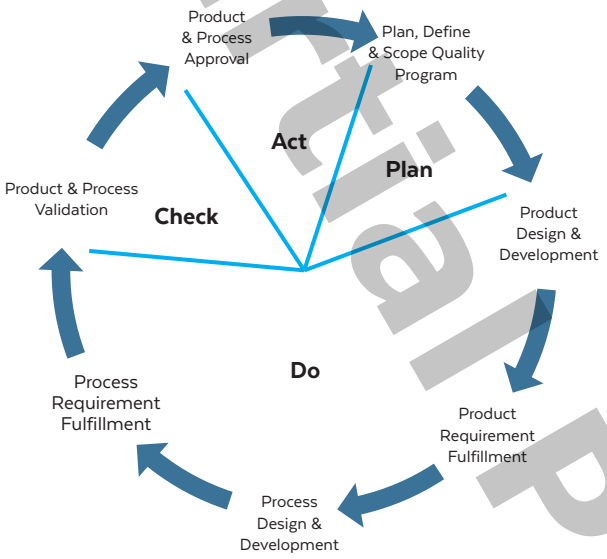


Product Quality Planning Cycle

The Product Quality Planning Cycle is shown below as a graphical illustration of the APQP4Wind Quality Program. The various phases are sequenced to represent planned timing and follow a typical Plan-Do-Check-Act (PDCA) cycle.

The purpose of the Product Quality Planning Cycle is:

- To set a clear path for planning, implementing, and verifying the product conformance to requirements through quality assurance activities.
- To enable Suppliers and Sub-Suppliers to deliver the right products with the required quality and quantity the first time and on time.



The Product Quality Planning Cycle emphasizes a cross-functional approach between the Customer and the Supplier, improving communication and collaboration in the entire product quality cycle.

Reference: Workbook Sheet: Product Quality Plan (PQP)

As an outcome of Product Quality Planning, all parties shall have quality plans which contains a list of quality deliverables that are outcomes of various quality assurance activities the organization executes.

The level of activities in the Product Quality Plan (PQP) may vary based on the product being developed.

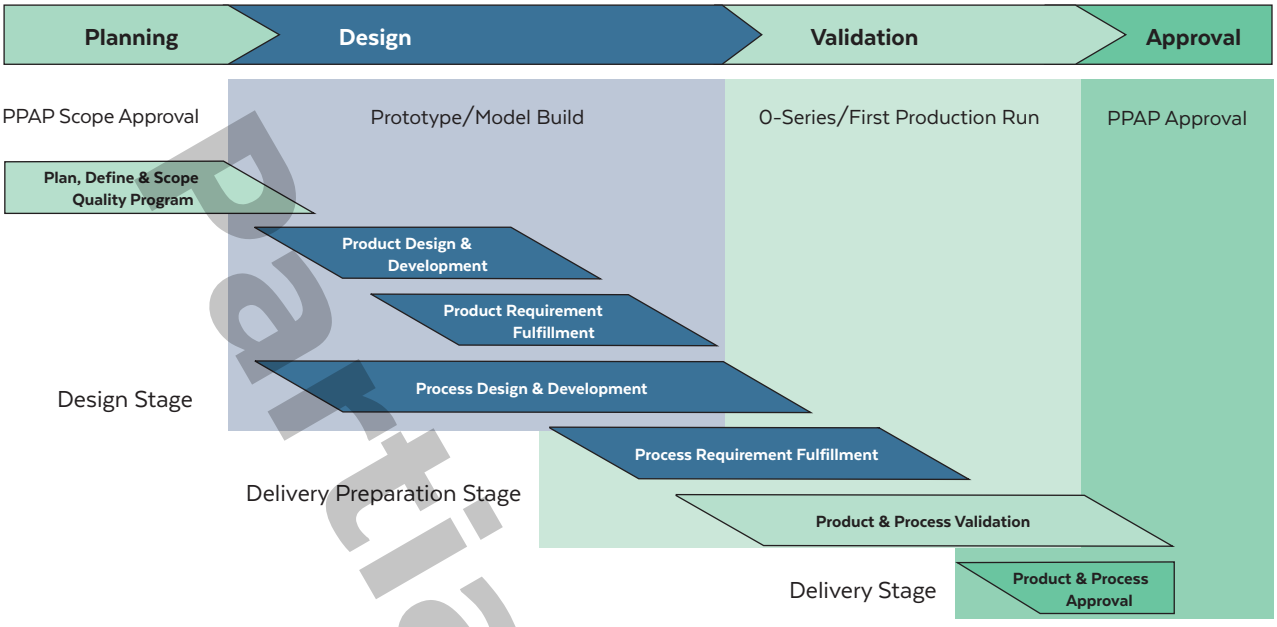
Responsibility Matrix

Supplier Nature

APQP4Wind Phases	Chapter	APQP4Wind Element	Design / Engineering	Design and Manufac-turing	Manufac-turing to specification	Service, Logistics, Installation
1.0 Plan, Define & Scope Quality Program	1.1	Voice of Customer (VoC)	x	x	x	x
	1.2	Design Goals	x	x	x	x
	1.3	Product & Process Benchmark Data	x	x	x	x
	1.4	Product & Process Assumptions	x	x	x	x
	1.5	Historical Data & Quality Information	x	x	x	x
	1.6	Sub-Supplier Screening	x	x	x	x
	1.7	APQP4Wind Kickoff	x	x	x	x
	1.8	Product Quality Planning Team	x	x	x	x
	1.9	Product Quality Plan (PQP)	x	x	x	x
2.0 Product Design & Development	2.1	Engineering Design Review (EDR)	x	x		x
	2.2	Drawing & Specification Review	x	x		x
	2.3	Team Feasibility Commitment (TFC)	x	x	x	x
	2.4	Capacity Planning & Contingency Planning	x	x	x	x
	2.5	Design Failure Mode & Effects Analysis (DFMEA)	x	x		x
	2.6	Special Characteristics	x	x		x
	2.7	Design for Manufacturability, Assembly, Transport & Service (DMATS)	x	x		x
	2.8	Design Verification Plan (DVP)	x	x		x
	2.9	New Equipment, Tooling, Gauge/Test & Facilities Requirement	x	x	x	x
	2.10	Preliminary Bill of Materials (BOM) & Bill of Materials (BOM) Management	x	x	x	x
	2.11	Sub-Supplier Assessments	x	x	x	x
	2.12	Engineering Change Management (ECM)	x	x	x	x
3.0 Product Requirement Fulfillment	3.1	Design Verification Report (DVR)	x	x		x
	3.2	Tool Design & Approval	x	x		x
	3.3	Out-Sourced Products with Special Characteristics	x	x	x	x
	3.4	Customer Engineering Approval	x	x		x
	3.5	Prototype/Model Control Plan	x	x		x
	3.6	Prototype/Model Builds	x	x		x
4.0 Process Design & Development	4.1	Preliminary Process Flow Chart & Floor Plan		x	x	x
	4.2	Process Failure Mode & Effects Analysis (PFMEA)		x	x	x
	4.3	Process Special Characteristics		x	x	x
	4.4	Measurement System Analysis (MSA) Plan		x	x	x
	4.5	Preliminary Process Capability Study Plan		x	x	
	4.6	Packaging & Transport Specifications		x	x	x
5.0 Process Requirement Fulfillment	5.1	Process Flow Chart & Floor Plan		x	x	x
	5.2	Production Tool Builds		x	x	x
	5.3	0-Series/First Production Run (FPR) Control Plan		x	x	x
	5.4	Work Instructions		x	x	x
	5.5	Preliminary Process Capability Study		x	x	
	5.6	Sub-Supplier Production Part Approval Process (PPAP) Completion		x	x	x
6.0 Product & Process Validation	6.1	0-Series/First Production Run (FPR)		x	x	x
	6.2	Performance Test Report & Certification		x	x	x
	6.3	Material Test Report & Certification		x	x	x
	6.4	Dimensional Report		x	x	x
	6.5	Appearance Approval Report		x	x	
	6.6	Measurement System Analysis (MSA) Report		x	x	x
	6.7	Product Validation Testing		x	x	x
	6.8	Form, Fit & Function (FFF)		x	x	x
	6.9	Production Control Plan		x	x	x
	6.10	Packaging & Transport Evaluation		x	x	x
7.0 Product & Process Approval	7.1	Production Part Approval Process Documentation (PPAP)	x	x	x	x
	7.2	Master Samples		x	x	
	7.3	Production Part Approval Process (PPAP) Submission & Part Submission Warrant (PSW)	x	x	x	x

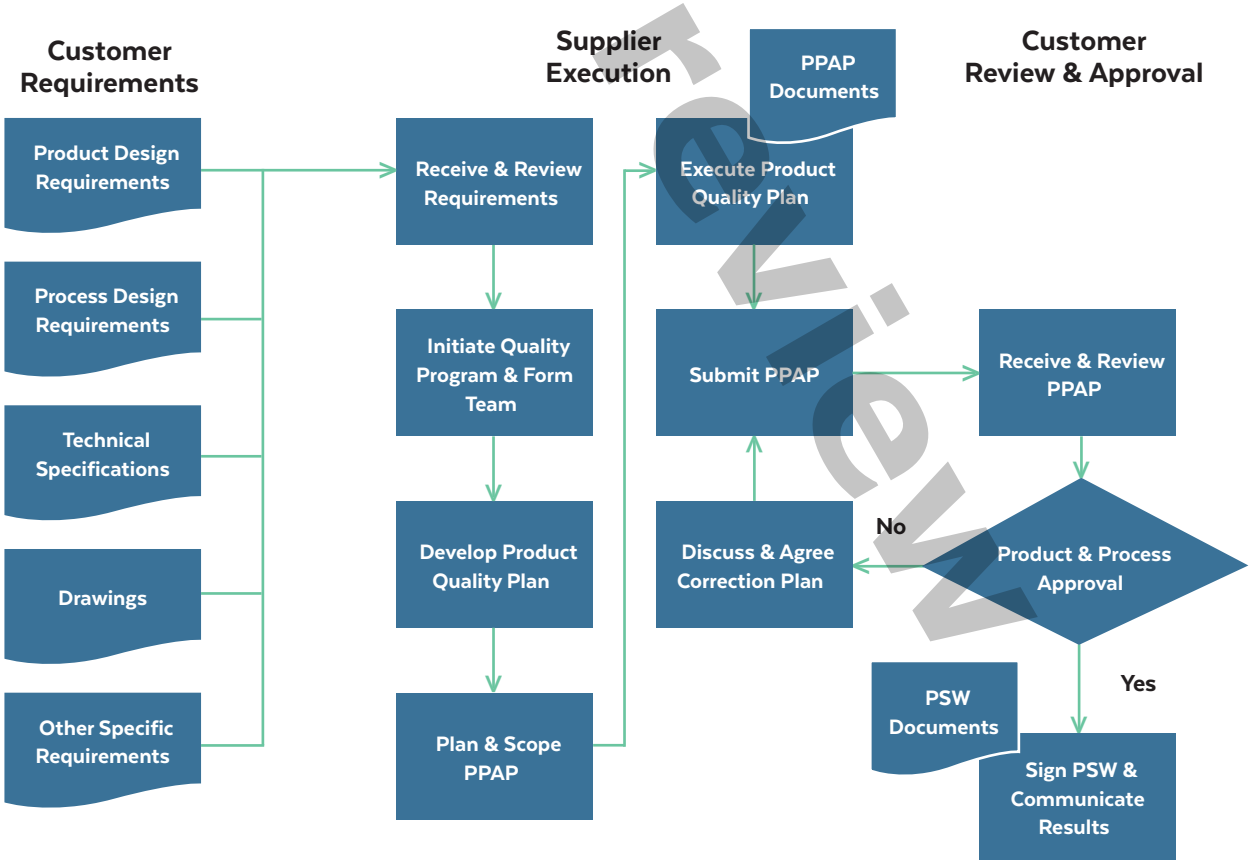
Design/Engineering: Design responsible for physical products, engineering, and design, but not final physical products.
Design and Manufacturing: Responsible for physical product design and manufacturing.
Manufacturing to Specification: Manufacturing responsible who does not own the design of the physical product, but manufactures based on the Customer's drawings, specifications, and requirements. This category also includes Suppliers who perform specific processes, e.g., heat treatment, surface treatment, etc., to the Customers' materials based on the requirements provided by the Customer
Service, Logistics, Installation: Responsible for the design and execution of a non-physical product.

APQP4Wind Framework



The above graphic shows the 3 stages of the 7 phases of APQP4Wind.
Each phase will be described in more detail in subsequent sections of this Manual.

APQP4Wind Process Flow

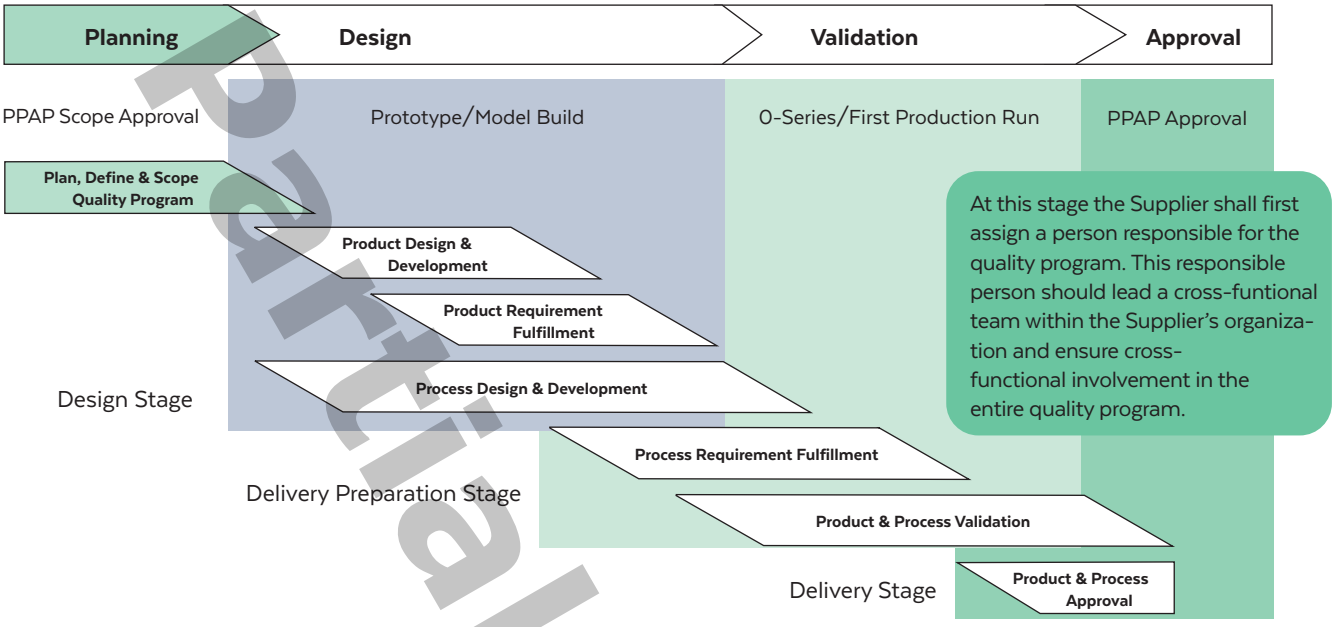


Phase Input & Output

	Input		Output
1.0 Plan, Define & Scope Quality Program	1.1 Voice of Customer (VoC) 1.3 Product & Process Benchmark Data 1.4 Product & Process Assumptions 1.5 Historical Data & Quality Information	1.2 1.6 1.7 1.8 1.9	Design Goals Sub-Supplier Screening APQP4Wind Kickoff Product Quality Planning Team Product Quality Plan (PQP)
	Input		**Output**
2.0 Product Design & Development	1.2 Design Goals 1.6 Sub-Supplier Screening 1.7 APQP4Wind Kickoff 1.8 Product Quality Planning Team 1.9 Product Quality Plan (PQP)	2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 2.10 2.11 2.12	Engineering Design Review (EDR) Drawing & Specification Review Team Feasibility Commitment (TFC) Capacity Planning & Contingency Planning Design Failure Mode & Effects Analysis (DFMEA) Special Characteristics Design for Manufacturability, Assembly, Transport & Service (DMATS) Design Verification Plan (DVP) New Equipment, Tooling, Gauge/Test & Facilities Requirement Preliminary Bill of Materials (BOM) & Bill of Materials (BOM) Management Sub-Supplier Assessments Engineering Change Management (ECM)
	Input		**Output**
3.0 Product Requirement Fulfillment	2.1 Engineering Design Review (EDR) 2.2 Drawing & Specification Review 2.3 Team Feasibility Commitment (TFC) 2.4 Capacity Planning & Contingency Planning 2.5 Design Failure Mode & Effects Analysis (DFMEA) 2.6 Special Characteristics 2.7 Design for Manufacturability, Assembly, Transport & Service (DMATS) 2.8 Design Verification Plan (DVP) 2.9 New Equipment, Tooling, Gauge/Test & Facilities Requirement 2.10 Preliminary Bill of Materials (BOM) & Bill of Materials (BOM) Management 2.11 Sub-Supplier Assessments 2.12 Engineering Change Management (ECM)	3.1 3.2 3.3 3.4 3.5 3.6	Design Verification Report (DVR) Tool Design & Approval Out-Sourced Product with Special Characteristics Customer Engineering Approval Prototype/Model Control Plan Prototype/Model Builds
	Input		**Output**
4.0 Process Design & Development	2.1 Engineering Design Review (EDR) 2.2 Drawing & Specification Review 2.3 Team Feasibility Commitment (TFC) 2.4 Capacity Planning & Contingency Planning 2.5 Design Failure Mode & Effects Analysis (DFMEA) 2.6 Special Characteristics 2.7 Design for Manufacturability, Assembly, Transport & Service (DMATS) 2.8 Design Verification Plan (DVP) 2.9 New Equipment, Tooling, Gauge/Test & Facilities Requirement 2.10 Preliminary Bill of Materials (BOM) & Bill of Materials (BOM) Management 2.11 Sub-Supplier Assessments 2.12 Engineering Change Management (ECM) 3.1 Design Verification Report (DVR) 3.2 Tool Design & Approval 3.3 Out-Sourced Product with Special Characteristics 3.4 Customer Engineering Approval 3.5 Prototype/Model Control Plan 3.6 Prototype/Model Builds	4.1 4.2 4.3 4.4 4.5 4.6	Preliminary Process Flow Chart & Floor Plan Process Failure Mode & Effects Analysis (PFMEA) Process Special Characteristics Measurement System Analysis (MSA) Plan Preliminary Process Capability Study Plan Packaging & Transport Specifications
	Input		**Output**
5.0 Process Requirement Fulfillment	4.1 Preliminary Process Flow Chart & Floor Plan 4.2 Process Failure Mode & Effects Analysis (PFMEA) 4.3 Process Special Characteristics! 4.4 Measurement System Analysis (MSA) Plan 4.5 Preliminary Process Capability Study Plan 4.6 Packaging & Transport Specifications	5.1 5.2 5.3 5.4 5.5 5.6	Process Flow Chart & Floor Plan Production Tool Builds 0-Series/First Production Run (FPR) Control Plan Work Instructions Preliminary Process Capability Study Sub-Supplier Production Part Approval Process (PPAP) Completion
	Input		**Output**
6.0 Product & Process Validation	5.1 Process Flow Chart & Floor Plan 5.2 Production Tool Builds 5.3 0-Series/First Production Run (FPR) Control Plan 5.4 Work Instructions 5.5 Preliminary Process Capability Study 5.6 Sub-Supplier Production Part Approval Process (PPAP) Completion	6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 6.10	0-Series/First Production Run (FPR) Performance Test Report & Certification Material Test Report & Certification Dimensional Report Appearance Approval Report Measurement System Analysis Report (MSA) Product Validation Testing Form, Fit & Function (FFF) Production Control Plan Packaging & Transport Evaluation
	Input		**Output**
7.0 Product & Process Approval	6.1 0-Series/First Production Run (FPR) 6.2 Performance Test Report & Certification 6.3 Material Test Report & Certification 6.4 Dimensional Report 6.5 Appearance Approval Report 6.6 Measurement System Analysis Report (MSA) 6.7 Product Validation Testing 6.8 Form, Fit & Function (FFF) 6.9 Production Control Plan 6.10 Packaging & Transport Evaluation	7.1 7.2 7.3	Production Part Approval Process Documentation (PPAP) Master Samples Production Part Approval Process (PPAP) Submission & Part Submission Warrant (PSW)

Phase 1. Plan, Define & Scope Quality Program

This phase describes the requirements to initiate a quality program by understanding the Customer's needs, requirements, and expectations, as well as scoping and planning the Product Quality Planning activities.



As a minimum, the Supplier shall:

- Understand the Customer's expectations.
- Identify potential constraints and risks in fulfilling the Customer's requirements.
- Identify cost and timeline for on-time delivery of product.
- Determine any assistance required from the Customer.
- Identify potential Suppliers, Sub-Suppliers, and processes to fulfill requirements.

The Customer shall provide the Supplier with all necessary documents pertaining to the requirements and specifications. These may include, but are not limited to, technical specifications, drawings, and standards. The Supplier shall analyze and review the requirements and expectations and use this review as a vital input to plan the quality program.

1.1. Voice of Customer (VoC)

The Voice of Customer (VoC) is a collective insight into the Customer's needs, expectations, perceptions, and preferences gained through information obtained from the Customer and the Supplier's knowledge and experience.

Means used to capture this information include:

- Surveys.
- Stakeholder interviews.
- Things Gone Right (TGR) report & Things Gone Wrong (TGW) report.
- Management comments and direction.
- Lessons Learned records.

The information discovered should be translated into meaningful objectives that help in closing any gaps between the Customer's expectations and the Supplier's offerings.