6th International Working Conference "TOTAL QUALITY MANAGEMENT - ADVANCED AND INTELLIGENT APPROACHES", With Second Special Conference "Manufuture in Serbia 2011", 7th – 11th June, 2011, Belgrade, SERBIA.

QUALIFICATION PROGRAM FOR DEVELOPING NEW PARTS IN AUTOMOTIVE INDUSTRY

UDC: 658.624; 330.313; 338.368, 658.526.

Sandro Dobovičekk, Duško Pavletić, Tonči Mikac, Milan Ikonić, Samir Žic

University of Rijeka, Faculty of Engineering, Vukovarska 58, Rijeka 51000, Croatia, sandro.dobovicek@riteh.hr.

Paper received: 24.02.2011.; Paper accepted: 14.03.2011.

Abstract: *Mass production of a complex products that requires engagement of a supply chain group lead to problem of synchronising and standardization within the supply group. Automotive industry is one of the first industries that created their internationally recognized standard and specific procedures. Those procedures are timeline-based, with specific requirements for each stage of product/process development. Some major automotive producers adopted those specific procedures due to specific requirements in their geographical region. This article shows Advanced Product Quality Program (APQP) for developing new parts generally accepted in automotive industry and Quality Program for new Parts (QPN), as its derivative used by Volkswagen group.*

Key Words: *product development, production process development, quality standards, mass production.*

1. INTRODUCTION

Development and market launch of a complex product like a car is a task with clearly defined objectives. Achieving those objectives implies existence of numerous constraints: tight deadlines, limited budget, required quantity and defined product quality.

Mass car production typically requires that manufacturers provide products and innovation that becomes crucial for successful market launch. These difficult challenges that organizations are facing today make it virtually impossible to retain in-house capability for all aspects of product realization.

An average car consists of the 1800 - 2200 components. Some parts, usually those with important function are made by car manufacturers themselves while others are left to suppliers. This implies that supplier is responsible for processes running as well as for their effectiveness and if necessary, process improvement.

Except if it is agreed differently, supplier's liability also applies to:

- Quality assurance of sub-supplier.
- Verification of sub-supplier's capability to meet customer's requirements (quality standards etc.).
- Qualification of sub-supplier (sub-suppliers test in real terms of production).
- Information flow in the supply chain.

Supply chain of complex (finished) products are usually very long (from suppliers of raw material to suppliers of a finished assemblies) and they require a synchronized and systematic development of processes among all participants in order to ultimately meet the end-user requirements and streamline communications within the organizations.

2. QUALITY SYSTEMS AND QUALITY PLANNING

Quality systems in the automotive industry are used for many years. Car manufacturers are one of the first who adopted the English Standard BS 5750 which later became the foundation of a series of internationally recognized standard ISO 9000 full family [1]. Requirements of ISO 9000 did not meet the needs of car manufacturers because they were too general. This led to the creation of different versions of standards within the automotive sector, figure 1.

USA (Ford, GM, Chrysler)	→	QS-9000	ISO/TS 16949
France (PSA, Renault)	→	EAQF	
Germany (VW, BMW, Mercedes)	→	VDA 6.1	
Italy (Fiat)	→	AVSQ	

Figure 1. Quality standards within automotive sector

ISO/TS 16949 is a Technical Specification (hence the TS is in the number) that in conjunction with ISO 9001, defines the quality management system requirements for the design and development [1]. ISO/TS 16949 was developed by The International Automotive Task Force (IATF), in conjunction with the International Organization for Standardization (ISO).

The IATF consists of an international group of vehicle manufacturers - BMW, DaimlerChrysler, Fiat, Ford Motor Company, General Motors Corporation, PSA Peugeot-Citroen, Renault and Volkswagen - plus national trade associations - AIAG (America), VDA (Germany), SMMT (UK), ANFIA (Italy) and FIEV (France). Japanese vehicle manufacturers association, JAMA, were also involved in the development of ISO/TS 16949:2002, opening the way for Japanese vehicle manufacturers to join IATF in the future.

Product quality planning is a structured method of defining and establishing the steps necessary to assure that a product satisfies the customer [2]. Quality planning is fundamental to the competitiveness of the automotive industry. Applied appropriately, it enhances supplier's ability to develop and produce products and systems that satisfy their customers.

3. ADVANCED PRODUCT QUALITY PLANNING

Quality planning in the automotive industry is based on the principles and requirements outlined in the Advanced Product Quality Planning (APQP) [3]. APQP is a disciplined process widely used in automotive industry to ensure that a structured sequence of activities is completed. These activities will ensure that an organisation can provide a quality product, on time, at the lowest cost and which exactly meets the customer's specific requirements.

APQP also provides a standardised means of communicating between customers and suppliers. It contains a framework of procedures and techniques and it is quite similar to the concept of Design For Six Sigma (DFSS).The main principles of implementing APQP plan are [2]:

- Organize the cross functional team
- Define the scope
- Team-to-team communication
- Training
- Customer and supplier involvement
- Concurrent engineering
- Control plans
- Concern resolution
- Product quality timing plan, figure 2.
- Plans relative to the timing chart

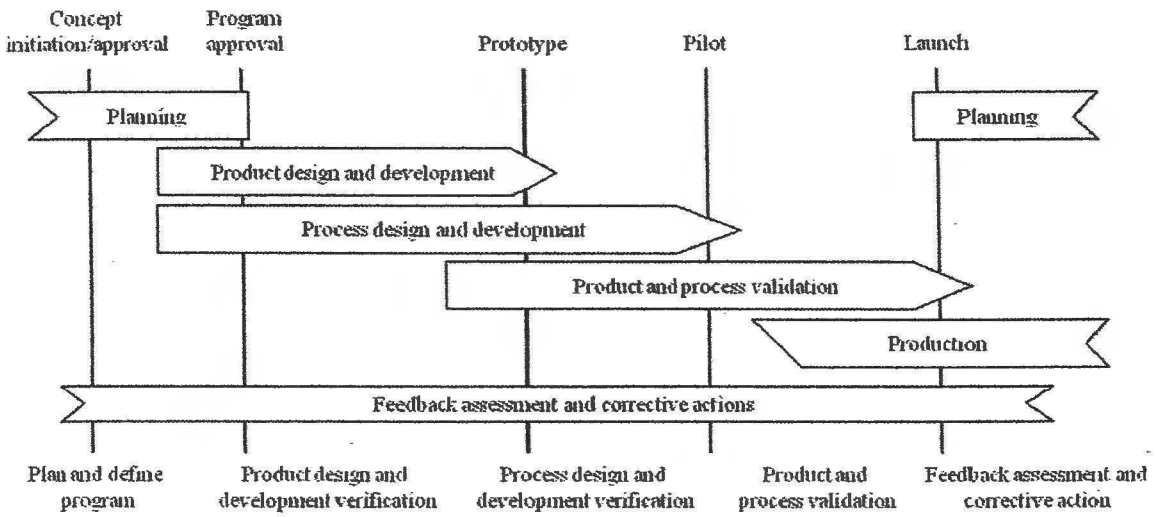

Figure 2. APQP product quality planning timing chart [2]

A further indication of the APQP process is to examine the process outputs by phases:

1. **Plan and define program**: design goals, reliability and quality goals, preliminary bill of materials, preliminary process flow, preliminary listing of special product and process characteristics, product assurance plan.
   Product design and development verification: design failure modes and effects analysis (DFMEA), design verification, design reviews, prototype build, engineering drawings, engineering specifications, drawing and specification changes, new equipment, tooling and facilities requirements, special product and process characteristics, prototype control plan, gages/testing equipment requirements.
2. **Process design and development verification**: packaging standards, product/process quality system review, process flow chart, floor plan layout, characteristics matrix, process failure modes and effects analysis (PFMEA), pre-launch control plan, process instructions, measurement system analysis plan, preliminary process capability study plan, packaging specifications.
3. **Product and process validation**: production trial run, measurement systems evaluation, preliminary process capability study, production part approval process (PPAP), production validation testing, packaging evaluation, production control plan, quality planning sign off.

One of the major elements of APQP process is proactive feedback and corrective action. That means that process provides feedback from other similar projects with the objective of developing counter-measures on the current project. Other mechanisms with verification and validation, design reviews, analysis of customer feedback and warranty data also satisfy this objective.

Design within process capabilities assumes that processes are under statistical control and process capability is determined. Once this is done, development personnel need to formally determine that critical or special characteristics are within the enterprise's process capability or initiate action to

improve the process or acquire more capable equipment. Design verification is testing to assure that the design outputs meet design input requirements.

Design verification may include activities such as: design reviews, performing alternate calculations, understanding tests and demonstrations, and review of design documents before release. Validation is the process of ensuring that the product conforms to defined user needs, requirements, and/or specifications under defined operating conditions. Design validation is performed on the final product design with parts that meet design intent. Production validation is performed on the final product design with parts that meet design intent produced in production processes intended for normal production.

Special and critical characteristics should be identified through quality function deployment or other similar structured method. Once these characteristics are understood, and there is an assessment that the process is capable of meeting these characteristics (and their tolerances), the process must be controlled.

A control plan must be prepared to indicate how this will be achieved. Control Plans provide a written description of systems used in minimizing product and process variation including equipment, equipment set-up, processing, tooling, fixtures, material, preventative maintenance and methods.

To verify manufacturer's ability to produce and to consistently provide an automotive part that fully complies with purchase order requirements, Production Part Approval Process (PPAP) is used. PPAP system is unique to the automotive industry.

Ford, GM and Chrysler's suppliers are typically required to follow APQP procedures and techniques and are also typically required to be audited and registered to ISO/TS 16949. In order to satisfy their own specific or additional standards, major automotive manufacturers created their own qualification programs for new parts., Renault and Nissan created – ANPQP, Peugeot and Citroen – AQMPP-Q3P, Toyota and Lexus – SQAM, Volkswagen group – QPN, etc.

4. QUALIFICATION PROGRAM FOR NEW PARTS (QPN)

With respect to certain specifics of German automotive industry standards VDA 6.1, the VW group has developed its own program with all elements of APQP and that includes their own specific standards - Qualification program for new product (QPN). It contains all the requirements of ISO/TS 16949 and VDA 6.1 and facilitates cooperation in the supply chain. The qualification program is structurally composed of two main parts: the development phases and production readiness review. Each of them contains modular components – phases, figure 3 [4].

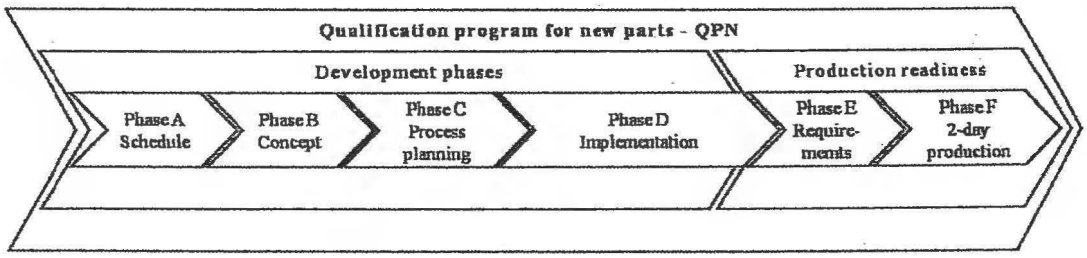

Figure 3. Qualification program for new parts timeline structure [4]

In the first part "Development phases" the manufacturing process development progress shall be monitored. Parts of same or similar production process can be monitored as group or a family of products. In second part "Production readiness" production processes are checked and finely tuned.

4.1 Part prioritization

Due to the variety of functional and security specifications for different car components, their qualification program should be different in terms of requirements for each phase. Solution for this is part prioritization [4]:

- Parts with Priority 1: Important parts that require special monitoring.

Parts with Priority 2: Parts that require general monitoring.

Parts with Priority 3: Parts where monitoring is not required.

4.2 Phase A - Schedule

Activity planning is a process that requires active communication and information exchange between customer and supplier. The schedule is used to visualise important project deadlines for the customer and to check them for agreement with the project goals/specifications. In this phase, document sheet called "Planned production process" is created. It has the following purpose [4]:

- Provide a first overview of the production process that is planned by the supplier and the planned measures for quality assurance.

Make it possible to take existing experience of the customer with current series parts (similar parts/ production processes) into account during the planning phase.

Simplify the processing of the questions (checklist points) with regard to the different process steps in QPN.

4.3 Phase B – Concept

At this stage, the supplier must define the project team and develop the concept of planned activities that will result in fulfilling the demands. Activities on the critical path of the project should be separately analyzed to ensure the execution of the project on time.

Making the concept or preliminary development of technology includes the planning of individual operations (number and sequence) but without further elaboration of the tool and machining parameters. At this stage, it is necessary to define the adequate production equipment and estimate (by experience) roughly the duration of operations. For the concept of the production process is necessary to make process FMEA.

Simultaneously, at this stage, the supplier is involved in making prototypes. Preliminary product design is related to the development of an optimal design for a new product. This involves a compromise between cost, functionality, quality and product performance.

4.4 Phase C – Process planning

The resulting documents of the Concept phase are the basis for detailed process planning that includes elements that were omitted in a rough concept. Previous phase laid the foundation for a detailed elaboration if the results of Phase B were not satisfactory.

In addition to the planned operations, it is necessary to plan the production parameters. This phase should result with all process mandatory documents (process FMEA, control plan, etc.). At this stage it is necessary to define the methods of quality assurance and define the resources to perform quality control.

4.5 Phase D – Implementation

This phase is crucial because a large number of special equipment which is implemented in the manufacturing process used in mass production. That is a reason why manufacturing processes must undergo a certain stage of adaptation and optimization to satisfy all requests.

Given that the qualification program consists of more complex development projects to gradually achieve the ultimate goals of quality and required quantity of manufactured products, the program contains key moments in which certain requirements must be met. Implementation phase includes:

Product functionality testing (pilot testing, testing of parts produced in serial conditions, etc.)

Process functionality testing (testing of reaching the required quantities produced, measurement systems repeatability tests, etc.)

Confirming the completion of previously phases (construction certificates, establishment of process capability index, evaluation of achieving the set goals, etc.).

As the qualification program is performed at production sites of suppliers and customers factories at different locations, there is a demand for its alignment. Series of products that are being used for that are called D/TLD pre-series. D/TLD pre-series contains supporting documentation which outlines the status of products, their origin and status of quality.

D/TLD pre-series includes:

BMG (construction certificate) - BMG parts are parts produced in mass production conditions, with tools for serial production.

PV series - purpose of this series is the production of parts that are used for fine-tuning of processes in factory-customer.

0-series - the purpose of 0-series is to assess the functionality of the tool/process and the satisfaction of the assembly in serial terms, before the adoption of a new product.

In addition, the supplier is obliged to present the initial samples. Presented initial samples must be produced under serial production conditions and submitted to customer's quality department. Supplier represents samples with their own assessment of the quality status that customer representative has the right to modify, if necessary.

4.6 Phase E – Requirements

The supplier is obligated to define the operational requirements necessary for 0-faults strategy and disclose customer records as evidence of ability to satisfy these requirements. For the important product characteristics following limits for process capability are set as:

Short-term process capability $Cpk \geq 1.67$.

Long-term process capability $Ppk \geq 1.33$ at the beginning stages of PV series production, with constant improvement to the $Ppk \geq 1.67$.

4.7 Phase F – 2-day production

QPN ends with 2-day production audit which takes place under complete series conditions, at least 6 hours without stopping, or at least until a planned quantity of parts is produced. In order to better record the entire production process, the customer usually determines the amount of parts which requires the production of more than one shift or a day to include elements such as night work, shift changes and specific conditions that exists in serial production.

5. CONCLUSION

Modern automotive industry demand sound quality planning of all development stages, especially within a supply chain. Synchronized and systematic developed processes are widely used in automotive industry to ultimately meet quality standards and end-user requirements. Benefits of that standardised qualification programs are multiple, ensuring the

timely achievement of the objectives throughout the supply chain.

REFERENCES

[1] Hoyle, D., *Automotive Quality Systems Handbook*, Butterworth-Heinemann Ltd, 2000.

[2] Bobrek, M., Sokovic, M., *Implementation of APQP-concept in design of QMS*, Journal of Materials Processing Technology, 162-163, 718-724, 2005.

[3] Stamatis, D. H., *Advanced Quality Planning – A Commonsense Guide to AQP and APQP*, Productivity Inc., 2001.

[4] VW AG,D.,*Formel Q Neuteile Integral*,Corporate QA, Purchasing,2006,http://www.vwpurchasing.co.za/Documents/en_formel_q_new_parts_integral_pdf.file.pdf.