DOKUZ EYLÜL UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

ADVANCED PRODUCT QUALITY PLANNING FOR PERFORMANCE EVALUATION OF NEW PRODUCT IMPLEMENTATION PROCESS AND AN APPLICATION IN A FACTORY

by

Ayşe Emel ÜNAL

October, 2019

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ADVANCED PRODUCT QUALITY PLANNING FOR PERFORMANCE EVALUATION OF NEW PRODUCT IMPLEMENTATION PROCESS AND AN APPLICATION IN A FACTORY

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Ayşe Emel ÜNAL

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M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"ADVANCED PRODUCT QUALITY PLANNING FOR PERFORMANCE EVALUATION OF NEW PRODUCT IMPLEMENTATION PROCESS AND AN APPLICATION IN A FACTORY"** completed by **AYŞE EMEL ÜNAL** under supervision of **ASST. PROF. DR. BURCU FELEKOĞLU** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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ADVANCED PRODUCT QUALITY PLANNING FOR PERFORMANCE EVALUATION OF NEW PRODUCT IMPLEMENTATION PROCESS AND AN APPLICATION IN A FACTORY

ABSTRACT

Each product is considered as new product in companies with order-based production system and challenges of not only producing new products but also changing market and competitive conditions are faced. In order to overcome these difficulties and sustain market share, to produce high quality products at one time with minimum cost in all stages in production of new products is necessary. In attempt to solve this critical problem, our study focuses on advanced product quality planning (APQP) technique in new product development (NPD) process to ensure survival and continuous improvement of company and reduce cost, time, labor and customer losses. In this study, firstly NPD process and use of APQP in NPD were explained and then example of APQP application in factory producing heat exchangers with order-based production system was given. APQP has been completed in five sections. The first two parts of APQP are related with product design. Since the company doesnot have design responsibility and it belongs to the customer, the documents of the first two sections have been provided by the customer. Three main sections of the other APQP application were realized in the company. These sections include; process design and development, product and process validation, feedback and corrective actions. Process management and control activities and tools such as establishment of team, selection of new product, feasibility studies, determination of workflow, reduction of risks, determination of process capability, measurement systems analysis, and control plan, production, dimensional and performance tests were performed. As a result of this study, it has been proved that new products produced by following NPD process that is continuously evaluated with APQP method, fully meet both customer and company requirements. By using APQP method in NPD, process is controlled and scrap rates, costs and customer complaints are reduced.

Keywords: New product development, advanced product quality planning, order-based production system

YENİ ÜRÜN UYGULAMA SÜRECİNİN PERFORMANS DEĞERLENDİRMESİ İÇİN İLERİ ÜRÜN KALİTE PLANLAMASI VE BİR FABRİKADA UYGULAMA

ÖZ

Siparişe göre üretim sistemine sahip işletmelerde her ürün yeni ürün olarak değerlendirilmektedir. Yeni ürün üretmenin zorluklarına, değişen pazar ve rekabet koşulları ile gelen zorluklar da eklenmektedir. Bu zorlukların üstesinden gelebilmek ve pazar payını düşürmemek için müşteriye göre özelleşen yeni ürünlerin üretiminde, siparişin alınmasından satış sonrası hizmetlerine kadar olan tüm aşamalarda minimum maliyetle, tek seferde, kaliteli ürün üretilmesi gerekmektedir. Çalışmamız bu kritik problemi giderebilmek için, sipariş bazlı üretim sistemine sahip, Isı Eşanjörü üretimi yapan bir işletmede, Yeni Ürün Geliştirme (NPD) sürecinde yaşanan maliyet, zaman, işgücü, müşteri kayıplarını azaltmak, proseslerini kontrol altına almak ve sürekli iyileştirmeyi ve işletmenin zorlu rekabet koşullarında ayakta kalabilmesini sağlamak için NPD'de kullanılan en etkin yöntemlerden biri olan İleri Ürün Kalite Planlaması (APQP) tekniğinin uygulanmasını ele almıştır. Çalışmamızda NPD süreci ve NPD'de APQP kullanımı anlatılmış ve APQP uygulaması örneği verilmiştir. APQP beş bölümde yapılmıştır. APQP nin ilk iki bölümü ürün tasarımı ile ilgilidir. Firmanın tasarım sorumluluğu olmayıp, üretici sorumluluğunda olması sebebi ile ilk iki bölüme ait dokümanlar müşteri tarafından sağlanmıştır. Diğer APQP'nin üç ana bölümü firmada gerçekleştirilmiştir. Bu bölümler; proses tasarımı ve geliştirme, ürün ve prosesin geçerlilik kazanması, geri bildirim ve düzeltici faaliyetlerdir. Bölümlerde; ekibin kurulması, yeni ürünün seçilmesi, fizibilite çalışmalarının yapılması, iş akışı belirlenmesi, risklerin azaltılması, proses yeterliliğin belirlenmesi, ölçüm sistemlerinin analizinin yapılması, kontrol planının oluşturulması, üretimin yapılması, tüm süreçlerin kontrolü, ürünün boyutsal ölçümlerinin ve performans testlerinin yapılması, çalışmaları yapılmıştır. Yapılan çalışmalar ile APQP yöntemi uygulanarak gerçekleştirilen NPD süreci sonunda ortaya çıkan ürünün müşteri ve firma şartlarını sağladığı kanıtlanmıştır. NPD'de APQP yönteminin kullanımı ile proses kontrol altına alınarak hurda oranları, maliyetler ve müşteri şikayetleri azaltılmıştır.

Anahtar Kelimeler: Yeni ürün geliştirme, ileri ürün kalite planlaması, sipariş bazlı üretim sistemi

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CHAPTER ONE
INTRODUCTION

1.1 Overview

The order-based production system is a production model used to create a new service or product. It is a production system covering a small quantity but high level of product range. In addition to the similarity of the products to be produced at some points, a special effort is required in order to achieve innovation in the order-based production system. It is a production model that is mostly privatized according to customer and has the least standards. Nowadays, with the changing market and competition conditions, the companies realize customer specific production in order not to fall behind the market and not to decrease their market share.

In the order-based production systems, to put business rules and to measure and control the processes by making them a certain standard is difficult. Product variety and low production quantity reduce the repetition in processes to a minimum. Therefore, right production in one time is an extremely important criterion.

During the product development process that beginswith the receipt of the order until the customer's use of the product, pre-determination of the failures and risks that may occur, taking the necessary measures, reducing of scraps, re-processing time, time and cost losses, customer losses and quality losses, offering the products to the market quickly is an important requirement for companies to be ahead of their competitors. In line with these reasons, in today's conditions, application of the quality management by the companies which has this type production system provides excellent advantages to them. Quality management is defined as a fullest extend of planned and systematic activities applied to ensure sufficient confidence in the fulfillment of the requirements of a new product or service.

When the studies in the literature are examined, application of Advanced Product Quality Planning (APQP) technique in new product development (NPD) process in mass production system has generally been seen. In our country, enterprises that have project-based production system in global competition takes an important place.

However, there are not sufficient studies in implementing APQP in NPD which minimizes the risk rates in this production system where the risk ratio, costs, customer satisfaction, quality, and product offer more rapid conditions. This research thesis was inspired by the lack of appropriate solutions in the NPD process in companies that have a project-based production system. For companies that have such production systems, APQP technique, which is an effective method for NPD process management, has been proposed. APQP technique is thought to provide significant benefits for both literature and enterprises.

1.2 Outline of the Research Thesis

The research thesis starts with the introduction. In chapter two, after the introduction, information is given about the new product development process. In this section, techniques used in the literature, new product definition, stages, problems lived in practical, performance criteria are given. In chapter three, is provides information about the definition and use of the Advanced Product Quality Planning (APQP) method used in the new product commissioning process. In chapter four, the information on problem definition and proposed methodology is given. In the chapter five, firstly, information about the ABC Company definition is given. The name of the case company is kept anonymous for confidentiality purposes and the company is referred as ABC Company. Then the company's perspective on new product development, the identification of the new product to be carried out of studies, and the implementation of the proposed methodology have given. In chapter six, the application results have presented. In addition, this section includes the benefits of studying from the point of enterprise. In Chapter seven, a summary of the study, contributions to the enterprises and the literature, and future studies have given place. The thesis flow diagram is given in Figure 1.1.

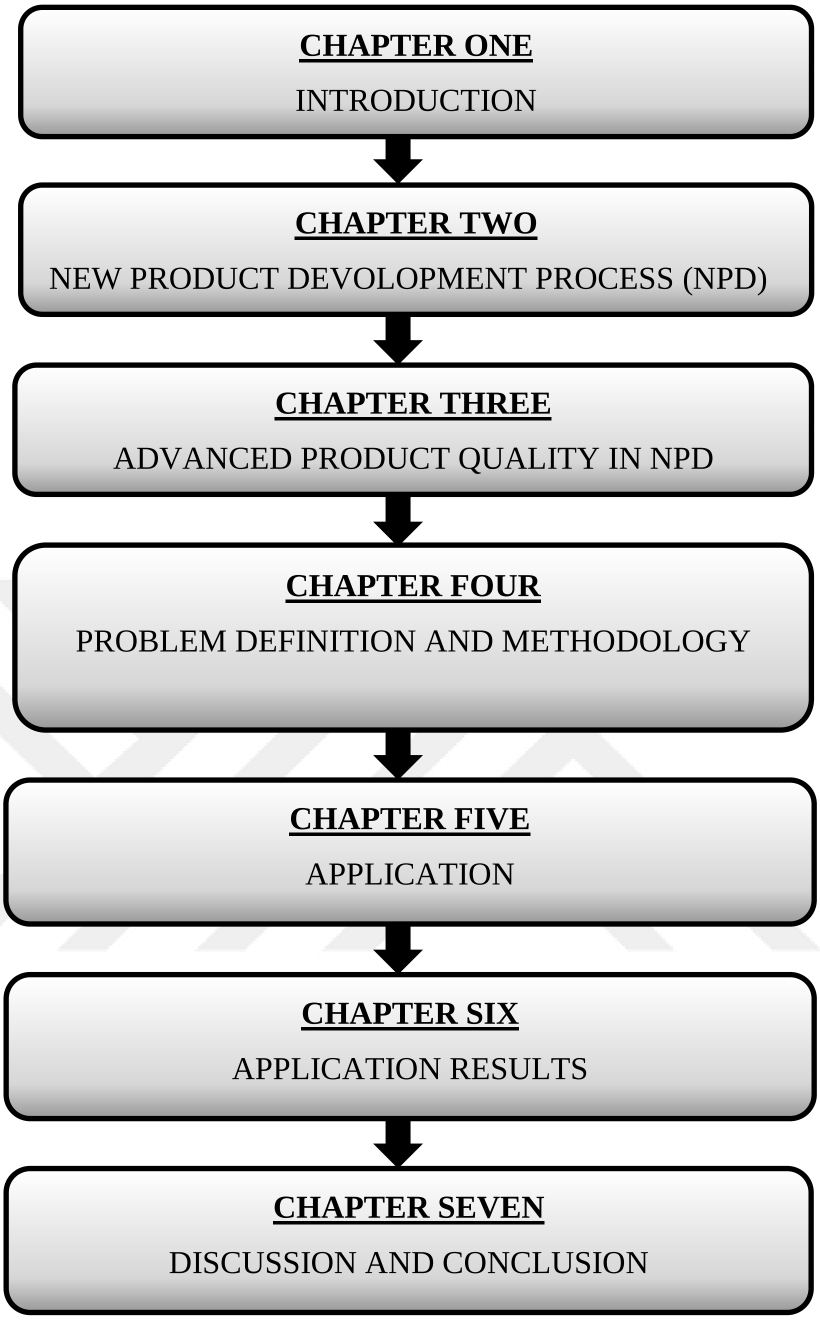

Figure 1.1 Outline of the thesis

CHAPTER TWO
NEW PRODUCT DEVELOPMENT PROCESS

2.1 What is New Product Devolopment (NPD)?

NPD means the research and development efforts that are revealed by the firms to develop original products, product changes or new brands that are required by the customer (Armstrong, Kotler, Saunders, & Wong, 2005). The new product may be something that has never been produced orchanges in the existing product such as style, color, performance variations, dimensional differences etc. (Onal, 2009).

NPD is important for most manufacturing organizations. NPD is necessary for reaching the target market for the new customers entering the market, as well as the existing companies in the market to survive, to improve and increase profitability (Paksoy, 2017).

Adiele and Amue (2012) has divided the new product into 6 different categories. These include; new products for the world, new product line, making additions to existing product line, revision and development of existing products, new positioned products, lower priced products.

2.2 NPD Process

NPD process includes strategic formulation, distribution, resource allocation and coordinated cooperation between people from different professions and nations, and many issues and challenges in a company such as systematic planning, monitoring and control. Therefore, the NPD activity is essentially a selection, transformation and coordination work (Loch & Kavadias, 2008).

Due to developing technology, changing customer needs and changes in the competitive environment, enterprises need to make changes in new product production process. However, in order to develop new product, important resources such as qualified personnel, money, and time are needed. In processes performed as effective, the above-mentioned resource utilization will be minimized and the success achived will increase (Paksoy, 2017).

2.3 NPD Process Stages

NPD process consists of three stages. These include; (Pakünlü, 2010)

1. Pre-development activities,
2. Development phase activities,
3. Decision to production and market entry

2.3.1 Pre-development Activities

- **New ideas and evaluation**

It is the section where the cost-benefit analysis, product technical characteristics and feasibility of the new product are investigated in relation to the products that create competitive advantage as a result of examining the ideas coming from a wide variety of sources with the business objectives and other products (Booz, Allen, & Hamilton, 1982).

- **Concept Development**

The market where the product will be offered and the benefits of the product are determined in this section. The product is brought together from the concepts that make up the product definition in a way that enables the consumer to adopt it (Kotler, 2000).

- **Strategy Setting**

The strategy should be determined before proceeding with product development activities. It is the section which the product characteristics, project team, project work plan, project completion time estimation, competitor product analysis, market share, profit targets, presentation time and presentation style are determined (Pakünlü, 2010).

- **Economic Analysis**

With financial feasibility studies, it is the stage where the targeted production quantities and prices are determined. Breakeven analysis, discounted cash flow analysis, return on investment analysis, surface anaysis are calculated at this stage (Cooper & Kleinschmidt, 1986).

2.3.2 Development Phase Activities

- **Product Development**

Coordination between process, people and departments, technical issues, determination of resources (human, plant, machine, raw material, semi-finished product, etc.), time and effort are investigated in this section. The aim is to ensure that the product is developed in good quality and has physical properties that can meet the customer's expectations in an economical manner (Cooper & Kleinschmidt, 1986).

- **Product Testing**

Two types of product testing are performed. The first is product tests, the second is market tests. Product tests are performed to determine if the product is working properly, control the functionality and reliability of the product under real-life operating conditions, and check the technical specifications to determine whether the product meets specifications, design standards, field tests. Market tests are intended to determine whether the product is suitable for marketing and whether it will provide expected sales in the long run (Cooper & Kleinschmidt, 1986).

2.3.3 Decision-Making to Produce and Market Penetration

Work flow, instructions, production plans, material management, quality management issues are organized in this phase. The technology to be produced is determined. All features and packaging of the product are made ready. Patent or certificate, personnel training is carried out at this stage. The product is ready to be launched (Pakünlü, 2010).

2.4 Problems in the NPD Process

Products based on order-based and project-type production systems are mostly new products. In addition to these, it is a fact that other companies have to produce new products in order to survive in a competitive environment. But the NPD pocess for all companies is a very difficult and comprehensive process. In order to manage this process successfully; it is necessary to analyze, define and apply key factors in a good way. However, companies often skip these steps. For this reason, many of the NPD processes result in failure.

The failure on the NPD process can create financial problems for businesses. An enterprise that is considered as good in terms of factors such as finance, technology and brand image can meet the losses of failure to a certain extent. However, a small and sometimes medium-sized enterprise (SME) can go bankrupt only if it fails once and even if this failure occurred during the project phase (Altuğ, 2017).

According to Armstrong and Kotler (2012), there are many reasons for the high rates of failure. These include; although the idea is good, the size of the market may not be sufficiently analyzed and the size of the market can be calculated larger than it actually is, the product can be poorly designed, the project timing may be erroneous, product may be a high-ranking or poorly advertised, despite the weak market research findings a senior manager can push the idea. Besides these; Hopkins (1981) stated that problems in production could lead to new product failure. As a result of all these researches, the factors causing the NPD process to fail are as follows;

- Poor communication with the customer, lack of information came from the customer, disregarding customer needs or misunderstanding
- Technology insufficiency
- Lack of experience, knowledge and experience in all departments or critical departments
- Incomplete or inaccurate cost analysis studies
- Nnecessary equipment and machinery could not be identified correctly, the missing ones could not be supplied or not used correctly
- Inaccuracies or deficiencies in the production phase
- Missing team members, difficulties in recruitment
- Inadequate training of team members, more workload than they can achieve
- Communication problems between team members

- Team members to pay more attention to their duties in their departments and to disregard project tasks.
- Wrong, incomplete or not compatible packaging works to customer requests
- Lack of customer confidence
- Lack of compliance with standards and safety rules
- Time planning is incomplete or poorly made or work is not done in accordance with the time schedule
- Lack of upper management support, inability to provide resources
- Resources allocated to projects that do not create value
- Incorrect selection of suppliers, lack of communication with suppliers, erroneous and / or slow transmission of information
- Faulty and / or incomplete material list, raw materials or parts to be difficult to supply and / or take a long time
- Not checking whether the customer requests are met at the end of the project
- The project is not suitable for the company's culture and capability
- Unsuitable transport service to customers' requirements or products
- Inadequate test or inadequate test equipment, not tested according to standards, insufficient test personnel
- Competitors are not analyzed good enough
- Failure of pre-determination of risks that may occur, not taking measures
- Customers have a closed vision in terms of innovation
- The product cannot meet the desired performance level
- Problem of transition between product stages, lack of process management
- Inadequate method of product development process (Kong, 1998).

Minimizing or eliminating all these risks can only be achieved with a good process model. The NPD process model, which is designed according to customer expectations, current technology and processes, and the effective management of this model, enables failure of the company to minimize and to achieve great advantages in the competitive environment.

2.5 Literature on NPD Process

In today's competitive conditions, it is very difficult for enterprises to survive. Businesses that use technology to transform their knowledge into products have significant advantages. According to Chang, Hussain, & Mirtalaie (2017), today's businesses need to protect their existing customers and increase their market share. They can do this by generating new ideas and developing products with new features. In this process, it is important that teams meet the needs of both existing customers and new customers in developing new products. In other words, the most important criterion in NPD is customer needs and expectations. According to Paksoy (2017), enterprises should correctly analyze the customer expectations and needs before starting the NPD process and determine the factors that will give advantage to the competition. The most important success factor is to have a high brand value. Determining the right need and customer satisfaction, efficient use of resources, accurate production process, accurate measurement of consumer perception, delivery of the product to the final consumer with the right marketing ways, rapid access of the product to the customer, production based on high technology are the important factors that enable new products to be held in the market. A cooperative approach with other businesses is of great importance in meeting customer needs. According to Agarwal, Jha, Fernandes, Nie, Tiwari, & Xiong (2017), due to uncertainties in the market, performance, quality and timing uncertainties in the development of new products in today's competitive market can be eliminated by collaborative decision-making.

Accurate understanding of customer needs and expectations as the first stage is an important constraint in NPD success. There are many ways to understand customer needs and expectations. One of them is the use of social media. According to Bashir, Malik, & Papamichail (2017), the use of social media in NPD processes offers significant advantages. Social media is among the fast-reaching resources. It can be seen as an informal source for understanding customers 'references, competitors' activities, market trends and product feedback. As a result of the obtained resources, customer participation is provided to NPD processes. According to Moscatelli, Perna, Rocca, & Snehota (2016), customer engagement in NPD activities significantly affects sales.

NPD process has evolved over time. Rothwell (1994) defined five different generations of NPD process. The first generation covers the 1950s, the second generation of the 1960s, the third generation of the 1970s, the 4th generation of the 1980s and the fifth generation of the 1990s. Today's enterprises are in the 6th generation in NPD processes (Taferner, 2017). In the 6th generation NPD process; companies must pay attention to efficiency, quality and speed factors simultaneously. Under these constraints, NPD is a difficult and comprehensive process and failures have high rates. Derbyshire & Giovannetti (2017) stated that there are many uncertainties due to the nature of NPD. The biggest source of uncertainty in NPD is the failure to understand the failure. It is the duty of top management to understand and accept these failures. According to Abu-Bakar & Yahaya (2007), there are four NPD management problem categories based on the decision-making approaches of senior executives in NPD. These include; strategic management problems, project management issues, NPD process and structural issues and human management issues.

Top management should set up the team before launching the NPD process. This team should support team work. Because inter-departmental cooperation in NPD is an important criterion for success. According to Kahn (2005), the marketing department reflects more status in the NPD process and the other departments have an indirect effect. NPD studies conducted with teams including marketing, manufacturing and R & D have a significant impact on product management performance. Interdepartmental cooperation is important for a successful NPD where no department should be given more status. In order to successfully progress the process, the NPD team must be able to define and analyze the performance factors in detail. According to Alin & Tudor (2007), continuous development and market entry speed has a significant share on future performance of the companies in the NPD process. With this study, the key factors that may affect the NPD process are described in detail and structured way. These criteria are examined in detail in section 2.7.

All literature studies show that the NPD process is a difficult and comprehensive process. The NPD process consists of successive and interactive activities. The outputs of an activity form the input of the next activity. In NPD processes with high failure rates, all activities must be analyzed in detail and managed effectively. To this end, effective decision-making approaches of the top management, the support it creates to the team, forming the teams to cover all relevant departments and analyzing the customer needs and expectations play an active role in the NPD process.

2.6 Performance Criterias in NPD Process

There are many factors to achieve success in developing a new product to a new market or to the existing market. Cooper (2000) collected the performance criteria in the NPD process in 10 different categories. These factors include; differentiated and superior products, preliminary studies - homework, listening to the customer's voice, clear, stable and early product definition, market research, go / kill decision points for the project, cross-functional project teams, determination of strong points and using them is the creation of a market and the support of top management (Cooper, 2000).

Ernst (2002), based on the literature studies on NPD, divided critical success factors into 5 categories, namely, NPD process, organizational structure, firm culture, senior management role and commitment, and strategy.

Desai, Mital, and Subramanian (2008), based on Cooper and Montoya-Weiss and Calantone studies, identified NPD performance criteria under the headings of uniqueness, customer orientation and adaptation to the market, preliminary studies, clear and early product promotion, the execution of activities, organizational structure, project selection decisions, marketing, the role of senior management, speed without compromising on quality, systematic finding of new product process, market attractiveness, experience and foundation competences.

Some of these criteria are explained below;

2.6.1 Uniqueness

The products that are successful in the market are unique and have clearly distinctive features.

New products that provide success;

- Provides maximum benefit with spent money
- Customers have requested and even have higher quality in demand
- Providing the customer's needs at maximum level and with unique features
- Has useful benefits.

In summary; the product development process should aim to develop products that provide maximum benefit, different from competing product specifications and provide clear and unique benefits for the customer (Desai, & Mital, & Subramanian, 2008).

2.6.2 Customer Orientation and Market Compliance

In successful product development, focusing on customer requests is critical. An excellent understanding of customer requests increases success and profitability.

Businesses wanting to gain a strong place in the market;

- Understand the nature of the market
- Know their competitors very well and analyze the competition
- Allocates resources to identify customer requests
- Shape product characteristics according to user needs
- Uses data from the customer as input for the entire product development process (product design, development, prototyping, testing and marketing) (Alin & Tudor, 2007).

2.6.3 Preliminary Studies

In order for a product to succeed in the market, careful work before product design is critical. These studies include technical evaluation of market competencies and requirements, market research and financial analysis for the rapid introduction of the product into the market. As a result, the decision to continue the project is taken. Due to the lack of interest shown in the preliminary studies, the problems in the product increase significantly. This is reflected in the company's advertising, sales force and costs (Desai, Mital, & Subramanian, 2008).

2.6.4 Clear and Early Product Definition

Preliminary development leads to a clear and early product identification and is important to reduce the market entry process. A product description involve;

- Outline of the concept and its benefits
- Required and desired product features
- The features of the potential market
- Outlines of business strategy

If a clear product definition is not made, the probability of failure increases by three times. A clear definition of the product leads to development and clear targets are set (Bhuiyan, 2011).

2.6.5 Carrying Out Activities

Successful product development teams work consistently throughout the activities identified through preliminary work and market research. These teams conduct market researches and conduct trial sales. (use the test market to see if the product can achieve success). Overall, the completeness, consistency and quality of the development process is important to reduce development time and achieve profitability. However, the quality of the activities is not limited to pre-development work. It should be a part of all development activities from the design stage to the market (Desai, Mital, & Subramanian, 2008).

2.6.6 Organizational Structure

Product development teams must be multifunctional and authorized to be successful. Product development teams must have the following features.

- Teams are made up of members in all basic departments. Research and development, engineering, production, quality, sales and marketing etc.

- Each member of the team is part of the team and represents the characteristics of the team, not the department.
- Teams spend most of their time on project planning and product development.
- Teams are in constant communication with each other.
- The team is solely responsible for all of the project, not the work itself.
- The leader of the team is strong and motivating.
- Strongly supported by top management.

Although these features are clearly stated, businesses are often unable to provide them. It is important for businesses to be supportive, to make efforts and to reward success. It should be avoided to encourage or penalize failure. In addition, top management should trust the team leader and trust the project. After assigning a strong team leader and selecting the team members, the team should be encouraged and provided the necessary resources. An institutional structure should be encouraged to provide ideas for new products, new technological studies and new initiatives (Akyüz, Yayla, & Yıldız, 2009).

2.6.7 Project Selection Decisions

Many companies also turn to many projects. As a result, it distributes its resources to many candidate projects. However, not all projects are possible. Product selection helps reduce candidate projects, so that resources can be directed to potential projects (Desai, Mital, & Subramanian, 2008).

2.6.8 Marketing

It is not enough to have a good product to get a place in the market. It would be a very wrong strategy to think that a good product would sell on its own. The product must be properly marketed. Sufficient resources should be allocated to market new products. Launch and marketing work should be supported by a professional team and after-sales services must be provided quickly. Ideally, if the product is properly designed and of high quality, this may not be an issue (Desai, Mital, & Subramanian, 2008).

2.6.9 The Role of Senior Management

As outlined in the organizational structure section, top management should support the product development team and provide the necessary resources. Senior management should know that there will be failure if time, money and human resources are missing. Senior management should also clearly state the business strategy for NPD. They should define targets for the new product, these targets include the percentage of market share to be captured, profits from the new product, technological developments to be focused, and long-term goals (Akyüz, Yayla, & Yıldız, 2009).

2.6.10 Speed without Concessions from Quality

The rapid introduction of a product into the market is an important determinant of profitability. If the product is speedy by compromising the quality of the product or the execution of the basic activities, it loses its advantage. Because speed is an important factor in the market, it must be ensured without compromising on quality. For this;

- Many activities should be carried out at the same time. Communication between teams should be strong and management should be kept open.
- All activities in the project should be planned as timeline. All activities should be given sufficient time and attention should be paid to the activity priority.

Violation of the timeline can be caused by a lack of discipline and / or a lack of resources needed. This causes the product to delay its delivery. Instead of infringing the timeline, it is a much better option to route more resources to the project (Desai, Mital, & Subramanian, 2008).

2.6.11 Following a Systematic New Product Process

Many companies define a stage-gate for managing the new product process. The product development process from the product design stage to the market stage is divided into logical stages. At the end of each phase, there are decision criteria. These criteria are determined by the management and are usually in the form of outputs for each stage. Each stage may include several concurrent activities, but each activity must meet certain criteria to proceed to the next stage. The criteria are expressed as quality control points (to ensure the quality of the operation). These criteria cannot be neglected, unless they are provided, they cannot pass to the next stage. Managing the product development process with time planning and taking such strict measures provides many advantages in terms of early detection of problems, higher success rate, better product launch and shorter time to market (Desai, Mital, & Subramanian, 2008).

2.6.12 Market Attractiveness

The market for launching the new product should be attractive. The desired market features are;

- The market volume is large and the product is required for the customer.
- Market has rapid growth potential
- Market is economically positive
- The demand for the new product is not periodic or unstable
- Customers should be able to adopt the new product and easily place the product in their lifestyle
- Customers are eager to try out the new product and have little to worry about
- Customers must have sufficient income

While it is desirable to have an attractive market, the development team should understand the market and customer needs and include them in product design. Such positive activities bring success (Desai, Mital, & Subramanian, 2008).

2.6.13 Experience and Basic Competencies

There is little chance of success in a completely new area of expertise. For success; technology, management capability, product knowledge, market requirements for products, resources are required. Generally; the stronger the link between NPD and the core competencies (expertise) of the company, the greater the chance of success. In particular, the following items should be provided;

- Technical expertise in terms of both production capacity and future research and development
- Management techniques
- Marketing, sales and customer service resources
- Market and customer needs

Generally, it is easier for businesses to be successful if there is a market in a region they know. However, this does not mean that an enterprise cannot or should not engage in different areas. If such a need arises, studies must be done carefully. One way to obtain expertise in another area is to obtain existing businesses in that area. Such actions are quite common nowadays (Desai, Mital, & Subramanian, 2008).

As a result, successful new products should have the following features.

1. They offer completely new benefits from existing products
2. In addition to the new primary benefit, they offer a new secondary benefit
3. They are compared with what their competitors offer
4. Eliminate a significant non-compliance with the current market
5. They offer a better-quality product than not available on the market
6. Use contemporary social trends
7. They provide price advantage compared to their competitors (Desai, Mital, & Subramanian, 2008).

2.7 Performance Evaluation in NPD Process

Performance evaluation; is considered as one of the main steps in the implementation of world-class production. Performance measurement plays a vital role in improving the competitiveness of companies (Backhouse & Brookes, 1998). Most firms have a history of success and failure in product development. Learning from mistakes and achieving achievements is crucial for companies that want to improve their NPD performance (Blythe, Poolton, & Waring, 2000).

The most commonly encountered technique in performance evaluation in NPD in literature is the Stage-Gate model developed by Robert Cooper. Studies show that approximately 68% of US product developers use the Stage-Gate model or similar methods to this model. This model is a conceptual and operational roadmap from the idea stage to the presentation stage. It creates a plan for improvement of efficiency. Parallel activities at a particular stage with the Stage-Gate method should be designed to manage the risk and to collect important information such as technical, market, financial transactions to reduce technical and commercial risks. The Stage-Gate method separates the NPD process to phases. Each stage contains specific activities. Between each stage there are Gates as a Go / Kill control point. In order to move from one activity to the next one, ie to open the door, evaluations are made and they must be successful according to the specified metrics. In addition to the evaluation of the transition to the next stage, the decision of whether to continue the project or not to transfer the resources to another project is evaluated (Cooper, 2000).

Ayyildiz, Cengiz, and Kırkbir (2006) have used the step threshold method developed by Cooper in their study. They identified the stages of the process and determined the stage thresholds related the stages. The stages and phase thresholds that they have determined are as follows in Table 2.1 below (Ayyildiz, Cengiz, & Kırkbir, 2006).

Table 2.1 NPD stages and stage thresholds (Ayyildiz, Cengiz, & Kırkbir, 2006)

PHASES	THRESHOLD OF PHASES
Produce an idea	Test Idea
Concept Development	Concept Test
Business Analysis	Business Analysis
Product Development	Product Test
Market Test	Analysis Test of Market Results
Put on Market	Evaluation after put on market (short term) Evaluation after put on market (long term)

Based on their performance evaluation criteria determined by firms in Turkey on the threshold method, statistical analysis was made. At the end of the study, they determined the rules to be complied with by the managers.

Rasli and Tan (2011) determined the metrics according to the five main performance measures (Product Level Measure, Customer Acceptance Measure, Market Level Measure, Financial Measure, Timing Measure) in the NPD performance evaluation study. They pointed out that the most important issues for continuous improvement in NPD are shortening product development time and reducing product costs. The study was conducted by applying a questionnaire in a company where research and development activities are of high importance. The level of NPD application efficiency in the company has been measured and studies have been conducted on how to best estimate the NPD performance. A methodology has been proposed to estimate NPD performance through regression analysis. In addition, critical NPD performance metrics have been identified. It was revealed to be that the most powerful determinants of NPD performance are the NPD structures of "Simultaneous Engineering Tools and Technique Implementation" and "Topdown CE approach". With these improvements, it is stated that the success of the new products of the companies will increase considerably (Rasli & Tan, 2011).

Godener and Söderquist (2014) grouped performance measurements into seven main perspectives. These include; Financial Perspective, Customer Satisfaction Perspective, Strategic Management Perspective, Process Management Perspective, Technology Management Perspective, Innovation Perspective, Knowledge Management Perspective. By introducing these perspectives in detail, they have introduced a conceptual framework that combines the main logic and purpose of each perspective, the central criteria, and the stages in which performance is measured in order to develop measurement strategies for managers.

Backhouse and Brookes (1998) reported the most suitable criteria for performance measurement. In order to determine whether the current performance measurement mechanism is applicable within the framework of the specified criteria, they used a case study and produced wider results for the creation of effective performance measures for product promotion (Backhouse & Brookes, 1998).

Measuring and evaluating a company's NPD performance and continually improving current performance is an important factor in increasing the success rates of companies. Activities that provide communication for information transfer during the development process and integrated activities that need to be carried out in the product development process are the most important areas of NPD performance measurement. Performance evaluation; It is used for the evaluation of a past product, a comparison between a successful product and a less successful product, a preliminary assessment of new products and comparisons between existing and alternative applications. In any case, the purpose of the assessment is to identify and improve the relatively low performance scores for product development stages (Blythe, Poolton, & Waring, 2000).

In this chapter comprehensive information on NPD was provided. Detailed description of NPD definition and process stages were given. The difficulties experienced during the new product commissioning process were detailed. Then, the studies carried out in the literature has been mentioned. The performance criteria required measuring the effectiveness of NPD and the performance evaluation studies made according to these criteria were mentioned. In the next chapter, information about APQP which is used as one of the most effective methods in NPD process both in literature and company applications will be given.

CHAPTER THREE
ADVANCED PRODUCT QUALITY PLANNING

3.1 What is Advanced Product Quality Planning (APQP)?

The ability of a company to survive under competitive conditions depends on the ability to create products that offer superior value to customers and to use it quickly by putting them on the market. Superior quality and project management optimizes the performance of organizations. Product quality planning defines the activities that determine customer needs and develops products and processes to meet these needs. In short, product quality planning is a structured method for identifying and realizing the steps in all processes such as production and marketing, where a new product idea is designed, researched, and designed to ensure customer satisfaction (Sanongpong, 2009).

APQP is a structured process developed by the Automotive Industry Action Group (AIAG) to develop new products using cross-industry teams (Ristow, 2002). APQP is a structured method for identifying and performing the necessary steps to ensure that a product will satisfy the customer. The purpose of APQP is to communicate with the relevant people to ensure that all steps are completed on time. Effective product quality planning depends on a company's top management commitment to the effort required to ensure customer satisfaction. APQP, directing resources to appropriate activities, determining the changes in advance, avoiding late changes, providing a quality product on time and at low cost are the biggest benefits (Khanna, 2005). APQP is a NPD process designed to enable the product to meet design, reliability and quality objectives (Ristow, 2002).

APQP facilitates communication with customers. Detailed requirements are clarified and further decomposed as the process continues. APQP is used in two ways:

1. New Product Production Process;

APQP focuses on the risks that will prevent failures and advance measures in product development processes. With this process, the results of the test are taken by preventing negative results or worse by avoiding problems with the customer. APQP focuses on all areas such as; product and process design, service and process control, packaging and continuous improvement.

2. Product or Process Change:

APQP monitors a product or process change other than Product Development and ensures that it is managed successfully by avoiding the problems caused by change.

3.2 Importance and Benefits of APQP

The APQP process has 3 main advantages over other conventional methods. These advantages are improved product quality, offering products to the market in a short time, and decrease in after sales problems. These advantages are achieved by providing the following principles.

The basic principles of the implementation of the APQP plan are:

Organize the team: The first step in product quality planning is to form a cross-functional team and determine their responsibilities. The team consists of engineering, manufacturing, logistics, purchasing, quality, sales, field service, suppliers and customers.

Define the scope: It is important that the product quality planning team determines the customer needs, expectations and requirements at the earliest stage of the product program.

Collaboration between teams: The product quality planning team must establish communication lines with other customer and supplier teams. This stage may include regular meetings of other quality teams.

Training: The success of a product quality plan depends on an effective training program that provides all the requirements and development skills to meet customer needs and expectations.

Customer and supplier engagement: Primary customers and suppliers must definitely participate in the quality planning process.

Simultaneous engineering: A process where cross-functional teams strive for a common purpose. Simultaneous operation of all sections. The sequential array in which the results are forwarded to the next field for execution replaces the series. The aim is to accelerate the rapid introduction of quality products.

Control plans: Control plans are systems that control parts and processes. A control plan covers three different stages: prototype, pre-series production and mass production.

Solving Problems: During the planning process, the team will face many problems related to product design and / or production. Disciplined problem-solving methods are recommended to solve these problems.

Product quality schedule: The first task of the product quality planning team should be the creation of a schedule plan. The type of product, complexity, and customer expectations should be taken into account in selecting the timing elements to be planned and listed. The schedule graph should show all activities, principals, start and end schedules. Progress points should be recorded to ensure easier reporting of the situation in the project.

Plans according to the timeline: The success of any program is to meet customer needs and expectations at a cost that represents value. It is possible to prevent failures when performed with product and manufacturing engineering activities working as Simultaneous Engineering. The product quality planning team should ensure that the timings are appropriate or earlier than the client schedule (Bobrek & Sokovic, 2005).

The APQP process forces product development team members to ensure that they meet the customer's requirements. The advantages of APQP are;

3.2.1 Product Quality

APQP requires customers to address the NPD process. APQP uses "customer voice" as one of its main inputs to the planning phase of a new product. In addition to communicating all the needs and expectations of the client with the traditional communication methods, APQP also adds direct customer participation at all stages of product development. With this feature, customers are distinguished from the traditional NPD efforts at the beginning of the process and at the stage of verification of the products (Book, Fick, Hopkins, Minkler, & Williams, 2008).

The real purpose of many product designs is to minimize product price. This makes it easier to sell the product, but ultimately brings more cost to the customer. NPD teams should focus on minimizing the cost of ownership with purchasing, production and maintenance costs. Developing design goals with the customer and integrating the customer into the development process enable the team to focus on developing the right product for the application. Continuous communication with the customer during product development reduces the risk of resource spending and the risk of increasing costs in properties without added value (Juran & Godfrey, 1999).

Participation in the supplier's design process is another advantage that distinguishes it from traditional NPD processes. Design engineers are experts in developing new product designs. But it is not expected to be an expert in all processes. As a matter of fact, the level of expertise in the process selection is very limited in terms of cost estimation and evaluation of designs. The best way to achieve the best quality designs is through the participation of suppliers and customers. It is important to provide a team that includes both internal and external suppliers. Expert information from suppliers is crucial to improving the design team's designs. In this way, it can provide early warning of problems and may reduce the design problems related to the process. A design team that clearly discusses new component or assembly designs with suppliers can receive feedback on features related to product quality and reproducibility. Using this feedback, the team can review product quality, reproducibility, and designs to reduce costs. To ensure significant cost savings, a NPD team must be connected to a continuous technical partnership with a supplier (Smith & Reinertsen, 1992).

3.2.2 Low Product Cost

The cost of a product is 70% and 80% is determined during the design phase. While the product development teams are in the design phase, they may not realize the problems to be experienced during the production phase or they may avoid being aware. The cost of making changes during the product development process increases exponentially. Analyzes showed that a 10% change at the end of the product development process was 100 to 1000 times the cost of the change at the beginning of the process. It has also been found that suppliers are involved in the entire process, reducing purchase costs by 10-15%. Product development teams who adopt traditional approaches communicate their designs to their suppliers. Suppliers do not have information on process information, customer requirements and purpose of use, so they offer a high price. APQP avoids the cost of subsequent changes in product design, aiming to integrate suppliers as long as possible, and minimizes procurement costs by taking advantage of suppliers' expertise (Ristow, 2002).

3.2.3 Shortening Time to Market

The APQP process aims to reduce the time to market for a new product. Reduction of time to market is accomplished in several ways: supplier participation, design and control plans for manufacturability (Ristow, 2002).

Supplier participation: Early and continuous supplier participation may lead to shortening of project times. In team meetings, the supplier's involvement ensures that they are aware of the project timeline, which enables them to use their resources effectively to fit the timeline. When the supplier receives engineering presses for bidding, he has knowledge of the design and has already thought about the production process and thus shortens the time of procurement.

Design for reproducibility: for Productivity Design does not only reduce costs and increase quality, but may reduce time to market. This reduces the time to market by changing designs to reduce cycle time and track rejection with these techniques.

Control plans: Planning the quality of a new product begins in the first phase of the APQP process. The team determines the design objectives in the project's Plan and

Identification Program phase. They also establish a product assurance plan that sets out the quality requirements for the successful completion of the project. As the project progresses, this plan is transformed into a Prototype Control Plan, then a Pre-Serial Production Control Plan, and finally a Production Control Plan (Ristow, 2002).

3.2.4 Reducing Problems

APQP minimizes problems with analytical tools needed during product design and development. In a typical NPD process, product design changes, production problems and quality issues arise. The APQP system is designed to identify and eliminate these problems before they occur. The inclusion of process experts, production experts, marketing, sales and quality personnel in the design process reduces the risk of problems (Ristow, 2002).

The purpose of APQP; (Ford Motor Company, 2000)

- Facilitate communication between all persons involved in this program,
- To ensure that all necessary steps are completed on time, at an acceptable cost in quality.

3.3 Evolution of APQP Studies

With the help of the mass production techniques developed by Henry Ford from the beginning of the 1900s, the automotive industry has entered the global agenda with mass and universal production. Previously, labor-art intensive production, ie, manual skills and different (mechanical, hydraulic, electricity, etc.) in the field of knowledge acquired by masters based on deep knowledge, even the local demand has failed to meet. In addition, due to the fact that each of the same parts produced based on manual skills is different, each piece had to be reworked with additional work before assembly (Gün, 2005).

With the techniques developed and improved in the automotive industry, both stages of production processes have become feasible by unqualified workers and production speeds have been increased to meet the high demand, and the engineering specifications and tolerance definitions brought to the parts have enabled usability of the parts in mass production conditions and service (Batmaz, 2010). The issue that occupies the agenda for a long time in automobile main and sub-industrial relations is undoubtedly the creation of a Quality Management System that will be accepted by all automobile manufacturers. To date, the absence of an international management system specific to the automobile industry has led each country's industry to create its own quality systems. In 1991, while the Quality Management System (VDA 6.1) was gained functionality for Germany and then the QS 9000 system was created by General Motors, Ford and Chrysler. Italy AVSQ and France EAQF quality systems were also witnessed. In particular, subcontracting firms have long remained in the void in what kind of certificate or correct definition they should place in their enterprises and what kind of quality system they should place. The sub-industry companies, which try to organize themselves according to the main industrial companies and / or export markets, have been obtained ISO 9001 and / or ISO 9002 certificates and demanded QS 9000 and / or VDA 6 certification. While the variety of certificates and audits has been pushed the sub-industry firms to big costs, at the same time the enterprises has started to spend their day with different audits. This issue, which carries a great burden for the enterprises, has been mentioned by the sub-industry companies on every platform and the demand for the monopolization of certificates and the reduction of audits has been strengthened (Yılmaz, 2001).

The admittance of reciprocal certificates among European car manufacturers has been swiftly achieved through a series of agreements. The chaos about the harmonized and main standards have been experienced between Europe and America. Germany (VDA), which is the leader in this field, has not accepted the QS 9000 which is common and valid in the American continent and has been insisted on own standards. Again, by the establishment of working groups on the initiative of sub-industry firms, a specific technical standard has been started to be adopted by everyone in the automobile industryA technical standard ISO / TS 16949, adopted by the majority and prepared by representatives of the 'International Automotive Task Force (IATF)' and ISO / TS 176, was established. While the VDA 6.1 and the QS 9000 do not accept each other mutually, they both accept ISO / TS 16949. The historical development of quality management systems is shown in Figure 3.1. (Tuğrul, 2008).

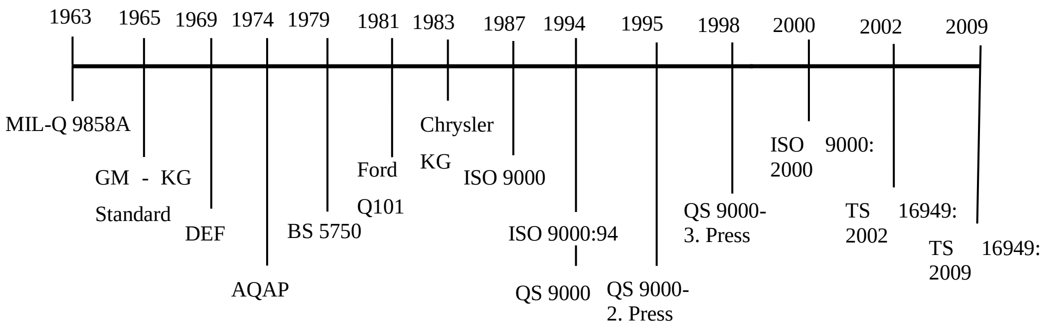

Figure 3.1 Formation of automotive quality management systems from past to present (Toker, 2007)

3.4 Literature on the Use of APQP in NPD

It is very difficult for companies to survive in today's competitive conditions. The first condition to sustain their assets is to meet customer needs and expectations (Ceocea, Oprean, Pop, Sandu, & Titu, 2018). In their work about aviation industry, to ensure customer satisfaction, continuous improvement necessity in terms of new products, security, reliability and continuity has defended. They have been stated that the improvement goal should at least meet these requirements, even if it is not above the level of customer and legal requirements. In order to get a positive customer feedback, improvements depend on managed with a good methodology that aims to ensure that the product development processes of the product from the design to the final market reach the quality of the product. The APQP methodology confirms that products that consistently fulfill all customer requirements expressed or not expressed during the manufacturing process. Ceocea et al. (2018) to plan the APQP process; It has emphasized that the training of the personnel should be a clear understanding of the organization's job descriptions, the good use of all methods and techniques, the use of multidisciplinary approaches, the determination of activities and a good plan. In this way, enterprises provide product quality decontaminated from risks, reduction on risk and reprocessing rates, reduction in waste and scrap, shorter delivery time and lower costs (Ceocea, Oprean, Pop, Sandu, & Titu, 2018).

Lixandru (2016) presents the requirements and expectations of the quality certificates in the automotive sector. During the NPD process, scraps carried out a case analysis study by specifying new product requirements to ensure initial disposal and improvements. In addition, one of the most important points to be taken into account, during the product life of the product to avoid unwanted inconvenience and to ensure customer satisfaction is stated. One of the best ways to achieve this is to perform APQP activities. APQP activities in automotive industry companies have stated that new product processes will help to reduce the failure ppm rates (Lixandru, 2016).

Sanongpong (2009) in their study on Thailand automotive suppliers, they defined the realization of a new product as a process in which a new product idea was designed, researched, produced, marketed. They defined that the process usually consists of five stages. These include; ‘Plan and Define Program’, ‘Product Design and Development’, ‘Process Design and Development’, ‘Product and Process Verification’ and ‘Mass Production, Feedback Evaluation and Corrective Action’. Inappropriately managing of these stages causes to reduce of product performance. For this reason, a revised process-based management concept, the APQP methodology, which focuses on measurements and controls for effective management, has been proposed. The most important performance criteria of the new product realization process are, the relevance, loyalty and support of the management and communication of the team with themselves and the senior management. Effective management of APQP is the most effective key in achieving these performance criteria. In another studies made by Komsan Sanongpong, on APQP, was proposed process management strategies focusing on controlling and measuring NPD. He has mentioned out that there are two rationale behind the strategies. First, the NPD is controlled to help achieve the desired results and to ensure continuous improvements. Second, the performance of the NPD is measured to provide a sufficient level of performance through the creation of appropriate metrics (Sanongpong, 2009). In their study, Kaushik, Khanduja, & Mittal (2012) stated that APQP is an effective methodology based on analytical methods, which is significantly better than other quality management systems that provide detailed statistics. In their work, they provide improvements in new products and existing products using APQP methodology for quality improvement in small and SME. The study has provided a method towards to high quality products and services with low cost for each SMEs. His work has shown that APQP is a multifaceted strategy to improve productivity and has a great potential as a quality improvement strategy with its use in product development. This study has showed how useful management techniques like APQP can be used to improve quality in existing products as well as in NPD (Kaushik, Khanduja, & Mittal, 2012).

Dogu, Ikiz, & Keskin (2008) provided the customer specific conditions to be associated with the steps in the APQP process with the help of the Quality Function Deployment (QFD) process. Work includes; it aims to identify the critical steps of the APQP process in meeting the 'customer specific requirements”. In this way, to ensure customer satisfaction, it will be determined that should focus on which APQP element of an organization in automotive sector. In the results of working; It was determined that 'Feedback and Corrective Action' first, 'Verification and Validation' in second place and 'Process Design' in third place (Dogu, İkiz, & Keskin, 2008).

Lee, Kwon, & Park (2007), in studies, was examined APQP, which has the best tool for providing six sigma and preventing failures in the NPD process and was demonstrated the way to improve the success of the NPD project. In the study, it was stated that it is best practice to use six sigma and APQP in an integrated way in the NPD process. They have stated that the development of new products is very important for the future competitiveness of a business, and if a company does not produce new products on time to the demands of the fast-changing market, it is difficult to guarantee future business. In the study, they have analyzed the factors affecting the performance of NPD. The results showed that APQP and six sigma processes can be very effective for successful development of new products if used as complementary. In addition, using APQP, an integrated model has proposed as a way to solve past problems and manage future ones (Lee, Kwon, & Park, 2007).

Belu, Grecu, & Misztal (2016) have examined the ISO TS 16949 standard. The ISO TS 16949 standard is primarily a quality management assurance system focused on the automotive industry. By applying this quality system standard, automotive manufacturers have stated that they can offer their customers superior products and good services. The methodology for which the ISO TS 16949 standard is most effective is the APQP. This study was focuses on the application of technical characteristics elements in APQP. The case study examined shows how effective adoption of technical tools can help increase customer satisfaction in the automotive industry for powder coating processes. A well-organized process assures that is supplied as minimize demand-related costs and that its image will not deteriorate in the customer's perception, and that future contracts are not compromised. They stated that the use of modern quality management methods in the long run is the only way to control the risk and cost of resources from the development of products and processes in the automotive industry in the current financial and economic context (Belu, Grecu, & Misztal, 2016).

Divoková, Forrai, Kliment, and Solc (2017) have interested with APQP method in their studies. They stated that this method provides production organizations that guide product quality planning which is an important target to meet customer needs. The benefits of APQP implementation in their studies;

- Provides customer satisfaction.
- Prevents non-conformities in the application and use of the product.
- Manages pre-production stages where the most failures occur.
- The process requires only a fraction of the costs that we spend on improper use during product application and use.
- It shows that the enterprise uses all means to ensure customer satisfaction and thus increases customer confidence in the products of the enterprise.
- Correct implementation of quality planning significantly increases the competitiveness of the enterprise.
- Facilitates mutual communication between anyone interested in timely completion of all steps (Divoková, Forrai, Kliment, & Solc, 2017).

Angelevska, Angelevski, Brankica, Kuzmanov, and Zdraveski (2016), in thier studies, have stated that emphasized that quality engineering and especially the automotive industry are facing further challenges arising from global changes in the technical, economic and social environment and they remarked that therefore, depending on the customer needs and satisfaction, companies need high value-added products. It is obvious that they will be able to survive in a competitive environment with a continuous innovative approach aiming to increase the quality of the innovation process as well as product quality. A never-ending cycle of APQP is because of it is geared towards continuous improvement. For a successful new product process, quality (Design Failure Mode and Effects Analysis (DFMEA), Process Failure Mode and Effects Analysis (PFMEA)) should be designed first, then production quality (control plans, process flow charts, measurement system analysis (MSA), capability analysis, process analysis etc.) should be provided. In addition, all customer requirements and needs must be met. APQP provides several benefits to both the supplier and the customer. Not only does it improve quality naturally, it reduces costs and provides a more efficient production process. This means better customer satisfaction and increased income generation (Angelevska, Angelevski, Brankica, Kuzmanov, & Zdraveski, 2016).

Studies show that businesses need an effective NPD process that meets customer needs and expectations in order to gain a significant advantage over their competitors. Having a good NPD and measuring and evaluating the performance of this process, enterprises will gain advantages such as reducing costs, delivering products to the market quickly, reducing scrap and re-processing rates as well as a quality product. Since it is significantly better than other methods in evaluating the NPD process and performance, using the APQP method provides the highest benefit for companies. However, research shows that although APQP is the most effective way to evaluate the NPD process and performance, it is generally used in the automotive industry. The use of APQP in other production lines and systems where the risk rates are high in the NPD process will provide significant advantages to both businesses and literature.

3.5 APQP Process and Performance Criteria in APQP Process

The success of a project depends on meeting customer needs and expectations on time. Product Quality Planning provides failure prevention works with time diagram. If the problem solving methodology is not sufficiently comprehensive, the solution will not be correct and the problem will reappear sooner or later. As shown in Figure 3.2, problems with an activity schedule will be prevented from occurring with Concurrent Engineering studies. The Product Quality Planning Team is responsible for ensuring that the timings are appropriate or earlier than the customer schedule. In Figure 3.3, input and output parameters relevant with the activities is given (Book, Fick, Hopkins, Minkler, & Williams, 2008 and Kaushik, Khanduja, & Mittal, 2012).

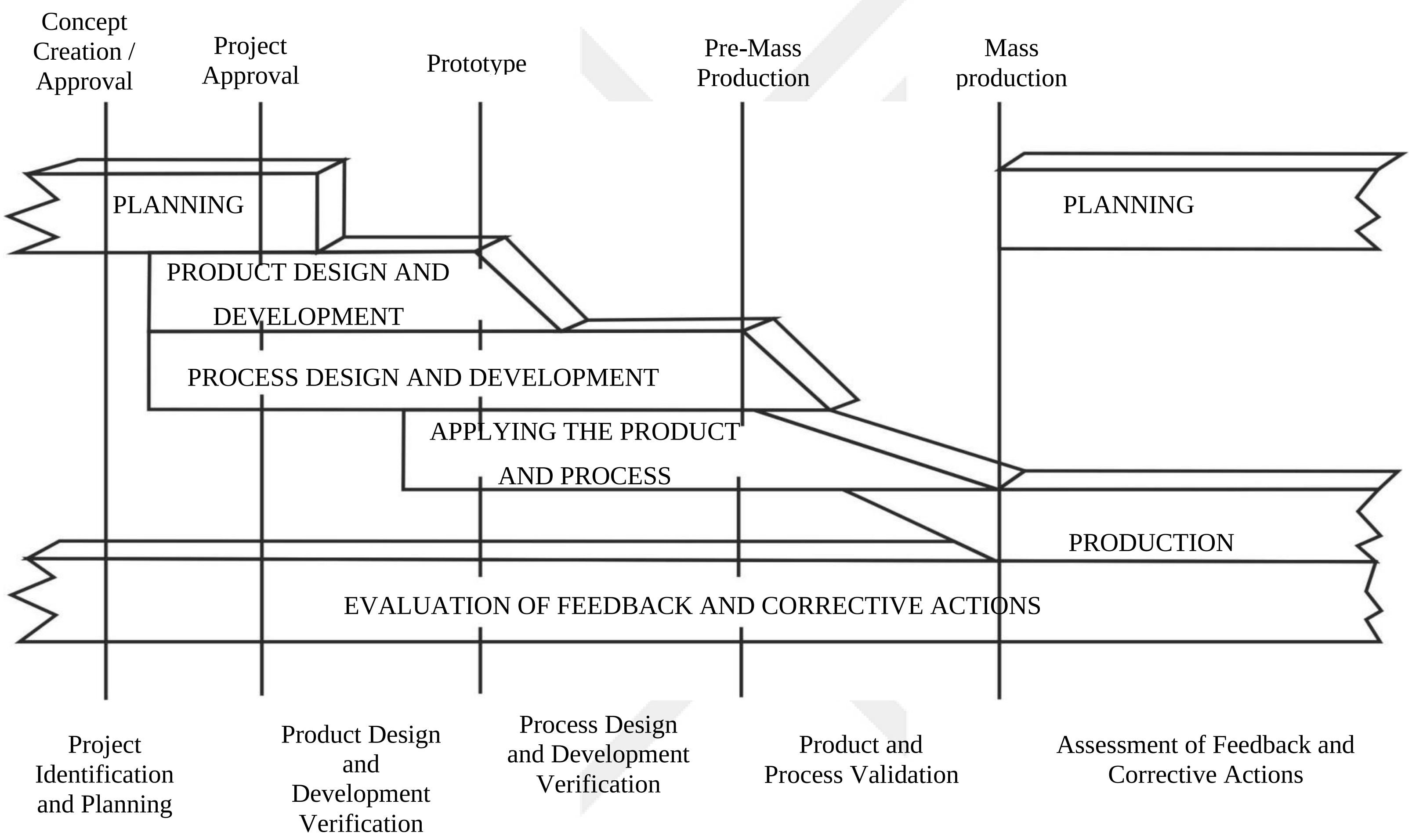

Figure 3.2 Advanced product quality planning time diagram (Book, Fick, Hopkins, Minkler, & Williams, 2008)

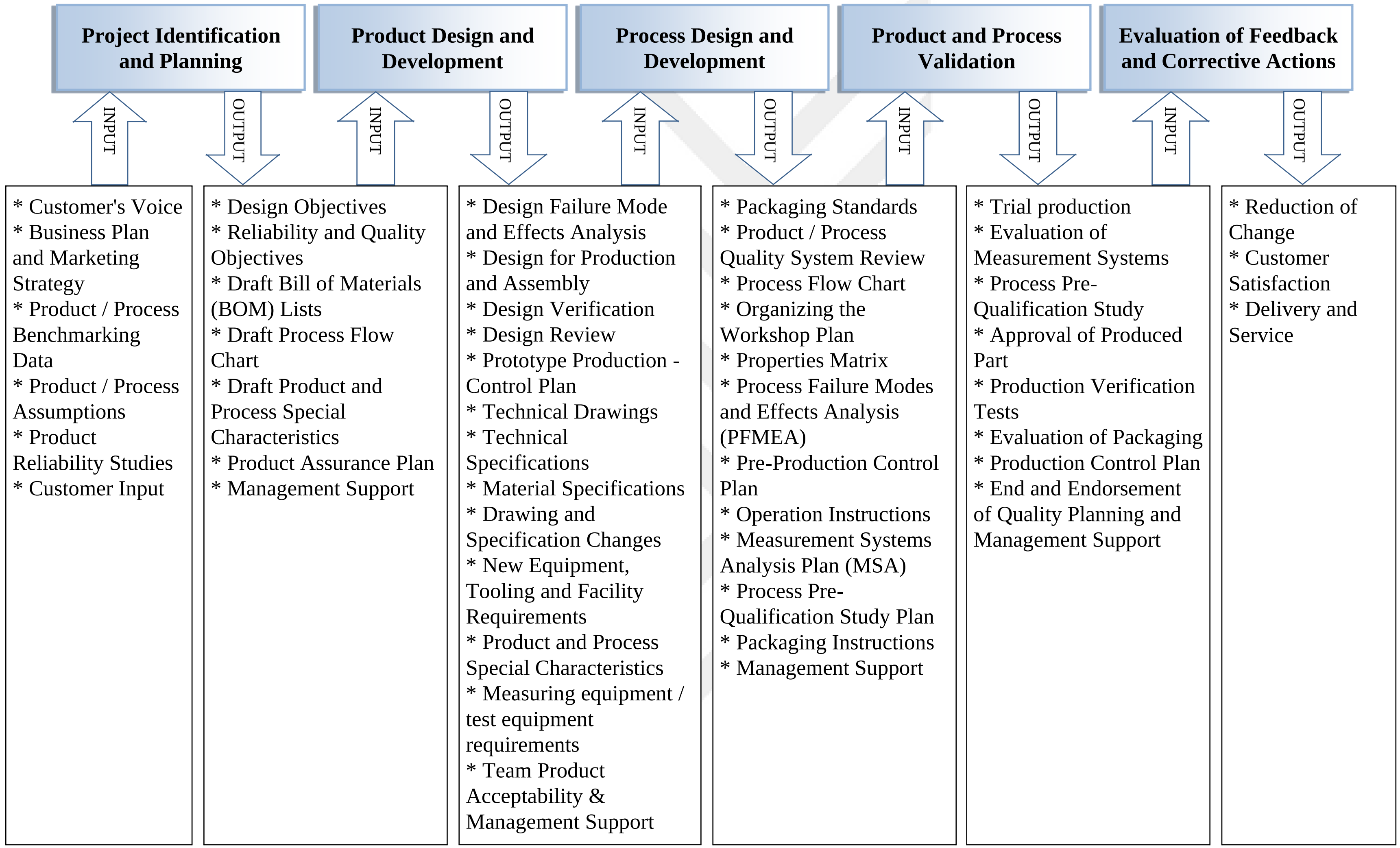

Figure 3.3 APQP inputs and outputs (Eaton, 2013)

3.5.1 Project Identification and Planning

It is the stage in which the customer needs and expectations, complaints, advice, data and information received from customers are determined (Kaushik, Khanduja, & Mittal, 2012). The crucial criterion at this stage is to ensure that customer needs and expectations are well understood. Competitor benchmarking data, quality reports and team experiences are evaluated. Based on the type of product, complexity and customer expectations, a timetable is prepared with a list of tasks, assignments and other events (Kaushik, Khanduja, & Mittal, 2012). The inputs and outputs of this phase differ according to the product, the process, the customer needs and expectations (Dogu, İkiz, & Keskin, 2008).

Inputs;

- Customer's Voice: This includes complaints, suggestions and other information obtained from internal and / or external customers. Market research, past quality reports and experience methods are used to obtain these data.
  - ✓ Market research should obtain data and information to reflect the Customer Voice using methods such as product quality planning team, customer interviews, customer surveys, market tests and market positioning reports, new product quality or reliability studies, examining studies of the quality of competing products.
  - ✓ Past quality reports: A list of past customer complaints and requests should be prepared to assess potential risks during the design, manufacture and use of the product. These should be included in the customer needs analysis. Complaints reports, warranty reports, problem solving reports, customer returns, internal non-compliance reports, etc. help in determining appropriate solutions.
  - ✓ Team Experience: Team, past QFD reports, media reviews, management comments and suggestions, comments from internal customers, legal obligations, service reports, etc. information should be used.
- Business Plan and Marketing Strategy: Business plans and marketing strategies should define the framework of product quality planning. Business plans can

include constraints such as time, cost, and resources. Marketing strategies should define the target customer, points of sale and the status of competitors.

- Product / Process Benchmarking Data: The usage of benchmarking technique is used to provide the necessary inputs for the performance objectives of products or processes. Method of successful comparison;
  - ✓ Determination of appropriate criteria,
  - ✓ To understand the reasons of the differences between the current situation and the competitor,
  - ✓ Improving a plan to close or pass the difference
- Product / Process Assumptions: A number of assumptions should be created about product specifications, design or manufacturing process, including technical specifications, new materials, reliability assessments, and new technologies.
- Product Reliability Studies: parts repair or replacement frequency, long term reliability / robustness tests results should be determined within a certain period of time.
- Customer Input: The needs and expectations of future users of the product should be determined (Book, Fick, Hopkins, Minkler, & Williams, 2008).

Outputs;

- Design objectives are the conversion of Customer Voice into measurable and testable design goals. Choosing the design objectives correctly will ensure that the voice of the customer is constantly involved in subsequent activities.
- Reliability and Quality Objectives: Reliability objectives; should be created by taking into account customer needs and expectations, project goals and reliability comparisons. Reliability objectives; should be expressed in terms of probabilities and reliability limits. Quality goals; targets continuous improvement. For this examplication, the number of faulty parts in a million (PPM), reducing of failure or scrap rates can be given
- Draft BOM: Draft BOM should be created in order to form a sub-supplier list, taking into account product / process assumptions.
- Draft Process Flow Chart: The production processes and flow charts should be defined by considering product / process assumptions and draft BOM.

- Draft Product and Process Special Characteristics: Product and process characteristics should be determined using the knowledge and experience of the customer or supplier. A draft list of specific product and process characteristics should be created by utilizing data such as product assumptions from customer needs and expectations analysis, reliability targets and conditions, estimated production processes, FMEA studies of similar products.
- Product Assurance Plan: Converts the design plan to design requirements. The product assurance plan includes the elaboration of the project necessity draft, the definition of reliability, endurance conditions, improvements technical conditions and failure types analysis and evaluation the elements such as of new technology, complexity, materials, applications, packaging, environment which can put the project at risk.
- Management Support: One of the most important success factors of Product Quality Planning is the support of senior management. The team should inform the management at every stage of the project in order to keep the senior management's support up to date. Management's support should be maintained by showing that all planned requirements are fulfilled and / or that any problems arise are documented and linked to the program for resolution (Dogu, İkiz, & Keskin, 2008).

3.5.2 Product Design and Development

At this stage, the design features and characteristics are developed in a form close to the final form. A suitable design provides production volume, production schedule, engineering requirements, quality, reliability, investment cost, unit cost and timing targets. This section includes prototyping to verify that the product or service conforms to the customer's expectations. It focuses on the fact that the proposed design can be produced, packaged and delivered in sufficient quantity at an acceptable cost (Aras, 2016 and Kaushik, Khanduja, & Mittal, 2012). It uses feedback from other similar projects to develop measures against the current project (Sanongpong, 2009).

Inputs:

Inputs of product design and development phase are outputs of project identification and plannind phase.

Outputs;

- DFMEA: DFMEA is a method that determines the possible failures and their effects on the product in product design and measures are taken. DFMEA is constantly updated according to customer complaints and needs.
- Design for Producability and Assembly: The design functions are designed to optimize the relationships between producability. In addition to customer needs and expectations, suppliers are active in this section. Production and / or assembly process, dimensional tolerances, performance requirements, number of parts, process adjustments, material movements etc. should be considered by Production Quality Planning team.
- Design Verification: It should be confirmed whether product design meets customer needs and expectations.
- Design Review: Review meetings should be held at regular intervals with the participation of suppliers, customers and other relevant units. It is an effective method for preventing project problems, monitoring project progress and reporting to management. Review of design; includes evaluation such as considering design requirements, safety objectives, comparative test reports, DFMEA, Experiment Design etc.
- Prototype Production - Control Plan: Prototype control plan should be prepared to define the dimensional measurements, material and functional tests to be produced during prototype production. These prototypes should be reviewed in terms of compliance with the technical specifications of the product or service and the characteristics of the process, packaging, conformity with the product and process specific characteristics, determination of any problems, deviations or cost effects and notifications to the customer. At this stage, the extent to how meets the customer's voice the product or service is provided by dimensional, material and performance tests.
- Technical Drawings: Technical drawings should include special characteristics, assembly, function, durability, safety regulations. The drawings should be reviewed to determine if there is sufficient information for the dimensional placement of the

parts, the requirements of the appropriate equipment for the controls, and the conformity with the manufacturing and measurement standards.

- Technical Specifications: A detailed examination of the technical specifications will help to determine the function, durability and appearance requirements of parts and assembly. If the sample size, frequency and acceptance criteria are not specified in the technical specification, it is determined by the team and added to the control plan.
- Material Specifications: Physical requirements, environmental, performance, transport and storage requirements should be reviewed and these characteristics should be included in the control plan.
- Drawing and Specification Changes: Drawing and Specification Changes: Changes on team, drawing and specifications should be reported and reported to all relevant departments.
- New Equipment, Tooling and Facility Requirements: New equipment, tooling and facility needs must be identified and added to the timeline in the form of substances and should be guaranteed on time.
- Product and Process Special Characteristics: Special characteristics of products and processes are determined upon customer needs and expectations. It should be determined based on the evaluation of design features and reported on the control plans.
- Measuring equipment / test equipment requirements: Measurement devices and test equipment needs must be determined and timed to ensure timely procurement.
- Team Product Acceptability & Management Support: At this stage, the proposed design should be evaluated in order to produce, test, pack, and deliver it to the customer in sufficient quantity and at acceptable cost. It should be reported as to the feasibility of the proposed design and should be submitted to the management to receive its support (Aras, 2016 and Dogu, İkiz, & Keskin, 2008).

3.5.3 Process Design and Development

At this stage, the development of the manufacturing system and the clarification of the control plan are dealt with in order to obtain products in accordance with the expectations and needs of the customer (Kaushik, Khanduja, & Mittal, 2012). The focal point is to create a process designed at the quality level, quantity and cost, developed at the previous stage, and at the same time ensuring that customer needs and expectations are met (Thisse, 1998).

Inputs;

Inputs of process design and development phase are outputs of Product Design and Development phase.

Outputs;

- Packaging Standards: Generally, the packing specifications are provided by the customer. If there is no specification, packaging design should be done to ensure product integrity.
- Product / Process Quality System Review: The team should review the Quality Guide Book. If additional controls and / or managerial changes are required to produce the product or service, the Quality Guide Book Control Plan must update. In this way, the opportunity to develop the existing quality system based on customer needs and expectations, team expertise and previous experience is captured.
- Process Flow Chart: This is the document detailing the stages of the product to be produced. Used to analyze machine, method, material and labor changes.
- Editing the Workshop Plan: The material flow depends on the process flow chart and the control plan. Assessments should be made towards to location such as workshop layout, control points, accessibility to visual aids, stock areas, faulty product area, repair area.
- Properties Matrix: It is an analytical method showing the relationship between process parameters and manufacturing operations. In this way, it is the document which documents which characteristic is generated at which stage of production.
- PFMEA: It is the document which controls the activities of taking measures by estimating possible deficiencies in the process design.
- Mass Pre-Production Control Plan: After the production of prototypes and before mass production, dimensional measurement, material and function tests are defined.

- Operation Instructions: They are detailed documents that give information about how to perform operations during the production phase.
- MSA Plan: Plan of MSA should be prepared. MSA should ensure linearity, precision, reproducibility of measuring tools and correlation of repeated measurements.
- Process Pre-Qualification Study Plan: A process competence study plan should be prepared and the characteristics to be calculated for the process competence should be determined.
- Packaging Instructions: Product-specific packaging must be designed and developed. Packaging design, product performance and features should not be changed during packaging, transportation and unpacking.
- Management Support: As a result of the process design and development process, an audit meeting should be held for management support (Dogu, İkiz, & Keskin, 2008 and Kaushik, Khanduja, & Mittal, 2012).

3.5.4 Product and Process Validation

At this stage, evaluation of the production process is carried out and approved. It focuses on methods and techniques for determining whether the mass production process can meet all the requirements investigated and documented in the previous stages (Thisse, 1998). In mass production conditions, trial production is carried out in the amount specified by the customer. The team must verify that the control plan, work flow chart and product meet customer expectations (Book, Fick, Hopkins, Minkler, & Williams, 2008).

Inputs;

Inputs of product and process validation phase are outputs of Process Design and Development phase.

Outputs;

- Trial production: Trial production is maked the production on mass production conditions to be used in the production of suitable apparatus, mold, environmental conditions, operator, plant and cycle time.

- Evaluation of Measurement Systems: It is the stage where the control of the suitability of the measurement devices and measurement methods to be used in the production of the product is examined.
- Process Pre-Qualification Study: For the characteristics specified in the control plan, it allows to evaluate whether the process is ready for production.
- Approval of Produced Part: It is confirmed that the product meets the engineering requirements.
- Production Verification Tests: The manufactured product is verified by sending it to tests that check whether it meets engineering standards.
- Evaluation of Packaging: This is to check the product with environmental protection and test instructions that are protected by proper packaging against damage during transportation.
- Production Control Plan: It is the document that defines the systems to be applied for the control of the product and processes. The control plan is a document that needs to be constantly updated by reviewing the experience gained in production.
- End and Approval of Quality Planning and Management Support: The APQP team must ensure that all control plans and workflow diagrams are implemented. An evaluation of the production site should be carried out and the project should be officially terminated, and the approval of the management should be obtained (Book, Fick, Hopkins, Minkler, & Williams, 2008).

3.5.5 Evaluation of Feedback and Corrective Actions

Product quality planning continues after process approval and putting into use of the project. All general and specific variations in the serial production of the product can be evaluated at this stage. All general and specific characteristics specified by the customer must be observed (Book, Fick, Hopkins, Minkler, & Williams, 2008). In this section, the corrective actions are performed to minimize the variability by evaluating the variations and the parameters that cause these variations. The goal is to achieve better product quality and continuous improvement (Toker, 2007).

Inputs;

Inputs of the evaluation of feedback phase are the outputs of the product and process validation phase.

Outputs;

- Reduction of Change: Process variations are created using control diagrams and other statistical techniques. It is used to reduce change with analyzes and corrective actions. Continuous improvement studies should be done to understand the causes of deviation and to reduce these deviations.
- Customer Satisfaction: Procurement of the product or service by the process may not always guarantee customer satisfaction. The product / service must be appropriate in the customer's environment. This is the phase at which most things can be learned. The supplier and the customer must cooperate in making changes to address the existing shortcomings.
- Delivery and Service: Continuous improvement should be continued until service stage. Service, quality, cost and distribution are of great importance to the customer. Failure to correct when a problem occurs will damage the supplier's reputation and disrupt the partnership with the customer. The experience gained during the service phase provides a reduction in the cost of inventory, process and quality and will ensure the right part or system in the next project (Book, Fick, Hopkins, Minkler, & Williams, 2008).

3.6 Production Quality Planning Responsibility Matrix

Responsibility matrix was created as shown in Table 3.1 to show the distribution of product quality planning functions according to suppliers. The purpose of this matrix is to help determine the scope of suppliers' planning responsibilities (Toker, 2007).

Table 3.1 Product quality planning responsibility matrix (Toker, 2007)

	Suppliers with Design Responsibility	Only Suppliers with Production Responsibility
Determination of Scope	X	X
Project Identification and Planning	X	
Product Design and Development	X	
Feasibility	X	X
Process Design and Development	X	X
Product and Process Validity	X	X
Feedback, Evaluation and Corrective Actions	X	X
Control Plans	X	X

In this chapter provides comprehensive information about the APQP method used in the NPD process. The definition has been made of APQP and detailed explanations of the importance, benefits and advantages of APQP. Academic studies in the literature have been mentioned. The developments in the history of APQP are mentioned. Then, the APQP process is detailed and the performance criteria required to measure the effectiveness of the APQP and the performance evaluation studies made according to these criteria has been mentioned. In the next chapter, the problem that ABC Company has experienced during the NPD process will be explained and selected methodology for problem solving and based on the proposed methodology will be given.

CHAPTER FOUR
PROBLEM DEFINITION AND METHODOLOGY

In this section, the problem experienced during the NPD process of ABC Company, which has a production-to-order system will be explained in detail. Finally, a NPD process model will be proposed in accordance with the problem solution.

4.1 Problem Definition

In ABC Company, which has order-based production system, each order is in the scope of the new product. Approximately 15% of the production amount is reproduction in terms of product types produced on annual basis. The remaining 85% production is evaluated within the scope of new product. Many factors, such as product type, dimensional characteristics of the product, material type, product circuit, direction and notation are differentiated the order. For this reason, material properties and production methods are varied for each product which is differentiating. There are exponentially increasing risks in the process of delivering the product on time, in quality and in desired quantity to the customer due to changing conditions. Such risks lead to increased scrap rates, time and cost losses and, most importantly, prestige and consequently customer losses. Along with to order a different product is very difficult and also the number of products ordered is very low. For this reason, making accurate production is required at one time. Under all these circumstances, new product manufacturing and process management at ABC are considerable complex and difficult.

Along with the challenges of having an order-based production system, in order to survive in a competitive environment, the company must offer products to the market quickly, in addition to products that appropriate for customer requests and do not compromise on quality. Because of the deadline of raw material is 6 weeks but deadlines of product are 2 weeks, this status making the NPD process more difficult.

By managing all these challenges in the NPD systematically, producing on the right amount and on correct quality products at the first time is an important constraint for the company. The works to be done for it will put the company ahead of its competitors and increased its profit margin.

4.2 Stage-Gate and APQP Model

Stage-Gate and APQP models are the most common models in the NPD processes in the literature. Both methods have very similar sides. In both models, there are the stages where actions take place, and the gates to which decisions are made on whether to proceed or not to advance to the next step. Although these models create a step-by-step process view, they have the flexibility to allow simultaneous activities. In order to minimize the risk of developing new products with the Stage-Gate and APQP model, parallel or simultaneous activities within a given phase should be designed together. In this way, vital technical and financial information as well as manufacturing and marketing information can be obtained together and the technical risk and project risk of the project can be minimized (Tektaş, 2006).

Stage-Gate and APQP models have many advantages in practice. These advantages; to reduce manufacturing failures, raw material failures and wastage, to focus on the right projects, to ensure good communication between different departments, and to ensure good communication between external stakeholders, including customers, partners and suppliers. They are disciplined process and good roadmap for the Project Leader. These models are easy to understand by everyone. The application forces you to pay more attention to quality. With these models, bad projects are blocked early and these models help resources to be directed to more efficient projects (Cooper, 2008).

In addition to the many advantages of the Stage-Gate model, the fact that it contains a strict disciplinary structure presents some difficulties in application to the enterprises. Gates identified as inter-stage quality control points are often ignored or do not include effective control. For this reason, many projects are allowed to proceed. This causes resource allocation to useless projects. One of the most important problems is that after the project is approved, it is not desired to cancel it. The other problem is the persistent attitude of the top management on a project. The weakness of the gates, ie the lack of effective decision criteria, the confusion of review meetings or Go / Kill meetings, is another common problem. It is also very difficult to define who will be gatekeepers.

The model that every top manager thinks should be gatekeapers, or that gatekeapers are also considered as project leaders, creates problems in implementation. Because of inefficient gatekeapers, meetings cannot be held and effective decisions cannot be made in meetings. Before applying the Stage-Gate model, project teams are left to themselves on what data to collect and how to obtain it. This results in inconsistent data collection. Each department documents all necessary or unnecessary information to guarantee itself. This not only leads to unnecessary redundancy of information, but also to the complexity of gatekeapers' decision-making knowledge. The Stage-Gate model contains very detailed templates. Because of these templates, it is thought that unnecessary works may be encouraged and the development of the team may be reduced if misused (Ayyıldız, Cengiz, & Kırkbir, 2006).

The APQP model is very similar to the Stage-Gate model and has been developed to minimize the problems mentioned above. The APQP model does not contain exact templates, so it is more flexible than the Stage-Gate model. The transitions between the stages have the quality control points contained in the statistical data. The decision of the transition to the next stage gives by project team within the framework of these statistical data. Because of that reasons APQP does not needs gatekeapers. APQP does not contain unnecessary activities, stages, processes. Because of its flexible structure, the activities that are seen as useless with the decision of the project team can be omitted or decreased. Therefore, all resources (time, money, labor etc.) are saved. Since all the individuals in the team have a clear understanding of the activities assigned to them and these activities are planned in accordance with their processes and projects, the uncertainties in carrying out the activities are eliminated and the process owners are prevented from preparing all unnecessary reports in order to ensure that they are not sure which information is required. Although the Stage-Gate model is the most widely used and continuously developed model, APQP has been determined as the most suitable NPD process model within ABC Company due to the advantages mentioned above.

4.3 Methodology

In this study, considering the difficulties in ABC Company has to deal with, a systematic process and product management approach based on key performance indicators will be developed for more effective and quality management of the NPD process.

This study will involve a NPD case in ABC Company, spesifically from the start-up of a new type heat exchanger to the stage of transition to mass production;

- Establishment of quality planning conditions,
- Ensuring more effective communication in product quality planning process,
- Ensuring that the product is produced in a timely and cost-effective manner according to customer expectations and requirements
- Determination of the process elements and those responsible,
- Process evaluation criteria will be established and
- Suggestions will be put forward for the processes that need to be developed or redesigned.

Within the scope of the research, APQP process will be applied for quality planning to avoid potential failures which will occur, which is aimed at continuously improve and to meet of the specific customer requests in the production of new type heat exchanger. With efficient using of APQP in NPD process, will be increased the success rate of the company and to meet the demands and expectations of the customers, to increase the speed to market according to the competitors and to achieve a competitive advantage.

In accordance with the responsibility matrix set out in section 3, ABC Company is classified in “suppliers with only production responsibility’’. The flow diagram of this study to be performed in accordance with this class is given in Figure 4.1.

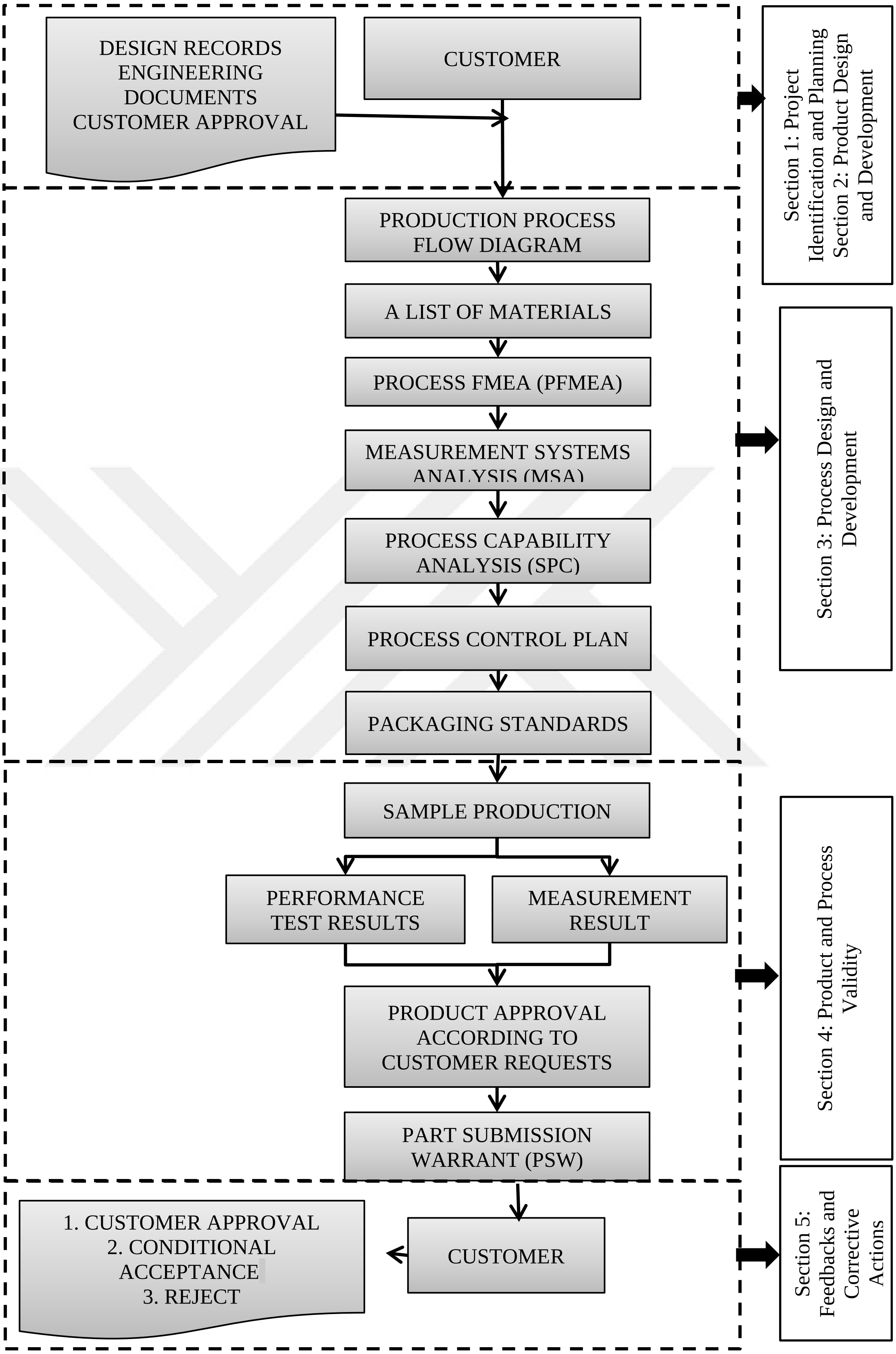

Figure 4.1 Methodology flow diagram

In this chapter, the problem that ABC Company, which owns an order-based production system and which is approximately 85% of the product volume, is a new product, is explained in detail in the NPD process. The similarities and differences between the stage-gate method and APQP method used in NPD have been mentioned. The proposed APQP model for the elimination of the problem in the NPD process is explained and the implementation steps are detailed. In the next chapter, will be mentioned the studies done according to these implementation steps.

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CHAPTER FIVE
APPLICATION

In this section, the ABC Company, which have an order-based production system and its products will be introduced, and the company's perspective on the NPD process will be examined. Then the application in the methodology proposed for the NPD process of the company in accordance with the flow will be implemented.

5.1 Information on the Case Company

ABC Company was established in 2004 on a 3200 m^2 production area with a total area of 6500 m^2 in Atatürk Organized Industrial Zone. It is one of the leading companies in the industrial refrigeration and heat exchanger production sector.

In 2012, it was moved to its new factory located in Manisa Organized Industrial Zone with a covered area of 12.000 m^2 with a total area of 17.500 m^2. In its new factory, it has increased its production capacity and offered better service to its domestic and foreign customers. ABC Company is imported the products it’s produced to Middle East, Africa and Europe.

The main principle of ABC Company is to provide customer focus and high-quality product production. For this reason, the Company has Eurovent Certificate as a product certificate and carries out its activities in accordance with TS EN ISO 9001: 2015, TS EN ISO 14001: 2015 and TS 18001: 2014 certificates.

5.2 Product Introduction

ABC Company have specialized in the production of industrial refrigeration and heat exchangers. Heat exchanger is a device used to transfer heat between one or more fluids. To avoid mixtures, the fluids may be separated by a solid wall or can be in direct contact (Kiran, Nagaraj, & Rajgopal, 2016).

Heat exchangers have two different application areas. These; Industrial uses and uses of in daily life.

Industrial Uses of Heat Exchanger;

- Heating and cooling of buildings
- In cooling installations of petrochemical and power plants,
- In ship building, paper manufacturing, wastewater facilities, cooling installations of heat recovery plants,
- Briefly, it is widely used in many industrial sectors.

Heat exchangers used in daily life;

- Car radiators,
- Air heaters
- Oil coolers
- Split air conditioner serpentines
- Water heaters in boiler

5.2.1 Product Types in ABC Company

5.2.1.1 Heat Exchangers with Water

- Hot-Cold Water Heat Exchangers

It is produced in suitable dimensions and capacities by is optimized the mechanical and thermal design. With the right design, by is avoided oversize, both economy and reliability are prioritized.

Application:

- ✓ Commercial and residential air conditioning systems
- ✓ Commercial and residential cooling systems

- Steam-heat exchangers

It is manufactured in suitable sizes and capacities. With the right design, by is avoided oversize, both economy and reliability are prioritized. For this reason, the circuit should be designed to pass through a single pipe.

Application

- ✓ Commercial and industrial heating system
- ✓ Commercial and industrial drying system

5.2.1.2 Heat Exchanger with Gas

- Evaporators: By optimizing the mechanical and thermal design, design in suitable sizes and capacities are realized. With the right design, by preserving pressure drops of both the air side and fluid side are worked to ensure the best performance. By is avoided oversize, both economy and reliability are prioritized.

Application

- ✓ Commercial and industrial cooling systems
- ✓ Commercial and residential air conditioning systems
- ✓ Heat pumps

- Condensens: By optimizing the mechanical and thermal design, design in suitable sizes and capacities are realized. With the right design, by preserving pressure drops of both the air side and fluid side are worked to ensure the best performance. By is avoided oversize, both economy and reliability are prioritized.

Application

- ✓ Commercial and industrial cooling systems
- ✓ Commercial and residential air conditioning systems
- ✓ Heat pumps

- Car Air Conditioning Coolers: Evaporator, condenser and heater battery are produced for car air conditioning systems via sample or approved technical drawing.

Application

- ✓ Trail
- ✓ Bus

- Bus Convectors

- Air Cooled Products

  ✓ Air Cooled Evaporators: Standard cold room evaporators have a wide range of products to meet the needs of customers. In the evaporators, aluminum lamella with 4, 6, 8, 10 and 12 mm spacing of blades and 1/2 6 copper pipes are used. They are manufactured without fans as standard. Fan can be added on request. Application; Commercial and industrial cooling systems

  ✓ Standard Conderser: Standard Condenser Batteries are designed as suitable to working in all outdoor conditions. It has a wide range of products to meet the needs of customers.

  Application; Commercial and industrial cooling systems

5.3 Company Organization Chart and Workflow

ABC Company has 11 departments. These; Senior Management, Management Information Systems, R & D, Engineering, Production, Technical Affairs, Planning and Purchasing, Sales and Marketing, Special Projects, Financial and Administrative Affairs and Quality Assurance Department. All departments are hierarchically structured, but separated from each other on a task basis. The information flow is provided between all departments. A team is formed from incumbents of the relevant departments in project-based jobs. Projects, NPD, KAIZEN, Single Minute Exchange of Dies, Poka Yoke, 8D are the projects based on continuous improvement, such as problem solution. The detailed organization chart of the company is as in Figure 5.1;

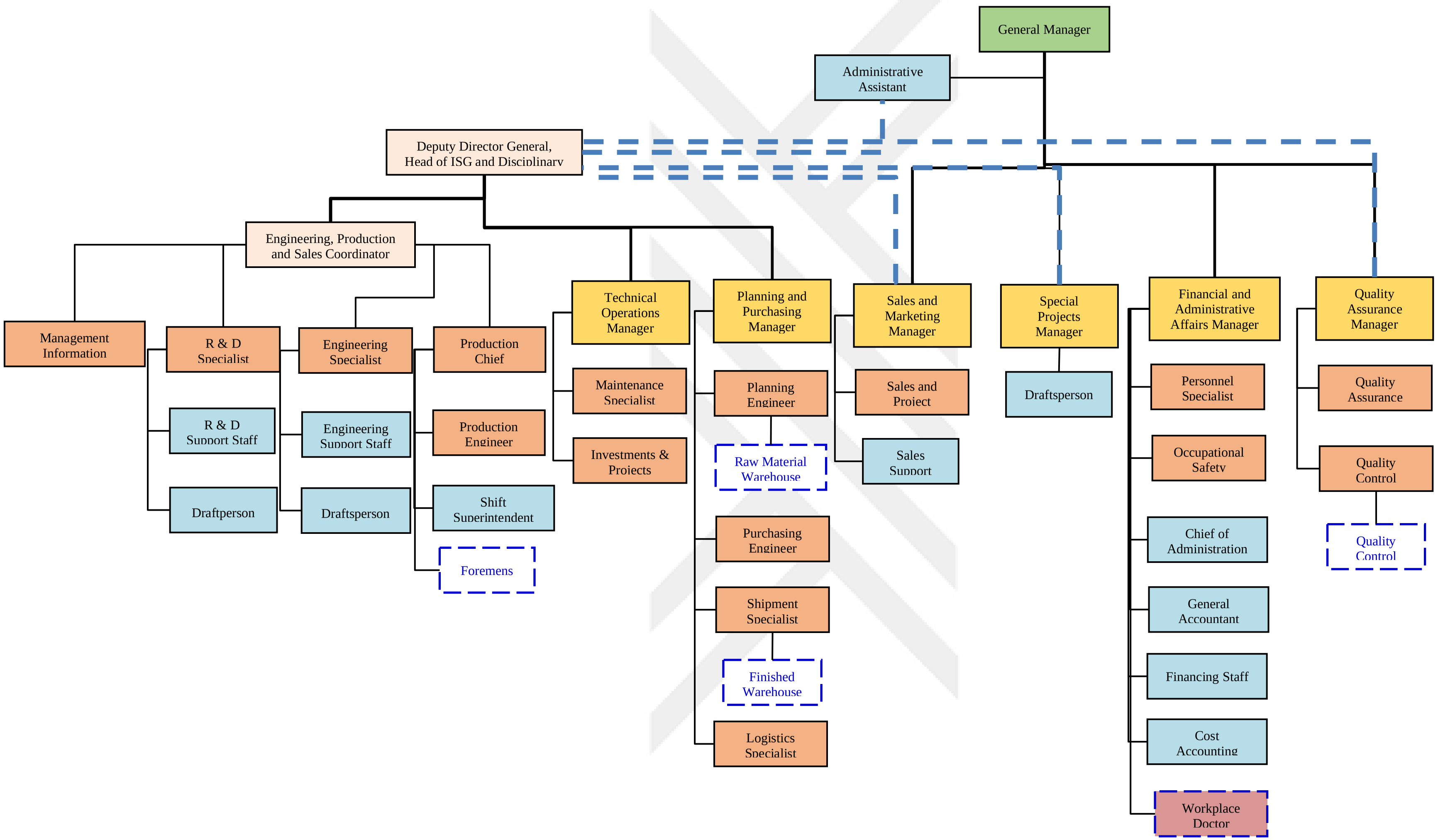

Figure 5.1 Organization chart of ABC Company

Figure 5.1 the tasks related to the NPD process of the departments specified in the organization chart are as follows.

Senior management;

- To provide financial resources relevant to the investments that will be made to fully meet the expectations of the customers.

Engineering;

- To participate in the feasibility meetings relevant to products that come with customer demand and to determine product feasibility with production and technical affairs department.
- Being dominated all processes related to NPD; working in coordination with other team members.
- In accordance with customer needs and expectations; planning and drawing of new product technical drawings that will be drawn, to ensure that the control as accordingly to customer demands and expectations, customer specifications and technical specifications, forward to sales and marketing department for customer approval.
- Delivering the new product drawings for taking the customer approval to the planning and purchasing department for opening a work order.
- To identify the factors affecting the problem and flow in the process and to participate in studies to eliminate obstacle factors. To request corrective / preventive actions for the current / potential nonconformities it has identified regarding the process. To correct the corrective / preventive activities initiated in relation to the department within the deadline date.
- Ensuring the archiving and supervising the engineering documentation and product images of NPD activities

Production;

- To participate in the feasibility meetings relevant to products that come with customer demand and to determine product feasibility with engineering and technical affairs department.

- Ensuring the production of new products in accordance with customer requirements and expectations within the specified deadline date.
- To plan the operators to be assigned in the production of new products, and to request training in the relevant departments for training if necessary.
- Determining the materials, equipment, tools and devices needed for production and informing the planning and purchasing department and ensuring the procurement. To determine whether the equipment used in production is proper and to report the improper ones.
- Performing production in accordance with the prepared operating instructions, providing controls in accordance with process control plans, keeping under control the unsuitable product / products, performing corrective action. To pack the finished product in accordance with the packaging instructions.
- Identify the factors affecting the problem and flow in the process and participate in the studies to eliminate the obstacle factors
- To coordinate the processes owned on NPD process and to manage the activities in order to achieve their goals.

Technical Affairs:

- To create the infrastructure that will carry out the desired tests according to the customer demands according to the appropriate standards.
- To participate in the feasibility meetings relevant to products that come with customer demand and to determine product feasibility with engineering and production department and making evaluations for new investments.
- Co-ordinate and implement the activities required for the commissioning of investment decisions.
- Manage machinery, equipment, existing facilities and infrastructure renovation activities
- To manage the design and image activities and to ensure the commissioning for new mold and apparatus needs as requested by the relevant departments for new product production. To provide to work in coordination with the planning

and purchasing department in order to produce the needed molds and apparatus inside or outside the company.

- To organize the identification of critical spare parts related to new machinery, molds and apparatus and to organize activities related to their stocking.

Planning, purchasing, logistics:

- Making production plan according to new product order and to control it in coordination with production department
- Carrying out the activities of determining the capacity planning and resource need in the transition of the new product to the mass production stage in cooperation with the production department.
- Creating a list of materials for the production of new products and to include in the MRP plan.
- Ensuring issue, a work order of the new product.
- Ensuring the delivery of the products at the planned time to the desired places according to the customer demands and legal regulations.
- Ensuring the realization of product / service procurement in accordance with the demanded and / or determined requirements for the production of new products. Making the cost analysis studies related to purchases and reporting to the NPD team.
- Sending the first sample order and the required technical and commercial documentation to the suppliers.
- Organize a meeting if necessary. To initiate corrective actions to the supplier related to the products identified as nonconformity in the input quality control process and to solve all commercial and technical problems, and to improve cooperation.

Sales and Marketing:

- To carry out research activities related to new projects, to create marketing strategies appropriate to research results and to present these strategies to senior management.

- Ensuring the all commercial terms that have already been negotiated with the customer are specified in detail.
- In order to obtain, understand and evaluate customer quotation requests, including the team feasibility studies, ensuring coordination with the relevant departments and managing the bidding process
- Managing cost analysis by working in coordination with engineering department for request of proposal.
- Managing and finalizing the activities necessary to create a new product sales contract with customers
- Manage the process of receiving feedback from the customer to ensure customer satisfaction (Customer visits, making customer satisfaction survey, complaint management, etc.)
- Ensuring the starting of the studies like the initiation, review and improvement of the feedback received from the customer, and organizing these works with the relevant departments.
- Ensuring that the technical drawing transmitted from the engineering department is communicated to the customer and approved and sharing the feedbacks received by the customer regarding the technical drawing with the engineering.
- To inform the customer about the deadline delays resulting from the company.

Financial and administrative affairs:

- Ensuring that all expenditures to be made for the production of new products are monitored effectively. If the resource is insufficient, investigating the source with the approval of the top management.
- Managing staff training requests of relevant departments. Ensuring the realization of business procurement activities in case of lack of personnel by related departments.

Quality assurance:

- To participate in the feasibility meetings regarding products that comes with customer demand, to determine the feasibility of quality control of the product.
- Identify and identify possible weak points in the new product or new product manufacturing process; to manage the activities that will take the corrective measures for the elimination of these weaknesses.
- Managing the activities required for the follow-up, registration and analysis of feedback from the customer
- Determining the test and measurement equipment required in the quality control stage. Supplying the missing ones and to perform the activities of performing the calibration of existing test and measurement instruments.
- Ensuring the control, updating and distribution of the prepared operation and packaging instructions. Manage activities that ensure the product is made in accordance with the instructions, keeping records and providing traceability.
- Managing the quality control of raw materials and materials in accordance the quality plans, recording their records and managing the traceability
- Conducting activities that ensure the final quality control of finished, packaging-ready products in accordance with the quality plans, keeping records and traceability
- Determining the nonconformities in the quality control points in the processes, using the authority to stop the production, managing the activities required to be recorded and monitoring the non-compliance until the undesirable situation is eliminated.
- Checking the qualifications of the quality control staff and informing the relevant departments for the training of insufficient personnel. Determining the areas where the quality control elements control and ensuring their rotation when necessary.
- Planning and implementation of laboratory studies
- Making studies for determination of the devices, methods and other technical specifications in the laboratory, determining the standards and publishing guide documents.

- Providing archiving of all documents related to laboratory activities and controlling.

Ensuring to maintain of the ABC Company productions in a standard workflow. Each order is included in the production as a technical drawing work order in accordance with the production plan. Technical drawings are drawn according to customer design, customer specific requirements and firm standards. The drawings are distributed to all relevant sections. The production is started with semi-finished products. There are three main semi-finished production lines and one auxiliary semi-finished production line. These four lines pull the materials from the raw material storage area in accordance with the specifications specified in the work order / technical drawing.

The production lines shown in Figure 5.2 are as follows;

Input quality control; the process in which the raw materials and / or semi-finished products purchased according to the customer order are checked in accordance with the customer requirements, company conditions and standards.

Hairpin semi-finished production line; different diameter and thickness, copper or aluminum pipes are cut to the desired size, hairpin-shaped pipes are produced. In addition, according to the product specifications, the pipe production the desired size is carried out on this line too.

Honeycomb production semi-finished production line; the production of honeycomb is made in accordance to the number of rows, pitch, number of pipes, notation and material properties which are determined on the work order. (flat aluminum in various thickness, epoxy coated aluminum, hydrophilic aluminum, copper foil).

Sheet metal cutting and curling semi-finished production line; is the line in which the sheet is cut and curled in accordance to line number, number of pipes, notation, width and height dimensions, crimp properties and material properties which are determined on the work order (aluminum, copper, galvanized and non-rustable in various thicknesses).

Collector auxiliary semi-finished production line; is a line which is made of specified size of the cutting and brazing operations in accordance to the line number, circuit direction, material specifications (various thicknesses, aluminum, copper and steel pipe).

Assembly production line; It is the process of combining the materials coming from 3 main semi-finished production lines according to circuit direction, circuit, material properties, technical dimensions and customer special requests according to work order.

Post-Assembly Quality Control; It is the process of checking the products coming from the assembly production line in accordance with the number specified in the sampling instruction. The points to be considered are the circuit direction specified in the technical drawing, material properties, dimensions specified in the technical drawing and customer specific requirements.

Expansion production line; is the line in which fixed to the combs by expanding the pipes of the products passed through quality control. The selection of the expansion apparatus according to the pipe properties (material type, wall thickness, diameter), the circuit and the product size are important.

Brazing production line; it is the production line which is the product that coming from the expansion production line, solder collectors coming from the collector auxiliary semi-finished production line, other materials (fittings, purjör, distributor, nipple, etc.), and curves, in accordance with the direction the circuit.

Post-Brazing Quality Control; is the quality control point where the circuit, circuit direction, collector dimensions, other product dimensions, auxiliary material properties, customer special requests and visual controls are made of the products coming from the brazing production line.

Leakage test; is the line where the working pressure of the products is 1.43 times the dry air inside the product and the bubble test is performed in the water pool where the products that have been approved for quality control are requested by the customer or where the customer request is not stated. All products have passed from the 100% leakage test.

Cleaning, painting and labeling; it is the line in which is products are visually prepared, cleaned, if the customer is requested to paint in special request, the desired color is dyed and dried, the material properties, the product entrance exit direction and if there are customer specific labels are attached, the gas heat exchanger is the line where the nitrogen gas is printed and the label is attached.

Final Quality Control; It is the stage where the whole product is visually checked for labels, impact, crush, tearing in the combs.

Packaging; if the customer has special requirements, the product is packaged in accordance with the requirements and if it is not any demand from customers then it is packaged in accordance with the company standards. The product is ready to be shipped.

Delivery; if the customer has special requests, delivery is occurred in accordance with the requests, if not; according to the company standards is the stage of the referral process.

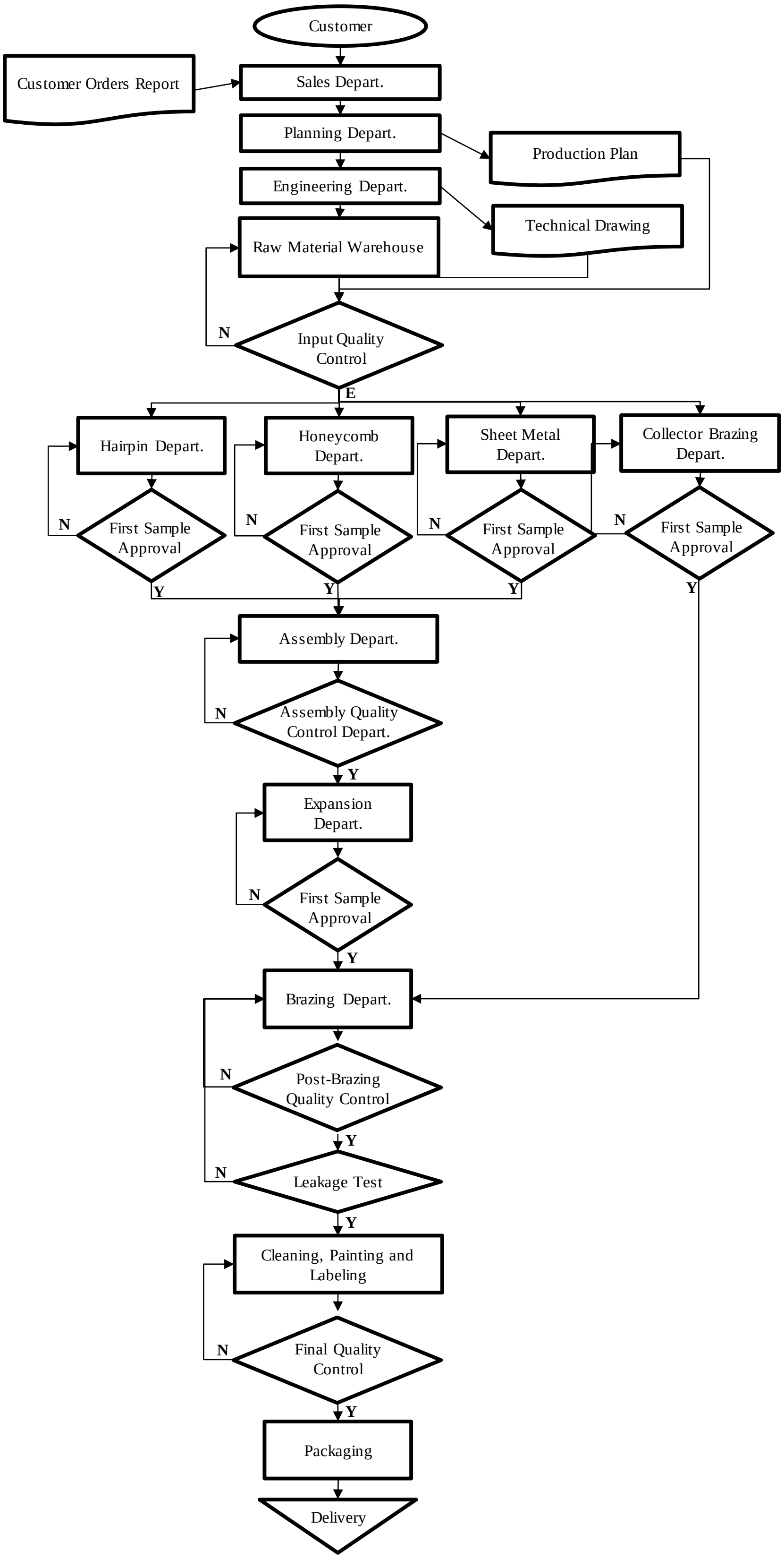

Figure 5.2 Production workflow

5.4 Company NPD Process

Figure 5.3 shows the workflow for ABC's new product manufacturing process.

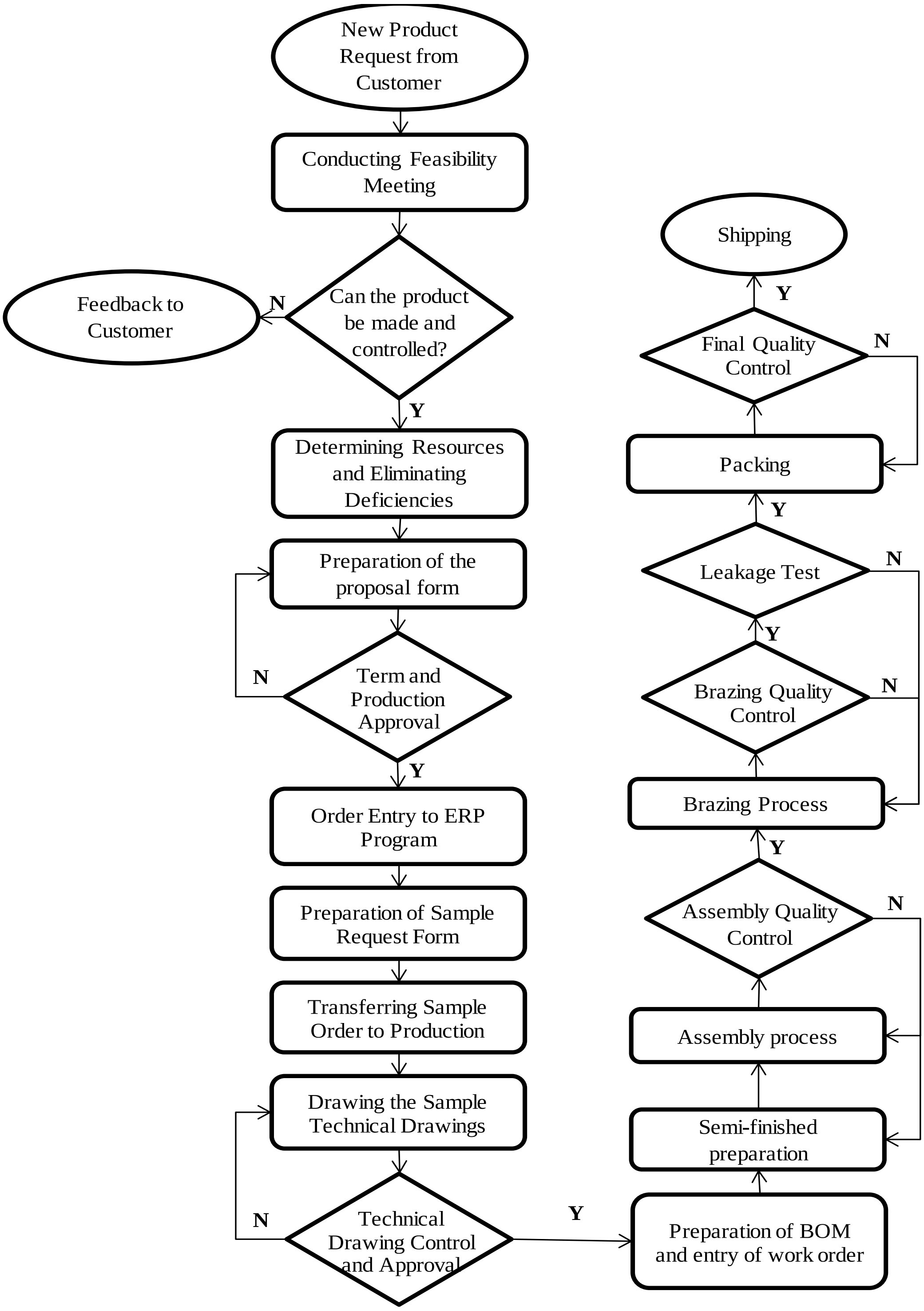

Figure 5.3 New product workflow

As indicated in the Figure 5.3 workflow diagram, the new product manufacturing process starts with the receipt of the demand from the customer and ends with the product being shipped to the customer. Each process is separated by precise lines and is independent of each other. It is not possible to move from one process to another without completion. In addition, the process is not managed by the team and there is not a team leader. Each department is responsible for its own processes, it is not interested that the processes in other departments and whether or not process objectives are achieved. The senior management is solely responsible for providing resources and is not interested in team formation, motivation, leader identification and supervision. Process capability is not measured and measurement systems are not analysed. Therefore, product quality may be lower than expected. Risks are not defined in advance and precautions are not taken. When problems occur, it is solved with a reactive approach. The prediction regarding the deadlines is poor and due to the possible problems cannot be detected, the deadlines are delayed. These and many other challenges, the APQP methodology will be implemented in line with the flow described in Figure 4.1 for the NPD process for ABC Company.

First Section of APQP Method: Project Identification and Planning and Second Section: Product Design and Development, as the product design belongs to the customer, all necessary information will be provided by the customer.

5.5 Section 1: Project Identification and Planning and Section 2: Product Design and Development

This section contains the new product design delivered by the customer and feasibility studies carried out to determine whether this design can be made at ABC will be applied.

5.5.1 Introduction of the Product that is Subject to Study

The product, which is the subject of the study, was created with the demand of Japan partner customer; it is the evaporator which is the main component of the vehicle air conditioner system which will minimize the heat transfer of the part allocated to carry the product. Part number and part name is “12345 Aluminium EVAP PETEGI

Al/Al”. The other term of the evaporator is the cooling coil. Evaporator is the part where the refrigerant fluid enters as a liquid and exits in gas form after it evaporates. When the refrigerant enters the channels of the evaporator, it absorbs heat from the refrigerated material or environment and, while absorbing heat from the environment, the refrigerant begins to boil and evaporates. As a result of these operations, the evaporator achieves the general purpose of the whole system, cooling. The cooling performance depends on the surface area of the evaporator, the total heat transfer coefficient and the temperature difference between the refrigerant and the material being cooled (Evaporatör nedir? 2019).

Taking into account many reasons such as vehicle type and capacity, air conditioner technical characteristics, climate characteristics in which the product will be used, product design and technical specifications have been determined together with customer to provide the most effective performance. The light weight is an important limitation as the product will be used in commercial vehicles. For this reason, the frame sheet, pipes, honeycombs and auxiliary parts of the product are designed as aluminium. The product has a gas cooling system. Since the fluid is gas, the product operates under a pressure of 20 bars. For this reason, the product must be subjected to a leak test under a pressure of more than 1.43 times the working pressure. The product will be tested under dry pressure of 35 bars for 2.5 minutes. The design, which is designed to ensure that the product operates according to the desired performance level, is given in Figure 5.4. According to product design, inlet connection is designed as distributor and outlet connection is designed as collector. The most suitable notation for performance was determined as 2522-2.1-5G-06-1050-05-XX. The detailed expansion of the notation is as in Figure 5.5.

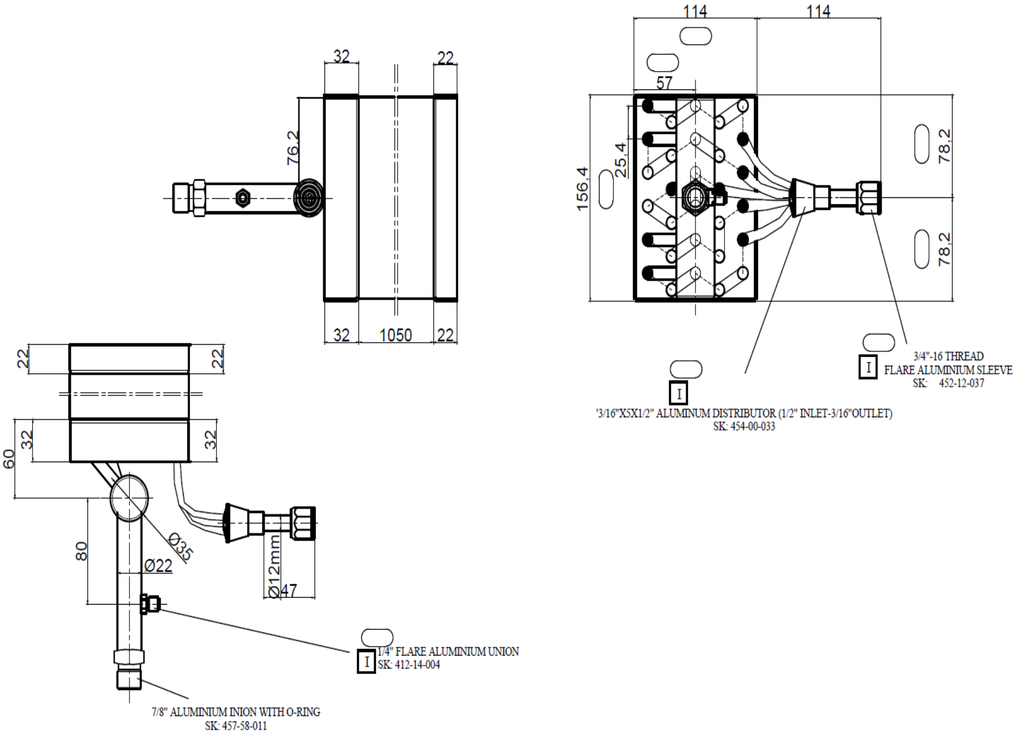

Figure 5.4 New product design

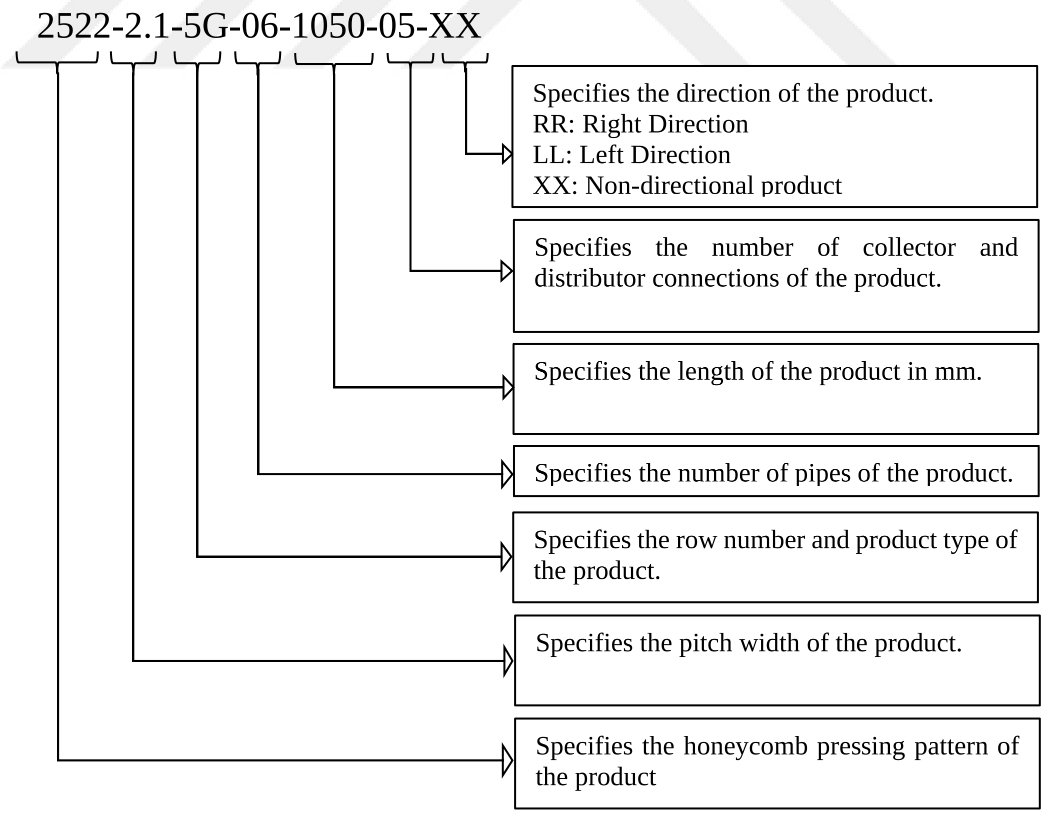

Figure 5.5 Product notation expansion

5.5.2 Feasibility Studies

Feasibility meetings are held in order to evaluate the feasibility of the order from the customer in terms of time, money, raw material and labor. With feasibility studies, all relevant departments evaluate whether the product can be made before order approval is given. In this way, losses, nonconformities and customer complaints that may occur later will be prevented.

The feasibility meeting was made with the participation of all department managers along with the order received from the customer. The new product project leader is unanimously elected at these meetings. The feasibility report of the meeting is given in Appendix-1.

According to the meeting report, the product can be made under the conditions of ABC Company. The packaging conditions are in the standards that ABC can provide. Product raw materials were evaluated and stock controls were provided. Some changes have been requested on the customer's technical drawing in order to use the product effectively and to avoid nonconformities. Due to the fact that the product is completely made of aluminium material and the softness of the aluminium material, it causes product wear in case of faulty use. The union is connected to the collector connections for product assembly. Flare is opened to the pipe end for union connection. When the product is being assembled, an incorrect force during the crimping of the union will cause the flare to corrode and therefore the assembly cannot be performed. In order to prevent this inconvenience, it was decided to make the union connection pipe from copper pipe which is a harder material by making use of technical accumulation. This issue will be communicated to the customer by the Sales and Marketing department and customer approval will be obtained.

The meeting was concluded with the approval of all departments. According to the meeting resolution, Sales and Marketing Manager was selected as the leader for this project.

5.6 Section 3: Process Design and Development

The product design was examined and the feasibility of ABC Company was approved at the feasibility meeting. Based on the past experience of ABC Company, customer approval has been obtained for the solutions proposed by them in product design and the product design has been revised in accordance with these solutions. The process design and development stages were initiated under the leadership of Sales and Marketing Manager, the leader of the new product project. In this section, production workflow, product material list, Process FMEA, MSA, Statistical Process Control (SPC), Control Plan and Packaging standards studies will be done.

5.6.1 New Product Production Flow Diagram

Product production flow diagram; same as standard production line. The technical drawing is drawn in accordance with the customer technical drawing, customer requirements and ABC Company requirements. Work order is created with technical drawing. After the technical drawing is distributed to all related processes, the production process starts. The production workflow is detailed in Appendix-2.

5.6.2 BOM for New Product

According to the product drawing, the materials to be used to produce the product are determined during the creation of the department-based work order. According to the determined raw material list, usage amounts are determined on the basis of quantity and kg. The stock status of raw material quantities is controlled by running MRP program. After determining the availability of stock status, the work order is approved and given to production. The raw materials, semi-finished product names and consumption list for the new product to be produced within the scope of the study are given in Table 5.1 below.

Table 5.1 Material requirements list

No.	Code	Component Name	Amount
1	110	2 mm 1200x2400 mm Aluminium Sheet	0.53 kg
2	111	280X0.10 mm Aluminium Foil	2.54 kg
3	115-1	3/8"X0.60 mm Coil Aluminium Pipe	1.60 kg
4	115-2	Ø35X1.5 mm Straight Aluminium Pipe	0.08 kg
5	115-3	Ø22X1.5 mm Straight Aluminium Pipe	0.05 kg
6	417	3/8"X0.80 mm-25.4X22 mm Aluminium Curve	10.00 pcs
7	115-4	3/8"X1 mm Aluminium Coil Pipe	0.19 kg
8	412	1/4" flare aluminum union (7/16"-20 thread) (Standard) [AA12 mm]	2.00 pcs
9	457	7/8" Aluminium Union with O-Ring (7/8"-14 thread) (Input:22 mm) [AA24 mm]	1.00 pcs
10	452	3/4" Flare Aluminium Sleeve [AA24 mm]	1.00 pcs
11	415	Ø35X1.5mm Convex Aluminium Plug (Material Thickness: 2 mm)	2.00 pcs
12	115-5	1/4"X0.80 mm Capillary Aluminium Coil Pipe	0.03 kg
13	115-6	Ø12X1 mm Straight Aluminium Pipe	0.03 kg
14	454	3/16"X5X1/2" Aluminium Distributor [Ø28 mm]	1.00 pcs
15	411	3/8"-1/4" Aluminium Aspirin [Ø12 mm]	5.00 pcs

5.6.3 PFMEA

FMEA systematically examines all types of defects that may occur in the production of a product and tries to prevent it from occurring. Therefore, it is a systematic process used for reliability analysis. Improves operational performance of production cycles and reduces overall risk level (Arena, Centazzo, Saccarola, & Scipioni, 2002).

FMEA; identifies potential failures and blocks them before they occur and to ensure that the product meets customer needs and expectations (Duru, Koç, & Taş, 2011).

Improving the quality, reliability and safety of products, reducing time and costs for product changes; documentation and monitoring of measures taken to reduce risks; help to establish strong control plans; identifying possible failures and assessing the severity of these failure effects; ensuring mass without problem and better customer deadlines by eliminating weak points in products and processes and preventing problems; to assist in determining critical and important product characteristics; lower production costs; further improvement of customer service; significantly reducing defects in product development, manufacturing and use phases; preventing faulty product developments and customer complaints; eliminating or preventing repeated failures; reducing the danger of recalling products from the field due to faults is a major FMEA benefit (Aran & Çevik, 2009).

PFMEA application steps are as follows:

5.6.3.1 Determination of Scope

FMEA covers all the processes necessary for the production of X gas evaporators. Processes; purchasing, input quality control, production, process quality control, performance tests, packaging, final quality control, transportation, after-sales services.

The form indicated in Figure 5.6 will be used for FMEA studies.

ABC

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (PROSES FMEA)

FMEA Number:	1	Prepared by:	2
Part Number / Name:	5	Process Responsibility	6
FMEA Date (Orig.)	3		
Model Year(s)/ Program(s)	7	Key Date	8
FMEA Date (Rev.)	4		
Core Team	9		

							Current Process							Action Results				
Process / Function	Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Classification	Potential Causes(s) of Failure	Current Process Controls Prevention	Occurrence	Current Process Controls Detection	Detection	R.P.N	Recommended Action	Responsibility & Target Completion Date	Actions Taken & Effective Date	Severity	Occurance	Detection	R.P.N
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28

Figure 5.6 PFMEA form

The explanation of the form according to the numbers given in Figure 5.6 is as follows:

1. FMEA No: The number is written for the control and traceability of PFMEA.
2. Author: Name of the Team Leader / Engineer responsible for the creation of PFMEA is written.
3. FMEA Date (Org.): The first PFMEA creation date is written.
4. FMEA Date (Rev.): If PFMEA has been revised, the revision date and number is written.
5. Part No / Name: The analysed product name and / or stock code is written.
6. Process Responsible / Department: The name of the department or group responsible for the design of the process is written.
7. Model Year/ Product: The model year and code of the analysed product and are written.
8. Key Date: Planned deadline is written.
9. Team Members: The names of the team members responsible for the development of PFMEA and the names of the departments are written.
10. Process Step / Function: The number and the operation description of each operation are written according to the operation sequence in the process flow chart. Recovery, modification, etc. should be mentioned in this section.
11. Requirement: The requirements for the analysed process step are listed. Requirements are inputs that are necessary to achieve the design purpose and customer requirements.
12. Potential Failure Mode: Potential failures that may be encountered in fulfilling the requirements of the process are defined.
13. Potential Effects of Failure: The effects perceived by customers are defined. The customer is the next operation in the process or end user. If the type of fault is considered to affect the safety of the end-user or that a violation of the regulations may occur, this must be clearly stated in PFMEA.
14. Severity: This is the most severe effect of the specified failure type.
15. Classification: This section can be used to identify high priority failure types or causes that may require additional engineering assessment.
16. Potential Causes / Mechanisms of the Failure: How the failure occurs is defined.

17. Existing Process Controls for Prevention: This section describes how to eliminate the cause of the failure type or what is done to reduce the frequency of failure occurrence.
18. Occurrence: The occurrence probability of a particular cause of failure.
    For the scoring of this probability, the process is expected to be stable and then the frequency of occurrence according to production quantities should be determined and scored. Otherwise, the scoring will not reflect the actual values.
19. Existing Process Controls for Detection: In process control to detect failure; which methods and methods it tries to determine the type of failure that may occur should be specified.
20. Detection: The degree/score of failure detection. The best approach for this application is to acknowledge the occurrence of the failure and increase the ability to control the inputs and outputs of the process.
21. Risk Priority Number (R.P.N): The R.P.N is a helpful tool for determining Action / Prevention priority. R.P.N is calculated as in Equation 5.1.

$$RPN = \text{Precaution (P)} \times \text{Frequency of occurrence (F)} \times \text{Determination (D)} \quad (5.1)$$

This number can vary from 1 to 1000.

22. Recommended Action: In general, preventive actions are preferred over detection activities. Failure prevention methods should be used rather than randomly applied quality controls. The purpose of the recommended measures / actions is to reduce the importance, frequency of occurrence and detection points, respectively.
23. Responsibility & Target Completion Date: Each department within the organization should be defined in this section in order to close the proposed activities on the target dates to be specified. The process supervisor / engineer / team leader is responsible for completing and implementing all proposed activities and writing them to a document.
24. Actions Taken & Effective Date: This section should be completed after the implementation date of the permanent measure/corrective action implemented and should contain a brief description of the results of the implemented measure / corrective action.

25. 26. 27. 28. Severity, Occurrence, Detection, R.P.N:. After the corrective action taken, importance, frequency of occurrence, determination points and R.P.N should be recalculated and recorded. All scores should be reviewed. Actions alone do not guarantee that the problem is solved. Acceptable analyses and tests should be performed for this reason. If further action is needed, repeat your analysis. The goal should be continuous improvement (Benedict et al., 2008).

5.6.3.2 Formation of the Team

The FMEA team is selected from the departments in which the APQP team is formed. As a team leader, an engineer from the Quality Assurance Department is selected. After the FMEA is completed, the FMEA leader also participates in critical gate meetings organized by the APQP team. It is the responsibility of the FMEA team leader to report to the APQP team the critical points identified in FMEA in production processes, quality control processes, procurement, transportation and post-shipment services.

The FMEA team consists of those responsible for Purchasing, Production, Sales and Marketing, Engineering, Planning, Logistics and Quality Assurance. Each responsible manages the FMEA processes of his department and also participates in other processes. Analyses are carried out as a whole team, so that the whole process is examined more quickly and in detail.

He takes part in critical suppliers in the analysis of purchasing processes in the FMEA process. Thus, the risks that may occur are eliminated on the supplier before they come to ABC Company.

5.6.3.3 Examination of the Process

X brand gas evaporator will be produced according to the work flow stated in Appendix - 2. Production will be carried out taking into account customer requirements, ABC requirements, legal and standard conditions.

5.6.3.4 *Determining Possible Failure Types*

The types of failures that may occur in the processes they have determined according to the work flow have been determined by PFMEA team using brainstorming technique. During the detection phase, the process foreman also asked for ideas. A detailed list of failure types can be found in the PFMEA form given in Appendix - 3.

5.6.3.5 *Determining Possible Causes of Failure*

The PFMEA team has determined the reasons for the types of failures they have identified with the help of past experience such as customer complaints and internal nonconformities. During the detection phase, the process foreman also asked for ideas. A detailed list of possible causes of failure is given in the form PFMEA given in Appendix - 3.

5.6.3.6 *Determination of Possible Failure Effects*

The PFMEA team has determined the reasons for the types of failures they have identified with the help of past experience such as customer complaints and internal nonconformities. During the detection phase, the process foreman also asked for ideas. A detailed list of possible causes of failure is given in the form PFMEA given in Appendix - 3.

5.6.3.7 *Identification of Existing Controls*

In all production processes, checks are made to detect the failure rather than preventing the failure. The input, process and final quality controls ensure that the failure does not proceed to the next operation and that early corrective actions are taken. However, the nonconformities are due to the absence of preventive activities. Among the preventive activities, the most important one is the planned maintenance. Failures are reduced to a certain extent with the maintenance periods determined according to process and machine.

Existing controls for both prevention and capture of processes are detailed in Appendix - 3.

5.6.3.8 *Determination of Severity, Occurrence, Detection Values*

The severity value calculation was based on past customer complaints, internal nonconformities, occupational accidents, regulatory and preventive action forms and professional experience. In the calculation of Severity, Occurrence, Detection values, a range of 1-10 points was used. The severity was calculated based on the data in Table 5.2, the degree of occurrence in Table 5.3, and the degree of detection in Table 5.4.

Table 5.2 Severity value score table **(**Benedict et al., 2008)

Effect	**Product dependence severity (Customer impact)**	**Severity**	**Effect**	**Process dependence severity (Production impact)**
Not meeting the safety and / or legal requirements	Potential failure type without warning, affecting user safety or violating legal obligations	10	Not meeting safety and / or legal requirements	Endangering the machine or assembly operator without warning
	Potential failure type with warning, affecting user safety or violating legal obligations	9		Endangering the machine or assembly operator with warning
Loss or decrease in main functions	Loss of main function (vehicle does not start but does not affect safety)	8	Major confusion	100% of the product is scrap. The line or shipment has stopped.
	Reduction of main function (the vehicle runs with low performance)	7	Significant confusion	Part of the product may be scrap. Deviation from the main process, which includes a reduced line speed or the addition of additional personnel.

Table 5.2 continues

Loss or decrease in secondary functions	Secondary function loss (vehicle starts but comfort and convenience functions do not)	6	Moderate confusion	100% re-processing of the product off-line and re-acceptance
	Secondary function reduction (vehicle starts but comfort and convenience functions operate at low performance)	5		Re-processing of some of the product off-line and re-acceptance.
Discontent	The vehicle runs, however, has the inconvenience of appearance or audible noise noticed by the majority of customers (> 75%)	4	Moderate confusion	100% of the product is recycled to the station before processing.
	The vehicle runs, however, has the inconvenience of appearance or audible Noise noticed by many customers (50%).	3		Part of the product is recycled in the station before processing.
	The vehicle runs, however, has the inconvenience of Appearance or Audible Noise noticed by selective customers (<25%).	2	Minor confusion	Minor non-compliance in process, operation or operator.
No Effect	No significant effect	1	No Effect	No significant effect

Table 5.3 Occurrence value score table (Benedict et al., 2008)

Failure Probability	**Criterion: Cause of occurrence PFMEA (event / parts / product)**		**Occurrence**
Very High	More than 100 in a thousand parts	**>=1/10**	10
	More than 50 in a thousand parts	**1/20**	9
High	More than 20 in a thousand parts	**1/50**	8
	More than 10 in a thousand parts	**1/100**	7
Moderate	More than 2 in a thousand parts	**1/500**	6
	More than 0.5 in a thousand parts	**1/2.000**	5
	More than 0.1 in a thousand parts	**1/10.000**	4
Minor	More than 0.01 in a thousand parts	**1/100.000**	3
	Less than 0.001 in a thousand parts	**1/1.000.000**	2
Very Minor	Preventive checks eliminate the failure		1

Table 5.4 Detection value score table (Benedict et al., 2008)

Detection opportunity	**Criterion: Possibility of Detection with process control**	**Rating**	**Detection possibility**
No chance of detection	No process controls available; cannot be captured or analysed.	10	Almost impossible
No chance of detection at any stage	The failure mode and or cause cannot be detection easily. (e.g. Random controls)	9	Too far
Post-process failure detection	After the process, the type of failure detected by the operator at eye, hand sensory tests vb.	8	Far
Detection the failure at source	During the process, the type of failure detected by the operator at eye, hand sensory tests vb.	7	Very low
Post-process failure detection	Detection the failure by the operator's dimensional controls after the process	6	Low
Detection the failure at source	Detection of the failure by qualitative controls by the operator in the process or by automatic checks of faulty parts and warning of the operator (audible, illuminated, etc.). Qualitative checks during first part inspection (set up failures only)	5	Moderate
Post-process failure detection	Automatic post-process control that detects defective parts and does not accept inappropriate parts and prevents further defective parts production	4	Good
Detection the failure at source	Automatic in-process control that detects defective parts and does not accept inappropriate parts and prevents further defective parts production	3	High
Failure detection and or failure prevention	In-process automatic control that detects failure (cause) and does not accept inappropriate parts and prevents further defective parts production	2	Very High
Failure prevention	Unsuitable parts cannot pass because the product / process design is based on the failure-free principle.	1	Almost Certain

The score of severity, occurrence and detection of the failure modes determined by the PFMEA team are detailed in Appendix 3.

5.6.3.9 Calculation of R.P.N Value

R.P.N, the purpose of calculating the value of; quantification and limitation of identified risks. R.P.N. the value is calculated as in Equation 5.2 by multiplying the significance, probability of occurrence and capture values.

$$R.P.N. = S \times O \times D \qquad (5.2)$$

S: Severity
O: Occurrence
D: Detection

The following conditions apply to the R.P.N value calculated in a PFMEA application;

S = Cannot be changed. The process design needs to be changed completely to change it.
D = It is necessary to investigate the effectiveness of control mechanisms.
O = It is necessary to control the product defect.

The R.P.N values to be considered are evaluated according to the rules in Table 5.5;

Table 5.5 R.P.N. evaluation (Duru, Koç, & Taş, 2011)

R.P.N Points	**Activities**
R.P.N <= 40	There is no need to take precautions.
40 < R.P.N <= 100	It is useful to take precautions.
R.P.N > 100	Precautions must be taken.

If the severity level is above 10 and the R.P.N value is above 40 or if the severity level is between 8-9 and the R.P.N value is above 90, it is absolutely necessary to take precautions.

The R.P.N value calculated for each failure mode is detailed in Appendix 3. The failure modes that should be taken according to the calculated R.P.N values are as in Table 5.6;

Table 5.6 PFMEA – PFMEA - failure modes to prevent

Process / Function	Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Classification	Potential Causes(s) of Failure	Current Process Controls Prevention	Occurrence	Current Process Controls Detection	Detection	R.P.N
70 - Brazing	Brazing of curves and collectors to product	Incorrect collector axis measurement	reprocessing of the product	6		Operator failure	brazing operation instruction + first sample approval	5	quality control after brazing process	5	150
		Incorrect size of distributor axis	reprocessing of the product	6		Operator failure	brazing operation instruction + first sample approval	5	quality control after brazing process	5	150
		faulty brazing operation	reprocessing of the product	5		Operator failure	brazing operation instruction + first sample approval + brazing operators' trainings	5	quality control after brazing process + leakage test	5	125
		deformation of mirror sheets	No products and / or semi-products can be used	5		Operator failure	Brazing operation instructions + initial sample approval + brazing operators' trainings	5	quality control after brazing process	5	125

5.6.3.10 Determination and Implementation of Measures to be Taken

The actions taken in order to reduce the occurrence and detection scores for the failure modes that score above 100 according to the RPN values calculated in the FMEA study given in Appendix – 3 are as follows;

According to the root cause analysis of the failure mode in the collector axis dimension and the failure mode in the distributor axis dimension, the two main causes of nonconformity were identified as “brazing operation without fixing the product” and “transport, leakage test, packaging, shipment operations in the company, transport and assembly operations on the customer side of the wrong”. Since the brazing operation is done without fixing, it causes inclined brazing of the collectors and / or distributor. This causes failures in the axis dimensions between the collector and the sheet, between the collector and the distributor and between the distributor and the sheet. For this purpose, a special fixture has been made in accordance with the design dimensions to ensure the fixation of the collector, distributor and product in the brazing operation. Sample production and order production will be done using this fixture. The collector and distributor are deformed due to transport and assembly failures and thus cause both axis failure and deformation. Bypass plate design is used for fixing both collector and distributor to sheet. In this sheet, the collector and the distributor shall be fixed and prevented from moving. The technical drawing prepared according to the new design is as in Appendix - 4. It prevents the assembly of the product on the customer's side as the bypass plate closes the collector side. For this reason, technical personnel from the engineering department have examined the place where the product will be assembled by the customer. The connection points and pipe sizes are determined. In order to enable the customer to assemble, holes are made in the by-pass sheet for the points where the pipes will pass. Due to design changes, approval was obtained from the customer through the sales and marketing department.

Two root causes of nonconformity were studied according to the root cause analysis of the improper brazing operation failure mode. These are; the lack of training of the operators and due to aluminium brazing is difficult, so the brazing wire cannot fill the solder range sufficiently. For operator trainings, an instructor specialized in brazing at the supplier company was invited to the company and both theoretical and practical trainings were given. According to the leakage test results, the leakage rates of the products with aluminium material were between 980-1090 ppm and this ratio was reduced to approximately 550 - 600 ppm after the training. Furthermore, a joint work was carried out with brazing wire supplier companies and many kinds of brazing wire were tested in production. Tested brazing wires; ring brazing wire, self-borax brazing wire and 20% silver brazing wire. The use of ring brazing wire was not approved due to the change of torch and because of the difficulty of operators in using the brazing wire. Borax brazing wire and silver brazing wires have been found suitable both for the use of operators and for improving leakage rates in the leak test. Due to the significant price difference between the price of silvery brazing wire and borax brazing wire, borax brazing wire has started to be used in aluminium brazing wire production.

Deformation of mirror sheets; According to the root cause analysis made for the failure mode, the main reason for the non-conformity was determined as “the deformation of the side sheets due to the brazing heat due to the softness of the aluminium material”. Two solutions have been developed to address this non-compliance. First, the cooling pool mechanism was developed by the technical directorate for cooling brazing the product. This mechanism will cool the mirror sheet with water. The visual of the cooling pool is as shown in Figure 5.7. The second solution is to increase the thickness of the side mirror sheets so that they are not affected by the heat during assembly and to apply double sheet application. This solution was submitted for customer approval due to both design and cost changes, but the solution was not approved.

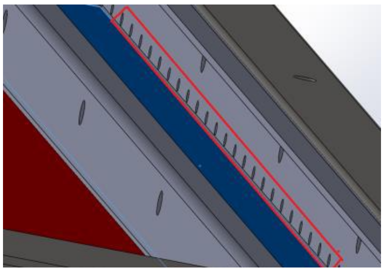

Figure 5.7 Cooling pool design

5.6.3.11 Calculation of the New R.P.N. value

As a result of the actions taken to reduce the occurrence and detection, new occurrence and detection points were determined and the new R.P.N value was calculated as a result. The new R.P.N value is as in Table 5.7;

Table 5.7 PFMEA - R.P.N value calculated after measures

Process / Function	Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Classification	Potential Causes(s) of Failure	Current Process Controls Prevention	Occurrence	Current Process Controls Detection	Detection	**R.P.N**	Recommended Action	Responsibility & Target Completion	Action Results				
														Actions Taken & Effective Date	Severity	Occurrence	Detection	**R.P.N**
70 - BRAZING	Brazing of curves and collectors to product	Incorrect collector axis measurement	reprocessing of the product	6		Operator failure	brazing operation instruction + first sample approval	5	quality control after brazing process	5	150	Fixtures will be made for the brazing operation (Fixtures no: F123) + by-pass sheet to be made.	UR	15.07.16	5	3	4	60
		Incorrect size of distributor axis	reprocessing of the product	6		Operator failure	brazing operation instruction + first sample approval	5	quality control after brazing process	5	150	Fixtures will be made for the brazing operation (Fixtures no: F123) + by-pass sheet to be made	UR	15.07.16	5	3	4	60
		faulty brazing operation	reprocessing of the product	5		Operator failure	brazing operation instruction + first sample approval + brazing operators' trainings	5	quality control after brazing process + leakage test	5	125	operator trainings will be provided + suitable brazing wire will be investigated	SA	15.07.16	5	3	5	75
		deformation of mirror sheets	No products and / or semi-products can be used	5		Operator failure	brazing operation instruction + first sample approval + brazing operators' trainings	5	quality control after brazing process	5	125	Cooling pool to be made	TM	15.07.16	5	3	5	75

5.6.4 MSA

Method of measurement analysis is used to determine the adequacy of measurement systems. The purpose of a measurement system is to understand the sources of variability that lead to the results obtained in the process. In MSA, multiple operators measure the same property of multiple parts many times. The reliability and variability of the measurement system are analyzed by comparing the measurement results of different operators with repeatability, reproducibility and stability analyzed. The aim here is, to determine whether the measurement results differ if the measurements are performed by the same or different persons (Acar, 2012).

5.6.4.1 Attribute MSA and Application

Mathematically, the analysis of measurement systems involves understanding and measuring the variance of measurement as described in equation 5.3 with respect to process variability and tolerance spread:

$$\sigma_T^2 = \sigma_P^2 + \sigma_M^2 \tag{5.3}$$

σ_T^2 = Total variance

σ_P^2 = Process variance

σ_M^2 = Measurement variance

• To reveal actual process variability, the variability resulting from the measurement system must first be identified and distinguished from the variability of the system.

• The aim is to develop a measurement system that is appropriate to the needs.

When evaluating measuring systems with two separate definitions evaluated. These; variability of the measurement system and accuracy. While discussing the repeatability, reproducibility and accuracy expressions of variability of the measurement system, bias, stability, and linearity define accuracy of measurement system (Ford Motor Company, 2010).

Bias: Refers to Difference between reference values with observed measurement averages.

The bias graph is as in Figure 5.8.

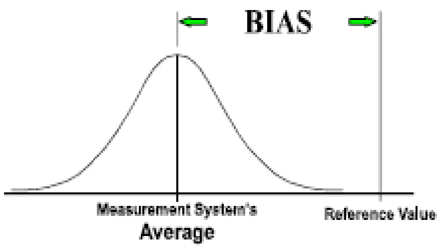

Figure 5.8 Trend graph (Ford Motor Company, 2010)

High bias; the instrument is not calibrated, measuring instrument, the equipment, the fixture is worn, the measured part is defective, wrong setting of master, environment depends on such reasons (GHSP, 2010).

Stability: Stability of the measurement system is the total amount of change over time in a particular part or main part of the system. The stability graph is as shown in Figure 5.9.

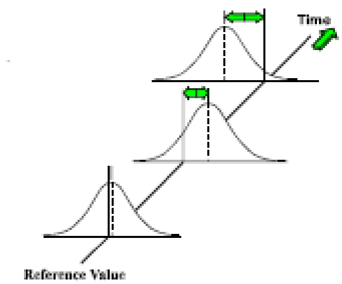

Figure 5.9 The stability graph (Ford Motor Company, 2010)

Linearity: Measuring instrument is the change of bias in the normal operating range. The linearity graph is as shown in Figure 5.10.

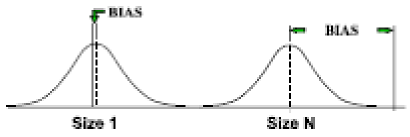

Figure 5.10 The linearity graph (Ford Motor Company, 2010)

Repeatability: Under certain measuring conditions, (fixed part, device, standard, method, operator, environment and assumptions) in-system variability resulting from successive trials.

Differences in measurement caused by the measurement tool itself and the position differences of the part within the measurement tool, causes of general repeatability failures. The reproducibility graph is as in Figure 5.11.

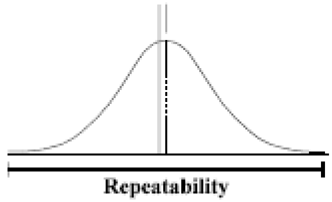

Figure 5.11 The reproducibility graph (Ford Motor Company, 2010)

Reproducibility: It is the average variation in the measurements performed by different operators of the same characteristic with the same measuring device. Failure may be from the operator, environment / time or method. The reproducibility graph is as in Figure 5.12.

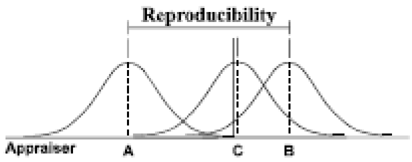

Figure 5.12 The reproducibility graph (Ford Motor Company, 2010)

5.6.4.2 *MSA Steps*

1. Determine the critical part.

"3/4" -16 Thread Flare Aluminum Sleeve" has been chosen as the critical part because it involves the risks in the customer connection. The technical drawing of the part is given in Figure 5.13.

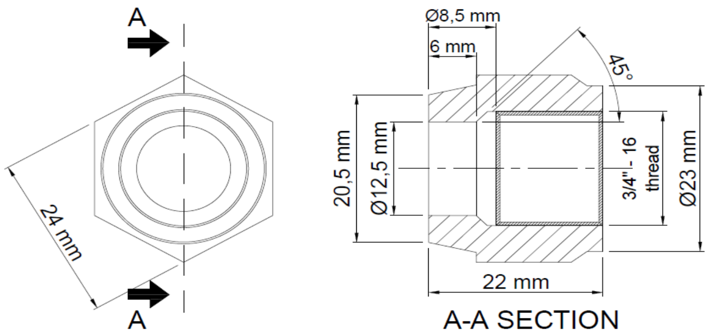

Figure 5.13 Flare sleeve technical drawing

2. Determine critical characteristics.

Wrench flat size is chosen as a critical characteristic for the flare sleeve.

Wrench flat size is 24 ± 0.5 mm.

3. The necessary settings are made to measuring instrument.

Digital caliper 15278752 was selected as the measuring instrument. The caliper has been calibrated.

4. 10 parts are select.

The parts were randomly selected from productions on different shifts.

5. Parts are being number.
6. Operators, preliminary information about the measurement is given.
7. First of appraiser, the part is measured at random. Measurements are repeated 3 times.
8. 2. and 3. of appraisers also apply step 7.

9. For repeated measurements of each appraiser, the ranges (R) are calculated by subtracting from the largest to the smallest.
10. The average means for each appraiser is calculated. ($\bar{R}_a$, $\bar{R}_b$, $\bar{R}_c$)
11. The average of the ranges is calculated as in equation 5.4. ($\bar{\bar{R}}$)

$$\bar{\bar{R}}=(\bar{R}_a+\bar{R}_b+\bar{R}_c)/\text{ number of operators} \tag{5.4}$$

12. $\bar{\bar{R}}$, multiply the constant D_4 and obtain the upper control limit (UCL) for the ranges. Operation is continued if all ranges are below the UCL. For ranges exceeding the limit, the problem is corrected and the operation is repeated. The UCL for the range is calculated as in equation 5.5.

$$UCL_R=\bar{\bar{R}}*D_4 \tag{5.5}$$

The value of constant D_4 is as in Table 5.8.

Table 5.8 D_4 constant value (Ford Motor Company, 2010)

Trials	**D_4**
2	3.27
3	2.58

13. Calculate the average for each appraiser and each trial.
14. The averages for each appraiser are added and divided by the number of attempts.
15. The difference between the largest and smallest average ($\bar{X}_{DIFF}$) is calculated as in equation 5.6.

$$\bar{X}_{DIFF}=\bar{X}_{max}-\bar{X}_{min} \tag{5.6}$$

16. For the part averages, the measured values obtained by all the appraiser of each part are summed, and divided by the number of measurements.
17. The average of the parts is calculated by subtracting the largest part average from the smallest part average.
18. Repeatability - equipment variance (EV) value is calculated as in Equation 5.7.

$$EV = \bar{\bar{R}} x K_1 \tag{5.7}$$

The value of constant K_1 is as in Table 5.9.

Table 5.9 K_1 the value of constant (Ford Motor Company, 2010)

Trials	**K_1**
2	0.8862
3	0.5908

19. The reproducibility - Appraiser variance (AV) value is calculated as in Equation 5.8.

$$AV = \sqrt{[(\bar{X}_{DIFF} x K_2)^2 - (\frac{EV^2}{nr})]} \tag{5.8}$$

The value of constant K_2 is as in Table 5.10

Table 5.10 K_2 constant value (Ford Motor Company, 2010)

Appraisers	**2**	**3**
K_2	0.7071	0.5231

n = number of parts

r = number of trials

20. Repeatability and reproducibility (GRR) value is calculated as in Equation 5.9.

$$GRR = \sqrt{(EV^2 + AV^2)} \tag{5.9}$$

21. The part variance (PV) value is calculated as in Equation 5.10.

$$PV = R_p x K_3 \tag{5.10}$$

The value of constant K_3 is as in Table 5.11.

Table 5.11 K_3 constant value (Ford Motor Company, 2010)

Parts	**K_3**
2	0.7071
3	0.5231
4	0.4467
5	0.4030
6	0.3742
7	0.3534
8	0.3375
9	0.3249
10	0.3146

22. The total variance (TV) value is calculated as in Equation 5.11.

$$TV = \sqrt{(GRR^2 + PV^2)} \tag{5.11}$$

23. The percentages of EV, AV, PV, and GRR in the TV are calculated as in Equations 5.12, 5.13, 5.14 and 5.15.

$$\%EV = 100x(EV/TV) \tag{5.12}$$

$$\%AV = 100x(AV/TV) \tag{5.13}$$

$$\%PV = 100x(PV/TV) \tag{5.14}$$

$$\%GRR = 100x(GRR/TV) \tag{5.15}$$

% GRR Evaluation;

• 10% Failure under - measuring system is acceptable.

• 10% - 30% Failure - The measurement system can be accepted depending on the importance of the application, the cost of the measuring device, the cost of repair vb. Corrective actions needs to be taken.

• Over 30% Failure - unacceptable - efforts should be made to improve the measurement system.

24. Number of distinct categories (ndc) is calculated as in Equation 5.16.

$$ndc=1.41x(PV/GRR) \tag{5.16}$$

If the ndc value is below 5, the measurement category is considered low and if it is above 5, the measurement category is accepted.

The representation of all MSA studies on the table is as in Appendix - 5.

According to MSA, the GRR value was calculated as 12.88%. The value is acceptable because it is between 10% and 30%. The APQP team decided not to make improvements based on the accuracy of the part. The ndc value was calculated 10.888 as a result of the analysis. Since the value is over 5, the part category value is acceptable. Also; the measured values according to the number of parts, operators and trials were solved in the MINITAB 15 statistical program. The graphs of the measurement results are as follows.

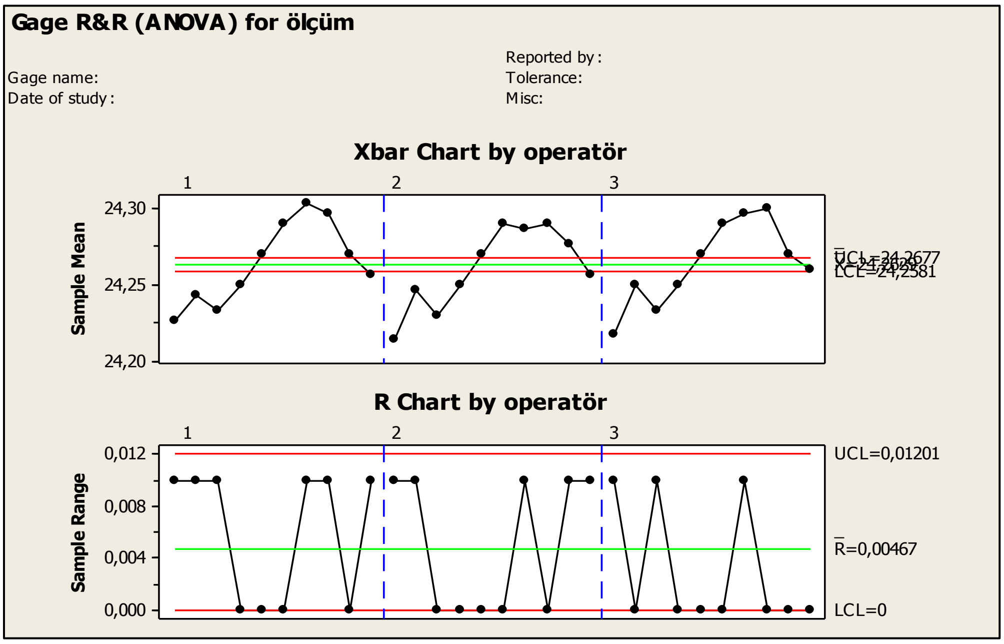

Figure 5.14 Xbar chart by operator and R chart by operator

The X bar Chart by operator graph shown in Figure 5.14 shows the average of the operators' measurements of the same part three times. Shown for all three operators respectively. All measurements are within part tolerance limits. (Part tolerance: 24 ± 0.5 mm)

The R chart by operator indicated in Figure 5.14 shows the difference between the maximum and minimum measurements of the three measurements of the operator. All measuring ranges are between UCL and LCL.

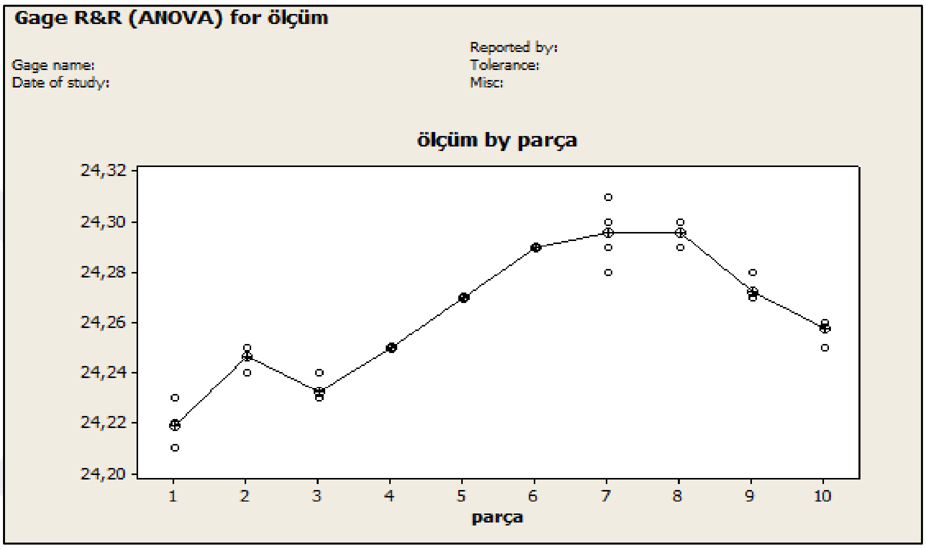

Figure 5.15 Part chart

The By part graph shown in Figure 5.15 shows the distributions of 9 measurements taken for each part. The measurements of the 1st, 2nd, 3rd, 7th, 8th, 9th and 10th parts are more dispersed than other parts, but the part measurements are within the tolerance limits and did not prevent the analysis of the measurement systems to be sufficient.

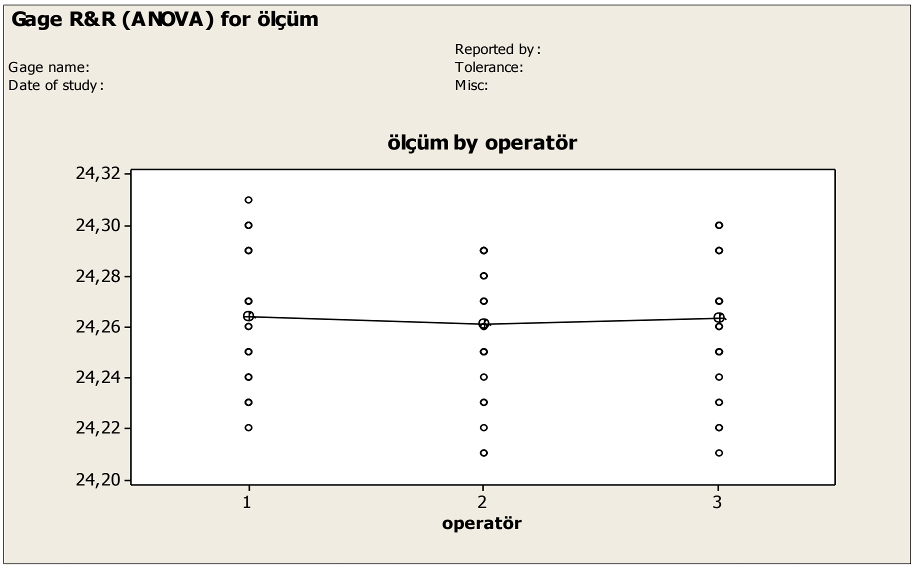

Figure 5.16 Operator chart

By the operator graphs specified in Figure 5.16, gives the average and distribution of the 90 measurements made by the operators. The measurement averages according to the operators are linear.

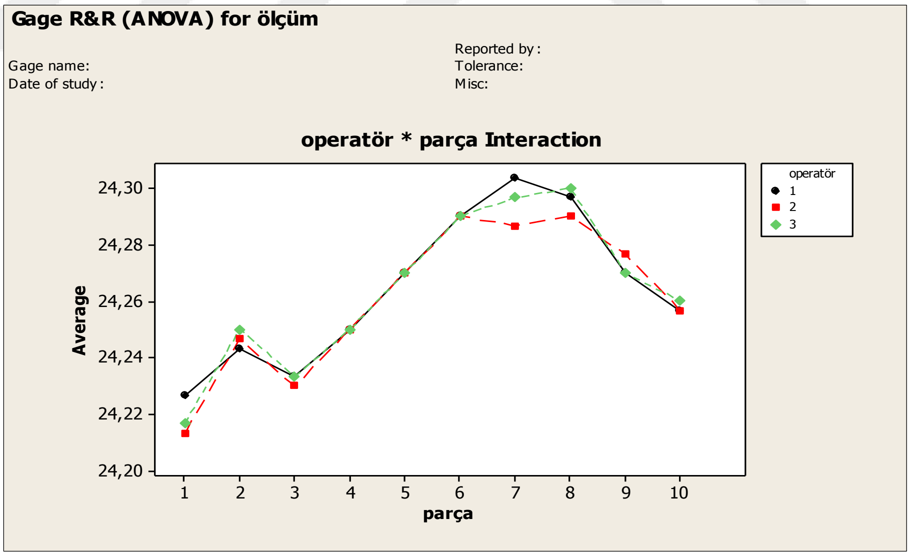

Figure 5.17 Operator * part interaction graph

The graph in Figure 5.17 shows the interaction of parts with the operator. There is a difference between the first, second, and third operator measurement means in parts 1, 2, 7, 8. However, this difference did not affect the adequacy of the analysis of the measurement system.

5.6.5 Statistical Process Control

Statistical process control (SPC) method uses to determine process variation after measurement variation is determined by MSA. S SPC is a method used to monitor the process for detecting abnormal behavior in a process that is caused by specific reasons that are unnatural, unpredictable, and unregulated for the process, consisting of an uncertain source. Statistical control charts use to detect failures. Control charts are very important in determining whether a process is operating under normal operating conditions (Baldan et al., 2018).

The aim of the SPC is to improve the performance of the process by following the process, to determine the specific causes of the change in the process and to ensure that measures are taken, to determine the limit values of the process, to provide the possibility of continuous improvement by keeping the process under control (Bulut, 2007).

5.6.5.1 Steps to Apply SPC

1. Identification of part and part number

SPC study was conducted for flare union U10 which is critical for customer connection. The technical drawing of the product is as shown in Figure 5.18.

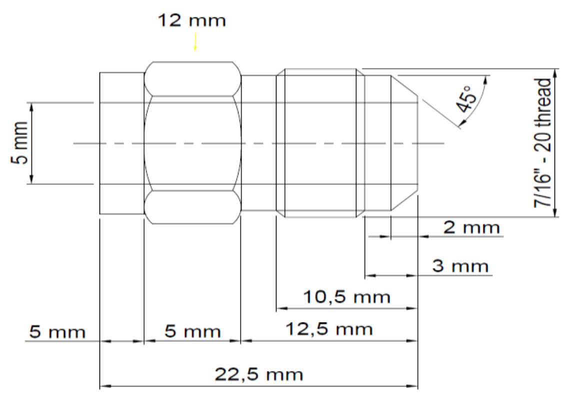

Figure 5.18 Technical drawing of flare union

2. Determination of the feature to be checked. The feature to be checked for flare union is determined as union length. According to customer requirements, the length of the union is 22.5 mm.

3. Determination of the upper and lower specification limits of the feature to be checked. (LTL: Lower tolerance limit, UTL: Upper tolerance limit)

   Specification limits are 22.5 ± 0.5 mm according to customer and ABC Company conditions.

   LTL = 22 mm and UTL = 23 mm

4. Determination of the control frequency and sample size of the property to be checked

   The control frequency is determined as 5 parts per hour.

5. Determination of the measuring tool in accordance with product property measurement

   The instrument is designated as 150 mm digital caliper 12345.

6. The machine number where the product feature is created or checked is written.

   T10MD001 CNC LATHE machine was selected.

7. Determination of the date, shift, day and time of the measurement

   The measurements were carried out on 11.04.2016 in the first shift.

   Sampling times:

   1. Recording time: 15:46:00

   2. Recording time: 16:49:00

   3. Recording time: 17:40:00

   4. Recording time: 19:06:00

   5. Recording time: 20:06:00

8. Plot the specification limits (LTL and UTL) on the X Arithmetic Mean graph.
9. Making measurements and writing to each sample group (X_1, X_2, X_3, X_4, X_5)

10. The sum of 5 measured values is given in equation 5.17, the value of the average of 5 measured values t is in equation 5.18 and the calculation of the interval value of 5 measured values is as in equation 5.19.

$$\sum X = X_1 + X_2 + \ldots\ldots + X_n \tag{5.17}$$

$$\bar{X} = (X_1 + X_2 + \ldots\ldots + X_n)/n \tag{5.18}$$

$$R = X_{max} - X_{min} \text{ (within each subgroup)} \tag{5.19}$$

n = number of samples in a subgroup

11. The measured X values and R values are entered in the Arithmetic Mean and Distribution Range charts.
12. Calculate the average of all measured values. The sum of the measurements is calculated as in equation 5.20, and the average of the total ranges is calculated as in equation 5.21.

$$\bar{\bar{X}} = (\bar{X}_1 + \bar{X}_2 + \cdots + \bar{X}_k)/k \tag{5.20}$$

$$\bar{R} = (R_1 + R_2 + \ldots\ldots + R_k)/k \tag{5.21}$$

k = number of subgroups used to determine the Grand Average and Average Range

13. UCL_X in Equation 5.22, and Lower Control Limit (LCL_X) in Equation 5.23 for the Mean Graph, UCL_R in Equation 5.24, and LCL_R in Equation 5.25 as calculated for the Distribution Graph.

$$UCL_X = \bar{\bar{X}} + (A_2 * \bar{R}) \tag{5.22}$$

$$LCL_X = \bar{\bar{X}} - (A_2 * \bar{R}) \tag{5.23}$$

$$UCL_R = D_4 * \bar{R} \tag{5.24}$$

$$LCL_R = D_3 * \bar{R} \tag{5.25}$$

The constant value table is as in Table 5.12.

Table 5.12 The constant value table (Benham, Cvetkovski, Down, & Kerkstra, 2005)

n	A2	D3	D4
2	1.88	0	3.268
3	1.023	0	2.574
4	0.729	0	2.282
5	0.577	0	2.114

14. Writing the UCL_X and LCL_X values on the Arithmetic mean graph and the UCL_R and LCL_R values on the Distribution graph
15. The standard deviation value is calculated as in Equation 5.26.

$$\sigma = \sqrt{\Sigma(X_i - \bar{X})^2 / _{n-1}} \qquad (5.26)$$

16. Process capability values are calculated as in Equations 5.27 and 5.28. (Cp, Cpk)

$$Cp=(UCL-LCL) / 6x\sigma \qquad (5.27)$$

$$Cpk=\min[(UCL\text{-}\bar{\bar{X}})/3\sigma; (\bar{\bar{X}} - LCL)/3\sigma] \qquad (5.28)$$

A detailed document containing the analysis of all SPC measurement results, UCL and LCL calculation values, Cp and Cpk values is as in Appendix - 6.

17. Interpretation of X-R graph

When interpreting the X-R graph, 7 basic control conditions should be considered.

The 7 basic control states of the tables are as follows;

1. There are marked points outside the control limit lines,

2. The total number of points on the center line is not close to the total number of points below the center line,

3. The marked points are not randomly located above or below the center line,

4. On the one side of the center line, 7 or more points are arranged sequentially,

5. 7 or more points going up or down trend towards the control limits,

6. Most of the points are located close to the center line or close to the control limits,

7. When there is a straight line, precautions are taken (Bulut, 2007).

According to all basic control situations; measurements are within the control limits. The number of measurements between the centerline and UTL and the number of measurements between the centerline and LTL are similar. All measurement results are distributed randomly to the center line and control limit areas and there is no straight line. There are not 7 consecutive points.

18. Interpretation of qualifications

Cp: This is an ability index. Compares process capability to the maximum permissible variability as specified by tolerance. This index provides a measure of how well the process meets variability requirements. The Cp index does not comment on the centering of the process, but provides a simple comparison of the TV with tolerances.

Cpk: This is an ability index. It takes into account both processes change and centering. For binary tolerances, Cpk will always be equal to or less than Cp (Benham et al., 2005).

Taking these into account, the values of the Cpk index given in Table 5.13 below indicate the level of confidence given to the process capability:

Table 5.13 Interpretation of Cpk values (Oakland, 2008)

Cpk<1	Insufficient process capability. Faulty parts will inevitably happen.
1<Cpk<1.33	It is a situation where the manufacturer is not really capable. Because any change in the process will cause some undetectable, and faulty parts will happen.
1.33<Cpk<1.5	Since nonconformity is not likely to be detected by process control charts, it is still far from acceptable;

Table 5.13 continues

1.5<Cpk<1.67	The process capability is not yet satisfactory, as there will be unsuitable parts and the chances of detection are still not good enough.
1.67<Cpk<2	Promising, there will be inappropriate outputs, but the probability of being detected is very high.
Cpk>2	Provides a high level of confidence in the manufacturer, provided that the control tables are used regularly.

According to the calculated Cp = 1.96532317 and Cpk = 1.949601, the process capability is appropriate. Although the process meets the desired conditions, there will be unsuitable parts in the process outputs. However, the probability of detection is quite high.

5.6.6 Control Plan

Control plan is a living document described the control system of company to providing the production the product, determined selection of control methods for minimazing the variances and how it should be applied in accordance with customer, producer, provisions and regulations and minimazing. Every controller planned to make the production in accordance with work flow take part in control plan such as input quality control, process quality control final quality control etc. The wastes reduce with control plans, quality of product and production run up, provides the reduction of cost without sacrificing quality.

5.6.6.1 Stage of Creating the Control Plan

1. Determination of Scope

Control plan is involved the controls in processes which is necessary for produce of X mark gaseous evaporator. Conrol plan is compared the customer requirements, general requirements of ABC Company, provision and standard requirements. Contol Plan is prepared by considering the MSA and FMEA results and workflow.

2. Setting the Team

Control Plan Team is selected from departments which is created by APQP team. As team leader, an engineer from quality assurance department is selected at all control plan studies as a matter of principle of ABC Company. Also, a quality control technician is get involved to the team. After completed the control plan of APQP team, control plan leader gets involve to critic gate meeting realised. Contol plan leader is responsible the feedbacks to all process of contol plan to both APQP leader.

Control plan team consist of persons worked in purchasing, production, technic, logistic and quality assurance departments. Each responsible person manages the Control Plan processes of his / her department and participates in other processes. Analysises are managed by all team, thus all process is examined fastly and detailed.

In control plan, critic control points in both purchasing and logistic process are shared with suppliers. Thus, the risks that will be occured are eliminated by the supplier.

3. Examination of Process will be Applied

Production of X mark gaseous evaporator will be made according to workflow indicated in Appendix - 2. Process controls, quality controls and performance tests are planned in general terms of control plan. Controls; input quality control, pipe manufacturing process control, honeycomb production process control, sheet metal production process control, assembly process process control, assembly quality control, expansion process control, collector production process control, brazing process process control, quality control after brazing, leakage test, packing process control, final quality control.

Production will be realized in accordance with technical drawing indicated in Appendix - 4. All control points in technical drawing are enumerated to transparently realized the controls according to control plan as Appendix - 7.

4. Preparation of Control Plan

Control plan studies will be implemented from form described in Figure 5.19.

ABC	CONTROL PLAN	Documet No	XXX-01
		Rev No/Date	00/22.12.2015
		Page No	1/1

1

☐ Prototype ☐ Pre-Launch ☐ Production

Control Plan Number 2		Key Contact/ Phone 7	Date (Orig.) 11	Date (Rev.) 12
Part Number/ Change Level 3		Core Team 8	Customer Engineering Approval-Date (If Req'd.) 13	
Part Name/ Description 4		Supplier/Plant Approval/ Date 9	Customer Quality Approval/Date (If Req'd.) 14	
Supplier/ Plant 5	Supplier Code 6	Other Approval/ Date (If Req'd.) 10	Other Approval/Date (If Req'd.) 15	

Part Process Number	Process Name- Operation Description	Machine, Device Jig, Tools For Mfg.	Characteristics			Special Cahr. Class	Methods					Reaction Plan	Registration form
			NO.	Product	Process		Product/ Process/ Specification/ Tolarance	Evaluation/ Measurement Technique	Sample		Control Method		
									Size	Freq.			
16	17	18	19	20	21	22	23	24	25	26	27	28	29

Figure 5.19 Control plan form

1. Prototype, Pre-Launch, Production: The most appropriate option among 3 options is selected.
2. Prototype Production Control Plan: In the prototype phase, dimensional measurements and performance tests are defined.

   Pre-Lauch Production Control Plan: After prototype production and before mass production in the pre-lauch stage, dimensional measurements and performance tests are defined.

   Mass Production Control Plan: In the mass production stage, process characteristics, controls, tests and measurement systems are defined.
3. Control Plan Number: This is the number given to the control plan for providing the retrospective traceability.
4. Revizyon- Part Number/ Change Level: The part number, revision number and revision date of the part to be checked are written.
5. Part Name/ Description: The name of the part to be checked is written.
6. Supplier/ Plant: The name of the manufacturer preparing the control plan is written.
7. Supplier Code: In line with the request of the customer, the number given to the manufacturer by the customer is written.
8. Key Contact/ Phone: Name, surname and contact information of the leader of the control plan is taken part.
9. Ekip/ Core Team: The name and surname of the entire team taken part in the preparation of the control plan is involved.
10. Supplier/Plant Approval/ Date: If necessary, factory approval may be obtained. Approval is usually given by the APQP leader.
11. Other Approval/ Date (If Req'd.): If necessary, the approval of other relevant departments (production, etc.) may be obtained.
12. Date (Orig.): The first publication date of the control plan is written.
13. Date (Rev.): The last revision date of the control plan is written.
14. Customer Engineering Approval-Date (If Req'd.): If necessary, the approval of the engineer who is responsible on the customer side may be obtained.
15. Customer Quality Approval/Date (If Req'd.): If necessary, the confirmation of quality department can be taken.

16. Other Approval/Date (If Req'd.): If necessary, the confirmation of relevant department may be obtained.
17. Part Process Number: The number which is description of process was written in work flow
18. Process Name-Operation Description: The process name specified in the workflow to be defined the production is defined.
19. Machine, Device Jig, Tools for Mfg.: The manufacturing tools which is necessary for determined operations is described
20. Characteristics: For product, the distinctive property, dimensions or parameters is determined. The technical drawing mentioned in Appendix – 4 will be used.
21. NO: Reference numbers specified in Appendix – 4 will be used
22. Product: Product characteristics are those defined in the technical drawing of the product. In addition to the product characteristics specified in the technical drawing, routine and monitored characteristics are included in the plan.
23. Process: Responsible for the process of product characteristics, process characteristics are determined to ensure that variability is controlled
24. Special Cahr. Class: The characteristics affecting occupational health and safety and legal conditions should be defined as special characteristics. In addition, processes considered to be risky according to FMEA outputs should be identified as a special characteristic in the control plan.
25. Product/ Process/ Specification/ Tolarance: Production requirements should be determined by considering customer requirements, technical drawing and engineering studies. Tolerances; It is given in accordance with TS 1980-1 EN 22768-1 standard.
26. Evaluation/ Measurement Technique: gauges, fixtures, tools, test equipment, etc., which are necessary to measure process output are described.
27. Sample Size: The sample size to be taken for each control is defined.
28. Sample Frequency: Sampling frequency for each control is defined.
29. Control Method: How to control the operation is defined. If there are detailed procedures and / or instructions are available, are described here.

30. Reaction Plan: The actions to be taken in the production of inappropriate products or loss of control in production are identified. If there are detailed procedures and / or instructions are described here.
31. Registration form: All the controls, document to be recorded are defined.

According to the form given in Figure 5.19, the controls in all processes required for the realization of X brand “12345 Aluminum EVAP Al / Al” production, FMEA and MSA documents, customer specific requirements, ABC Company requirements were prepared. The Control Plan prepared is as in Appendix - 8.

5. Customer Approval, Representment of Control Plan to Related Departments and APQP Team

Regarding to the preparation and approval of the control plan by the team, as a first step, is demanded a meeting to APQP team by control plan leader and the control plan prepared is presented in detail. The sections that need to be modified and changed by the APQP team are decided and changed with the process owner. After all changes are completed, they are submitted to the customer's approval by the Sales and Marketing department. The departments on which customer approval is required must be informed to the customer. The approved control plan; is informed to relevant process owners and production and quality control personnel. If necessary, instructions are prepared and trainings are given.

5.6.7 Packing Standards

Product packaging standards are realized in accordance with customer packaging conditions, ABC Company packaging conditions and legal regulations. Determined items related to packaging are as follows;

- During shipment, the products should not be held from the collectors in point of create a risk of leakage at the brazing point.
- Pallet and case boards must be 2 cm thick with baked and stamped boards.
- Pallet and case dimensions should be prepared in the packaging section in accordance with product dimensions. In the production of pallets, it is

ensured that the space dimension under the pallet is enough to entering of the double-sided forklift knife.

- Thick cardboard should be placed on the aluminum honeycomb sides of the products placed on the pallet and the product should be stretched.
- Stretched products should be placed inside the case.
- Customer order number, ABC Company order number, product name, production date, barcode number indicating the label on the case is pasted over the all cases.
- Stick the label to be broken on the case.
- As customer special request; nails are used on the front and top surface of the case, do not used the screw. The entire case are connected with black scarves.

Packaging standards were prepared as instructed and forwarded to the packaging and final quality control department.

5.7 Section 4: Product and Process Validation

Production workflow, product material list, Process FMEA, MSA, SPC, Control Plan and Packaging standards studies for the new product were conducted. At the end of each study, the study leaders, all data, documents, analyzes, findings and preventive studies were presented to the APQP team. As a result of the studies, all risks that may cause loss of time, money and firm prestige in product production were eliminated. In this section, production will be carried out in accordance with the product technical drawing and the control plan prepared, performance test and dimensional measurements will be made. The product will be packaged according to the specified packaging standards. The product shall be packaged according to the specified packaging standards. All stages of pre-packing will be photographed for customer approval. Part Submission Warrant (PSW) will be prepared for customer approval and will be sent to customer with all documents.

5.7.1 Sample Production

In accordance with the technical drawing of the product, sample production was carried out according to the workflow given in Appendix - 2. In each process, process controls were applied by operators which made production in accordance with the control plan. Fixtures prepared to minimize the occurrence of defects in the product have been used. Input quality control, assembly quality control, post-brazing quality control, final quality control processes were carried out by quality control operators in accordance with the frequency and sample size specified in the sampling instructions in accordance with the product control plan. No problems were encountered in product production, both processes and quality control stages.

5.7.2 Dimensional Measurements and Performance Test Results

Product test results are based on dimensional measurements and leakage performance test results.

Dimensional measurements were checked in accordance with the final revision technical drawing prepared by the improvement works done by the customer. Measurement tolerances are based on TS 1980-1 EN 22768-1 standard. Dimensional measurement results are given in Appendix - 9.

The performance test is a leakage test in which dry air at 35 bar pressure is pressed into the product, bubble formation in the test pool is checked and leaks at the brazing points are checked. Leakage test performance results are as in Table 5.14.

Table 5.14 Leakge test report – 1. test

ABC	LEAKAGE TEST FORM		XXX-02 02/03.04.2013
ORDER NO: 1605405 - 2	Start: 12:55	DATE: 08.03.2016	
CUSTOMER: X	Finish 13:05		
PIECE: 1		TEST OPT.: İbrahim	
NAME OF WELDER	LEAK OF CURVE BRAZING	LEAK OF CURCUIT BRAZING	LEAK OF COLLECTOR BRAZING
13			
17			
CUTTING IN FRAME :	HAIRPIN TEARING :	OTHER ………… :	
PRODUCT LEAKAGE IN THE MIDDLE :	LEAK OF IRON COLLECTOR BRAZING :		

As indicated in Table 5.14, leakage has been detected at the brazing curve of the welder 13 and the brazing circuit of the welder 17. During the test, the leak points were corrected and re-tested. After correction, the product was retested and no leak was detected. 2. the leakage test result for the test is as in Table 5.15. As the brazing correction did not cause any dimensional and visual change in the product, it was not re-entered into the quality control process.

Table 5.15 Leakge test report – 2. test

ABC	**LEAKAGE TEST FORM**		**XXX-02 02/03.04.2013**
ORDER NO:	1605405 - 2	Start: 13:15 DATE:	08.03.2016
CUSTOMER:	X	Finish 13:20	
PIECE:	1	TEST OPT.:	İbrahim
NAME OF WELDER	LEAK OF CURVE BRAZING	LEAK OF CURCUIT BRAZING	LEAK OF COLLECTOR BRAZING
13			
17			
CUTTING IN FRAME :	HAIRPIN TEARING :		OTHER ………… :
PRODUCT LEAKAGE IN THE MIDDLE :	LEAK OF IRON COLLECTOR BRAZING :		

5.7.3 PSW

Dimensional measurement report and performance test results, photos taken during packaging and sample production are sent to the customer. Parts Presentation Guarantee is prepared in which the customer's approval “Approved”, “Rejected” or “Conditional Acceptance” decisions will be indicated. According to the approval decision of the part presentation guarantee; the project can be canceled, revised or approved for mass production. According to all data presented to X Company relevant with “12345 Alüminium EVAP. Al/Al”, the PSW prepared is as in Appendix - 10.

5.8 Section 5: Feedback and Corrective Actions

Based on all data presented about "12345 Aluminum EVAP Al / Al" to X Company, the product has been checked by the customer and the product has received customer approval. No corrective action was requested for the product. On the customer side, the product is included in the approved product list in the approved supplier category. The product has started mass production.

In this chapter, application studies were carried out for the new product which was selected in accordance with the APQP model proposed for NPD process in ABC Company. According to the studies, sample production was realized. The sample production was carried out at one time in accordance with the design, standards and ABC standards of the customer. The sample production was carried out at one time in accordance with the design, standards and ABC standards of the customer. The produced sample product has been subjected to performance tests and dimensional measurement tests and obtained approval from quality control. The product, which is approved for quality control, is packaged in accordance with the specified packaging standards. The documents prepared under the leadership of APQP team, sample product, photographs taken at all stages, PSW were sent to the customer. As a result of the document and product examination performed by the customer, the product has been approved. In the next chapter, evaluation and results of application studies will be mentioned.

CHAPTER SIX
APPLICATION EVALUATION AND RESULTS

In the ABC Company, which has an order-based production system, 12345 coded aluminum evap honeycomb from Japanese partner X Company, using APQP technique for the production of the new product, all stages were carried out effectively and the results were analyzed.

As a result of the analyzes, the APQP team applied PFMEA as the first analysis after determining the feasibility, production flow diagram and material list. As a result of the analysis, 72 potential failure modes were determined. R.P.N. value of these 17 potential failures were below 40, the R.P.N. value of 51 of them were between 40 to 100, The R.P.N. value of 4 of them was found to be over 100. R.P.N. 4 failure modes with a value of over 100 were focused on and preventive actions were initiated. With preventive actions, the R.P.N value of 4 critical failure modes was reduced to less than 100.

As a second analysis, MSA was applied. Y2 coded Flare Sleeve 3/4 "- 16 thread semi-finished products to be used new product 12345 Aluminum evap. have been selected for MSA. 10 samples taken from the production were randomly measured to 3 different quality personnel with 3 replications. According to the MSA, the GRR value was found to be 12.88%. Since the measurement system was between 10% and 30%, it was determined that the measurement systems are acceptable. In addition, the ndc value was found to be 10.858. Since the ndc value was greater than 5, it has been found that the measuring equipment has sufficient distinguishing feature.

As the third analysis, SPC was applied to determine process adequacy levels. SPC, Y3 coded 1/4" flare aluminum union semi-finished products to be used new product were selected. 5 semi-finished products were selected. 5 sets were taken at different times provided that there were 5 samples in each set. As a result of SPC application on a total of 25 samples, all measurement results were in the range of part tolerance. For the measurement range, UCLr was calculated as 0.50 and LCLr was calculated as 0. According to the graph R drawn according to UCLr and LCLr values, the calculated range values for all sets remain within the limits range and Cp and Cpk values were calculated to measure process capability. Cp value was calculated as 1.96 cpk value was calculated as 1.94. According to the common conditions of the customer and ABC Company, Cpk value ws required to rise above 1.67. Cpk value above 1.67 indicates that the process is carried out under sufficient conditions.

After eliminating the risks for the production of new products and determining that the measurement systems and processes were sufficient, a control plan was prepared in which all the processes that would enable the possible failures to be minimized were included. Information training was organized for all departments related to the control plan and necessary documentation was provided.

Dimensional measurement and leakage test was performed on the product which was produced according to the determined work flow and provided accuracy according to the control plan. Dimensional measurements were within tolerances. According to the leakage test, it was confirmed that there was no brazing leakage on the new product.

All these analyzes, dimensional measurements and performance tests were documented and presented to the customer with the product. The product has been approved based on the customer's documentation review and product controls.

Obtaining customer approval without corrections indicates customer satisfaction. Thanks to the right and high quality production in one operation, which is targeted in the study, both customer satisfaction and cost and time savings have been achieved. In this way, customer expectations were fully met, thus provided customer-oriented products and services.

Since the production of 85% of the company is a new product and the proposed methods shows a high success rate, the studies carried out have become the activities applied continuously in the company. SPC studies have been extended to all critical processes. FMEA works have been turned into a living document within the company for the improvement works and the risks that may occur continuously have been identified and eliminated beforehand. MSA studies were repeated at regular intervals. As these studies were carried out on a routine basis, new product production was carried out in a shorter and more effective manner. Thanks to the APQP method proposed for new products, customer satisfaction, improvement in product quality and reduction in cost rates have been achieved. When the ppm data related to production activities in Table 6.1 were analyzed, it was observed that scrap and re-processing rates decrease compared to months. The net representation of the decrease in ppm rates by months was as in Figure 6.1. This has resulted in a reduction in both cost and transaction time, as well as an increase in customer satisfaction and return to customers.

Table 6.1 Scrap, rework (ppm)

ppm/year-month	2015			2016								
	10	11	12	1	2	3	4	5	6	7	8	9
Scrap	6.059	3.068	2.051	2.417	2.935	2.456	1.226	1.064	448	1424 *	562	825
Rework	6.699	3.213	3.148	4.034	2.781	2.193	1.961	1.548	990	993	782	693

* The reason for the high scrap rate in the 7th month of 2016 has been toppled in the product packaging area.

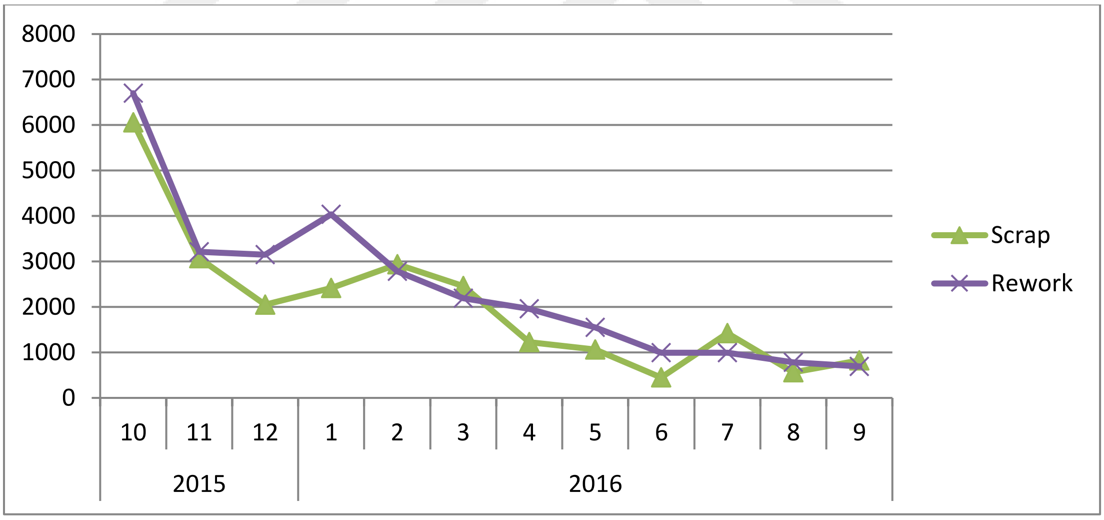

Figure 6.1 Scrap, rework (ppm) graph

The ppm data prepared according to the months for customer complaints were given in Table 6.2. Table 6.2 shows that there was a significant reduction in customer complaints to the company. The proposed method has achieved customer satisfaction by fully meeting the customer expectations and created a strong image in the competitive environment

Table 6.2 Customer complaints (ppm)

ppm/year-month	2015			2016								
	10	11	12	1	2	3	4	5	6	7	8	9
Customer complaints	1.094	1.526	2.066	1.564	1.982	993	1021	954	785	261	302	447

Table 6.3 shows the monthly distribution of the costs calculated for internal and external nonconformities. Thanks to the method applied for the new product, the right production principle was achieved in one go, and as a result of the reduction in scrap and re-processing rates, labor and resource costs spent on the production of a product were reduced. As a result of production that was in line with expectations, accurate and timely production, the number of nonconformities experienced by the customer has been reduced and the correction and reproduction costs have been reduced. In this context, a significant reduction in total cost was observed.

Table 6.3 Internal and external nonconformities cost table

Cost/ year-month	2015			2016								
	10	11	12	1	2	3	4	5	6	7	8	9
Internal nonconformities	₺10.507	₺13.975	₺26.250	₺6.693	₺21.209	₺15.048	₺2.812	₺3.198	₺4.862	₺5.557	₺2.105	₺3.190
External nonconformities	₺20.007	₺41.952	₺0	₺4.798	₺1727	₺1.368	₺0	₺1269	₺0	₺0	₺760	₺450
Total Cost	**₺30.514**	**₺55.927**	**₺26.250**	**₺11.491**	**₺22.936**	**₺16.416**	**₺2.812**	**₺4.467**	**₺4.862**	**₺5.557**	**₺2.865**	**₺3.640**

As a result of all these improvements, as a result of a significant increase in customer satisfaction, demands from different customers, rapid response to customer expectations, investment opportunities for different types of products, increase in efficiency due to increased productivity. In addition to these benefits, the planned execution of all activities, the awareness of all departments at all stages, reduces work stress and reduced any concerns that may arise in the project. In this way, the greatest risk in order-based production systems, just in time, the right amount, and the right product were provided to a large extent, a competitive advantage in the competitive environment has been achieved.

In this chapter, the achievements obtained by the application of APQP model proposed for NPD process by ABC Company were shown. The gains have evaluated on the basis of scrap and recycle ppm rates, ppm rates on customer complaints and cost criteria for internal and external nonconformities. In the next chapter, the evaluation and results of the implementation studies will be mentioned. Chapter will be included summary and concluding remarks, implications for practice, implications for future research.

CHAPTER SEVEN
DISCUSSION AND CONCLUSIONS

7.1 Summary and Concluding Remarks

The order-based production system has high variety of products and a small quantity of products in each variety. In addition to the similarity of the products to be produced at some points, all products are evaluated in the new product class. In addition to the challenges of producing new products, it is also added to the challenges that come with changing market and competitive conditions today. In order to overcome these difficulties and not to decrease the market share, it is necessary to produce high quality products at minimum cost in all stages from the receipt of the order to the after-sales services in the production of new products customized for the customer. It is difficult to control processes by specifying standard procedures and instructions due to differences in products in order-to-production systems.

In order to produce the product in the first and only time, in the right quantity, in accordance with the expectations of the customers, with quality and with minimum cost, to determine the risks that may occur in all stages in advance, to take measures, analyze all systems, evaluate the adequacy, control all activities and keep negative feedback from customers to a lesser level is important. In addition to the fulfillment of these constraints, the customer should be provided with prompt service. These conditions depend on the planned and systematic progression of studies according to particular system, certain rules and effective monitoring and control of all activities. APQP technique is used as the most effective NPD process management method to meet customer expectations and to realize product production with minimum cost in today's tough competition conditions.

The APQP technique provides benefits such as ensuring product quality in new product production, reduction in delivery speed, customer satisfaction, lowering costs, and controlling processes. This tehnique ensures the systematic management of the processes by ensuring the participation of all employees with the continuous improvement of all activities in this technical organization. The APQP technique, which ensures that product realization activities are carried out under controlled conditions, is proposed and applied in ABC Company which has an order-based production system where 85% of the product variety is evaluated as a new product and where the competitive conditions are the most difficult, and has a costly product and production line such as a heat exchanger.

When the studies in the literature are examined, it is seen that APQP technique, which is used in NPD studies, is generally applied in automotive industry and automotive sub-industries with serial production system. In terms of production systems, the number of enterprises with order-based production system is quite high in our country. The number of companies using APQP technique in the new product production processes is very low in order-based production systems where risk ratios and competitive difficulties are very high and it is of utmost importance to produce quality products at minimum cost and to provide products to the customer quickly. This research thesis was inspired by the lack of use of the APQP technique, which provides the highest benefit in the NPD process in companies with an order-based manufacturing system.

All activities are planned to implement the APQP model in the production of new products in the company where the research was conducted. APQP team was determined and new product to be applied was selected among the demands from the customer. The application was completed in 5 main sections. The first two parts of APQP were related with product design. Since the company has not design responsibility and it belongs to the manufacturer, the documents of the first two sections have been provided by the customer. Three main sections of the other APQP application were realized in the company. These sections; Process Design and Development, Product and process validation, Feedback and corrective actions. Inter-departmental critical meetings were held with the APQP team. Evaluations were made about the studies and the progress of the process. First, feasibility studies were conducted and the feasibility of the company was investigated. Product workflow was determined. The sections were completed according to the determined product flow. Some statistical techniques were used in practice. These; PFMEA, SPC, Process capability analysis, MSA. Using these statistical techniques, TV was measured, capabiilities were evaluated and risks were reduced. Then, production was made according to work flow. The whole process was controlled according to the determined control plan. Dimensional measurements control and performance tests have been performed on the completed product and it has been proved that it meets customer requirements and company requirements. The product, which has been approved, has been sent to the customer with all documents in accordance with the packaging and transportation conditions determined by the joint decision of the company and the customer. Thanks to the communication established between the customer and the company in the whole process from the order to the delivery of the product to the customer, many studies became easy to understand and unnecessary time losses were prevented. The customer has reviewed and approved the new product and documents. The APQP model was approved as an evaluation model for new product performance by the top management due to the advantages of APQP technique such as ensuring the right production of the product at one time and thus reducing the labor, time, cost and scrap rates, detecting and eliminating the failures at the source before supplying them to the customer, ensuring customer satisfaction, preparing the control plan for the product. Since 85% of the production is a new product, APQP technique has been used in the production of all products. In this way, the company has achieved a significant advantage over its competitors in terms of both price and quick return to the customer. As a result, it is aimed to increase the current market rate of the enterprise and to enter new markets.

7.2 Implications for Practice

In the production of new products, the APQP model is frequently used by companies in the automotive and aerospace sectors, which have a mass production system. Unlike these sectors and production systems, our work was carried out in the air conditioning and refrigeration sector and a company that has an order-based production system. The results of our study show that, the companies applying the APQP model in the NPD process, which have an order-based production system and which have high product and production costs, will have gains such as reduced product cycle times, increased productivity, reduced costs, increased customer satisfaction. In addition, increasing the quality of the final product, providing competitive advantage, increasing the existing market share, increasing the opportunities to enter new markets are among the other advantages. As a result, companies that implement all the activities in this study fully and make continuous improvement the main principle will increase their profitability rates.

7.3 Implications for Future Research

As a result of the lack of studies in the literature, which have an order-based production system or different from the automotive and aerospace sectors, our study has created an academicly important resource. These studies can be used in academic papers that have the same or similar subjects.

As a result, the APQP model, which is thought to be beneficial for the new product production processes in the automotive and aerospace sectors with only mass production systems, has proved to be beneficial for the air-conditioning and cooling sector with order-based production systems. In future studies, APQP model can be developed for enterprises with production systems other than mass production and order-based production systems. Academic studies can be conducted on generic APQP models for enterprises with order-based production systems. Air conditioning and refrigeration, automotive, automotive sub-industry can be carried out in the same or similar studies in other sectors.

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APPENDICES

APPENDIX-1

Table A.1 Feasibility meeting report

ABC	**FEASIBILITY MEETING REPORT**	**Document No**	ST-F016
		Rev No/Date	01 / 24.02.2016
		Page No	2

SALES DEPARTMANT

	Customer :	**X COMPANY**			
	Special	**X**	Standard		Offer Completion Date: 14.01.2019
First Sample - Prototype Requested?			YES	**X**	NO
MODEL CODE:		2522-2.1-5G-06-1050-05-XX			

PRODUCT TYPE

EVAPORATOR	**X**	KONDENSER		FAN COIL	
COOLER		HEATER		STEAMY	
CUSTOMER TECHNICAL DRAWING		YES	**X**	NO	
CUSTOMER TECHNICAL SPECIFICATIONS		YES	**X**	NO	

GENERAL DIMENSIONS

LL	**1050**	LH	
LDMAX**	**1276.69**	HR	

**Ldmax: 50 MM+ LL + COLLECTOR DIAMETER+ COLLECTOR CONNECTION PIPE (MIN 65 MM)

	INPUT	OUTPUT	PIECE		
COLLECTOR DIAMETER	**Ø22 * Ø35**		**1**		
DISTRIBUTOR	**5 Al Dist.**		**1**	CAPILLARY DIAMETER	**3/16"x0.70**
DIRECTION	**XX**				

MATERIALS

FRAME :	AL. 2 mm
HONEYCOMB :	0.10 mm. Alu.
PIPE :	Ø3/8"*0.60 Al
COLLECTOR :	Input: 5'li Distributor (1/2" Input - 3/16" Output) Output: Connection - Ø22, Output - Ø35
TEST PRESSURE :	35 bar
OTHER :	

ADDITIONAL MATERIALS	YES	NO	EXPLANATION
BY-PASS SHEET		**X**	

Table A.1 continues

DRIP SHEET	X		
PURGER		X	
PAINT		X	Because the product is aluminum, it will be painted with varnish.

OTHER INFORMATIONS

PACKING TYPE	There will be packing in case.
TRANSPORT TYPE	Highway
CUSTOMER'S SPECIAL REQUEST	

COMMERCIAL INFORMATION

DELIVERY METHOD	
CUSTOMER DELIVERY DATE REQUEST	

PRODUCTION DEPARTMENT

	Yes	No
Does the model correspond to the current production?	X	
If no; Cause and Corrective Action		
Is the product technically feasible?	X	
If no; Cause and Corrective Action		
Are the raw materials in the BOM available in stocks?	X	
If not, commissioning the purchase	Auxiliary materials specified in the customer technical drawing shall not be purchased, they will be produced at ABC.	
Does the product's packaging specification meet ABC criteria?	X	
If no; Alternative solutions and customer approval are required. (Sales)		
Are customer tolerances within ABC production capability?	X	
If no; Alternative solutions and customer approval are required. (Sales)		

PLANNING AND PURCHASING DEPARTMENT

	Yes	No
Is there any need for raw materials, semi-finished products, molds and fixtures?		X
If yes; lead time		
Do the packaging and shipping criteria of the product meet?	X	
If no; Alternative solutions and customer approval are required. (Sales)		

Table A.1 continues

Are the material standards, general conditions and special requirements specified in the Technical Specifications suitable for purchasing?	Yes	X	No		
If no; Alternative solutions and customer approval are required. (Sales)					
QUALITY DEPARTMENT					
Does it meet all acceptance criteria specified in the Technical Specifications?	Yes	X	No		
If no; Alternative solutions and customer approval are required. (Sales)	The flare is opened to the distributor aluminum pipe end for the ion connection. Due to the softness of the aluminum pipe, this flare may deteriorate during the customer's assembly process. Therefore, the copper pipe, which is much more robust than aluminum, will be brazed to the aluminum pipe end and the flare will be opened to the copper pipe.				
Are special test requests available?	Yes	X	No		
If no; requirements in terms of feasibility					
TECHNICAL DEPARTMENT					
Does the product require investment, resource planning and additional labor?	Yes		No	X	
If yes; Causes and remedies					
DECISION					
The product is feasible with existing resources. The brazing of copper pipe to the aluminum pipe end will be explained to the customer with all the reasons. Process will be initiated based on customer approval. The Sales and Marketing Manager was unanimously elected as the leader of the new product development process for this project.					
DECISION					
Product feasibility:	Yes	X	No		
If no; Causes and Remedies					

CONFIRMATION					
	Sales Depratmant	**Production Depratmant**	**Purchasing Depratmant**	**Quality Depratmant**	**Technical Depratmant**
NAME & SURNAME					
SIGNATURE					

CONTROL - OBSERVATION		
NAME & SURNAME	**Deputy General Manager**	**General Manager**
SIGNATURE		

APPENDIX-2

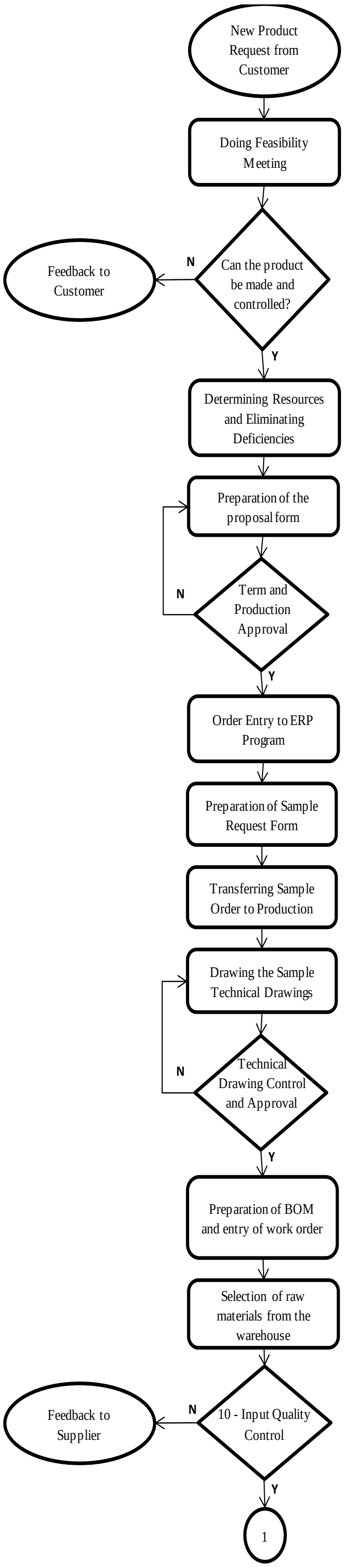


Figure A.2 Flow diagram

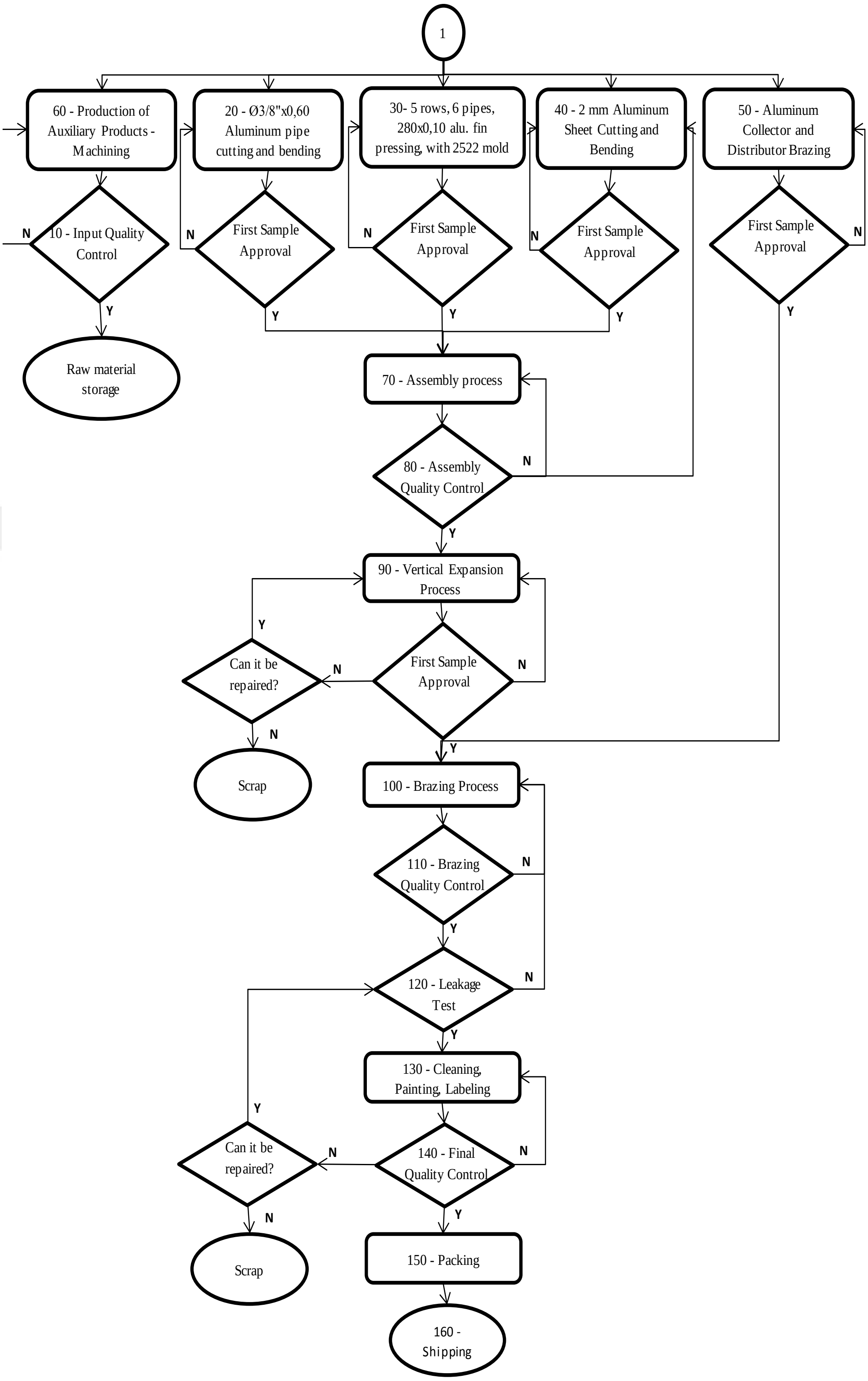


Figure A.2 continues

APPENDIX-3

Table A.3 Process FMEA

FAILURE MODE AND EFFECTS ANALYSIS (PROCESS FMEA)

FMEA Number: 8

Prepared by: Quality Assurance Responsible

Part Number / Name:	12345 Aluminum EVAP - AL / AL	Process Responsibility	QUALITY ASSURANCE
Model Year(s)/ Program(s)	X BRAND EVAPORATOR - 2522-2.1-5G-06-1050-05-XX	Key Date	

FMEA Date (Orig.) 20.01.2016

FMEA Date (Rev.) 03.02.2016

Core Team Purchasing Responsible, Production Responsible, Sales and Marketing Responsible, Engineering Responsible, Planning Responsible, Logistics Responsible and Quality Assurance Responsible

KY-F046 / Rev.00-02.07.2014

							Current Process							Action Results				
Process / Function	Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Severity	Classification	Potential Causes(s) of Failure	Current Process Controls Prevention	Occurrence	Current Process Controls Detection	Detection	**R.P.N**	Recommended Action	Responsibility & Target Completion Date	Actions Taken & Effective Date	Severity	Occurrence	Detection	**R.P.N**
10 - INPUT QUALITY CONTROL	3/8"x0.60 Aluminum pipe control	faulty pipe axis	failure of assembly and expansion operations	3		manufacturer failure	Supplier quality report + TDÖF	2	input quality control + process control	5	30							
	3/8"x1 Aluminum pipe control	faulty pipe axis	failure of assembly and expansion operations	3		manufacturer failure	Supplier quality report + TDÖF	2	input quality control + process control	5	30							
	1/4"x0.80 Capillary Aluminum pipe control	faulty pipe axis	failure of assembly and expansion operations	3		manufacturer failure	Supplier quality report + TDÖF	2	input quality control + process control	5	30							
	Ø35X1.5 MM Aluminum pipe control	faulty pipe axis	failure of assembly and expansion operations	3		manufacturer failure	Supplier quality report + TDÖF	2	input quality control + process control	5	30							
	Ø22"X1.5 MM Aluminum pipe control	faulty pipe axis	failure of assembly and expansion operations	3		manufacturer failure	Supplier quality report + TDÖF	2	input quality control + process control	5	30							
	Ø12"X1 MM Aluminum pipe control	faulty pipe axis	failure of assembly and expansion operations	3		manufacturer failure	Supplier quality report + TDÖF	2	input quality control + process control	5	30							
	280x0.10 aluminum foil control	size incompatibility + surface deformation	foil cannot be processed in the press machine and the production waste is high	3		manufacturer failure	Supplier quality report + TDÖF	3	input quality control + process control	5	45							
	2 mm aluminum sheet control	size incompatibility + surface deformation + undulation	sheet metal cannot be processed in punch machine	3		manufacturer failure	Supplier quality report + TDÖF	4	input quality control + process control	5	60							
	1/4" flare aluminum union (7/16 "-20 thread) control	size incompatibility + surface deformation	cannot be used semi-finished	7		manufacturer failure	Supplier quality report + TDÖF	3	input quality control + process control	4	84							
	7/8" aluminum union with o-ring control	size incompatibility + surface deformation	cannot be used semi-finished	7		manufacturer failure	Supplier quality report + TDÖF	3	input quality control + process control	4	84							
	3/4" -16 thread flare Aluminum Sleeve [AA24 MM] control	size incompatibility + surface deformation	cannot be used semi-finished	7		manufacturer failure	Supplier quality report + TDÖF	3	input quality control + process control	4	84							
	Ø35x1.5 convex aluminum plug [material thickness: 2 mm) control	size incompatibility + surface deformation	cannot be used semi-finished	7		manufacturer failure	Supplier quality report + TDÖF	3	input quality control + process control	4	84							

Table A.3 continues

	3/8"-1/4" aluminum aspirin	size incompatibility + surface deformation	cannot be used semi-finished	7		manufacturer failure	Supplier quality report + TDÖF	3	input quality control + process control	4	84							
	3/8"x0.80 mm – 25.4x22mm aluminum curve control	size incompatibility + surface deformation	cannot be used semi-finished	7		manufacturer failure	Supplier quality report + TDÖF	3	input quality control + process control	4	84							
	3/16"X5X1/2" Aluminum Distributor [Ø28 MM] control	size incompatibility + surface deformation	cannot be used semi-finished	7		manufacturer failure	Supplier quality report + TDÖF	3	input quality control + process control	4	84							
20- HAIRPIN DEPART.	3/8"x0.60 aluminum hairpin production	damage on the hairpin	failure of expansion process	5	Ö	manufacturer failure operator failure	Supplier quality report + TDÖF Machine operation and maintenance instructions + first sample approval	3	process control instruction and form	5	75							
		occur the black blemish on the hairpin	leakage in test process	5		manufacturer failure operator failure	Supplier quality report + TDÖF + first sample approval	2	process control instruction and form	5	50							
		Burrs on hairpin ends	failure of assembly operation	3		operator failure + machine failure	Machine operation and maintenance instructions + first sample approval	5	process control instruction and form	5	75							
		occur the deformation on the hairpin bends	Decrease in product working performance	8		manufacturer failure operator failure machine failure	Supplier quality report + TDÖF Machine operation and maintenance instructions + first sample approval	2	process control instruction and form	5	80							
		Hairpin pipes are not the same size	failure of expansion process	4		operator failure machine failure	Machine operation and maintenance instructions + first sample approval	4	process control instruction and form	5	80							
		Hairpin size is not suitable	failure of assembly and expansion process	4		operator failure	Machine operation and maintenance instructions + first sample approval	2	process control instruction and form	5	40							
		tearing on the hairpin bend	failure of assembly, expansion and test process	6		manufacturer failure operator failure machine failure	Supplier quality report + TDÖF Machine operation and maintenance instructions + first sample approval	2	process control instruction and form	5	60							
30 - HONEYCOMB DEPART.	280x0.10 aluminum foil production	Honeycomb foil type not suitable	cannot be used semi-finished and decrease in product working performance	8		operator failure	Machine operation and maintenance instructions + first sample approval	2	process control instruction and form and assembly quality control plan	5	80							
		deformation of honeycomb edges	failure of assembly process and cannot be used semi-finished	7		operator failure machine failure	Machine operation and maintenance instructions + first sample approval	2	process control instruction and form and assembly quality control plan	5	70							
		occur the deformation on the pitch	failure of assembly process and cannot be used semi-finished	7		manufacturer failure operator failure machine failure	Supplier quality report + TDÖF Machine operation and maintenance instructions + first sample approval	2	process control instruction and form and assembly quality control plan	5	70							
		deformation of the round curve in the pitch	failure of assembly process and cannot be used semi-finished	7		manufacturer failure operator failure machine failure	Supplier quality report + TDÖF Machine operation and maintenance instructions + first sample approval	2	process control instruction and form and assembly quality control plan	5	70							
		failure in the pitch size	failure of assembly process and cannot be used semi-finished	5		operator failure machine failure	Machine operation and maintenance instructions + first sample approval	3	process control instruction and form and assembly quality control plan	5	75							
40-SHEET METAL DEPART.	2 mm aluminum sheet production	incorrect sheet thickness	failure of assembly process, cannot be used semi-finished, and customer rejection	5		manufacturer failure mislabeling operator failure	Input quality control + Supplier quality report	3	process control instruction and form and assembly quality control plan	5	75							
		incorrect hole size on the sheet	failure of assembly process, cannot be used semi-finished, and customer rejection	5		punch program failure + wrong tool usage	Machine operation and maintenance instructions + first sample approval + process controls and upper unit control	3	process control instruction and form and assembly quality control plan	5	75							

Table A.3 continues

		incomplete operation	failure of assembly process, cannot be used semi-finished, and customer rejection	6		punch program failure + missing tool usage	Machine operation and maintenance instructions + first sample approval + process controls and upper unit control	2	process control instruction and form and assembly quality control plan	5	60							
		faulty width and length	failure of assembly process, cannot be used semi-finished, and customer rejection	6		punch program failure + incorrect setting of clams	Machine operation and maintenance instructions + first sample approval + process controls and upper unit control	3	process control instruction and form and assembly quality control plan	5	90							
		incorrect hole height	failure of assembly process, cannot be used semi-finished, and customer rejection	5		punch program failure + wrong tool usage	Machine operation and maintenance instructions + first sample approval + process controls and upper unit control	2	process control instruction and form and assembly quality control plan	5	50							
		burrs of holes and sheet edges	failure of assembly process, cannot be used semi-finished, and customer rejection	6		operator failure machine failure	Machine operation and maintenance instructions + first sample approval	2	process control instruction and form and assembly quality control plan	5	60							
70- ASSEMBLY DEPART.	product assembly	use of materials that do not belong to the product order	customer rejection, and cannot be used semi-finished or product	8		mislabeling operator failure	hairpin, sheet, press process control instruction	2	assembly quality control plan	5	80							
		Mounting the mirror sheet in the opposite direction	customer rejection, and cannot be used semi-finished or product	8		wrong technical drawing + operator failure	Assembly process instructions + first sample approval + process controls and upper unit control	2	assembly quality control plan	5	80							
		making an incorrect on the hairpin curciut	cannot be used semi-finished or product	6		wrong technical drawing + operator failure	Assembly process instructions + first sample approval + process controls and upper unit control	3	assembly quality control plan	5	90							
		faulty product length	customer rejection, and cannot be used product	6		wrong technical drawing + operator failure	Assembly process instructions + first sample approval + process controls and upper unit control	3	assembly quality control plan	5	90							
90-EXPANSION DEPART.	provide to pass tightly the pipe to aluminium sheet and honeycomb	use of wrong expansion ball	decrease in product working performance	8		operator failure + machine material wear	Process instructions + first sample approval	2	quality control after expansion process	5	80							
		wrong product pitch	change in product performance	6		Incorrect expansion setting + operator failure	Process instructions + first sample approval	3	quality control after expansion process	5	90							
		faulty product length	customer rejection + product not available	5		Incorrect expansion setting + operator failure + unsuitable fixture use	Process instructions + first sample approval	3	quality control after expansion process	5	75							
		damage on the hairpin	reprocessing of the product	3		Incorrect expansion setting + operator failure	Process instructions + autonomous maintenance instruction + first sample approval	2	quality control after expansion process	5	30							
		product axis is faulty	customer rejection + product not available + reprocessing of the product	3		operator failure	Process instructions + first sample approval	3	quality control after expansion process	5	45							
		deformation of mirror sheet	customer rejection + product not available + reprocessing of the product	5		operator failure + unsuitable fixture use	Process instructions + first sample approval	2	quality control after expansion process	5	50							
50 - COLLECTOR BRAZING DEPART.	Ø35 aluminum collector's production	aluminum collector pipe with aluminum connecting pipe brazing nonconformity	leakage in the product + reprocessing of the product	5		Lack of operator training	Process instructions	4	leakage test	3	60							
		failure of measurement and axis in aluminum ion and collector connection pipe brazing	customer rejection + product not available + reprocessing of the product	5		Lack of operator training	Process instructions	4	quality control after brazing process	4	80							

Table A.3 continues

		use of wrong flare union	customer rejection + product not available + reprocessing of the product	5		Lack of operator training + mislabeling	stock label Input quality control	2	quality control after brazing process	4	40							
		use of wrong o-ring union	customer rejection + product not available + reprocessing of the product	5		Lack of operator training + mislabeling	stock label Input quality control	2	quality control after brazing process	4	40							
		Union with collector brazing nonconformity	leakage in the product + reprocessing of the product	5		Lack of operator training	Process instructions	4	leakage test	3	60							
		non-conformity brazing of collector pipe and plug	leakage in the product + reprocessing of the product	5		Lack of operator training	Process instructions	4	leakage test	3	60							
		non-conformity in the collector brazing with the switching pipe	leakage in the product + reprocessing of the product	5		Lack of operator training	Process instructions	4	leakage test	3	60							
	3/16"X5X1/2" aluminum distributor collector production	use of defective material	customer rejection + cannot be used semi-finished or product	8		mislabeling + operator failure	collector operation instruction	2	quality control after brazing process	5	80							
		wrong flare sleeve selection	customer rejection + cannot be used semi-finished or product	5		Lack of operator training + mislabeling	stock label Input quality control	2	quality control after brazing process	4	40							
		incorrect capillary tube dimensions	customer rejection + cannot be used semi-finished or product	5		Lack of operator training	collector operation instruction	4	quality control after brazing process	4	80							
		faulty brazing of flared sleeve with copper pipe	leakage in the product + reprocessing of the product	5		Lack of operator training	Process instructions	4	leakage test	3	60							
		faulty brazing of distributor with copper pipe	leakage in the product + reprocessing of the product	5		Lack of operator training	Process instructions	4	leakage test	3	60							
		faulty brazing of distributor with capillary pipe	leakage in the product + reprocessing of the product	5		Lack of operator training	Process instructions	4	leakage test	3	60							
100 - BRAZING DEPART	brazing of curves and collectors to product	faulty circuitry	reprocessing of the product	6		wrong technical drawing + operator failure	brazing operation instruction + first sample approval	3	quality control after brazing process	5	90							
		incorrect collector axis measurement	reprocessing of the product	6		operator failure	brazing operation instruction + first sample approval	5	quality control after brazing process	5	150	fixtures will be made for the brazing operation (Fixtures no: F123) + by-pass sheet to be made.	UR	15.07.2016	5	3	4	60
		Incorrect size of distributor axis	reprocessing of the product	6		operator failure	brazing operation instruction + first sample approval	5	quality control after brazing process	5	150	fixtures will be made for the brazing operation (Fixtures no: F123) + by-pass sheet to be made.	UR	15.07.2016	5	3	4	60
		faulty brazing operation	reprocessing of the product	5		operator failure	brazing operation instruction + first sample approval + brazing operators' trainings	5	quality control after brazing process + leakage test	5	125	operator trainings will be provided + suitable brazing wire will be investigated	SA	15.07.2016	5	3	5	75
		use of defective or improper brazing wire	reprocessing of the product	5		mislabeling + operator failure	brazing operation instruction + first sample approval	2	quality control after brazing process + leakage test	5	50							
		deformation of mirror sheets	No products and / or semi-products can be used	5		operator failure	brazing operation instruction + first sample approval + brazing operators' trainings	5	quality control after brazing process	5	125	cooling pool to be made	TM	15.07.2016	5	3	5	75
		blockage of circuit pipes	reprocessing of the product	7		operator failure	brazing operation instruction + brazer trainings	2	leakage test	5	70							
120 - LEAKAGE TEST	Determination of conformity of brazing points in the product according to Directive 97/23 / EC	test pressure does not match the product or customer request	customer rejection due to leakage + reprocessing of the product	5		operator failure + failure to perform scheduled maintenance on time + no calibration of the instrument	leakage test instruction + Customer specific test pressure form	2	green colored checked label + green numbered operator label + leakage test process control form	5	50							

Table A.3 continues

		test time does not match the product or customer request	customer rejection due to leakage + reprocessing of the product	5		operator failure + failure to perform scheduled maintenance on time + no calibration of the instrument	leakage test instruction + Customer specific test pressure form	2	green colored checked label + green numbered operator label + leakage test process control form	5	50							
150 - PACKING DEPART.	labeling and packaging according to customer request	do not press nitrogen on the product or press more or less than the desired value	disruption of customer production	4		operator failure	Packing instruction + technical drawing	2	Final quality control	4	32							
		the contents of the metallized label are incorrect, the wrong label is glued or does not stick at all	customer's production delay	4		operator failure + incorrect order entry process	automatic warning in prescription preparation process + packing instruction + assembly metallized label	2	Final quality control	4	32							
		incorrect pallet dimensions	ürün yükleme ve / veya müşteri stoğu ile ilgili sorunlar	3		operator failure	packing instruction	2	casing form + Final quality control	5	30							
		incorrect packaging dimensions	ürün yükleme ve / veya müşteri stoğu ile ilgili sorunlar	3		operator failure	packing instruction	2	casing form + Final quality control	5	30							
		packaging type is not suitable for the product or transport type	product damage during shipping	5		operator failure	packing instruction	3	Final quality control	5	75							
		the pallet label is incorrect or missing or does not stick at all	customer's production delay	3		operator failure +carelessness of the logistics officer	packing instruction	2	Final quality control	5	30							
		not plugging the plug into the product or not installing the appropriate plugs	contamination inside the product (dust, burr)	4		operator failure	Packing instruction + technical drawing	2	Final quality control	5	40							

APPENDIX-4

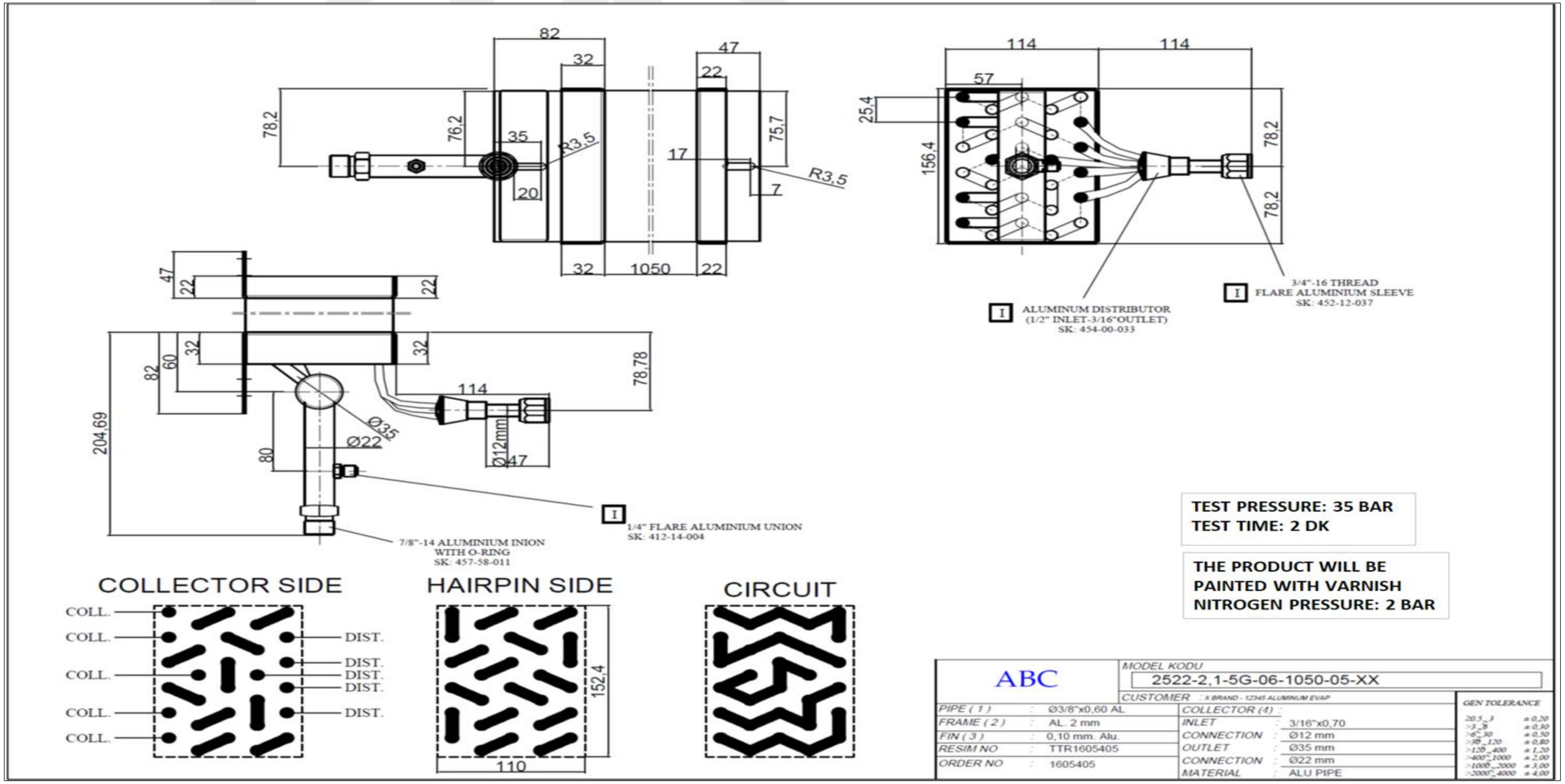


Figure A.4 Technical drawing

APPENDIX-5

Table A.5 MSA – GR&R

GAGE REPEATABILITY AND REPRODUCIBILITY DATA SHEET
VARIABLE DATA RESULTS

Part Number Y2		Gage Name kumpas		Appraiser A **Operator A**	
Part Name Flare Sleeve 3/4 "- 16 thread		Gage Number 15278752		Appraiser B **Operator B**	
Characteristic 24	Specification 23.5 24.5	Gage Type callipers		Appraiser C **Operator C**	
Machine		Trials 3	Parts 10	Appraisers 3	Date Performed 15.02.2016

APPRAISER / TRIAL #	**PART**										**AVG**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1, 1 1	24.23	24.24	24.23	24.25	24.27	24.29	24.3	24.29	24.27	24.26	24.263
2, 2	24.22	24.24	24.24	24.25	24.27	24.29	24.31	24.3	24.27	24.26	24.265
3, 3	24.23	24.25	24.23	24.25	24.27	24.29	24.3	24.3	24.27	24.25	24.264
4, AVE	24.23	24.24	24.23	24.25	24.27	24.29	24.30	24.30	24.27	24.26	x_a= 24.264
5, R	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.01	r_a= 0.006
6. 2 1	24.21	24.25	24.23	24.25	24.27	24.29	24.29	24.29	24.28	24.26	24.262
7, 2	24.22	24.24	24.23	24.25	24.27	24.29	24.29	24.29	24.28	24.25	24.261
8, 3	24.21	24.25	24.23	24.25	24.27	24.29	24.28	24.29	24.27	24.26	24.260
9, AVE	24.21	24.25	24.23	24.25	24.27	24.29	24.29	24.29	24.28	24.26	x_b= 24.261
10, R	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	r_b= 0.005
11. 3 1	24.22	24.25	24.23	24.25	24.27	24.29	24.3	24.3	24.27	24.26	24.264
12, 2	24.21	24.25	24.23	24.25	24.27	24.29	24.29	24.3	24.27	24.26	24.262
13, 3	24.22	24.25	24.24	24.25	24.27	24.29	24.3	24.3	24.27	24.26	24.265
14, AVE	24.22	24.25	24.23	24.25	24.27	24.29	24.30	24.30	24.27	24.26	x_c= 24.264
15, R	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	r_c= 0.003
16. PART AVERAGE	24.22	24.25	24.23	24.25	24.27	24.29	24.30	24.30	24.27	24.26	X= 24.263 R_p= 0.077
17, $(r_a + r_b + r_c)$ / (# OF APPRAISERS) =											R= 0.0047
18, x_{DIFF} = (Max x - Min x) =											x_{DIFF}= 0.0030
19, * UCL_R = R x D_4 =											UCL_R= 0.0120

* D_4 =3.27 for 2 trials and 2.58 for 3 trials. UCL_R represents the limit of individual R's. Circle those that are beyond this limit. Identify the cause and correct. Repeat these readings using the same appraiser and unit as originally used or discard values and re-average and recompute R and the limiting value from the remaining observations.
Note
s:

Table A.5 continues

GAGE REPEATABILITY AND REPRODUCIBILITY DATA SHEET VARIABLE DATA RESULTS

Part Number Y2	Gage Name kumpas		Appraiser A Operatör A	
Part Name Flare Sleeve 3/4 "- 16 thread	Gage Number 15278752		Appraiser B Operatör B	
Characteristic 24 / Specification 23.5 24.5	Gage Type kumpas		Appraiser C Operatör C	
Machine 0	Trials 3	Parts 10	Appraisers 3	Date Performed 15.02.2016

Measurement Unit Analysis	% Total Variation (TV)
Repeatability - Equipment Variation (EV) EV = R x K_1 = 0.000 x 0.5908 = 0.0028	% EV = 100 (EV/TV) = 100(0.000/0.000) = 11.34
Reproducibility - Appraiser Variation (AV) AV = $\{(x_{DIFF} \times K_2)^2 - (EV^2/nr)\}^{1/2}$ = {(000 x 0.5231)^2 - (000 ^2/(10 x 3))}^1/2 = 0.0015 n = parts r = trials	% AV = 100 (AV/TV) = 100(0.000/0.000) = 6.11
Repeatability & Reproducibility (GRR) GRR = $\{(EV^2 + AV^2)\}^{1/2}$ = {(0.000^2 + 0.000^2)}^1/2 = 0.00313	% GRR = 100 (GRR/TV) = 100(0.000/0.000) = 12.88 *Gage system may be acceptable*
Part Variation (PV) PV = $R_P \times K_3$ = 0.000 x 0.3146 = 0.02412	% PV = 100 (PV/TV) = 100(0.000/0.000) = 99.17
Total Variation (TV) TV = $\{(GRR^2 + PV^2)\}^{1/2}$ = {(0.000^2 + 0.000^2)}^1/2 = 0.0243	ndc = 1.41(PV/GRR) = 1.41(0.000/0.000) = 10.86 *Gage discrimination acceptable*

Trials	$\mathbf{K_1}$
2	0.8862
3	0.5908

Appraisers	**2**	**3**
K_2	0.7071	0.5231

Parts	$\mathbf{K_3}$
2	0.7071
3	0.5231
4	0.4467
5	0.4030
6	0.3742
7	0.3534
8	0.3375
9	0.3249
10	0.3146

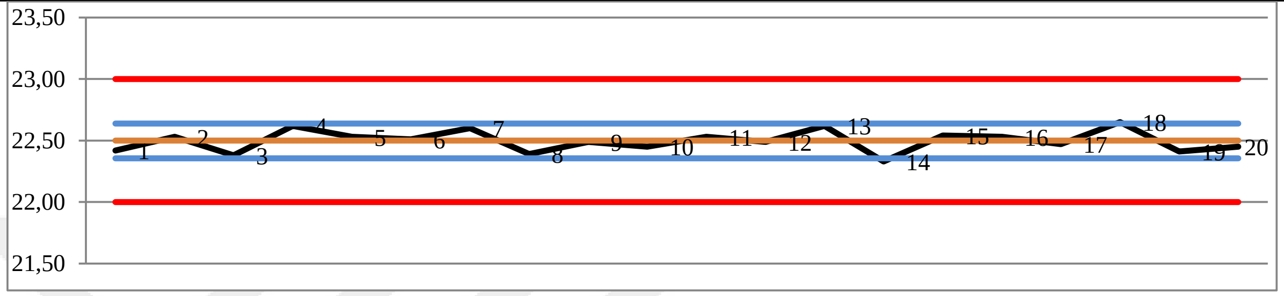
For information on the theory and constants used in the form see *MSA Reference Manual*, Third edition.

APPENDIX-6

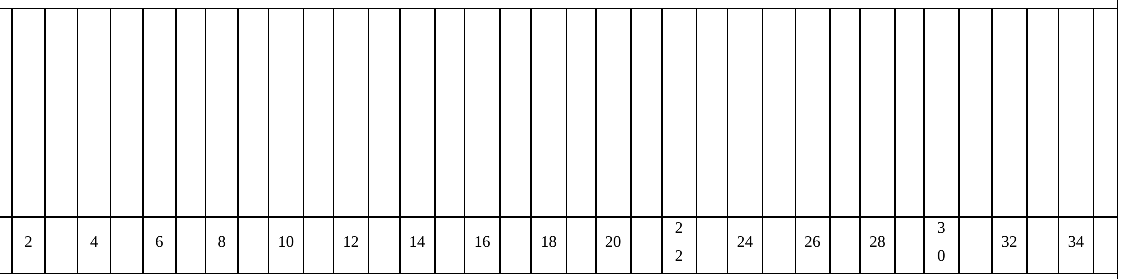
Table A.6 SPC

	STATISTICAL PROCESS CONTROL DIAGRAM (X / R)				MACHINE NO	FORM NO	2	LONG TERM	
					T10MD001-GLS2000	ROW NO	1	SHORT TERM	
NAME OF THE PRODUCT	FEATURE TO CONTROL	SPECIFICATION	SAMPLING FREQUENCY	GAUGE	PRODUCT NO	NUMBER OF SAMPLES		START DATE	17.02.2016
Y3 - 1/4" Flare aluminum union	UNION LENGTH	22.5 $^{\pm 0.5}$ *mm*	5 pcs / hour	12345 caliper (150 MM)	*U10*	*25*		COMPLETION DATE	17.02.2016

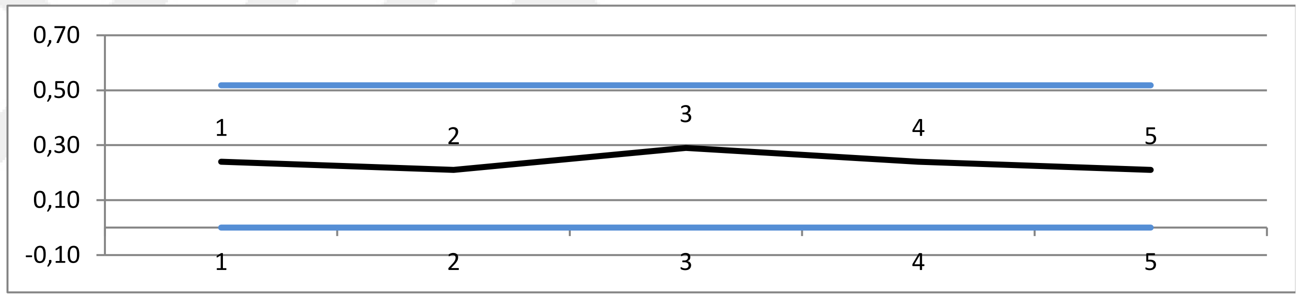
X CONTROL GRAPHICS



(DISTRIBUTION OF VARIABLE X)



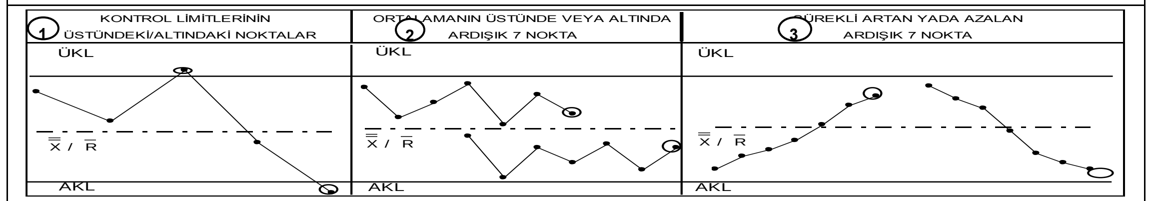
R CONTROL GRAPHICS



ALL MEASUREMENTS BEYOND CONTROL

INTERVENTION TO THE PROCESS IN THE FOLLOWING CONDITIONS:

1. POINTS ABOVE / UNDER CONTROL LIMITS
2. 7 EXTERNAL POINTS ABOVE OR UNDER THE AVERAGE
3. CONTINUOUS INCREASING OR DECREASING 7 POINTS
4. ANY NON-RANDOM DISTRIBUTION



MEASURING TOOL / GAGE						$\bar{\bar{X}}$	22.504	$\bar{R}$	0.24
CALIBRATION	05.01.2016	05.01.2016	05.01.2016	05.01.2016	05.01.2016	$UCL_x = \bar{\bar{X}} + (A_2 * \bar{R})$		22.641326	
SHIFT	1	1	1	1	1	$LCL_x = \bar{\bar{X}} - (A_2 * \bar{R})$		22.366674	
HOUR	15:46:00	16:49:00	17:40:00	19:06:00	20:06:00	$UCL_R = D_4 * \bar{R}$		0.503132	
DAY	11.04.2016	11.04.2016	11.04.2016	11.04.2016	11.04.2016	$LCL_R = D_3 * \bar{R}$		0	

						Nu. of samples	Constants				
X1	22.42	22.51	22.53	22.53	22.53	Nu. of samples	Constants			Cp=(Üst.Tol.-Alt Tol.) / 6xS	1,96532317
X2	22.53	22.6	22.49	22.47	22.57	n	A2	D3	D4	$UCL_R = \bar{R}/d_2$	0.084803695
X3	22.38	22.39	22.62	22.65	22.4	2	1.880	0	3.268	Cpk = Zmin / 3xS	1.949600587
X4	22.62	22.49	22.33	22.41	22.55	3	1.023	0	2.574	$Z_1 = \bar{\bar{X}} - Min.Spek$	0.504
X5	22.53	22.45	22.54	22.45	22.61	4	0.729	0	2.282	$Z_2 = Max.Spek - \bar{\bar{X}}$	0.496
∑X	***112.48***	***112.44***	***112.51***	***112.51***	***112.66***	5	0.577	0	2.114		
X	***22.496***	***22.49***	***22.502***	***22.50***	***22.53***	CONTROL				CONFIRMATION	
R	***0.24***	***0.21***	***0.29***	***0.24***	***0.21***						

PROCESS COMPETENCY VALUES	*Cp*	***1.96532317237675***	*Cpk*	***1.94960058699774***	**PROCESS:**	STABLE	X	UNSTABLE		SUFFICIENT	X	INSUFFICIENT	

APPENDIX-7

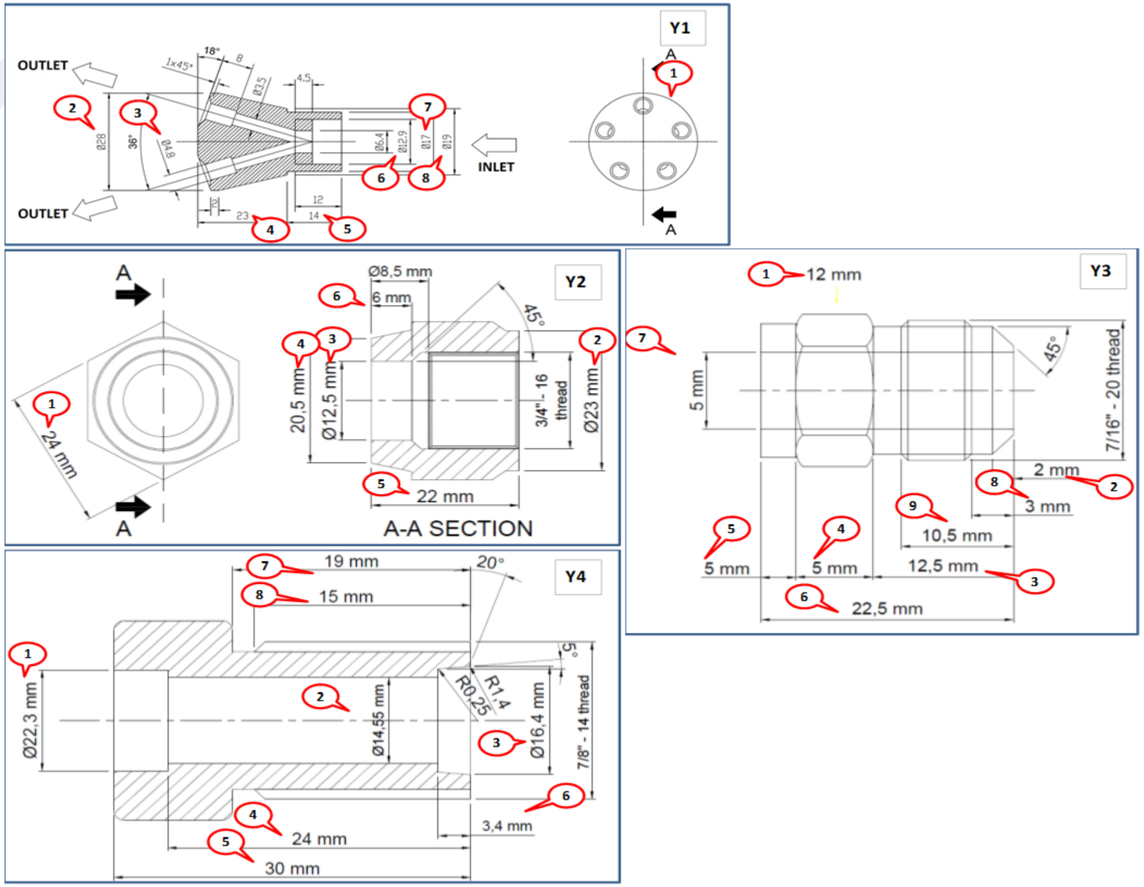


Figure A.7 Semi-finished technical drawing – numbered and technical drawing – numbered

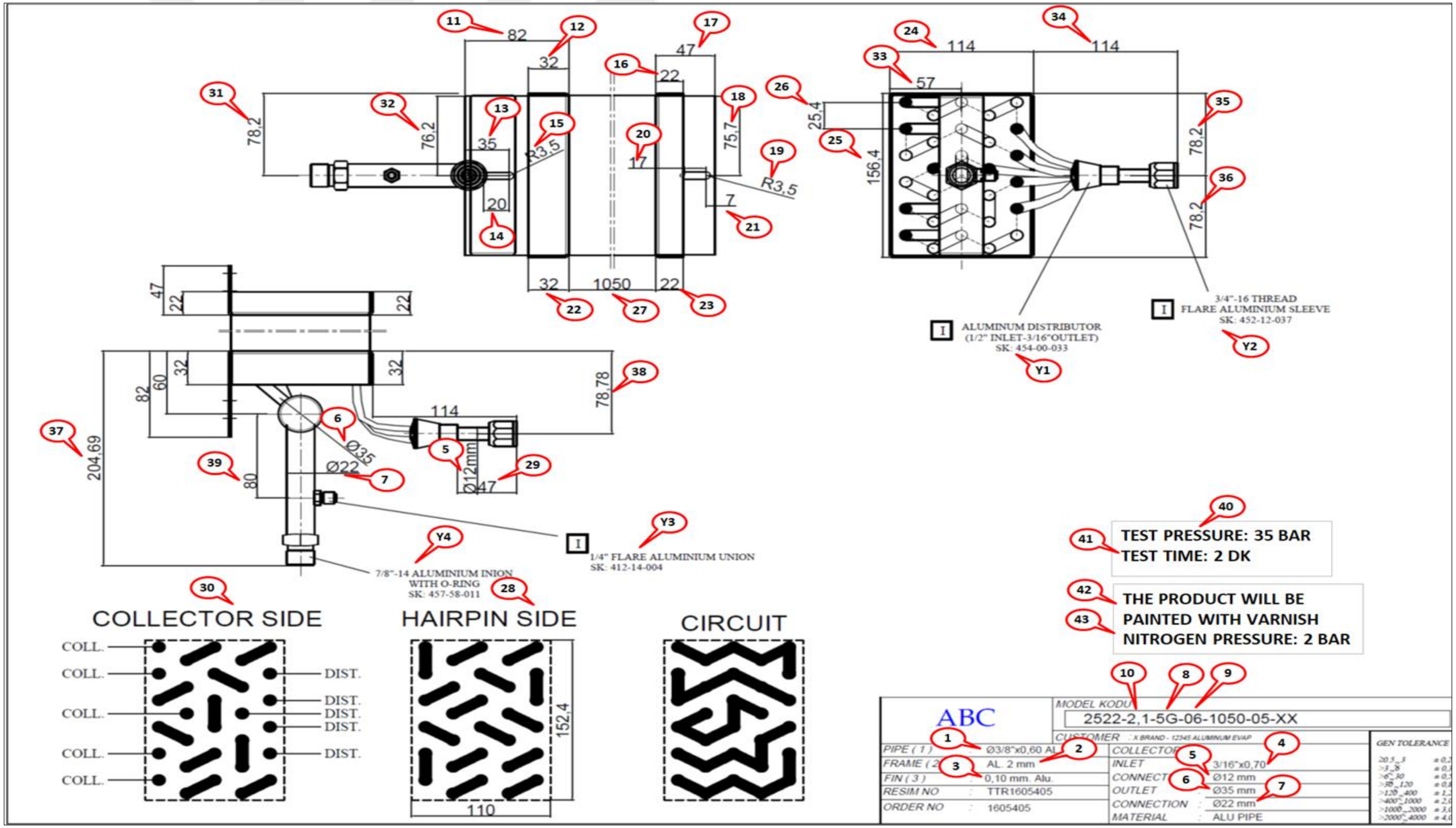


Figure A.7 continues

APPENDIX-8

Table A.8 Control plan

	CONTROL PLAN					
					Doküman No	XXX-01
					Rev No/Tarih	00/22.12.2015
					Sayfa No	1/1
Prototype	X	Pre-Launch		Production		
Control Plan Number 1608		Key Contact/ Phone Control Plan Responsible - 0123 456 78 99			Date (Orig.) 25.02.2016	Date (Rev.)
Part Number/ Change Level X MARKA EVAPARATÖR - 2522-2.1-5G-06-1050-05-XX		Core Team Purchasing Responsible, Production Responsible, Sales and Marketing Responsible, Engineering Responsible, Planning Responsible, Logistics Responsible and Quality Assurance Responsible			Customer Engineering Approval-Date (If Req'd.) 26.02.2016	
Part Name/ Description 12345 Aluminium EVAP. Al/Al		Supplier/Plant Approval/ Date 25.02.2016			Customer Quality Approval/Date (If Req'd.)	
Supplier/ Plant ABC A.Ş	Supplier Code -	Other Approval/ Date (If Req'd.) Üretim - 25.02.2016			Other Approval/Date (If Req'd.)	

Part Process Number	Process Name-Operation Description	Machine, Device Jig, Tools For Mfg.	Characteristics: NO.	Characteristics: Product	Characteristics: Process	Special Cahr. Class	Methods: Product/ Process/ Specification/ Tolarance	Methods: Evaluation/ Measurement Technique	Methods: Sample Size	Methods: Sample Freq.	Methods: Control Method	Reaction Plan	Registration form
QUALITY CONTROL INPUT (10)	Waybill and label control of incoming material				Label compliance and waybill information check		Labels containing company name, lot number, production date, quantity, kg, other information must be affixed on the packaging of purchased materials. Labels should be legible, not torn. The waybill information should be in line with the party. Check that the party is the same (not confused).	Visual control	min. 1	Every batch entering raw warehouse	Input Quality Plan (KY-T002)	Giving information to purchasing responsible	Input Quality Control Form (KY-F022)
	Material identification labels				Material Definition Labels		All materials coming to the warehouse must have a material identification label with the definitions such as material type, quantity, customer name, order number, material lot number, production date.	Visual control	min. 1	Every batch entering raw warehouse		Giving information to warehouse officer	material identification card
	Control of warehouse for placement and stocking suitability				Warehouse Layout		After the verification of the purchased material is completed, the warehouses should be stocked in the area defined for the product. The physical conditions of the warehouses must be appropriate.	Visual control	min. 1	Every batch entering raw warehouse	PL-T002 Material Storage Instruction	Giving information to 5S responsible and Giving information to	
	Stock rotation FIFO				FIFO		Stock rotation should be applied according to FIFO. The waiting party should be placed in front and the next party should be placed in the back.	Visual control	min. 1	Every batch entering raw warehouse	Visual control	Giving information to Giving information to	
	Compliance of Product Certificates				Product Certificates		The lot number indicated on the identification label of the product shipped by the supplier must match the lot number indicated on the product certificate.	Visual control	min. 1	Every batch entering raw warehouse	Input Quality Plan (KY-T002)	Giving information to purchasing responsible	Input Quality Control Form (KY-F022)
	Packing conformity check				Packing suitability		The packaging of the purchased materials should not be damaged, and there should be no tearing or crushing. The packaging of the incoming material should be standard and should not differ within the lot.	Visual control	min. 1	Every batch entering raw warehouse	Visual control	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
	Quality control of incoming material			280x0.10 aluminum foil	width measurement		The width of the aluminum foil must be the same as the width specified in the waybill and product certificates. 280 mm	Meter	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)

Table A.8 continues

					thickness		The wall thickness of the aluminum foil must be the same as the wall thickness specified in the waybill and product certificates. 0.10 mm	Micrometer	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					weight		The weight of the incoming aluminum foil must be the same as the weight in the waybill.	Weighbridge	min. 1	Every batch entering raw warehouse	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					coil sizes		Core diameter of incoming aluminum foil coil = 150 mm and max. External diameter = 1000 mm.	Meter	min. 1	Every batch entering raw warehouse	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming aluminum foil surface should be visually appropriate	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				3/8"x0.60 Aluminum pipe	diameter		The diameter of the aluminum coil pipe must be the same as the diameter specified in the waybill and product certificates. 9.52 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					wall thickness		The wall thickness of the aluminum coil pipe must be the same as the wall thickness specified in the waybill and product certificates. 0.60 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					weight		The weight of the incoming aluminum coil pipe must be the same as the weight in the waybill.	Weighbridge	min. 1	Every batch entering	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming aluminum coil pipe surface should be visually appropriate	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				3/8"x1 Aluminum pipe	diameter		The diameter of the aluminum coil pipe must be the same as the diameter specified in the waybill and product certificates. 9.52 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					wall thickness		The wall thickness of the aluminum coil pipe must be the same as the wall thickness specified in the waybill and product certificates. 1 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					weight		The weight of the incoming aluminum coil pipe must be the same as the weight in the waybill.	Weighbridge	min. 1	Every batch entering raw warehouse	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming aluminum coil pipe surface should be visually appropriate	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				1/4"x0.80 Capillary Aluminum pipe	diameter		The diameter of the aluminum coil pipe must be the same as the diameter specified in the waybill and product certificates. 6.35 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					wall thickness		The wall thickness of the aluminum coil pipe must be the same as the wall thickness specified in the waybill and product certificates. 0.80 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					weight		The weight of the incoming aluminum coil pipe must be the same as the weight in the waybill.	Weighbridge	min. 1	Every batch entering raw warehouse	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)

Table A.8 continues

					surface control		The incoming aluminum coil pipe surface should be visually appropriate	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				2 mm aluminum sheet	width measurement		The width of the aluminum sheet must be the same as the width specified in the waybill and product certificates.	Meter	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					length measurement		The length of the aluminum sheet must be the same as the length specified in the waybill and product certificates.	Meter	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					thickness		The wall thickness of the aluminum sheet must be the same as the wall thickness specified in the waybill and product certificates. 2 mm aluminium	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					weight		The weight of the incoming aluminum sheet must be the same as the weight in the waybill.	Weighbridge	min. 1	Every batch entering raw warehouse	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming aluminum sheet surface should be visually appropriate	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				Ø35X1.5 MM Aluminum pipe	çap		The diameter of the straight flat aluminum pipe must be the same as the diameter specified in the waybill and product certificates. 35 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					et kalınlığı		The wall thickness of the straight flat aluminum pipe must be the same as the wall thickness specified in the waybill and product certificates. 1.5 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					ağırlık		The weight of the incoming straight aluminum pipe must be the same as the weight in the waybill.	Weighbridge	min. 1	Every batch entering raw warehouse	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					yüzey kontrolü		The incoming straight aluminum pipe surface should be visually appropriate	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				Ø22"X1.5 MM Aluminum pipe	diameter		The diameter of the straight flat aluminum pipe must be the same as the diameter specified in the waybill and product certificates. 28 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					wall thickness		The wall thickness of the straight flat aluminum pipe must be the same as the wall thickness specified in the waybill and product certificates. 1.5 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					weight		The weight of the incoming straight aluminum pipe must be the same as the weight in the waybill.	Weighbridge	min. 1	Every batch entering raw warehouse	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming straight aluminum pipe surface should be visually appropriate	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				Ø12"X1 MM Aluminum pipe	diameter		The diameter of the straight flat aluminum pipe must be the same as the diameter specified in the waybill and product certificates. 12 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)

Table A.8 continues

					wall thickness		The wall thickness of the straight flat aluminum pipe must be the same as the wall thickness specified in the waybill and product certificates. 1 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					weight		The weight of the incoming straight aluminum pipe must be the same as the weight in the waybill.	Weighbridge	min. 1	Every batch entering raw warehouse	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming straight aluminum pipe surface should be visually appropriate	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
		T10MD001 - CNC LATHE	Y3 - 1	1/4" Flare aluminum union (7/16 "-20 thread) (412-14-004) control	wrench flat control		The wrench flat dimension of the union must be the same as the wrench flat dimension specified in the Y3 technical drawing. AA12 ±0.50 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 03 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
			Y3 - 2 Y3 - 3 Y3 - 4 Y3 - 5 Y3 - 6 Y3 - 7 Y3 - 8 Y3 - 9		control of all dimensions		All dimensions must be the same as those in technical drawing Y3 2 ±0.20 mm 12.5 ±0.50 mm 5 ±0.30 mm 5 ±0.30 mm 22.5 ±0.80 mm 5 ±0.30 mm 3 ±0.20 mm 10.5 ±0.50 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 03 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming aluminum union surface should be visually appropriate.	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 03 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					thread control		The incoming aluminum union must pass through the go-gauge, it must not pass through the no-go-gauge	Gauge	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 03 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
		T10MD001 - CNC LATHE	Y2 - 1	3/4" -16 thread flare Aluminum Sleeve [AA24 MM] (452-12-037) control	wrench flat control		The wrench flat dimension of the sleeve must be the same as the wrench flat dimension specified in the Y2 technical drawing. AA24 ±0.50 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 02 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
			Y2 - 2 Y2 - 3 Y2 - 4 Y2 - 5 Y2 - 6		control of all dimensions		All dimensions must be the same as those in technical drawing Y2 23 ±0.50 mm 12.5 ±0.50 mm 20.5 ±0.50 mm 22 ±0.50 mm 6 ±0.30 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 02 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming aluminum sleeve surface should be visually appropriate.	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 02 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					thread control		The incoming aluminum sleeve must pass through the go-gauge, it must not pass through the no-go-gauge	Gauge	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 02 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
		T10MD001 - CNC LATHE	Y4 - 1	7/8" aluminum inion with o-ring (7/8"-14 thread) (457-58-011) control	Pipe diameter control		The diameter of the union pipe should be the same as the diameter specified in the Y4 technical drawing. 22.3 ±0.50 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 01 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)

Table A.8 continues

			Y4 - 2 Y4 - 3 Y4 - 4 Y4 - 5 Y4 - 6 Y4 - 7 Y4 - 8 Y4 - 9		control of all dimensions		All dimensions must be the same as those in technical drawing Y4 14.55 ±0.50 mm 16.4 ±0.50 mm 24 ±0.50 mm 30 ±0.50 mm 3.4 ±0.30 mm 19 ±0.50 mm 15 ±0.50 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 01 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming aluminum union surface should be visually appropriate.	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 01 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					Thread control		The incoming aluminum union must pass through the go-gauge, it must not pass through the no-go-gauge	Gauge	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 01 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				Ø35x1.5 convex aluminum plug [material thickness: 2 mm) control	diameter		The diameter of the incoming dished aluminum plug must be the same as the diameter specified in the technical drawing. 35 ±0.80 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					wall thickness		The wall thickness of the incoming dished aluminum plug must be the same as the wall thickness specified in the technical drawing. 1.5 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming dished aluminum plug surface should be visually appropriate.	Gauge	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				3/8"-1/4" aluminum aspirin control	Outer diameter control		The outer diameter of the incoming aluminum asprin should be the same as the outer diameter specified in the drawing. 9.525 ±0.50 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					inner diameter control		The inner diameter of the incoming aluminum asprin should be the same as the inner diameter specified in the drawing. 6.35 ±0.50 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming aluminum asprin surface should be visually appropriate.	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
		T10MD001 - CNC LATHE	Y1 - 1	3/16"X5X1/2" Aluminum Distributor [Ø28 MM] control (454-00-033)	Number of holes control		The number of output holes of the distributor must be the same as the number of output holes in the technical drawing Y1. 5	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 04 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
			Y1 - 2 Y1 - 3 Y1 - 4 Y1 - 5 Y1 - 6 Y1 - 7 Y1 - 8		control of all dimensions		All dimensions must be the same as those in technical drawing Y1 28 ±0.50 mm 4.8 ±0.30 mm 23 ±0.50 mm 14 ±0.50 mm 12.9 ±0.50 mm 17 ±0.50 mm 19 ±0.50 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 04 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					Material and surface control		The material of the incoming aluminum distributor must be suitable and the surface visually appropriate.	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 04 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)

Table A.8 continues

					Input, and output hole diameter control		The incoming aluminum distributor's inlet and outlet diameter dimensions must be the same as those in the technical drawing Y1. 12.7 ±0.5 mm 4.8 ±0.3 mm	Gauge	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002) 1605405 - 04 Technical drawing	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
		T07MD005 - CURVE CUTTING		3/8"x0.80 mm – 25.4x22mm aluminum curve control	Pipe diameter control		The incoming aluminum curve diameter must be the same as the diameter specified in the technical drawing. 9.525 ±0.50 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					wall thickness		The incoming aluminum curve wall thickness must be the same as the wall thickness specified in the technical drawing. 0.80 mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					measurement control		The incoming aluminum curve dimensions must be the same as the dimensions specified in the technical drawing. 25.4x22mm	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					surface control		The incoming aluminum curve surface must be visually appropriate.	Visual control	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				FONTARGEN AF 407 Solder Wire	diameter		The diameter of the FONTARGEN AF 407 Brass Brazing Wire must be the same as the diameter in the DIN 8513 Supplier Specification.	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					length measurement		The length of the FONTARGEN AF 407 Brazing Wire must be the same as the length in DIN 8513 Supplier Specification.	Meter	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					weight		The weight of the FONTARGEN AF 407 Brazing Wire must be the same as the weight in the DIN 8513 Supplier Specification.	Scale	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				AGP 3005 Hard Solder Wire	diameter		The diameter of the AGP 3005 Brass Brazing Wire must be the same as the diameter in the DIN 8513 Supplier Specification.	Caliper	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					length measurement		The length of the AGP 3005 Brazing Wire must be the same as the length in DIN 8513 Supplier Specification.	Meter	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
					weight		The weight of the AGP 3005 Brazing Wire must be the same as the weight in the DIN 8513 Supplier Specification.	Scale	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
				Senflax GassFLux	weight		The weight of SenFlux GassFlux must be the same as the weight in the DIN EN 1045 FH 21-2 Supplier Specification.	Scale	Sampling Instructions	Sampling Instructions	Input Quality Plan (KY-T002)	ÜR-P001 Non-Conformıng Product Control Procedure	Input Quality Control Form (KY-F022)
20	**HAIRPIN PROCESS**	T07MF001 - AUTOMATIC HAIRPIN MACHINE T07MD005 - CURVE CUTTING		Visual control of the hairpin pipe	visual control		burring, undulation, tearing, crushing, blackness control	Visual control	all products	all products	ÜR-T034 Hairpin Process Control Instruction Technical Drawing No:7	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F002 Aluminum Pipe Bending Process Control Form
			27	hairpin pipe length	measurement control		3/8" ±3 mm x0.60 aluminium pipe 1050+47 mm Product technical drawing (technical drawing no: 7)	Caliper	1 each frequency	Each order	ÜR-T034 Hairpin Process Control Instruction Technical Drawing No:7	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F002 Aluminum Pipe Bending Process Control Form
				Visual control of the curve	visual control		burring, undulation, tearing, crushing, blackness control	Visual control		all products	ÜR-T034 Hairpin Process Control Instruction Technical Drawing No:7	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F002 Aluminum Pipe Bending Process Control Form
				curve length (Hmax)	measurement control		3/8"x0.80 aluminium pipe 23.5 mm ±0.05	Caliper	min. 1 each frequency	Each order	ÜR-T034 Hairpin Process Control Instruction Technical Drawing No:7	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F002 Aluminum Pipe Bending Process Control Form

Table A.8 continues

				distance between the axes of the curve (Measure A)	measurement control		3/8"x0.80 aluminium pipe 25.4 mm ±0.05	Caliper	min. 1 each frequency	Each order	ÜR-T034 Hairpin Process Control Instruction Technical Drawing No:7	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F002 Aluminum Pipe Bending Process Control Form
30	HONEYCOMB PROCESS	T01KP001 - ALUMINUM FIN MOLD T01MP001 - ALUMINUM FOIL PRESS		Honeycomb surface and edge type	visual control		Check the compatibility of the honeycomb foil with the surface and edge type according to prote programming	Visual control	min. 1 each frequency	Each order	ÜR-T035 Press Process Control Instruction	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F003 Honeycomb Process Control Form
				honeycomb visual control	visual control		check the foil edges for deformation	Visual control	all products	all products	ÜR-T035 Press Process Control Instruction	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F003 Honeycomb Process Control Form
			3	wall thickness control	measurement control		0.10 mm alüminyum	Micrometer	min. 1 each frequency	Each order	ÜR-T035 Press Process Control Instruction	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F003 Honeycomb Process Control Form
			8-9	row number, pipe number control	visual control		05 row control 06 pipe control	Visual control	min. 1 each frequency	Each order	ÜR-T035 Press Process Control Instruction	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F003 Honeycomb Process Control Form
			10	pitch size control	measurement control		2.1mm	Caliper	min. 1 each frequency	Each order	ÜR-T035 Press Process Control Instruction	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F003 Honeycomb Process Control Form
				pitch visual control	visual control		visual control of the holes in the foil	Visual control	all products	all products	ÜR-T035 Press Process Control Instruction	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F003 Honeycomb Process Control Form
40	SHEET METAL PROCESS	T02MA001 - ABKANT, T02MC001 - PUNCH PRESS, T02MD001 - GUILLOTINE, T02MD002 - CORNER REMOVING MACHINE	2	2 mm aluminum sheet thickness	measurement control		2 mm alüminyum Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			11	2 mm aluminum sheet size control	measurement control		82 ± 0.80 mm Product technical drawing (technical drawing no: 2)	Meter	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			12	2 mm aluminum sheet size control	measurement control		32 ± 0.80 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			13	2 mm aluminum sheet size control	measurement control		35 ± 0.80 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			14	2 mm aluminum sheet size control	measurement control		20 ± 0.50 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			15	2 mm aluminum sheet size control	measurement control		R3.5 ± 0.30 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			16	2 mm aluminum sheet size control	measurement control		22 ± 0.50 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			17	2 mm aluminum sheet size control	measurement control		47 ± 0.80 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			18	2 mm aluminum sheet size control	measurement control		75.7 ± 0.80 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			19	2 mm aluminum sheet size control	measurement control		R3.5 ± 0.30 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form

Table A.8 continues

			20	2 mm aluminum sheet size control	measurement control		17 ± 0.50 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			21	2 mm aluminum sheet size control	measurement control		7 ± 0.50 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			22	2 mm aluminum sheet size control	measurement control		32 ± 0.80 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			23	2 mm aluminum sheet size control	measurement control		22 ± 0.50 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			24	2 mm aluminum sheet size control	measurement control		114 ± 0.80 mm Product technical drawing (technical drawing no: 2)	Meter	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			25	2 mm aluminum sheet size control	measurement control		156.4 ± 1.20 mm Product technical drawing (technical drawing no: 2)	Meter	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
			26	2 mm aluminum sheet size control	measurement control		25.4 ± 0.50 mm Product technical drawing (technical drawing no: 2)	Caliper	min. 1 each frequency	Each order	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
				Edge smoothness of 2 mm aluminum sheet	measurement , and visual control		check if the pipe hole height on the sheet is 3 mm burr visual control	Caliper & Visual control	all products	all products	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
				2 mm aluminum sheet visual control	visual control		Crush, deflection, burr and visual control on all materials	Visual control	all products	all products	ÜR-T045 Sheet Process Control Instruction Technical Drawing No:2	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F048 Sheet Process Control Form
70	**ASSEMBLY PROCESS**	T03MD002 - PNEUMATIC NAILERS		the material is suitable according to the technical drawing	measurement control		foil: 280x0.10 alüminium pipe: 3/8"x0.60 aluminium sheet: 2 mm alüminium control Product technical drawing (technical drawing no: 3)	Caliper & Micrometer	all products	all products	ÜR-T042 Assembly Instruction Technical Drawing No:3	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F005 Assembly Production Quality Control Form
			24	Width of 2 mm aluminum mirror sheet	measurement control		114 ± 0.80 mm Product technical drawing (technical drawing no: 3)	Meter	all products	all products	ÜR-T042 Assembly Instruction Technical Drawing No:3	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F005 Assembly Production Quality Control Form
			25	Height of 2 mm aluminum mirror sheet	measurement control		156.4 ± 1.20 mm Product technical drawing (technical drawing no: 3)	Meter	all products	all products	ÜR-T042 Assembly Instruction Technical Drawing No:3	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F005 Assembly Production Quality Control Form
				Direction of mirror sheet	visual control		direction control according to the circuit Product technical drawing (technical drawing no: 3)	Visual control	all products	all products	ÜR-T042 Assembly Instruction Technical Drawing No:3	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F005 Assembly Production Quality Control Form
			27	honeycomb length	measurement control		1050 ± 3.00 mm Product technical drawing (technical drawing no: 3)	Meter	all products	all products	ÜR-T042 Assembly Instruction Technical Drawing No:3	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F005 Assembly Production Quality Control Form
			28	hairpin side circuit control	visual control		check the conformity of the product hairpin circuit according to the technical drawing Product technical drawing (technical drawing no: 3)	Visual control	all products	all products	ÜR-T042 Assembly Instruction Technical Drawing No:3	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F005 Assembly Production Quality Control Form
80	**ASSEMBLY QUALITY CONTROL**		1 - 2 - 3	the material is suitable according to the technical drawing	measurement control		foil: 280x0.10 alüminium pipe: 3/8"x0.60 aluminium sheet: 2 mm alüminium control Product technical drawing (technical drawing no: 1)	Caliper & Micrometer	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			28	hairpin side circuit control	visual control		check the conformity of the product hairpin circuit according to the technical drawing	Visual control	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)

Table A.8 continues

				Product visual control	visual control		Crush, deflection, burr control on all materials	Visual control	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			24	Width of 2 mm aluminum mirror sheet	measurement control		114 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			25	Height of 2 mm aluminum mirror sheet	measurement control		156,4 ± 1.20 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			27	honeycomb length	measurement control		x1050 ± 3.00 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			11	2 mm aluminum sheet size control	measurement control		82 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			12	2 mm aluminum sheet size control	measurement control		32 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			13	2 mm aluminum sheet size control	measurement control		35 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			14	2 mm aluminum sheet size control	measurement control		20 ± 0.50 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			15	2 mm aluminum sheet size control	measurement control		R3.5 ± 0.30 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			16	2 mm aluminum sheet size control	measurement control		22 ± 0.50 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			17	2 mm aluminum sheet size control	measurement control		47 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			18	2 mm aluminum sheet size control	measurement control		75.7 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			19	2 mm aluminum sheet size control	measurement control		R3.5 ± 0.30 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			20	2 mm aluminum sheet size control	measurement control		17 ± 0.50 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			21	2 mm aluminum sheet size control	measurement control		7 ± 0.50 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			22	2 mm aluminum sheet size control	measurement control		32 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			23	2 mm aluminum sheet size control	measurement control		22 ± 0.50 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			24	2 mm aluminum sheet size control	measurement control		114 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)

Table A.8 continues

			25	2 mm aluminum sheet size control	measurement control		156.4 ± 1.20 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			26	2 mm aluminum sheet size control	measurement control		25.4 ± 0.50 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			10	pitch control	measurement control		pitch size: 2.1 mm ± 0.20 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
				model code control	visual control		check the conformity of the product to the technical drawing notation	Visual control	Sampling Instructions	Sampling Instructions	KY-T004 Assembly Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
90	**EXPANSION PROCESS**	T08MŞ006 - VERTICAL EXPANSION MACHINE	1	expansion ball control			check the suitability of the expansion ball to the product pipe (3/8"x0.60)	Dimensional control	min. 1	Each order	ÜR-L011 Expansion Ball Diameter List	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F009 Vertical - Horizontal Pipe Expanding Process Control Form
			28	hairpin side circuit control			check the conformity of the hairpin side circuit according to the technical drawing Product technical drawing (technical drawing no: 3)	Visual control	min. 1	Each order	ÜR-T007 Vertical Pipe expansion Machine Instruction	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F009 Vertical - Horizontal Pipe Expanding Process Control Form
			10	pitch control			pitch size: 2.1 mm ± 0.30 mm Check that the pitch of the first product is in accordance with the technical drawing Product technical drawing (technical drawing no: 3)	Visual control	min. 1	Each order	KY-T004 Assembly Control Quality Plan	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F009 Vertical - Horizontal Pipe Expanding Process Control Form
			27	Product length control	measurement control		1050 ± 3.00 mm Product technical drawing (technical drawing no: 3)	Meter	min. 1	Each order	KY-T004 Assembly Control Quality Plan	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F009 Vertical - Horizontal Pipe Expanding Process Control Form
				Product visual control	visual control		crush, stabilization and sheet deformation	Visual control	all products	Each order	KY-T004 Assembly Control Quality Plan	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F009 Vertical - Horizontal Pipe Expanding Process Control Form
50	**COLLECTOR BRAZING PROCESS**	T06MD001 - AUTOMATIC PIPE BENDING MACHINE, T06MD011 - CONNECTION HOLE DRILLING MACHINE, T06MD014 - PIPE CUTTING, CIRCULAR SAW, T06MD019 - COLLECTOR PUNCHING MACHINE, TORCH	Y1	distributor control	measurement & visual control		3/16"X5X1/2" Aluminiun Distributor [Ø28 MM] control Product technical drawing (technical drawing no: 4)	Caliper & Visual control	min.1	Each order	ÜR-T020 Aluminum Collector Process Instruction Technical Drawing No:6	ÜR-P001 Non-Conformıng Product Control Procedure	
			Y2	Flare aluminum sleeve control	measurement & visual control		3/4" -16 thread flare Aluminum Sleeve [AA24 MM] control Product technical drawing (technical drawing no: 4)	Caliper & Visual control	min.1	Each order	ÜR-T020 Aluminum Collector Process Instruction Technical Drawing No:6	ÜR-P001 Non-Conformıng Product Control Procedure	
			Y4	aluminum union control	measurement & visual control		7/8" Aluminium union with O-Ring control Product technical drawing (technical drawing no: 4)	Caliper & Visual control	min.1	Each order	ÜR-T020 Aluminum Collector Process Instruction Technical Drawing No:6	ÜR-P001 Non-Conformıng Product Control Procedure	
			Y3	aluminum union control	measurement & visual control		1/4" flare aluminum union (7/16"-20 thread) control Product technical drawing (technical drawing no: 4)	Caliper & Visual control	min.1	Each order	ÜR-T020 Aluminum Collector Process Instruction Technical Drawing No:6	ÜR-P001 Non-Conformıng Product Control Procedure	
			6	collector pipe control	measurement control		35 ± 0.80 mm aluminium pipe Product technical drawing (technical drawing no: 4)	Caliper	min.1	Each order	ÜR-T020 Aluminum Collector Process Instruction Technical Drawing No:6	ÜR-P001 Non-Conformıng Product Control Procedure	
			5	collector pipe control	measurement control		12 ± 0.50 mm aluminium pipe Product technical drawing (technical drawing no: 4)	Caliper	min.1	Each order	ÜR-T020 Aluminum Collector Process Instruction Technical Drawing No:6	ÜR-P001 Non-Conformıng Product Control Procedure	
			7	collector pipe control	measurement control		22 ± 0.50 mm aluminium pipe Product technical drawing (technical drawing no: 4)	Caliper	min.1	Each order	ÜR-T020 Aluminum Collector Process Instruction Technical Drawing No:6	ÜR-P001 Non-Conformıng Product Control Procedure	

Table A.8 continues

			39	collector - semi-finished axis dimensions	measurement control		80 ± 0.80 mm Product technical drawing (technical drawing no: 4)	Meter	all products	all products	ÜR-T020 Aluminum Collector Process Instruction & Technical Drawing No:6	ÜR-P001 Non-Conformıng Product Control Procedure	
			29	collector - semi-finished axis dimensions	measurement control		47 ± 0.80 mm Product technical drawing (technical drawing no: 4)	Caliper	all products	all products	ÜR-T020 Aluminum Collector Process Instruction & Technical Drawing No:6	ÜR-P001 Non-Conformıng Product Control Procedure	
				distributor, sleeve, and union position angle control	measurement control		The collector position angle should be 90° with according to the upper and lower sheet. Product technical drawing (technical drawing no: 4)	Protractor	all products	all products	ÜR-T020 Aluminum Collector Process Instruction Technical Drawing No:6	ÜR-P001 Non-Conformıng Product Control Procedure	
				control of solder wire (collector between dıstributor, sleeve, and union)	visual control		FONTARGEN AF 407, Aluminum brazing operation control	Visual control	min.1	Each order	ÜR-T020 Aluminum Collector Process Instruction	ÜR-P001 Non-Conformıng Product Control Procedure	
				control of solder wire (collector between aluminum core)	visual control		FONTARGEN AF 407 solder wire, solder operation control	Visual control	min.1	Each order	ÜR-T020 Aluminum Collector Process Instruction	ÜR-P001 Non-Conformıng Product Control Procedure	
				brazing smoothness	visual control		check for missing or excessive braze fill	Visual control	all products	all products	ÜR-T020 Aluminum Collector Process Instruction	ÜR-P001 Non-Conformıng Product Control Procedure	
100	**BRAZING PROCESS**	T04MD008 - FIXED COLUMN DRILL, TORCH, FIXTURE NUMBER F123	30	collector side circuit control	visual control		check the conformity of the collector side circuit to the technical drawing Product technical drawing (technical drawing no: 4)	Visual control	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
				Collector size and position angle control	measurement control		The collector position angle should be 90 ° with according to the upper and lower sheet. Product technical drawing (technical drawing no: 4)	Protractor	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
			31	collector axis dimensions	measurement control		78.2 ± 0.80 mm Product technical drawing (technical drawing no: 4)	Meter	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
			32	collector axis dimensions	measurement control		76.2 ± 0.80 mm Product technical drawing (technical drawing no: 4)	Meter	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
			33	collector axis dimensions	measurement control		57 ± 0.80 mm Product technical drawing (technical drawing no: 4)	Meter	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
			34	collector axis dimensions	measurement control		114 ± 0.80 mm Product technical drawing (technical drawing no: 4)	Meter	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
			35	collector axis dimensions	measurement control		78.2 ± 0.80 mm Product technical drawing (technical drawing no: 4)	Meter	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
			36	collector axis dimensions	measurement control		78.2 ± 0.80 mm Product technical drawing (technical drawing no: 4)	Meter	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
			37	collector axis dimensions	measurement control		204.69 ± 1.20 mm Product technical drawing (technical drawing no: 4)	Meter	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	

Table A.8 continues

			38	collector axis dimensions	measurement control		78.78 ± 0.80 mm Product technical drawing (technical drawing no: 4)	Meter	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
				brazing smoothness	visual control		check for missing or excessive braze fill	Visual control	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
				brazing wire control	visual control		check the suitability of the brazing wire for the product	Visual control	min.1	Each order	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
				check whether the circuit is blocked	visual control		check whether the product is blocked by pressing air into the product	Visual control	all products	all products	ÜR-T020 Aluminum Brazing Process Instruction Technical Drawing No:4	ÜR-P001 Non-Conformıng Product Control Procedure	
110	**BRAZING QUALITY CONTROL**			label control	visual control		check if the production card is hanging on the product. Compare the order number on the production card with the order number on the drawing. Product technical drawing (technical drawing no: 1)	Visual control	1 product on each pallet	Each palette	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			Y1	distributor control	measurement & visual control		3/16"X5X1/2" Aluminiun Distributor [Ø28 MM] control Product technical drawing (technical drawing no: 1)	Caliper & Visual control	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			Y2	Flare aluminum sleeve control	measurement & visual control		3/4" -16 thread flare Aluminum Sleeve [AA24 MM] control Product technical drawing (technical drawing no: 1)	Caliper & Visual control	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			Y4	aluminum union control	measurement & visual control		7/8" Aluminium union with O-Ring control Product technical drawing (technical drawing no: 1)	Caliper & Visual control	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			Y3	aluminum union control	measurement & visual control		1/4" flare aluminum union (7/16"-20 thread) control Product technical drawing (technical drawing no: 1)	Caliper & Visual control	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			6	collector pipe control	measurement control		35 ± 0.80 mm aluminium pipe Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			5	collector pipe control	measurement control		12 ± 0.50 mm aluminium pipe Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			7	collector pipe control	measurement control		22 ± 0.50 mm aluminium pipe Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			39	collector - semi-finished axis dimensions	measurement control		80 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			29	collector - semi-finished axis dimensions	measurement control		47 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Caliper	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			31	collector axis dimensions	measurement control		78.2 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			32	collector axis dimensions	measurement control		76.2 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			33	collector axis dimensions	measurement control		57 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)

Table A.8 continues

			34	collector axis dimensions	measurement control		114 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			35	collector axis dimensions	measurement control		78.2 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			36	collector axis dimensions	measurement control		78.2 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			37	collector axis dimensions	measurement control		204.69 ± 1.20 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			38	collector axis dimensions	measurement control		78.78 ± 0.80 mm Product technical drawing (technical drawing no: 1)	Meter	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
				collector visual control	visual control		check for crush, breakage in collector pipe	Visual control	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			30	collector side circuit control	visual control		check the conformity of the collector side circuit according to the technical drawing Product technical drawing (technical drawing no: 1)	Visual control	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
				Product visual control	visual control		check the product for deformation (burns in the fins, sheet distortion, burrs in the pipe)	Visual control	Sampling Instructions	Sampling Instructions	KY-T005 Brazing Control Quality Planı Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
120	**LEAKAGE TEST**	T09MD002 - TEST POOL (LARGE)		leakage control	visual control		check for leakage in the product and leak check after rework	Visual control	all products	100%	ÜR-T008 Leakage Test Instruction	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F032 Leakage Test Chart
			40	pressure control(35 bar)	measurement control		check the suitability of the test pressure to the product or customer request (35 bar)	Manometer	all products	100%	ÜR-T008 Leakage Test Instruction KY-F044 Customer Test Pressure Request Form	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F032 Leakage Test Chart
			41	Control of test time	measurement control		check the suitability of the test period to the product or customer request	Stopwatch	all products	100%	ÜR-T008 Leakage Test Instruction KY-F044 Customer Test Pressure Request Form	ÜR-P001 Non-Conformıng Product Control Procedure	KY-F032 Leakage Test Chart
130	**PAINTING, CLEANING, LABELING**	T05MD002 - AUTOMATIC PAINT MACHINE, T05MD005 - PAINT OVEN	42	Paint Control	visual control		visual control of the varnish of the product (surface defects, varnish adhesion, painting of the whole product)	Visual control	all products	100%	ÜR-T010 Packing and Shipping Instructions Technical Drawing No:5	ÜR-P001 Non-Conformıng Product Control Procedure	
				Product visual control	visual control		visually check the product (honeycomb, sheet and pipe deformation)	Visual control	all products	100%	ÜR-T010 Packing and Shipping Instructions Technical Drawing No:5	ÜR-P001 Non-Conformıng Product Control Procedure	
				labet control	visual control		check that the green tested label is affixed	Visual control	all products	100%	ÜR-T010 Packing and Shipping Instructions Technical Drawing No:5	ÜR-P001 Non-Conformıng Product Control Procedure	
					visual control		check if the order number on the product metallized label matches the order number on the assembly metallized label	Visual control	all products	100%	ÜR-T010 Packing and Shipping Instructions Technical Drawing No:5	ÜR-P001 Non-Conformıng Product Control Procedure	
				plug control	visual control		check that all open pipes are fitted with suitable plugs Product technical drawing (technical drawing no: 5)	Visual control	all products	100%	ÜR-T010 Packing and Shipping Instructions Technical Drawing No:5	ÜR-P001 Non-Conformıng Product Control Procedure	
			43	Nitrogen pressure control	visual control		check that the product is printed with 2 bar nitrogen and that the nitrogen printed label is affixed	Visual control	all pallet	100%	ÜR-T010 Packing and Shipping Instructions Technical Drawing No:5	ÜR-P001 Non-Conformıng Product Control Procedure	
140	**FINAL QUALITY CONTROL**			Product visual control	visual control		check for visual control on sheet metal, pipe honeycomb, collector	Visual control	all products	100%	KY-T006 Final Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			42	Paint Control	visual control		visual control of the varnish of the product (surface defects, varnish adhesion, painting of the whole product)	Visual control	all products	100%	KY-T006 Final Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)

Table A.8 continues

				labet control	visual control		Check the notation, order number, test pressure, customer codes on the Product Description Label (Metallized Label) from the technical drawing. Product technical drawing (technical drawing no: 1)	Visual control	all products	100%	KY-T006 Final Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
				plug control	visual control		check that all open pipes are fitted with suitable plugs Product technical drawing (technical drawing no: 1)	Visual control	all products	100%	KY-T006 Final Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
			43	Nitrogen pressure control	visual control		Check if nitrogen has been released from the KY-F036 Nitrogen Delivery Chart. Check for Nitrogen printed label on product	Visual control	all products	100%	KY-T006 Final Control Quality Plan Technical Drawing No:1	ÜR-P001 Non-Conformıng Product Control Procedure	Product technical drawing (technical drawing no:1)
150	**PACKING PROCESS**	T05MD006 - PNEUMATIC NAILERS, T05MD009 - WOOD CUTTING		Product visual control	visual control		visually check the product (honeycomb, sheet and pipe deformation)	Visual control	all products	100%	ÜR-T010 Packing and Shipping Instructions Technical Drawing No:5	ÜR-P001 Non-Conformıng Product Control Procedure	
				pallet control	visual control		pallet packing control according to customer request, shipping terms and ABC requirements	Visual control	all pallet	100%	ÜR-T010 Packing and Shipping Instructions Technical Drawing No:5	ÜR-P001 Non-Conformıng Product Control Procedure	
				pallet label control	visual control		check the conformity of the pallet label with the metallized label and technical drawing (no: 5)	Visual control	all pallet	100%	ÜR-T010 Packing and Shipping Instructions Technical Drawing No:5	ÜR-P001 Non-Conformıng Product Control Procedure	

APPENDIX-9

Table A.9 Dimensional measurement test report

ABC	SAMPLE PRODUCT APPROVAL FORM	Document No	XXX-03
		Rev No/Date	01 / 16.01.2012
		Sheet No	1/1

Customer Name:	X	**Date :**	10.03.2016
Order no:	1605405	**Piece :**	1 psc.
Notation:	2522-2.1-5G-06-1050-05-XX	**Department:**	Quality Assurance
Drawing no / Rev no :	TTR1605405		

No	Value in Technical Drawing	Measured Value	Result	Exp.	No	Value in Technical Drawing	Measured Value	Result	Exp.
1	Pipe: Ø3/8"x0.60 Alu.		√		**25**	156.4	156	√	
2	Frame:2 mm Alu.		√		**26**	25.4	25.4	√	
3	Foil: 0.10 mm Alu.		√		**27**	1050	1048.7	√	
4	Inlet: Ø3/16"x0.70 Alu.		√		**28**	Hairpin side circuit		√	
5	Inlet connection: Ø12x1 Alu.		√		**29**	47	46.3	√	
6	Outlet: Ø35x1.5 Alu.		√		**30**	Collector side circuit		√	
7	Outlet connection: Ø22x1.5 Alu.		√		**31**	78.2	78	√	
8	Row number: 8		√		**32**	76.2	76	√	
9	Pipe number: 6		√		**33**	57	57.3	√	
10	Pitch: 2.1		√		**34**	114	114.6	√	
11	82	82.3	√		**35**	78.2	78	√	
12	32	32	√		**36**	78.2	78	√	
13	35	34.8	√		**37**	204.69	204.6	√	
14	20	20.3	√		**38**	78.78	78	√	
15	R3.5	3.5	√		**39**	80	79.3	√	
16	22	22	√		**40**	test pressure: 35 bar		√	
17	47	47.4	√		**41**	test time: 2dk		√	
18	75.7	75	√		**42**	paint: varnish		√	
19	R3.5	3.5	√		**43**	nitrogen pressure: 2 bar		√	
20	17	17.8	√		**44**	Y1: 5 holes dist. (1/2" input-3/16" output)		√	
21	7	7	√		**45**	Y2: 3/4"-16 thread flare union		√	
22	32	31.7	√		**46**	Y3: 1/4" Flare aluminum union		√	
23	22	21.6	√		**47**	Y4: 7/8"-14 thread union with o-ring		√	
24	114	113	√						

SONUÇ:

☒	Accept
☐	Reject

Ayşe Emel BİRİCİK

Quality Assurance Engineer

APPENDIX-10

Table A.10 Part submission warrant letter

Part Submission Warrant

Part Name: 12345 Aluminum EVAP. Al/Al — Cust. Part Number: 12345

Shown on Drawing Number: TTR1605405 — Orig. Part Number: 1605405

Engineering Change Level ______ Dated ______

Additional Engineering Changes ______ Dated ______

Safety and/or Government Regulation ☒ Yes ☐ No — Purchase Order No. 9362 — Weight (kg) ______

Checking Aid Number ______ Checking Aid Eng. Change Level ______ Dated ______

ORGANIZATION MANUFACTURING INFORMATION	**CUSTOMER SUBMITTAL INFORMATION**
ABC.A.Ş.	X A.Ş.
Organization Name & Supplier/Vendor Code	Customer Name/Division
Manisa Organize Sanayi Bölgesi	Mehmet TAŞ
Street Address	Buyer/Buyer Code
MANİSA 45030	
City Region Postal Code Country	Application

MATERIALS REPORTING

Has customer-required Substances of Concern information been reported? ☒ Yes ☐ No ☐ n/a

Submitted by IMDS or other customer format: ______

Are polymeric parts identified with appropriate ISO marking codes? ☐ Yes ☐ No ☐ n/a

REASON FOR SUBMISSION (Check at least one)

☒ Initial submission	☐ Change to Optional Construction or Material
☐ Engineering Change(s)	☐ Sub-Supplier or Material Source Change
☐ Tooling: Transfer, Replacement, Refurbishment, or additional	☐ Change in Part Processing
☐ Correction of Discrepancy	☐ Parts produced at Additional Location
☐ Tooling Inactive > than 1 year	☐ Other - please specify

REQUESTED SUBMISSION LEVEL (Check one)

☐ Level 1 - Warrant only (and for designated appearance items, an Appearance Approval Report) submitted to customer.

☐ Level 2 - Warrant with product samples and limited supporting data submitted to customer.

☒ Level 3 - Warrant with product samples and complete supporting data submitted to customer.

☐ Level 4 - Warrant and other requirements as defined by customer.

☐ Level 5 - Warrant with product samples and complete supporting data reviewed at organization's manufacturing location.

SUBMISSION RESULTS

The results for ☒ dimensional measurements ☒ material and functional tests ☒ appearance criteria ☒ statistical process package

These results meet all design record requirements: ☒ Yes ☐ No (If "No" - Explanation Required)

Mold / Cavity / Production Process ______

DECLARATION

I affirm that the samples represented by this warrant are representative of our parts, which were made by a process that meets all Production Part Approval Process Manual . I also certify that documented evidence of such compliance is on file and available for your review. I have noted any deviation from this declaration below.

EXPLANATION/COMMENTS: ______

Is each Customer Tool properly tagged and numbered? ☐ Yes ☐ No ☒ n/a

Organization Authorized Signature ______ Date 10.03.2016

Name, Surname: Ayşe Emel Ünal — Phone No. 0123 456 78 90 — Fax No. 0123 456 78 91

Title: Quality Assurance Engineer — E-mail: emelunal@abc.com

FOR CUSTOMER USE ONLY (IF APPLICABLE)

PPAP Warrant Disposition: ☒ Approved ☐ Rejected ☐ Other

Customer Signature ______ Date 17.03.2016

Name, Surname: Mehmet TAŞ — Customer Tracking Number (optional)

APPENDIX-11: List of Abbreviations

NPD	New Product Development
APQP	Advanced Product Quality Planning
SME	Medium Sized Enterprise
DFMEA	Design Failure Modes and Effects Analysis
PFMEA	Process Failure Mode and Effects Analysis
FMEA	Failure Mode and Effects Analysis
QFD	Quality Function Deployment
BOM	Bill of Materials
MSA	Measurement Systems Analysis
PSW	Part Submission Warrant
SPC	Statistical Process Control
R.P.N	Risk Priority Number
UCL	Upper Control Limit
LCL	Lower Control Limit
EV	Equipment Variance
AV	Appraiser Variance
GRR	Repeatability and Reproducibility
PV	Part Variance
TV	Total Variance
ndc	Number of Distinct Categories
LTL	Lower Tolerance Limit
UTL	Upper Tolerance Limit
LCL	Lower Control Limit
UCL	Upper Control Limit