

## ENHANCING SUPPLIER'S QUALITY BY PREVENTIVE QUALITY ASSESSMENTS DURING DESIGN OF AUTOMOTIVE ELECTRONICS

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### 1. Importance of mechanical vendor parts' quality

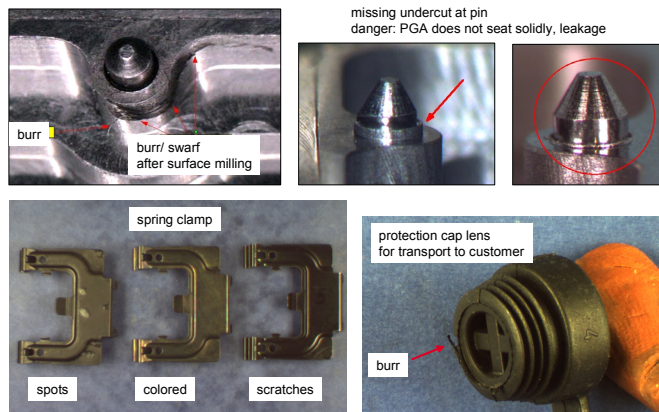
In the following, proceeding and results of a strategic improvement project aiming at enhancing quality of mechanical vendor parts are presented. Bosch Automotive Electronics is an automobile supplier with globally distributed development and production. Many mechanical components are provided by local suppliers. For the last few years, the ability to produce with a defect rate less than 10 parts per million (ppm) advanced as criterion for market entry of automotive electronics products. Therefore much effort was spent on quality improvements. One of the most important influence factors on product quality were electronic vendor parts. Present quality statistics prove success of actions taken. For example, in the years 2003 to 2006, 0-miles-defects of electronic vendor parts were diminished from 0.18 ppm down to 0.04 ppm. However, the better electronics quality became, the more mechanics quality was spotlighted. In contrast to electronics, quality problems with mechanical vendor parts in high level series production sometimes follow no pattern. Problems can occur unexpectedly and may have massive effects. As an example, a well proven tooling may suddenly cause immense problems if a wrong tooling insert for a specific connector plug was taken.

What makes quality of mechanical vendor parts even more critical is that suppliers are often medium-sized businesses with little capacity for process development. Automotive capability involves steadily increasing requirements, e.g. minimization of particle contamination. In comparison, suppliers of electronic vendor parts typically are large-scale enterprises ensuring their production processes independently. For them, automotive electronics products make up only small share of the market. Further, electronic vendor parts are released comprehensively for many projects and are standardized as far as possible. Mechanical components and toolings however have to be released for each project. Therefore, their release process always lies on critical path of a development project.

### 2. Typical weak points and their reasons

Some examples of typical weak points of mechanical components are given in figure 1. Presently one of the most severe problems is particle contamination causing corrosion, short cut and gluing problems. As shown on left side on top of figure 1, particle contamination can result from a milling process. Particles can also be burrs of elastomere, as shown on the right side at the bottom. In the illustrated example they are caused by a lens protection cap used for transport of a night vision system. If turning process is not completed correctly as illustrated on right side at top, overall functional problems may result due to crooked seat of PGA (Pin Grid Array). Typical surface defects are spots, colouring or scratches (left side at the bottom). In case of passivation, e.g. against corrosion, damaged surfaces may result in functional problems. In many cases however, surface defects only have optical

impact. Although they will not be visible in the car, such optical problems may lead to a customer refusal.



**Figure 1. Examples of typical mechanical defects**

Weak points of mechanical vendor parts can be caused by each involved party along order processing. However, design including supplier/designer interface sets the course for any following action and therefore plays a very important role within process chain. Typical design-driven reasons for defects of mechanical vendor parts are critical mechanical concepts, wrong material choice, often changes, too high requirements or rather too tight tolerances, e.g. concerning contamination, surface quality, dimensional tolerances. At the interface between supplier and designer, the supplier's competency may be over-estimated, supplier's hints and recommendations may be neglected or specifications are tightened subsequent to ordering vendor parts.

### 3. Solution approach

Analyzing weak points of past development projects lead to the following solution approach supplementing ongoing quality work with suppliers. Milestone reference plan of product development was supplemented by preventive quality assessments (section 3.1). As tooling knowledge was identified as key success factor, company-internal tooling experts were set up (section 3.2). The new procedure was defined in a new development guideline and globally rolled out (section 4).

#### 3.1 Preventive quality assessments

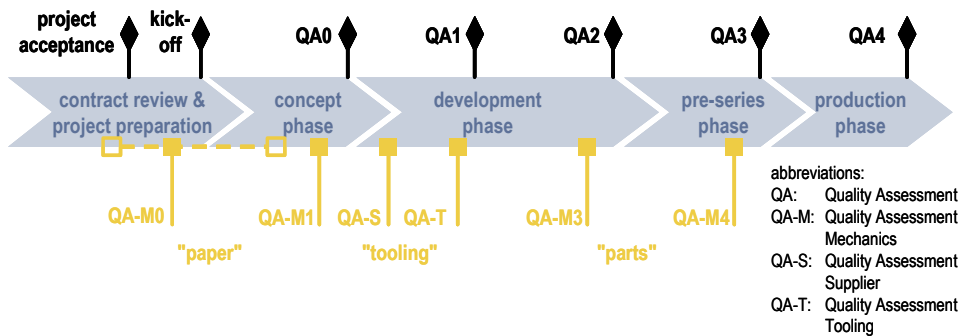
In order to identify and eliminate potential problems with mechanical vendor parts as early as possible, preventive quality assessments called “QA-M (Quality Assessment Mechanics)” became part of product development’s reference plan. QA-M’s are interlinked with QA’s (Quality Assessments) serving as milestones of each development phase on level of the whole product. Further goals of establishing QA-M’s were:

- to expand development competency by experts' networking and exchange of experience
- to demand reasonable requirements from the supplier, which are feasible for the supplier
- to select the best possible supplier regarding quality, supply availability and cost
- to ensure production competency of the supplier
- to integrate plant's competency concerning process flow and quality aspects at an early stage during development and process of supplier award

Depending on project’s complexity, QA-M is practiced as a meeting of two hours up to one day. Due to efficiency reasons, the number of participants is limited to a maximum of 8 persons. At optimal 4 participants take part: a mechanical engineer, a purchaser, a colleague from quality department and an additional senior expert. In early development phases, experts are retrieved from design, later on

experts in the field of tooling are needed. As further participants, project manager, plant's production engineer, plant's quality engineer and plant's process engineer can be considered. Appropriate composition of participants permits an efficient discussion with useful hints from preceding projects on the one hand and decision authority on the other hand. Participants are composed from working level – instead of management level - and empowered to evaluate release status as well as to define appropriate measures. Evaluation is supported by a QA-M checklist comprising a list of quality relevant questions. Thus design decisions relevant for quality are made transparent by QA-Ms. Even in case of a tight project schedule, QA-similar mechanism provides time for ensuring a robust mechanical concept, supplier's competency as well as capability of tooling and manufacturing method. Experiences and knowledge is exchanged between projects in cause of participation of a senior expert, who is not part of the project team. Also, know-how of each individual increases due to cross-functional team-work within QA-Ms.

In whole, 6 QA-M's take place during platform development (figure 2). The more components are re-used in application projects, the less QA-M's need to be passed. QA-M0 is only applied in platform development projects. Main content is discussion of overall mechanical concept, feasibility and risk evaluation. As indicated in figure 2, timing of QA-M0 varies depending on situation and circumstances. An ideal point of time is before project acceptance because evaluation results can then be taken as input for quote.



**Figure 2. Preventive quality assessments within product development process**

Most projects start with QA-M1. QA-M1 takes place when a first comprehensive mechanical concept has been worked out. Besides overall mechanical concept each single mechanical vendor part is discussed. Manufacturability - in sense of quality, availability of suppliers and cost - of each mechanical vendor part is reviewed. Further, degree of application of subsequent QA-S and QA-T is defined. Results of QA-M1 are taken as input for supplier request for quotation. QA-M2 comprises QA-S and QA-T. The shortening “QA-S” stands for “Quality Assessment Supplier” and includes reviewing suppliers concerning their process capability. Within QA-S special characteristics (customer requirements) and additional critical aspects are discussed with the supplier, production concept including tooling aspects are evaluated and supplier’s way of ensuring quality is inspected. QA-S therefore usually takes place at the supplier’s location. As result of QA-S – in case of positive evaluation - the business is awarded to the supplier. “QA-T” stands for “Quality Assessment Tooling” and takes place after the supplier has finished tooling design and before tooling for mass production is produced. At this point of time tooling concept can be evaluated and potential risks are identified and eliminated. As tooling usually is permanently improved, QA-T takes place not only for each new tooling, but also for replacement toolings. After reviewing tooling concept by QA-T, tooling for mass production can be ordered. Main goal of QA-M3 is to release first produced parts and process. Therefore, parts production is observed at the supplier and process stability is evaluated. Release process is supported by filling in release sheets. Release sheets have to be signed by the supplier and each function involved in order processing. Once parts and process are released, production volume at the supplier increases steadily. Due to rationalisation reasons, volume increase typically comes along

with changes in parts handling and interlinking of machines. In order to ensure ramp-up at the supplier and thus - with short time-delay – ensure ramp-up at Bosch plant, plant’s quality engineer can summon a QA-M4. At QA-M4, high volume production at the supplier is observed. Special focus is driven on changes to production compared with status at QA-M3. Depending on specific circumstances of each project, the extent of QA-M application is defined. Fixed point of QA-M process consists in QA-M1, as QA-M1 is mandatory for each design project. Due to discussion of the overall mechanical concept with each planned mechanical vendor part in QA-M1, the following QA-M steps and thus the extent of QA-M application is planned at this point of time.

### 3.2 Tooling experts

Substantial added value of solution approach does not only consist in establishing new processes, but also in enriching processes by experts knowledge and thus preventing future quality problems. Whereas design expertise is needed at time of QA-M0 and QA-M1, success of QA-T and to some extent also of QA-S, QA-M3, QA-M4 depends on tooling experts’ competency. Tooling experts have practical knowledge about limits of producibility and key influence factors on quality. They are able to work on problems together with all involved parties until they are solved. As they bring in their knowledge into many projects, they make critical quality topics and latest solutions known across projects. According to main material groups most important fields of expertise in this case study are:

- plastics molding,
- stamping parts,
- aluminium die casting.

Within these material/process groups, technical experts know, which is possible and which is not. As the network of experts is key success factor of QA-M process, it was completed at short term. Just as important as authority of technical expertise is ease of handling expert’s knowledge. Technical experts must be taken as 'sparring partners' with whom people like to exchange know-how. A culture of questioning results critically without loss of face has to develop within organization. Giving and receiving useful hints and tips must be learned on both sides.

## 4. Global roll-out

In order to make QA-M’s widely accepted, a global roll-out of the new procedure was initiated. A strategic improvement project with the goal to ensure quality of mechanical vendor parts by applying QA-M process was launched. The project was entitled “Implementing Business Process 'Release of Mechanical Vendor Parts'”. Implementation basis was a new development guideline comprising QA-M’s. Although optimization potential of the guideline and open questions were already known, it was decided to first start roll-out, collect international feedback and then optimize the guideline according to gained practical insights. Time-frame of the project was one year. Within this period, the new procedure had to be put into practise in each development and production location worldwide. Mostly affected departments were design, purchasing and quality management.

First step was to analyse existing and potential barriers (figure 3). Insights won from this analysis were used for detailed project planning and prioritisation of next steps. Barriers which were prerequisite of implementation were addressed directly. Thus several problems, e.g. funding, were solved at the beginning. Meanwhile an interactive training concept was worked out and tested in several project teams. In the whole, about 4000 employees had to be informed about the new procedure and convinced to apply QA-M’s. In respect of such high number of trainees, the project was structured into three waves of roll-out:

- training corporate development departments,
- training European plants,
- training overseas plants.

Trainings in first roll-out wave were applied to each individual platform development project with the project’s team members as only training participants. This approach had the advantage that project specific circumstances could be discussed and decisions about next steps could directly be taken within the training. Although efforts of these first project-specific trainings were rather high, they

made an example of QA-M application in the most important design projects right at the beginning of roll-out. Team members of smaller projects however were combined with others and trained some months later.

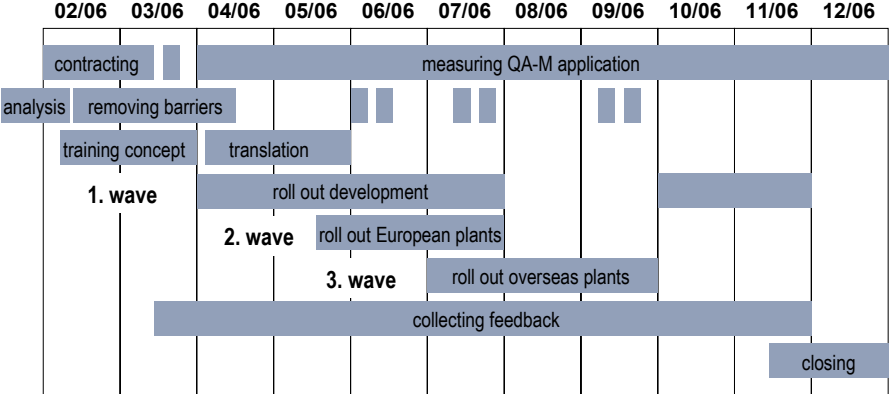


Figure 3. Project schedule

Second wave started with purchasing and quality departments in European plants. In order to minimize efforts, each plant training took place on site. Third wave addressed local development, purchasing and quality departments in overseas plants. At each visit location specific circumstances were discussed and gathered. Many of these impulses called for new decisions and were helpful feedback for optimizing the development guideline. Besides training activities, measuring QA-M application was initiated. First, calculation basis with all on-going development projects had to be gathered. Then data collection of practised QA-M's in each project was organized and put into action.

5. Achieved results

In each training a list of participants was compiled. Training progress was recorded regarding projects, departments and locations. Figure 4 illustrates training progress in corresponding locations.

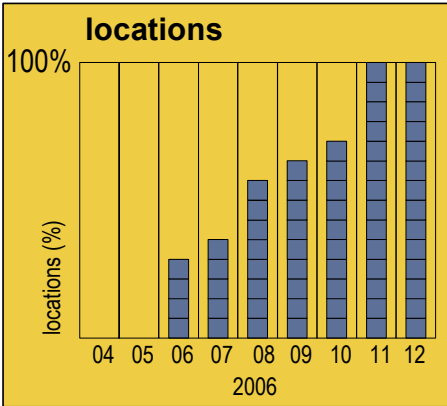


Figure 4. Training progress regarding locations

Thus an almost complete training of all employees involved in the new procedure was achieved. Directly addressing each individual employee resulted in broad acceptance of QA-M's. Intensive and controversial discussions on working level lead to many helpful optimization impulses. Among these were a correction of timing of some QA-M's for a better fit with design progress during

order processing. Technical as well as organizational responsibilities for each QA-M were put into question and finally fixed in a RASIC chart. QA-M checklists were revised many times in order to supplement new critical aspects and insights. Escalation procedure in case of negative QA-M evaluation was defined and complemented in the guideline. One of the most important insights won during roll-out was the necessity to adjust degree of QA-M application to specific circumstances of the project instead of making all QA-M steps mandatory. Process improvements were the result of the decision to roll out first comprehensive version of the guideline and gather feedback before revising written development guideline. The new version of guideline comprising process improvements was passed in February 2007.

Implementation progress was measured by QA-M application in development projects and feedback about applied technical expertise. As illustrated in figure 5, QA-M application in early design phases (QA-M0 until QA-M2) already turns out satisfactory, while QA-M3 application is rather low. This is caused by the many development projects which were already ongoing when QA-M process was rolled out. Low application rate of QA-M4 is due to its optional character. In order to ensure achieved implementation success, it was decided to keep up this measuring and integrate it into policy deployment of design, purchasing and quality management.

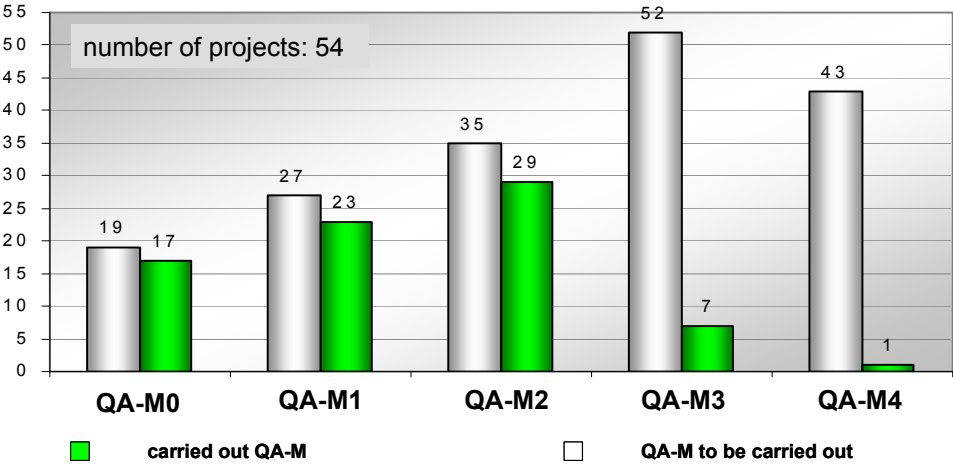


Figure 5. QA-M application in development projects

Effects of applying QA-M process on quality of mechanical vendor parts will show with a time delay of about 2 years. Then first development projects which have completely applied QA'Ms will be in production ramp up phase.

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