VDA | Verband der Automobilindustrie

Quality Management in the Automobile Industry

Joint Quality Management in the Supply Chain

Product creation

- A process description covering special characteristics (SC)

1st edition 2011

A process description

covering special characteristics (SC)

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Verband der Automobilindustrie e.V. (VDA)

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Berlin, May 2011

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Process description covering special characteristics

1 Preface

This VDA publication serves as a starting point for determining, specifying, tracking, documenting and archiving special characteristics. These must be agreed between customer and supplier throughout the entire supply chain.

This publication is a recommendation for the practical use of significant and critical characteristics, while complying with the framework conditions set out in standards and in legislation.

As a process model the VDA publication "Product creation; maturity level assurance for new parts" has been taken by way of example. If preferred, a company's own in-house product creation process can be used.

2 Objectives of the process covering special characteristics; definitions and limitations

The special process describes the way in which significant and critical characteristics are identified and specified.

Special characteristics are characteristics which require special care and are not controlled by other processes. This does not exclude the possibility that special characteristics may be identified also in these other processes.

The expression "other controlled processes" covers processes which (like the special process) classify characteristics and, if appropriate, define any requirements over and above the general technical level of care required. Examples include:

- ISO 26262 Functional security (probable publication date 2011)
- ISO 14001 Environment and emissions
- OHSAS 18001 Health and safety at work
- 2000/53/EG Vehicle end-of-life directive
- Symbols for safety items to VDA 4902/3.2 : labels

Systems, components or parts with an immediate influence on:

- safety/security
- vehicle registration
- function

may require extra care and attention.

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These systems, components or parts can be validated with the aid of special characteristics.

The term "extra care and attention" refers to the layout and security of the function / the characteristic by using appropriate solutions. This includes:

- identification and specification
- implementation and establishment
- documentation and archiving

of the special characteristics.

Among other matters, this care and attention refers to requirements which extend over and above the general technical care required, where one or more of the following aspects may be involved.

Development process

- Layout of characteristics
- Ensuring the function required
- Calculations and simulation
- Tests and trials
- Monitoring during operation
- Validation of fail-safe features, robust operation)
- Emergency running concepts
- Acceptance checks and releases
- Documentation and archiving

Production process

- Process, measurement and test/inspection equipment capability
- Process control covering manufacturing, test/inspection, maintenance, handling, storage, packing, conservation, shipping, transport fixings and transport
- Documentation and archiving
- Traceability
- Certification for customers

The extra work which may be involved with the heightened level of care and attention is justified by the possible consequences of a failure of the function.

"As much as necessary; as little as possible" is the watchword in guaranteeing adequate security. These mean that, the more robust and validate the design, the fewer special characteristics will be necessary.

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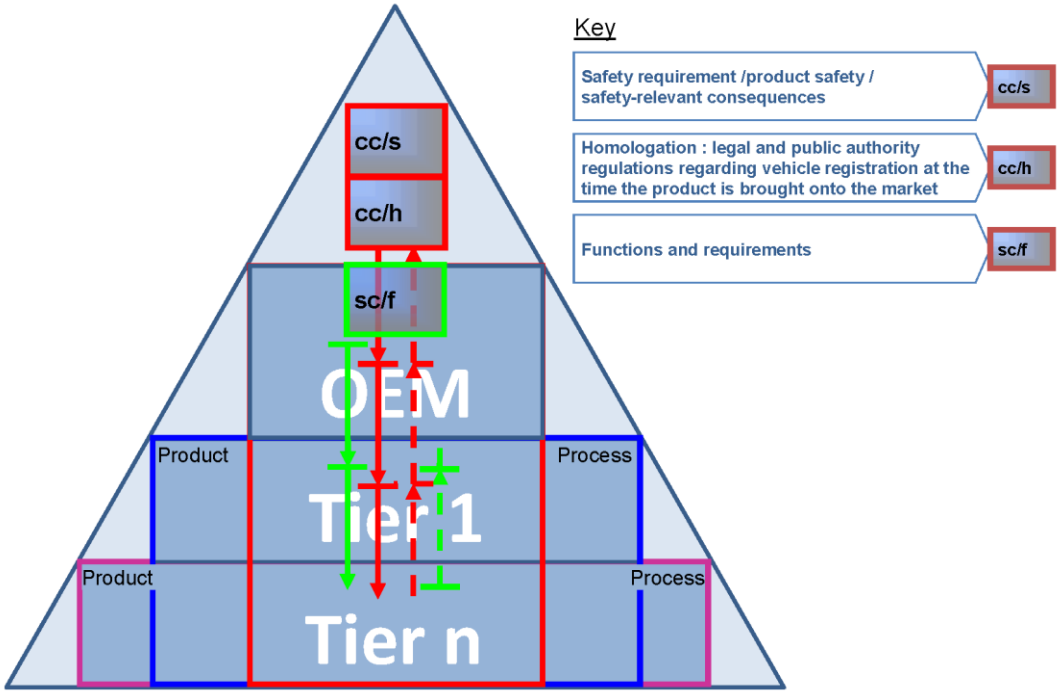
3 Categories of special characteristics

The term "characteristic" covers identifying features, starting from the functional level to the level of features identifying the product and the process.

Special characteristics are merely some of the characteristics which identify the product or process. They are divided into 3 categories.

- **cc/s** (cc = critical characteristic, s = safety): safety requirement / product safety / safety-relevant consequences (special characteristic related to safety)
- **cc/h** (cc = critical characteristic, h = homologation): legal and public authority requirements relating to vehicle registration at the time the product is brought onto the market (special characteristic related to legal and regulatory requirements)
- **sc/f** (sc = significant characteristic, f = function): functions and requirements (special characteristic related to functions and requirements)



Hierarchy of special characteristics

- The critical characteristics classified as **cc/s** (safety requirements) and **cc/h** (legal, public authority and vehicle registration requirements) have effects down to the lowest level of the hierarchy (Tier n) if they have not been validated at a higher level.

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- In the same way, each **cc/s** and **cc/h**, which is determined at a lower level can be taken forward to the customer (OEM, Tier 1) at the higher level.

- The significant characteristics **sc/f** (functions and requirements) operate downwards into the lower levels and only in exceptional cases upwards into the higher levels.

The importance of special characteristics

Characteristics which have consequences if they are not achieved or maintained, fall into the following categories.

cc/s cc = critical characteristic. These are safety/security requirements, those involving product safety and those with safety-relevant consequences, whose failure or deficiency may be an immediate danger to life and limb. In addition, such causal events must be foreseeable and not exceeding all probability.

Criteria may be:

- Protection for passengers in accidents
- Prevention of:
  - momentary loss of sight of the road
  - brake failure
  - steering failure
  - drive function failure
  - sudden loss of power
  - uncontrolled drive
  - leakage of fuel / risk of fire
  - insecure loads / trailers / parts
  - injury when travelling or when using the vehicle in any way

cc/h cc = critical characteristic. Legal and public authority regulations relating to registration of the vehicle at the time the product is introduced to the market.

- Registration-related (e.g., locking system, headlights)
- Homologation (e.g., exhaust gases, vehicle emissions, regulations issued by vehicle registration authorities)
- Legislation-related (recycling, warranty)

sc/f sc = significant characteristic. Functions and requirements

- Important functional requirements – the "4 x F" of Form, Fit, Function and perFormance), tolerances, etc.).
- Technical manufacturing demands (difficult to assemble, etc.)
- Severe economic damage to customer and/or supplier

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- Note 1: For a definition of the term "characteristic" see DIN EN ISO 9000:2005/3.5 : "Characteristic-related terms"

- Note 2: The critical characteristics covered by VDA Band 1, "Documentation and archiving" are merely a selection of the definition of the term "Special characteristics". These are sc/f and cc/h.

- Note 3: For a definition of the term "Significant characteristics" see ISO/TS 16949/3.1.2.

- Note 4: The categories cc/s, cc/h and sc/f are neutral, informative terms and are not prescriptive. They are put forward as proposals to achieve desired uniformity.

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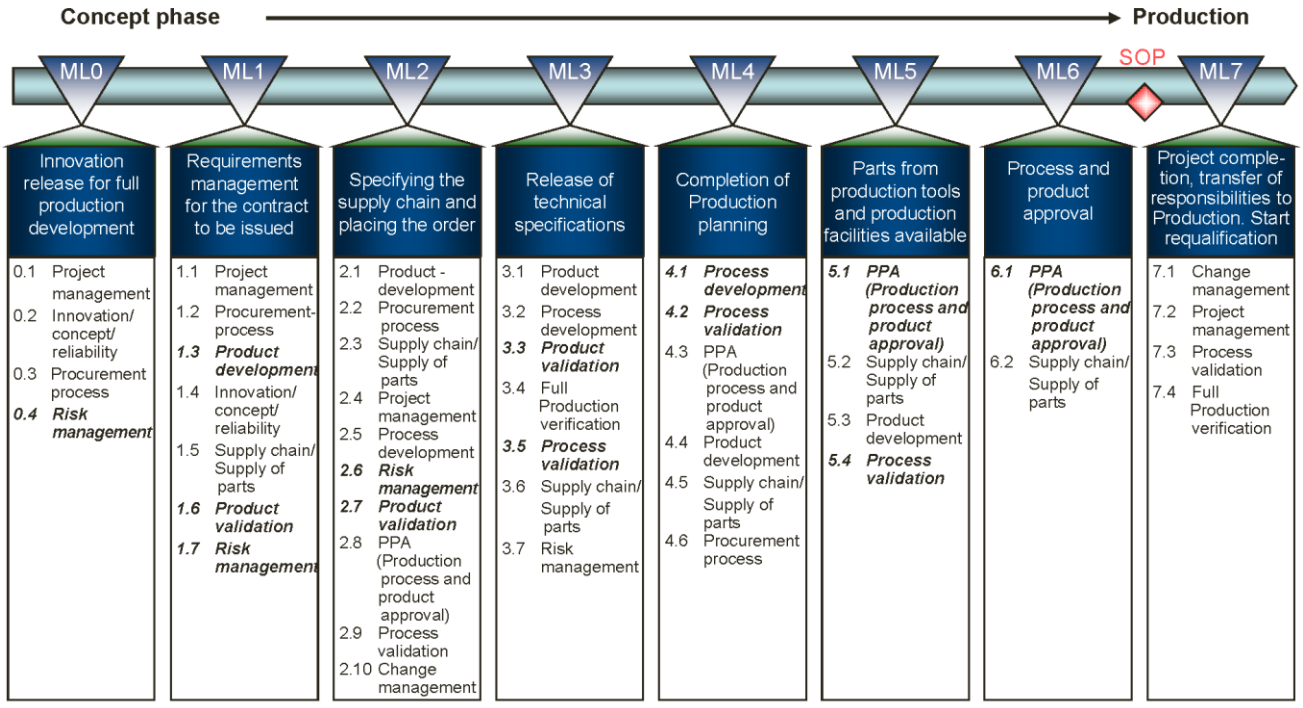
4 The process of applying special characteristics in the product creation process

As a process model the VDA publication "Product creation; maturity level assurance for new parts" has been taken as an example. If preferred, a company's own in-house product creation process can be used. The requirements relating to significant and critical characteristics must be taken into account when carrying out maturity level assurance.

The considerations highlighted in the following illustration show areas with a direct relationship to significant and critical characteristics.



Maturity level model from VDA Volume "Product creation; maturity level assurance for new parts“

The following sequential illustration is provided for clarity. The process model is based on simultaneous engineering, in which process stages overlap in terms of time.

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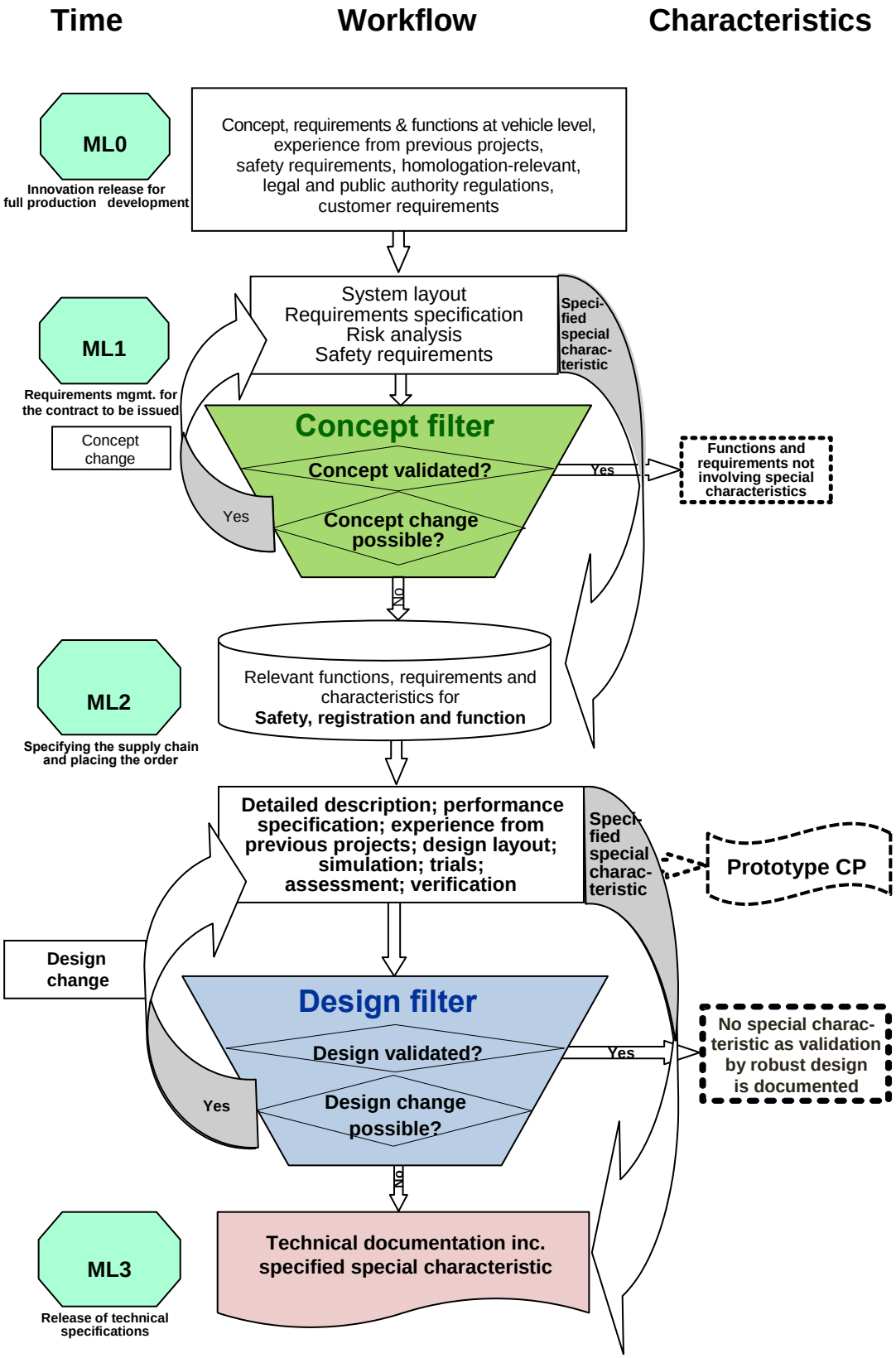
4.1 Description of the development process sequence



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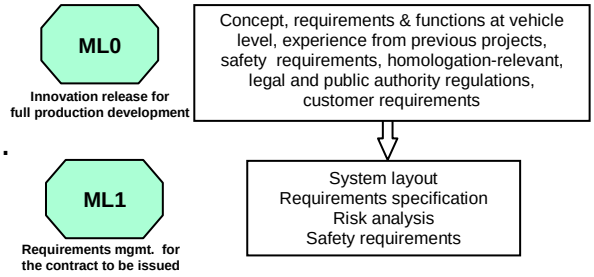
4.1.1 Requirements regarding the concept

As a first step an examination is made of the relevant functions and requirements regarding the vehicle concept and experience from previous projects.



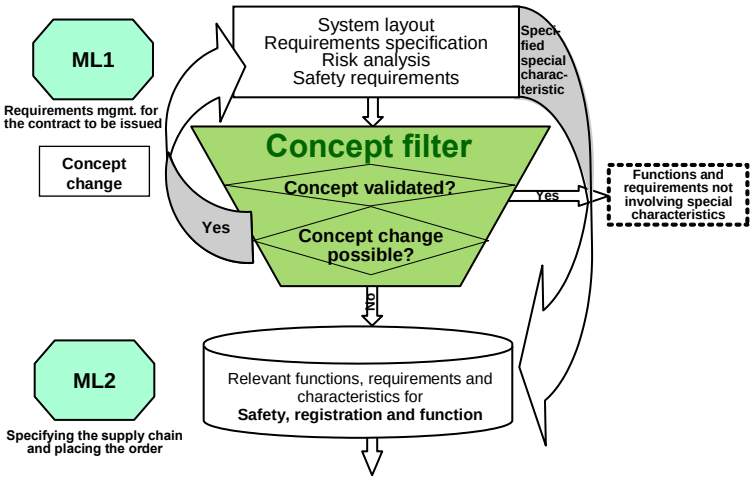
System layout, requirements specifications and safety / security demands form the basis for the risk analysis.
In addition there are different types of failure and their consequences. These results flow into the concept filter so that relevant functions, requirements and characteristics can be determined.

4.1.2 Concept filter

Special characteristics regarding functions, safety / security requirements or legal and public authority regulations which have already been specified, as well as customer requirements, must be adopted directly without filtering. Special characteristics from previous projects are passed through the filter and do not necessarily have to be adopted.

In the concept filter the first step is to clarify if the concept is validated.

Methods of concept validation are set out in Section 4.3 : "References to validation methods".



In terms of the concept, requirements can be validated by, for example:

- error tolerances
- redundancies
- secure fall-back levels

Functions and requirements which have been validated in the concept need not be tracked further.

The validation must be demonstrated and documented.

In the case of functions, requirements and characteristics not validated by the existing concept, a change in the concept is considered. If a change in the concept is not possible, or if the concept change does not result in successful validation, these functions, requirements and characteristics are examined further in the design.

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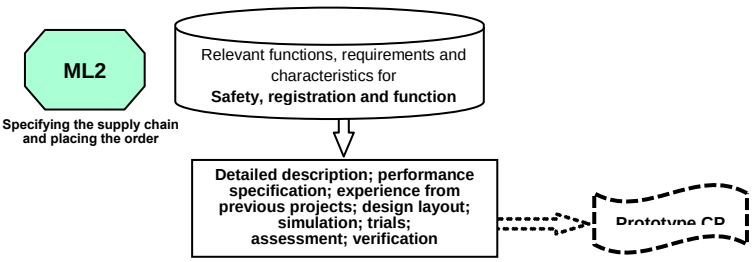
4.1.3 Requirements regarding the design

The non-validated functions and requirements which have been identified are taken into account when drawing up the performance specification and deciding on the course of the development.



The information gained from the detailed description, from the performance specification, together with experience from previous projects and layouts, as well as the results of simulations, trials, assessments and verifications are also included in the design filter for further consideration.

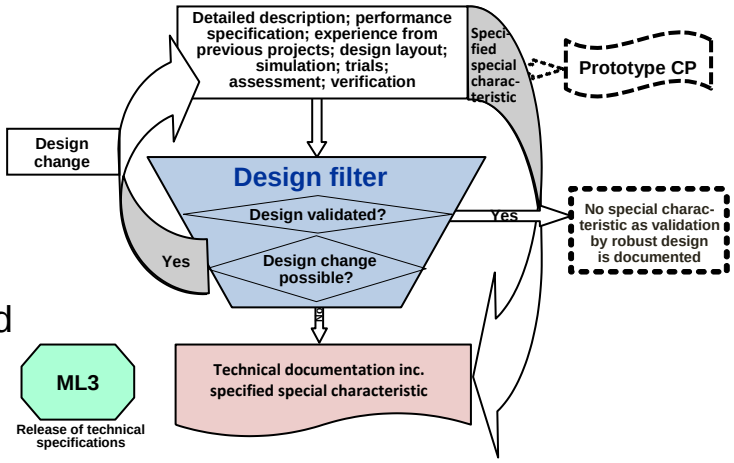
If a prototype production control plan is required, the relevant characteristics are included in this.

4.1.4 Design filter

Special characteristics which have already been specified must be included directly in the technical documentation of the development, with no filtering.

In the design filter the first step is to determine whether the design is validated and secure.

Methods for validation are set out in Section 4.3 "References to validation methods".
If the design is robust (see Section 4.4) or if the designed has been validated, the sc or cc under examination is not tracked any further. Otherwise, a change in the design must be considered.



The validation must be demonstrated and documented.

Significant and critical characteristics can be defined, for example, if:
- they are extremely sensitive to manufacturing conditions and/or the slightest changes in material characteristics
- the manufacturing tolerances can be maintained only with considerable effort.

The special characteristics which have been specified and have been identified with the aid of the filters must be recorded in the technical documentation for the project and must be forwarded to the production planning department and, if appropriate, also to the customer.

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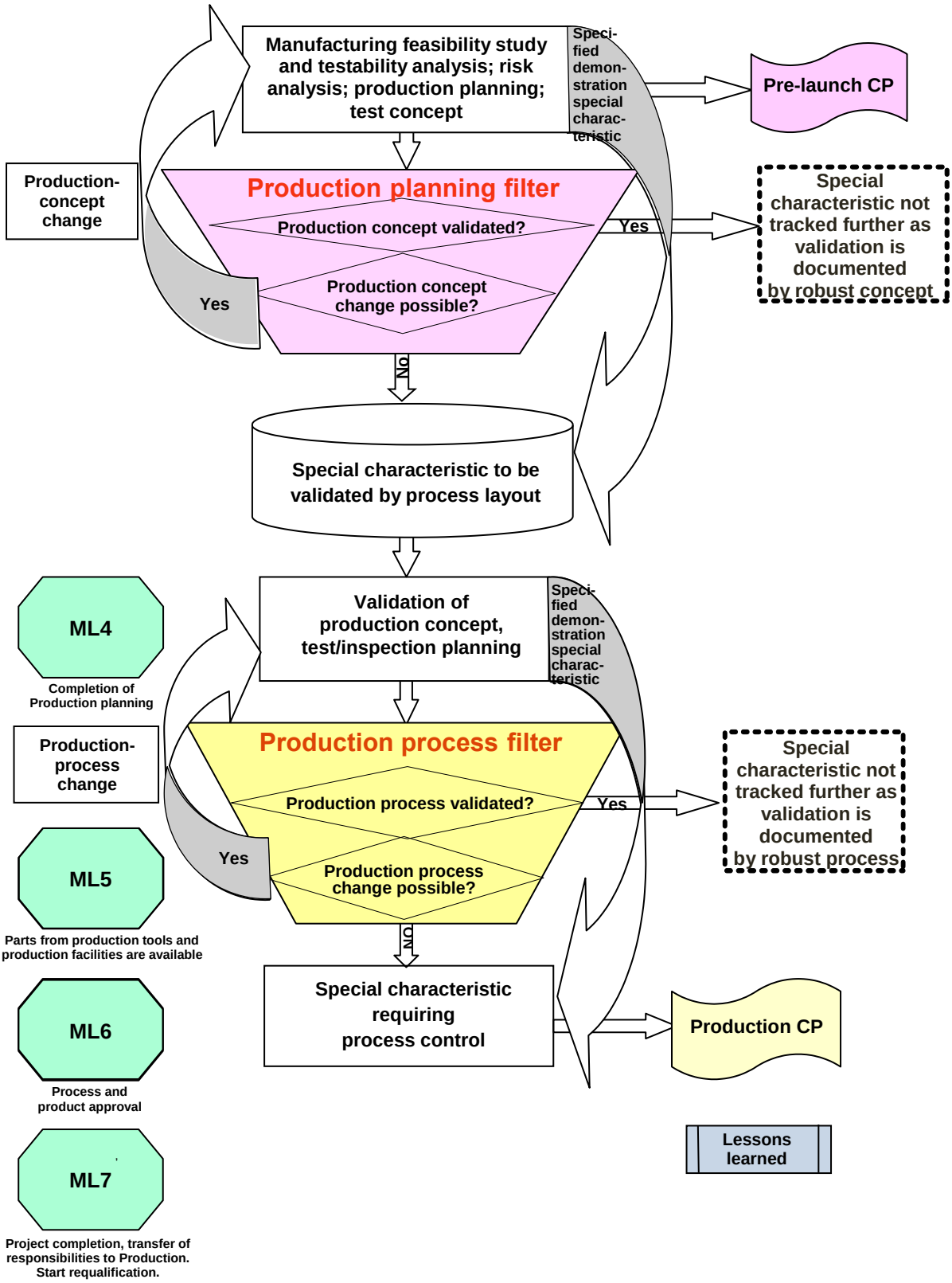
4.2 Description of the process sequence in production

Time **Workflow** **Characteristics**



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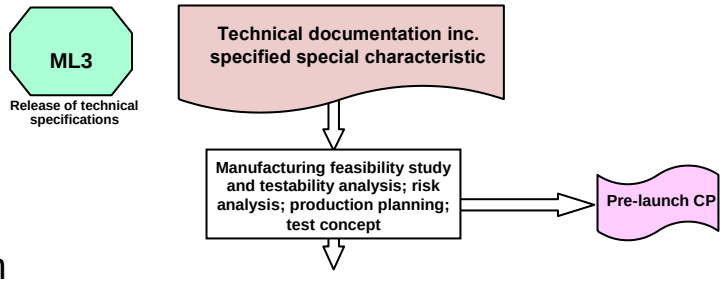
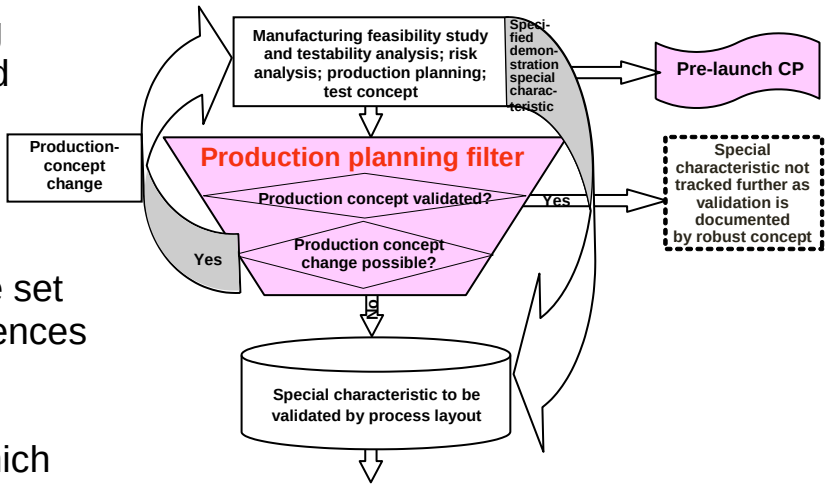
4.2.1 Requirements regarding production planning



Any special characteristics specified in the technical documentation must be analysed within the framework of the manufacturing feasibility study and testability analysis, the risk analysis, the production planning and the test/inspection concept. The results must be documented in the production control plan for pre-production. In this way the concept requirements for the production process are arrived at and these then flow into the production planning filter for further examination.

4.2.2 Production planning filter

Special characteristics and test/inspection specifications which must be adopted directly in the next stage can be specified in the technical documentation.



In the production planning Filter it must be clarified whether the production concept is validated and therefore secure.

Methods for validation are set out in Section 4.3: "References to validation methods ".

Special characteristics which have been validated in the production concept do not need to be tracked any further.

Validation of the production concept must be demonstrated and documented.

If the special characteristic cannot be validated by the production concept, the first step is to consider a change to the product concept. If a change is not possible of if the change does not result in successful validation, the characteristic(s) must be carried forward to the production process filter.

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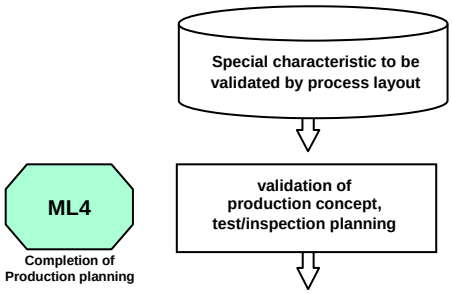
4.2.3 Requirements regarding the production process filter

The validation of the production concept and test/inspection planning can generate indicators for further special characteristics in the process.

The special characteristics which have been identified are examined further.



4.2.4 Production process filter

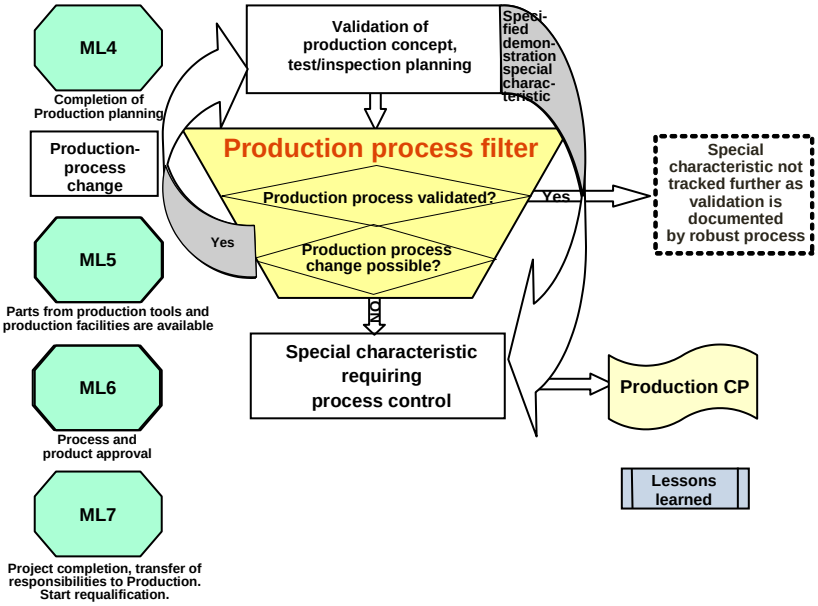
Special characteristics already specified must be carried forward directly.

In the production process filter it is clarified whether the sc and/or cc is validated and secured by the production process.

Methods for validation are set out in Section 4.3: "References to validation methods".

The special characteristics which have been validated and secured by a robust production process do not need to be tracked any further.

The robust production process must be proven and documented.



If the special characteristic cannot be validated and secured by the production process, the first step is to consider a change to the production process. If a change is not possible of if the change does not result in successful validation, the characteristic(s) and the methods used to check and monitor them are incorporated in the production control plan for full production

If the special characteristic cannot be checked directly on the product, the necessary associated process parameters must be monitored and the product must be checked on a random sample basis.

The results of the checks and monitoring must be recorded.

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4.3 References to validation methods

Risk detection and actions to minimize risks, including verification and validation of the implementation of these actions, are among the methods used to validate and secure product and process.

Methods of risk analysis and risk assessment are described in VDA publications, among others, such as:

- Failure Mode and Effects Analysis (FMEA)
- Fault Tree Analysis (FTA)

The most important elements in all risk analyses are:

- Functions
- Characteristics
- Possible failure modes; deviations; non-conformances
- Possible effects of failure modes
- Risk assessment
- Specifying appropriate actions

Alternatively, the following activities can also be carried out:

- **Hazard analysis and risk assessment**
- Event Tree Analysis (ETA)
- Value Analysis / Value Engineering (VA / VE)
- List comparison
- Team of experts
- ……

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4.4 Expanded details of the process description covering significant and critical characteristics

Premises

- The special characteristics must be determined on an inter-disciplinary basis.
- Experience gained from previous projects is an input factor in determining significant and critical characteristics.
- Special characteristics must be determined without any consideration of the work involved, within the framework of what is specified as legally reasonable.
- Experience from product observation must be taken into account.
- If changes are made to product and/or process the exercise of determining special characteristics must be carried out again. This applies particularly where production is transferred to another location.
- A proportion of safety-relevant critical characteristics and homologation-related characteristics may be specified by the customer. However, as a general principle, the supplier must also, on his own responsibility, identify special characteristics.

Robust design

The term "robust design" describes a design which reacts without undue sensitivity to fluctuations and interference factors (for example, if individual features exceed tolerance limits) – in other words, it continues demonstrably to fulfil the functions which are expected and required.

Proof of robust design is the obligation of the development function responsible and can be provided, for example, by DoE (Design of Experiments).

Robust process

In the same way, a robust process is seen as a process which reacts without undue sensitivity to fluctuations and interference factors (e.g., voltage fluctuations; insulation defects on varnished wire or tool wear – that is, the manufactured product demonstrably continues to perform as required – see the VDA publication: "Product manufacture and delivery – robust production process“.

Proof of robust process is the obligation of the process planning department responsible and can be provided, for example, by capability certification.

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Production control plan (Production CP)

The production control plan describes the planned activities to validate and secure the product and process characteristics. The production control plan is defined in ISO/TS 16949/7.5.1.1 and in the appendix.

4.5 Identification

Identifying special characteristics in documents using suitable symbols serves primarily to provide clear and simple identification. Against this background the symbols should not contain too much specific information.

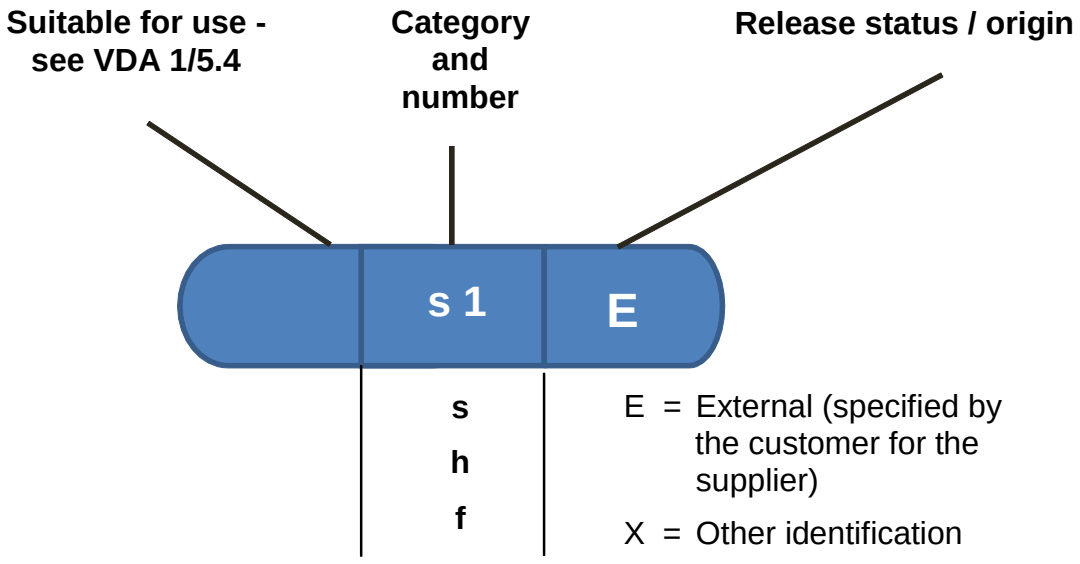
It is recommended that the so-called "Zeppelin" be used to identify characteristics. This airship-shape symbol contains an identifying letter for the category of the characteristic (s, h or f) and, for each category, a sequential number to differentiate it in the release document.

The identification of the characteristic can also be preceded by a separate identifier, as described in VDA Volume 1, section 5.4 in the table "Identifying documents with critical characteristics“.

Attachments can also be made to the identification "Zeppelin", such as the release status, the origin, or a separate symbol for in-house differentiation and control of the characteristic.

Any further information associated with the characteristic (who what, how and how many, with what documentation) can ideally be included in the same document in a table.

"Zeppelin" symbol – identifier for special characteristics



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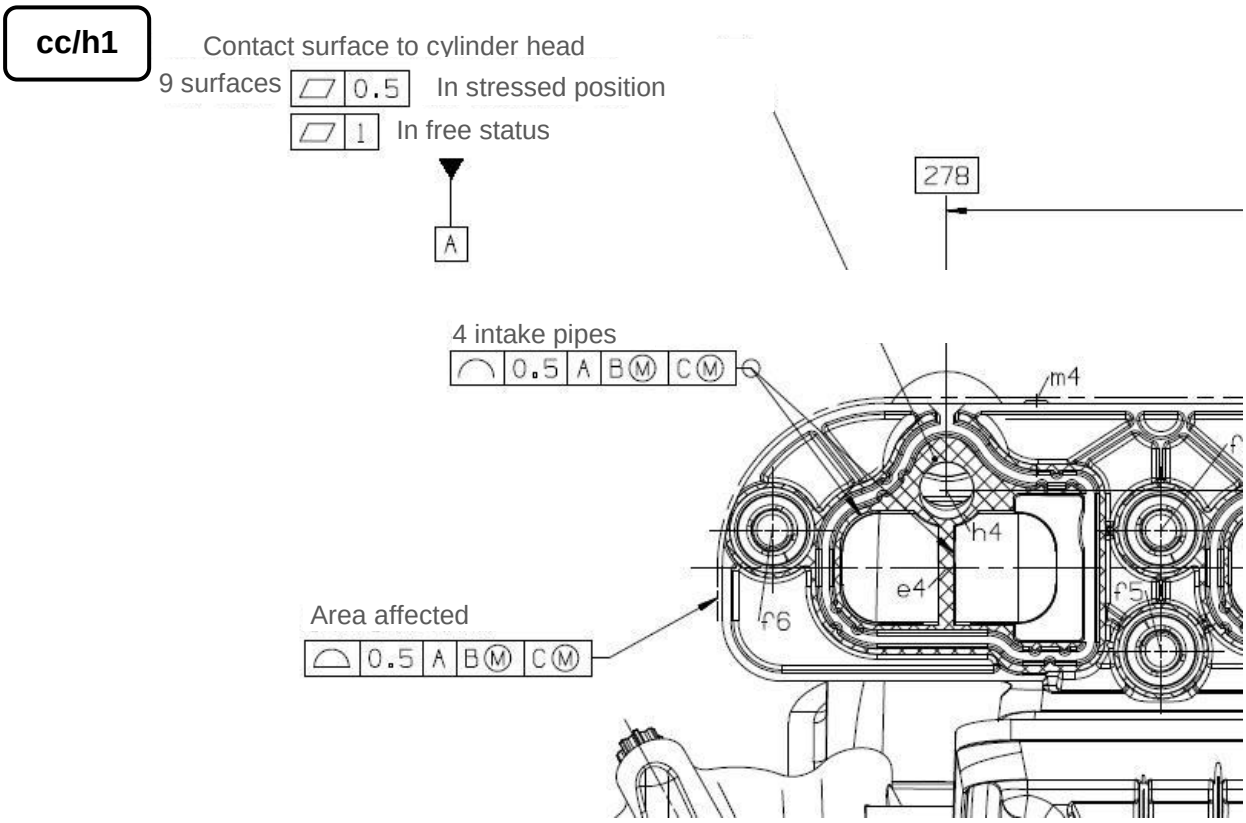
Example: Component drawing showing the intake module of an internal combustion engine:



The flatness of the flange surface in the hatched area is identified as a critical characteristic with relevance to homologation (thus giving the cc/h1 identifier). The consequence of not achieving the characteristic could be a leak in the inlet tract, which might result in high emissions of harmful substances.

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Any further details relating to the special characteristic can be entered in a table in the drawing or in a separate document.

0	1	1	Number of characteristics by category on the drawing		Categories: s = safety-relevant h = Homologation-relevant f = function-relevant			
s No.	h No.	f No.	Characteristic	Execution Point (who / where	Type of Implementation (what)	Requirements regarding Implementation (how / how many	Zone	Sheet
	cc/h1		Levelness	Supplier Production	Must meet tolerances	SPC / c_{pk} = 1,67 or 100%	H21	1
		sc/f1E	Diameter of part-circle	Supplier Production	Must meet tolerances	100% gauge check to checking instructions	F2	1

The second example in the table shows a significant characteristic which has been specified by the customer. Characteristics of this kind are identified with an "E" – see "sc/f1E" in the third column.

In documents such as requirements specifications or safety certificates which may not contain any illustrations, an explanatory commentary and the category can be added to the table. In the following example in a requirements specification, the critical characteristic is defined as sc/f1-E with the "E" indicating a customer requirement.

Description	Characteristic and specification	Category	Action by	Implementation (what / how and how many)	Documentation
Flange surface on cylinder head	Levelness  when clamped in free state	cc/h1E	Supplier / production	SPC / 6 sigma or 100%	VDA 1 / 5.4

According to ISO/TS 16949 the organisation must identify the documents for the control of the production process, including drawings, FMEAs, production control plans and operating instructions.

With regard to the FMEA the "Classification" column can be used – see Section 5.

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Example of a Product FMEA: Follower disc to screwed plate for converter

Potential effects of failure	S	Potential failure mode	C	Potential cause of failure	Preventive actions	O	Detection actions	D	R P N	R/DL/Status
System element: Follower disk to screwed plate for converter										
Function: Ensure manufacturing fasibility of threaded connection										
Functional failure: Force transfer via threaded connection not ensured	9	Manufacturing feasibility ofonnection not ensured threadedc	sc/f	Access for standard tool in accordance with prototype control plan not provided	Initial status: 15. Oct. 2011					
					none	10	Access checked in virtual simulation Restricted access detected	2	180	Developer 31. Dec. 2010 completed
							Fitment trial carried out with standard tool as in prototype control plan Process is nit securebecause of restricted access			
					Action status: 15. Jan. 2011					
					Process development with modified special tool	2	none	1	*18	Planner 30. Sep. 2011
					none		Drawing must specify sc/f for inclusion in pre-launch control plan			Developer 31. Mar. 2011

* valued not yet saved evaluation

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Example of a Process FMEA: Assembly of follower disc

Potential effects of failure	S	Potential failure mode	C	Potential cause of failure	Preventive actions	O	Detection actions	D	R P N	R/DL/Status
System element: Assembly of a follower disc										
Function: Screw follower disc to converter. Process capability in accordance with standard for sc/f										
Functional failure: Force transfer via threaded connection not ensured	9	Follower disc not screwed to converter as specified	sc/f	Access for standard tool is not provided	Initial status: 15. Oct. 2011					
					Screw tool development to access the restricted space	2	Assembly simulation carried out with special tool Satisfactory result	2	36	Planner 30. Sep. 2010 completed
					Action status: 30. Oct. 2011					
					none	2	Provide proof of process capability in production control plan in accordance with standardfor sc/f and document the result	1	*18	Manufacturer 15. Nov. 2011

* valued not yet saved evaluation

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4.6 Consequences

The process used to determine special characteristics must be demonstrated. Associate documents must be stored – see Section 4.7: "Documentation and archiving".

The following activities regarding special characteristics must be agreed on an inter-disciplinary basis:

- The special characteristics relating to technical documentation are forwarded to the relevant production department
- Special characteristics which have been identified in the technical documentation must be taken into account in all essential documents for controlling the production process
- It must be specified how compliance with the special characteristics is to be demonstrated
- Monitoring of the special characteristics must be specified
- The traceability of products with special characteristics must be specified

In the supply chain the customer must advise his suppliers of special characteristics and agree on the way they are to be monitored.

The fact that the customer specifies special characteristics does not release the supplier from his own responsibility to identify special characteristics and to deliver conforming products.

4.6.1 Recommended activities in product development

- Product development – design layout (including, for example, emergency running, redundancies, operating and display concept)
- Concept revision
- Manufacturing feasibility study / analysis – stimulus for carrying out a detailed manufacturing feasibility study for this characteristic
- Planning to cover tests and trials
- Special attention to special characteristics in test/inspection planning and documentation as required in the prototype production control plan

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4.6.2 Recommended activities in process development

- Process development – the need to carry out trial manufacturing on a large scale must be checked and specified if required, together with recommended quantities
- Manufacturing feasibility study / analysis – stimulus for carrying out a detailed manufacturing feasibility study for this characteristic
- Provisional process capability study (VDA Volume 2: "Quality Assurance of Supplies " or additional customer agreements")
- Particular consideration of special characteristics in the test/inspection planning and documentation, in pre-launch and production control plan
- Proof of full production capability / suitability for product launch; special requirements covering long-term process capability (VDA Volume 2: " Quality Assurance of Supplies " or additional customer agreements")

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4.7 Documentation and archiving

The documentation includes, for example:

- **Technical documentation** with drawings and other relevant documents, such as FMEAs, production control plan and work instructions
- Test/inspection results and associated decisions
- Process parameters
- Demonstration/proof of test/inspection equipment calibrations
- Special procedures for products with special characteristics

The documents used to control production processes containing special characteristics must be specifically identified in accordance with ISO/TS 16949. All departments involved must be advised of the special treatment which these require.

When deciding on the periods for which the documents are to be used and archived, a differentiation must be made between documents stating requirements and quality records.

Requirements documents

The period of use begins with the release and ends when the document is rendered invalid - for example because of a change (new version) or the expiry of a set period (a deviation approval), or the end of production of the product / process - see VDA volume 1, "Documentation and archiving ".

The archiving period begins when the document is rendered invalid, in accordance with the quality management system requirements for controlling documents and data (e.g., appropriate identification).

Examples of requirements documents relating to special characteristics include:

- Regulations for dealing with safety-relevant screwed connections
- Production control plans
- Regulations covering process qualification – e.g., process capability, suitability of test/inspection processes
- …

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Quality records

The period of use depends on the type of use and begins when the quality record is created – for example, the documentation of a test result, a completed process control chart, a process capability certificate, or an initial sample inspection report. The records must not be modified once they have been completed – see also VDA volume 1, "Documentation and Archiving", Section 4.2 "Composition of documents". The archiving period begins from this point.

A further use of records is normal here – e.g., for analysis purposes.

Examples of quality records (certification documents) with relevance to special characteristics:

- Product test/inspection results for special characteristics
- Proof of process capability, including quality control charts
- Certification of the suitability of test/inspection processes
- …

Archiving period

The archiving period for requirement documents and quality records is as stated in VDA volume 1, "Documentation and Archiving", figs. 5-1 and 5-2. Here a minimum period of 15 years is recommended for critical characteristics (cc/h and cc/s). Quality records for components with function-related significant characteristics (sc/f) must normally be kept for 3 years. In addition, consideration must be given to customer-specific requirements or other stipulations.

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5 Inter-action with the FMEA

In the FMEA special characteristics can be:

- identified, documented and tracked for implementation
- documented after they have been specified by other procedures (to meet the requirements of ISO/TS 16949 and / or for special consideration when carrying out the analysis of actions in the FMEA)

The special characteristics can be shown in the FMEA:

- using the "Classification" column (see VDA volume 5, section entitled "Product and Process FMEA"
- by identifying the relevant functions / characteristics in the function network
- or at the relevant possible failure points in the failure network
- in the form of actions or
- by some other appropriate means

It should also be possible to detect the origin and reason for the special characteristic.

An assessment of the severity as 9 or 10 does not automatically result in an sc/f or cc/h or cc/s.

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A Appendix

Abbreviations used in this document

cc/h	Critical characteristic based on homologation
cc/s	Critical characteristic based on safety
DIN	Deutsche Industrie Norm (German industrial standard)
EN	European standard
ETA	Event Tree Analysis
FMEA	Failure Mode and Effects Analysis
FTA	Fault Tree Analysis
ISO	International Standardization Organization
OEM	Original equipment manufacturer
OHSAS	Occupational Health and Safety Advisory Services
ML	Maturity level
MLA	Maturity level assurance
sc/f	Significant characteristic based on function
VA	Value analysis
VE	Value engineering

Other examples

DMR	Diameter	in Appendix A5
ECU	Electronic control unit	in Appendix A6
EPB	Electronic parking brake	in Appendix A6

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Examples

The following examples illustrate practical use in different degrees. The methodical procedure is shown in each case.

The examples have been provided by various VDA member companies and make no claim to comprehensiveness in terms of their contents. No guarantee of any kind applies in any case.

A.1 Example : Fuel tank vent

A.2 Example : Light sensor

A.3 Example : Headlights

A.4 Example : Input shaft to steering system

A.5 Example : Steering wheel interlock

A.6 Example : Electric parking brake

A.7 Example : Electronic control unit earthing cable

A.8 Example : Sliding roof drive motor

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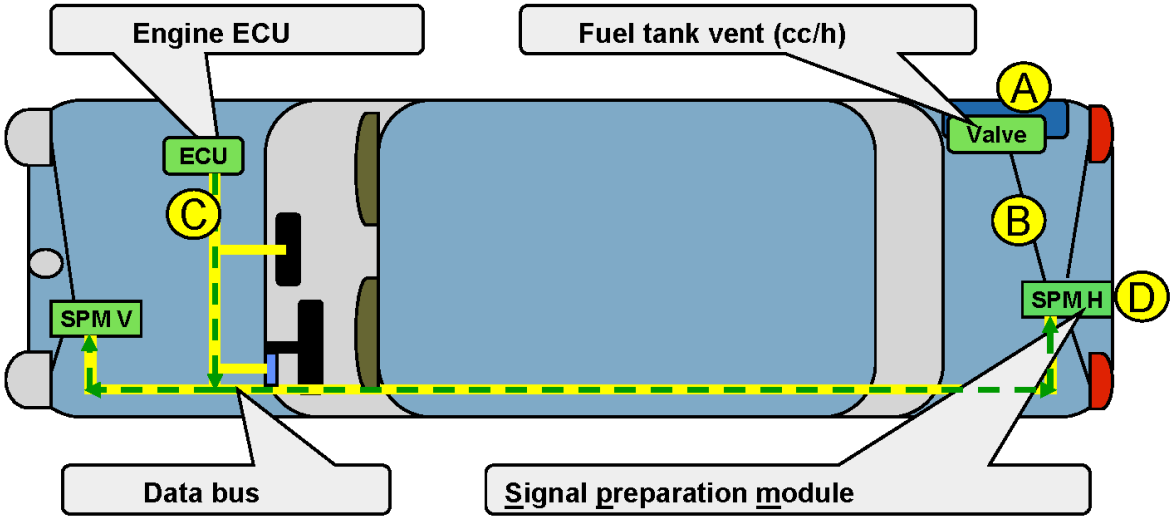
A.1 Example : Fuel tank vent

The function "fuel tank vent" is to be installed in a vehicle

The function is initiated by the engine ECU

Concept: Initial launch-pad for solutions

A. Install a valve at the tank
B. Electrical connection from the existing signal preparation module (SPM H) at the rear of the vehicle with a short line to the valve
C. Control signal from the ECU via the data bus to the SPM H
D. Control the valve via the SPM H



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A.1 Example : Fuel tank vent

System: Fuel tank vent

Function: Vent valve is controlled by the engine ECU

Characteristic: Open the valve to vent the fuel tank

National regulations: Exhaust-relevant / homologation => cc/h

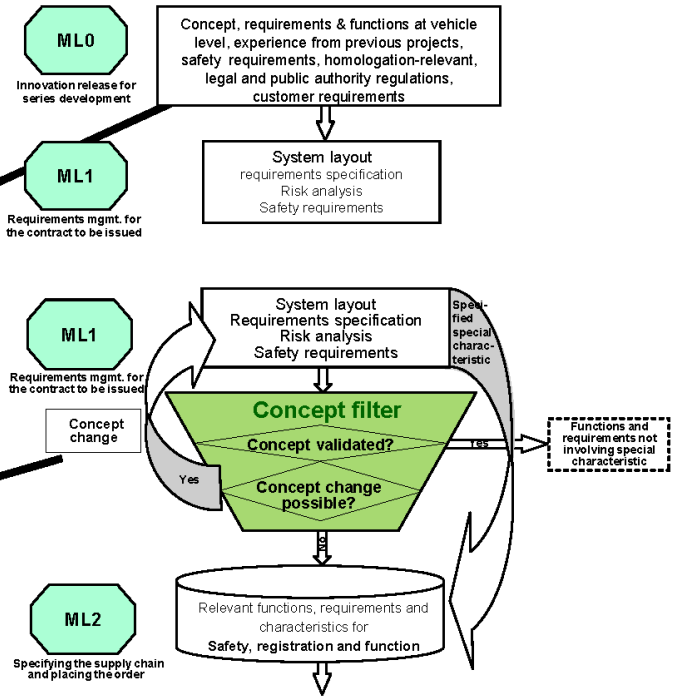
Features affected: Certification, length of guarantee, ...

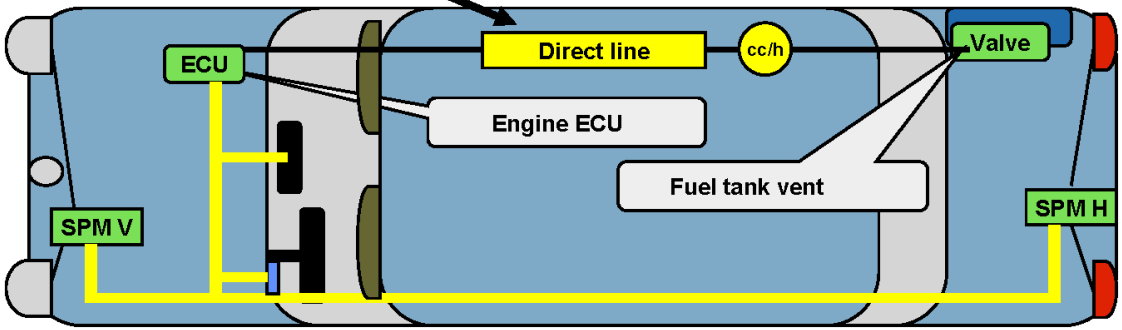
Consequences:

If the valve is controlled by the rear signal preparation module via the CAN bus, all the components involved will be subject to certification and the longer guarantee period.

Change of concept:

Control with a direct link between engine ECU and valve





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A.1 Example : Fuel tank vent

Summary:

The "fuel tank vent" function is checked for special characteristics and, because it is seen to be subject to certification regulations, it is classified as "**cc/h**".

A change of concept is required and is documented. As a result of the change of concept the characteristic (**cc/h**) is secured and is not considered further in subsequent development processes.

The actions are documented to certify :

- that this function has been investigated
- what actions were taken to secure the function
- information for subsequent models
- why this special characteristic is not examined further in subsequent development processes.

Note:
For the production process the **"connecting wire"** is identified as "**cc/h**". It must be ensured that this wire is installed.

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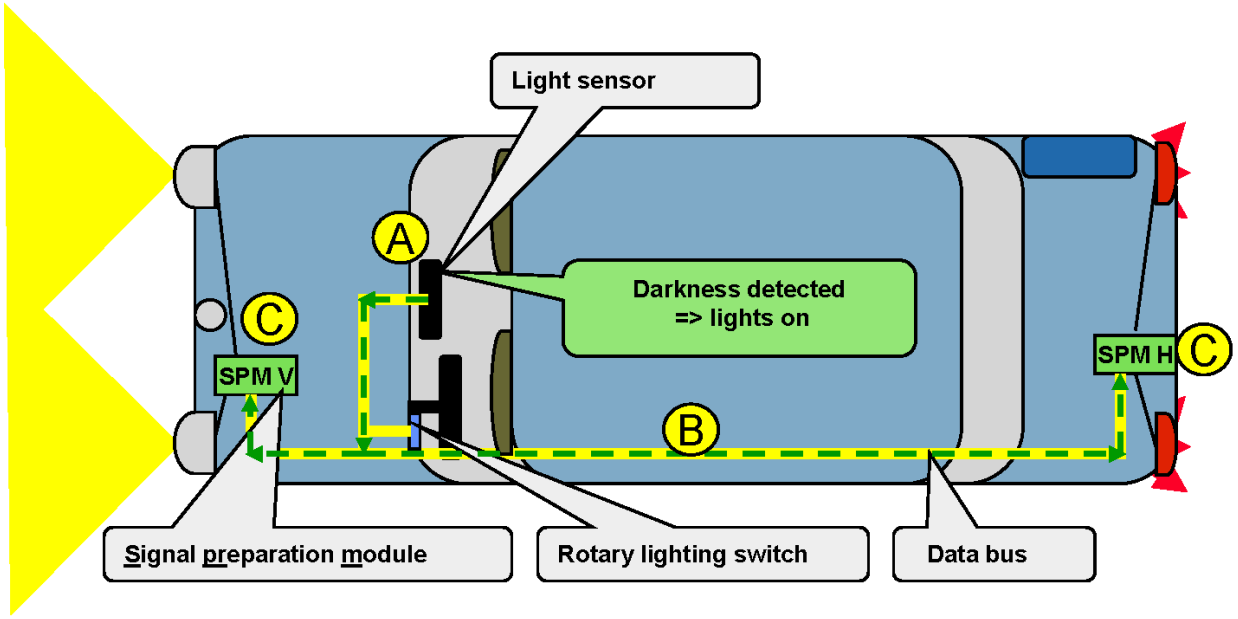
A.2 Example : Light sensor

In a vehicle, the function : "switch on lights automatically in dark conditions" is to be provided.

Concept : Initial launch-pad for solutions

A. Fit the light sensor to the windscreen
B. When dark conditions are detected, send a signal on the data bus
C. Control the headlights and rear lights by the signal preparation modules (SPMs)



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A.2 Example : Light sensor

Function: Lights on if dark conditions are detected : cc/s

Risk analysis:

If there is a defect in the light sensor the lights may go out so that the view forwards is lost.

This is a safety risk and the function is identified as "safety-relevant" in the development phase documentation

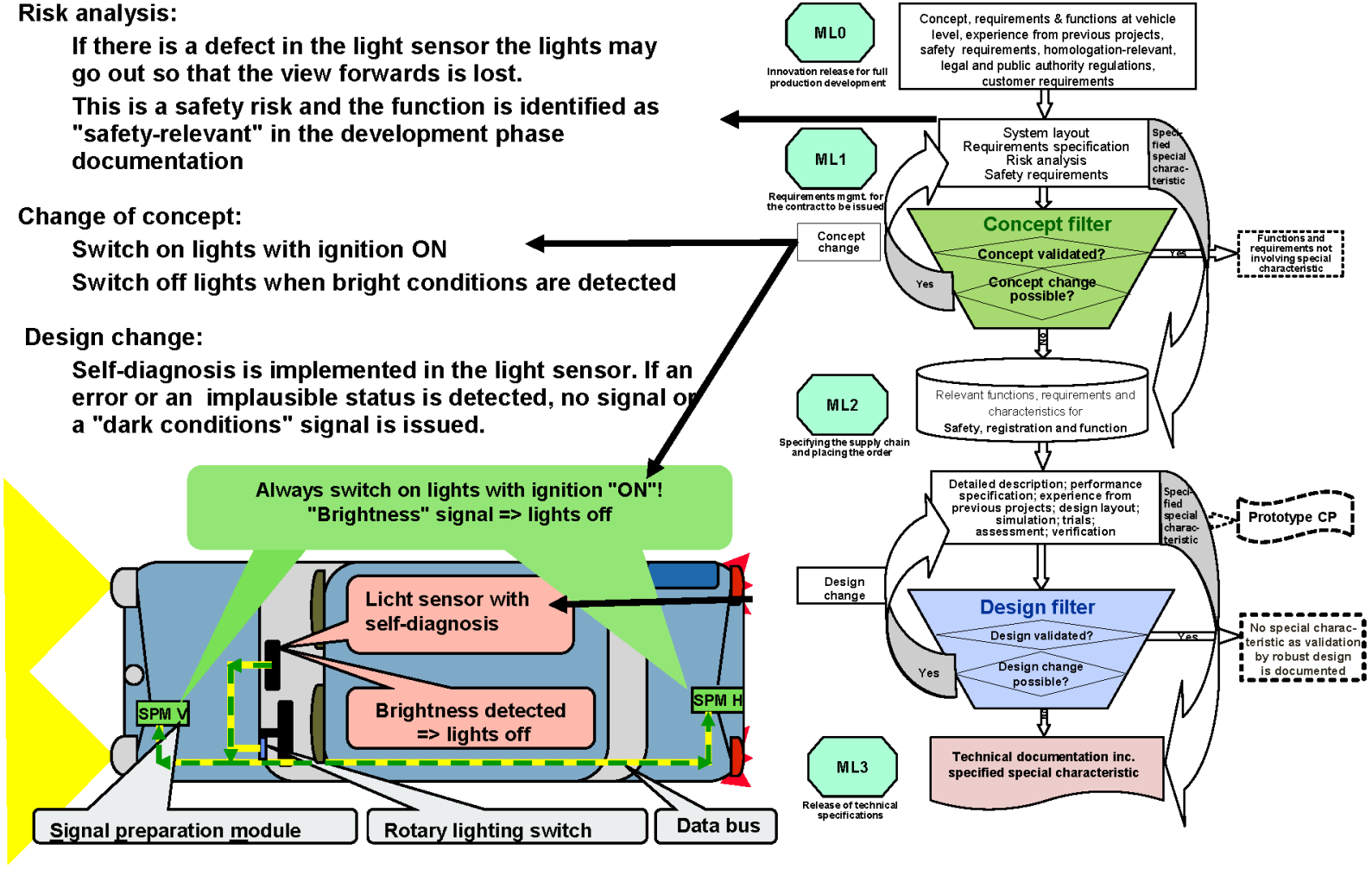
Change of concept:

Switch on lights with ignition ON

Switch off lights when bright conditions are detected

Design change:

Self-diagnosis is implemented in the light sensor. If an error or an implausible status is detected, no signal or a "dark conditions" signal is issued.



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A.2 Example : Light sensor

Summary:

The function is checked for special characteristics. In the risk analysis the function is classified as a "safety risk" and identified as "safety-relevant".

A change of concept is necessary and documented.

A residual risk still exists, so the function remains identified for the design phase.

In the design layout the implementation of a self-diagnosis function is introduced as a change.

In the design filter it is noted that, with the concept design layouts, a safe status is always achieved in the event of a defect. The design is secured.

Further examination in subsequent processes is not necessary.

The actions are documented to certify:

- that this function has been investigated
- what actions were taken to secure the function
- information for subsequent models
- why this special characteristic is not examined further in subsequent production processes.

Note:
No action and no special characteristics in the production process

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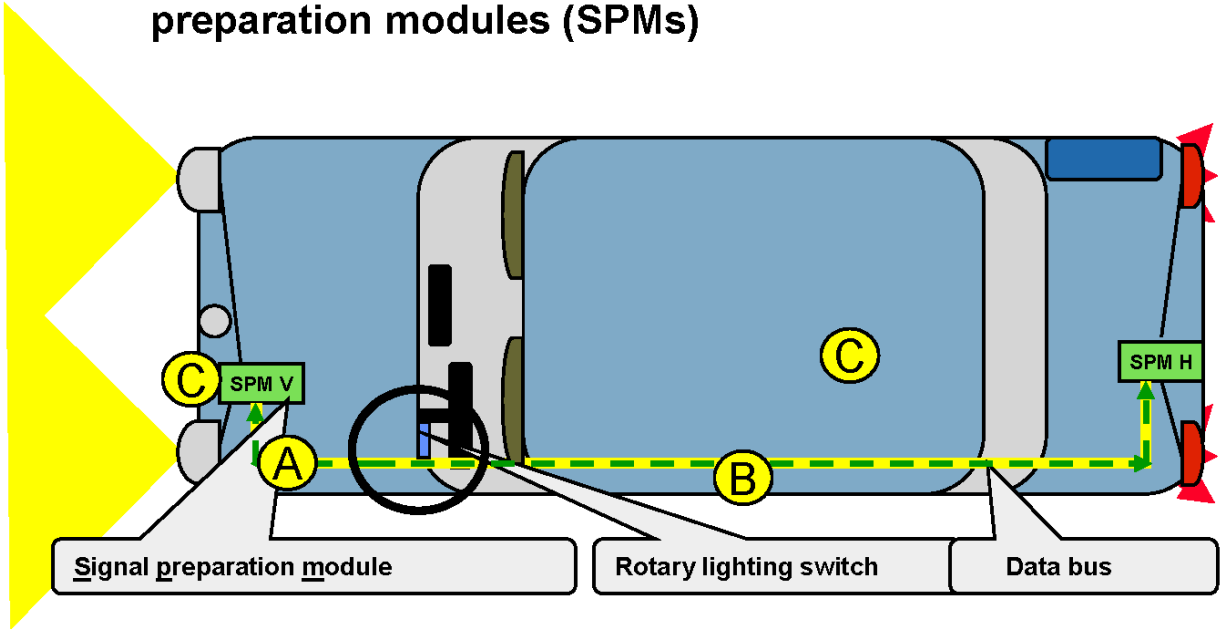
A.3 Example : Headlights

The headlight function is to be provided in a vehicle.

Concept : Initial launch pad for solutions

A. Switch on the lights manually with the rotary lighting switch
B. The light switch sets the "lights on" signal on the data bus
C. The headlights and rear lights are controlled by the signal preparation modules (SPMs)



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A.3 Example : Headlights

Function: "Lights ON" with rotary lighting switch
= cc/s

Risk analysis:

If a connector becomes loose the lights may fail, so that the view forward is lost.

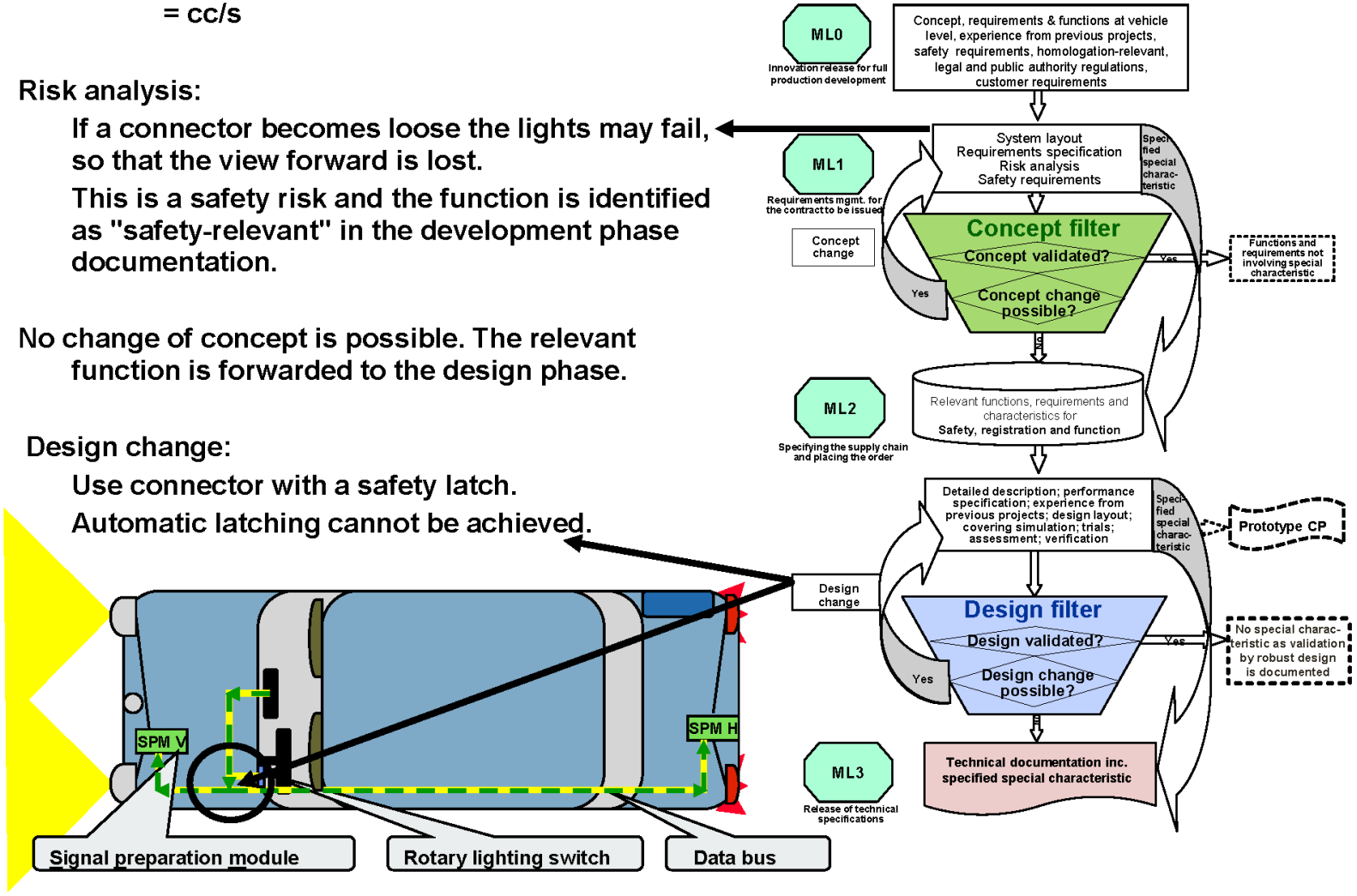
This is a safety risk and the function is identified as "safety-relevant" in the development phase documentation.

No change of concept is possible. The relevant function is forwarded to the design phase.

Design change:

Use connector with a safety latch.

Automatic latching cannot be achieved.



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A.3 Example : Headlights

Summary:

The "headlights" function is checked for special characteristics. In the risk analysis the plug connector is classified as a "safety risk" and identified as "safety-relevant ".

A change of concept is not possible, so the function remains identified for further consideration in the design phase.

In the design layout the use of a latch prevents the connector from becoming loose and the risk is secured.

However, the connector is prevented from becoming loose only if the latch has engaged securely. An assembly error is still possible.

The "engagement of the connector latch" is identified as a cc/s and is forwarded to the assembly process.

Note:
An action is required in the production process to ensure that the latch is engaged securely.

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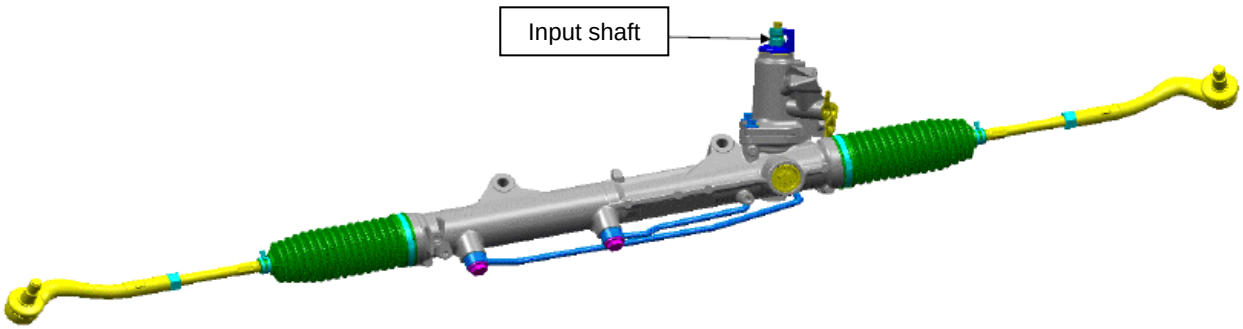
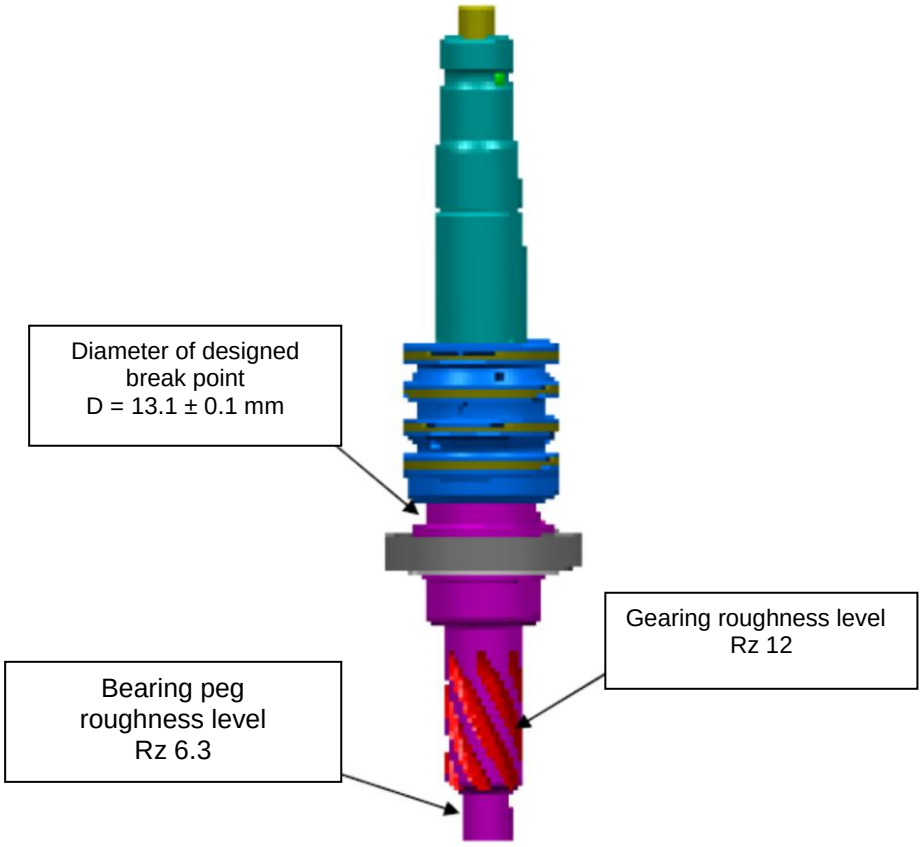
A.4 Example : Input shaft to a steering system



Steering system assembly



Zoom view on the input shaft

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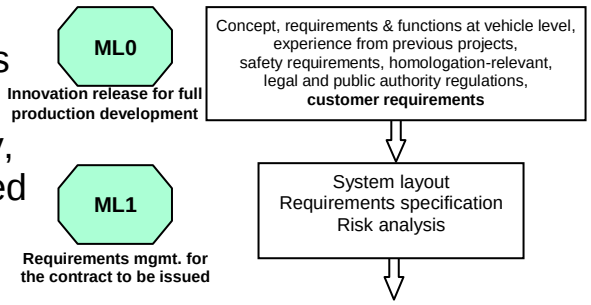
A.4.1 Description of the development process sequence

A.4.1.1 Requirements regarding the concept

The concepts and functions at vehicle level, experience from previous projects and relevant functions, together with requirements relating to safety, security, homologation and function are examined for possible special characteristics.

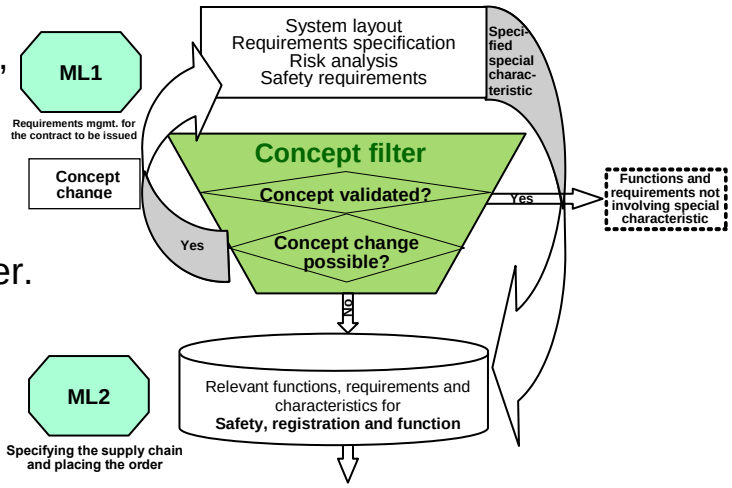


In the case of the input shaft to a steering gear, the customer has specified as a critical safety characteristic (cc/s) the hardness of the bearing seat, which must be 650HV +110HV1.

The system layout, requirements specification, risk analysis and safety requirements reveal no further relevant requirements and functions relating to safety, homologation and function.

A.4.1.2 Concept filter

The critical safety characteristic (cc/s) specified by the customer, that thehardness of the bearing seat must be 650HV+110HV1, is taken forward as a relevant safety characteristic without passing through the concept filter.



The concept is examined. Risks are detected for the diameter of the designed break point, the roughness of the bearing peg and the roughness of the gearing. These cannot be changed by a change in concept and are considered further as being relevant. These fixed characteristics are allocated to the relevant requirements and functions for safety, homologation and function. They then go forward for further examination in terms of the design.

Other requirements and functions which have been secured by the concept have been confirmed by trials and tests and are not considered further as relevant regarding special and critical characteristics.

The trials and tests are described in instruction ref. V18/05. The results are documented.

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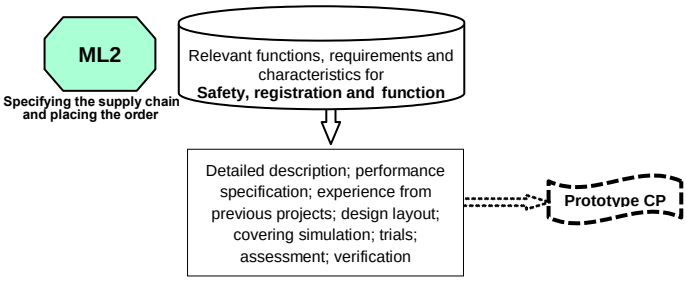
A change to the concept is considered, to take account of the requirements, functions and characteristics not secured by the existing concept. If the modified concept does not achieve the necessary level of assurance, these requirements, functions and characteristics are examined further at the design level.

A.4.1.3 Requirements regarding the design

The characteristics which have been identified are set out in detail.

Relevant for homologation are:

- the diameter of the designed break point: D_{spec} = 13.1 ± 0.1 mm
- the roughness of the bearing peg: Rz = 6.3



Relevant for function is:

- the gearing roughness level Rz = 12

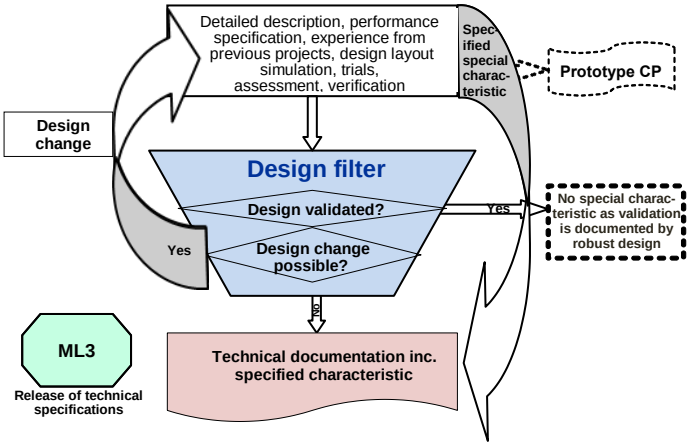
These identified requirements, functions and characteristics are taken into consideration when drawing up the performance specification and preparing the layout in the development phase.

A.4.1.4 Design filter

The design layout of the designed break point is examined in Trial V18/09.

The trial confirms that the diameter of the designed break point D_{spec} = 13.1 ± 0.1 mm is a robust design.

The results of the trial are filed in the "NF9 steering gear" file. =>Ikone



The design diameter is secure and does not represent a special characteristic.

No further requirements, functions and characteristics representing special characteristics are noted in the development.

In the technical documentation covering the development the following special characteristics are specified and forwarded to the production planning department.

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Safety-relevant special characteristic

- **cc/s**: Hardness of the bearing seat 650HV+110HV1.

Homologation-relevant special characteristic:

- **cc/h:** Surface roughness of the bearing peg Rz = 6,3

Function-relevant special characteristic:

- **sc/f:** Gearing roughness level Rz = 12

Once specified, these special characteristics are included in the prototype control plan.

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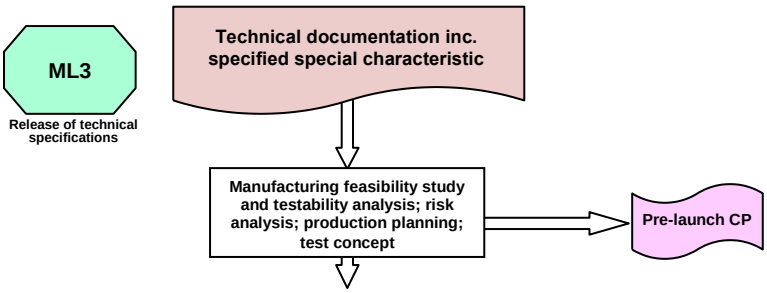
A.4.2 Description of the production process sequence

A.4.2.1 Requirements regarding production planning

The special characteristics forwarded from the technical documentation in the development phase and specified for consideration at the production planning stage are processed further and included in the production control plan for the pre-production phase.



These special characteristics are:

Safety-relevant:

- **cc/s**: Hardness of the bearing seat 650HV+110HV1.

Homologation-relevant:

- **cc/h:** Surface roughness of the bearing peg Rz = 6,3

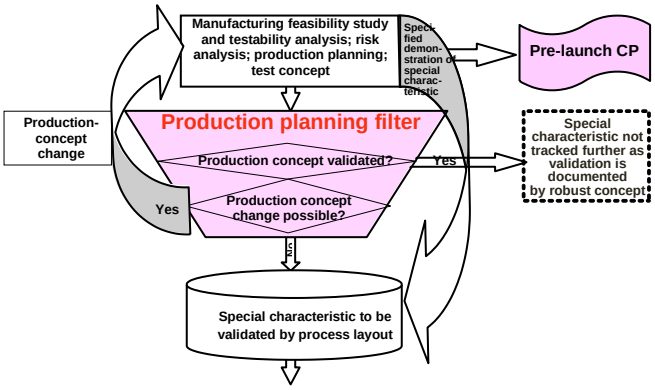
Function-relevant:

- **sc/f:** Gearing roughness level Rz = 12

These and all other special characteristics are verified within the framework of the manufacturing feasibility analysis and testability, risk analysis, production planning, test/inspection concept and the design review. Checks must also be made to determine whether test/inspection specifications contain product characteristics and any requirements regarding process parameters.

A.4.2.2 Production planning filter

The special **cc/s** safety characteristic specified by the customer for the hardness of the bearing seat (650HV+110HV1) does not pass through the production planning filter. Instead, it is forwarded as a special safety characteristic.
The other information gained flows into the production planning filter in order to identify the special characteristics.



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The purpose of the production planning filter is to clarify whether the production concept is secure. The homologation-related special characteristic **cc/h** (the surface roughness of the bearing peg Rz = 6,3) is secured by the design of the tool. This characteristic is therefore no longer included as a special characteristic in the production process.

Proof of security is demonstrated and is documented in the production planning papers.

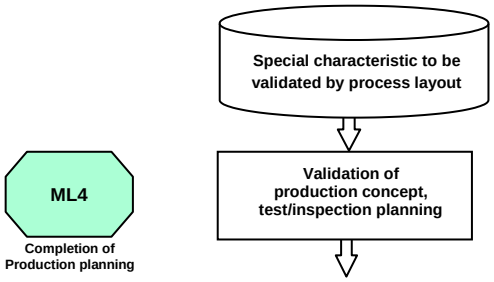
The function-relevant special characteristic **sc/f** (gearing roughness level Rz = 12) cannot be secured by the production concept.

A change to the production concept does not result in a secure product. This special characteristic is therefore included in the production process filter and in the production control plan for pre-production.

A.4.2.3 Requirements regarding the production process filter

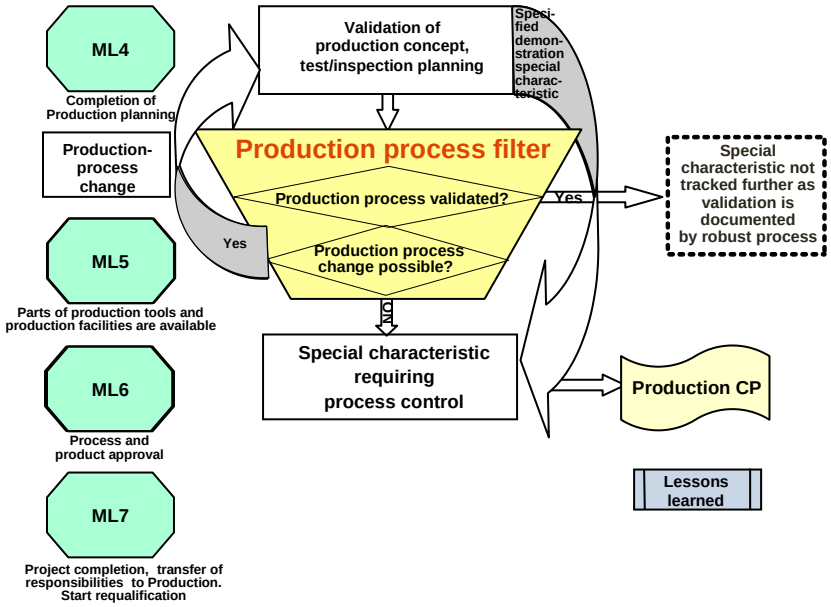
The actions taken to validate the production planning and test/ inspection planning do not reveal any further special characteristics.

The relevant requirements, functions and characteristics which have been identified are set out in more detail.



A.4.2.4 Production process filter

The special **cc/s** safety characteristic specified by the customer for the hardness of the bearing seat (650HV+110HV1) does not pass through the production process filter. Instead, it is forwarded as a special safety characteristic.



The function-relevant special characteristic **sc/f** (gearing roughness level Rz = 12) can be secured in the process, based on lessons learned from a previous project.

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This robust process is documented in the production description, with proof of capable production. No consideration is given to a change in the production process. The special characteristic is secured by the production process.

Because it is now secure, the special characteristic is not incorporated in the production control plan for full production.

A.4.3 Result

The safety-relevant special characteristic **cc/s** specified by the customer (hardness of the bearing seat 650HV+110HV1) by-passes all the filters and is carried forward to the production control plan for full production. It must be taken into account in the manufacturing process and covered by documentation.

The homologation-relevant special characteristic **cc/h** (roughness of the bearing peg Rz = 6,3) was secured by the production concept and is not included as a special characteristic in the manufacturing process. The fact that it has been secured by the production concept is documented.

The function-relevant special characteristic **sc/f** (gearing roughness level Rz = 12) is secured in the production process by a robust process. Experience from previous projects is available here.

In total, on safety-relevant special characteristic is carried over into the production control plan for full production. The special characteristics relating to homologation and function have been secured and are not included in the production control plan.

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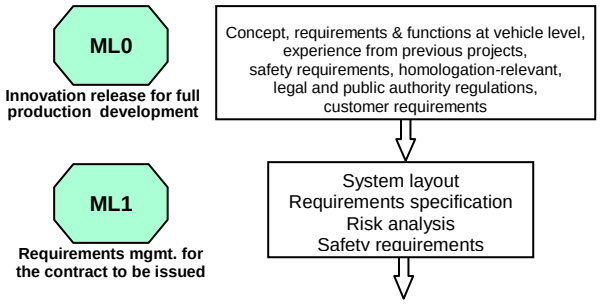
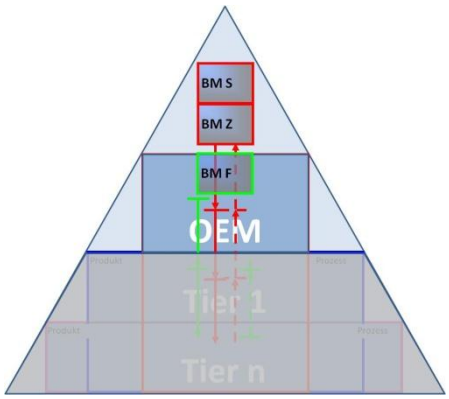
A.5 Example: Special characteristics for a steering wheel interlock





A.5.1 Process stages for the OEM : ML0 and ML1

A.5.1.1 Determining the functions at vehicle level

Vehicle

Transport the passengers from A to B under the control of the driver
Protect the passengers from injury
Protect all persons involved from serious injury in an accident situation
Protect passengers from environmental influences
Protect the vehicle against theft
Comply with noise requirements
Minimize vehicle operating costs
.....

A.5.1.2 Identifying and describing functions relevant to special characteristics, based on external and internal requirements at vehicle level

Vehicle

Transport the passengers from A to B under the control of the driver
➡s_ Protect the passengers from injury
➡s_ Protect all persons involved from serious injury in an accident situation
Protect passengers from environmental influences
➡h_ Protect the vehicle against theft
Comply with noise requirements
➡f_ Minimize vehicle operating costs
.....

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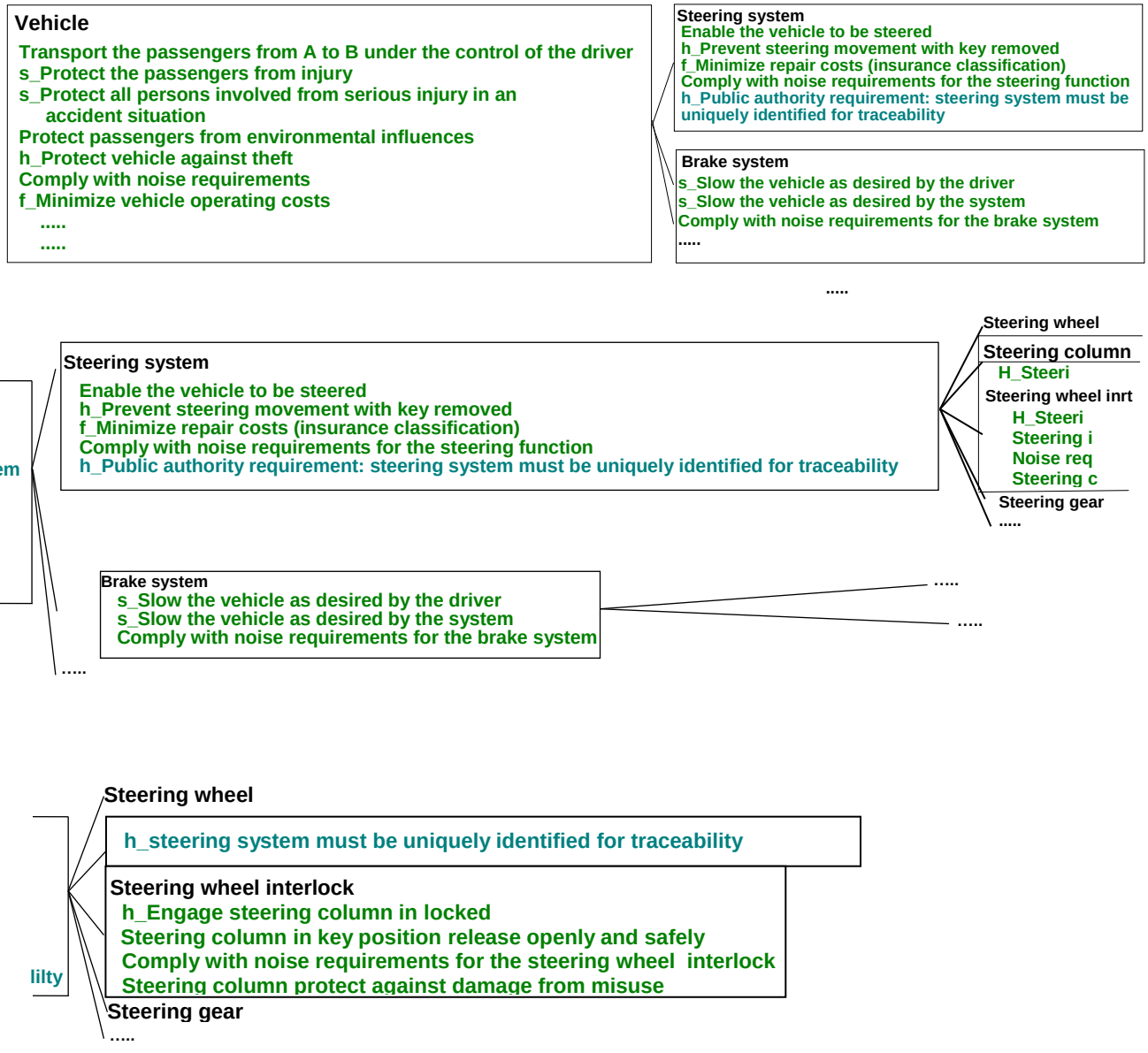
A.5.1.3 Breakdown of identifications for part-functions and part-systems

Vehicle	Steering system	Steering wheel interlock
h_Protect vehicle against theft	h_Prevent steering wheel movement with key removed	h_Engage steering column in locked key position

Identification of requirements relating to homologation at part-system level:

The steering system must be uniquely identified for traceability



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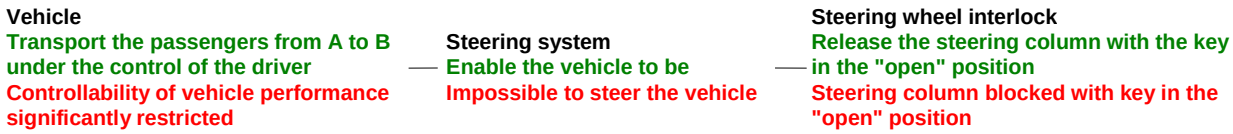
A.5.1.4 Identifying and classifying functions relevant to special characteristics, based on a risk analysis



The chain of defects is assessed as **safety-relevant** and this causes the function **"Transport the passengers from A to B under the control of the driver"** to be classified at vehicle level with **S_** as a function for which a special characteristic is relevant.
The classification is then broken down into part-functions and part-systems.

A.5.1.5 Deriving special characteristics by the OEM

A characteristic can be specified on the basis of an homologation requirement at part-system level:

⏩ **The steering system must be uniquely identified for traceability => BM Z1**

If the steering wheel interlock is subjected to misuse forces, a "hard" interlock (a latching peg, for example) can damage the steering column, perhaps resulting in high repair costs. For this reason the ⏩ **hardness of the interlock component** is determined as **sc/f1**.

A.5.1.6 Transferring the information from the OEM to the steering system supplier (for example, in the development requirements specification)

Steering wheel interlock functions for which special characteristics are relevant:
h_lock the steering column with the key in the "closed" position
s_guarantee release of the steering column with the key in the "open" position
f_protect the steering column from damage in the event of misuse

Special characteristics relating to the steering wheel interlock:
Hardness of the interlock component: sc/f1_material hardness 268HB

Special characteristics relating to the steering column:
The steering column must be uniquely identified for traceability cc/zZ1

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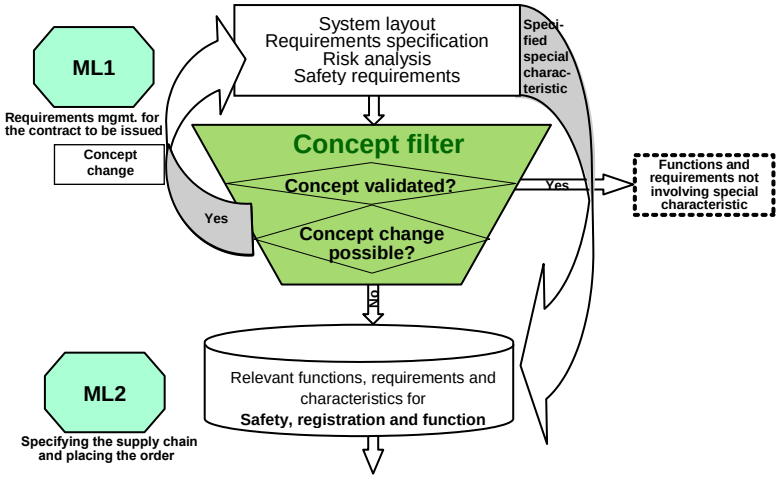
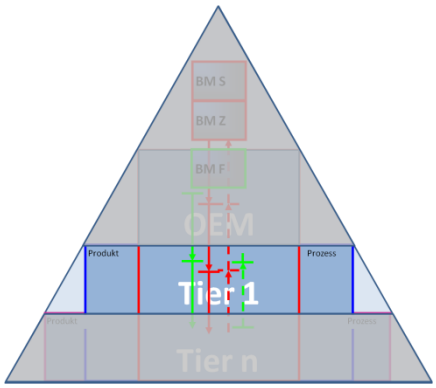
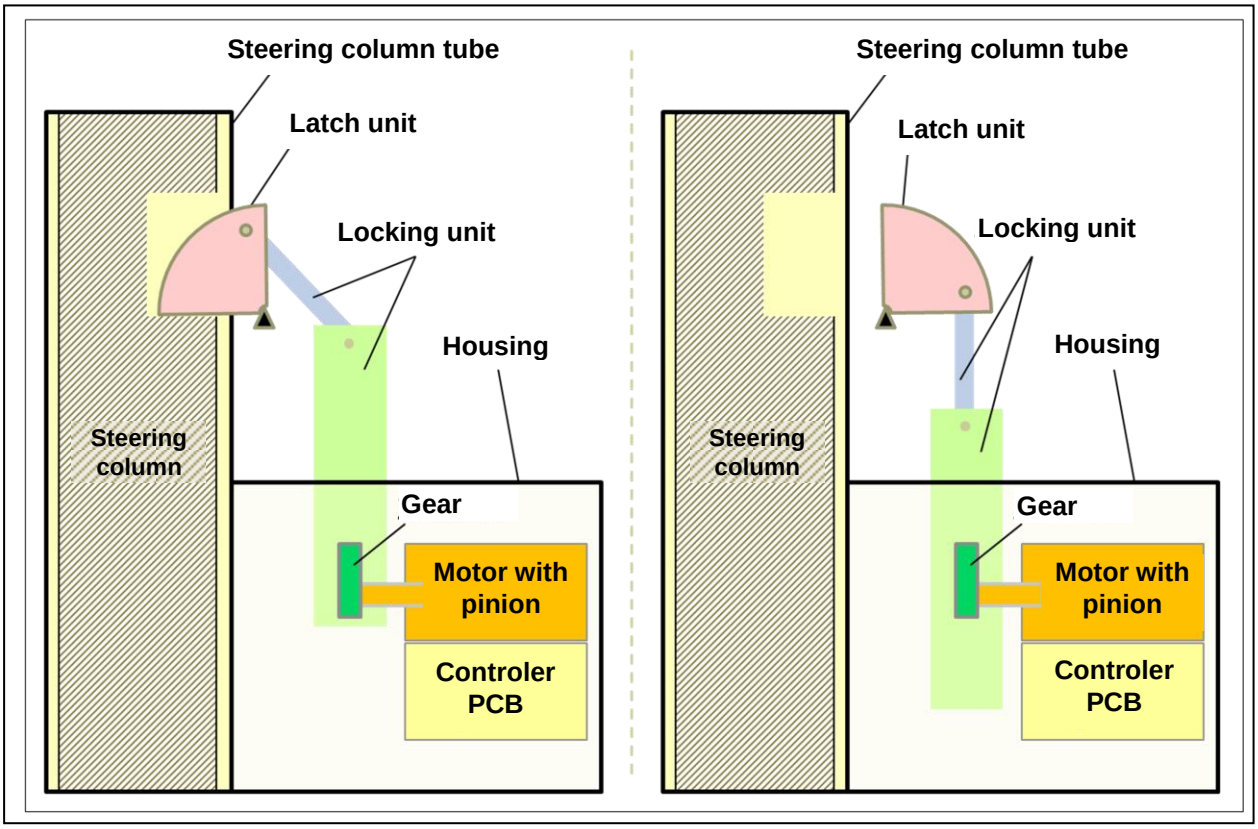
A.5.2 Process stages at Tier 1 level (ML1)





A.5.2.1 Taking s, h and f characteristics to the part-functions (concept level)



The steering wheel interlock concept:

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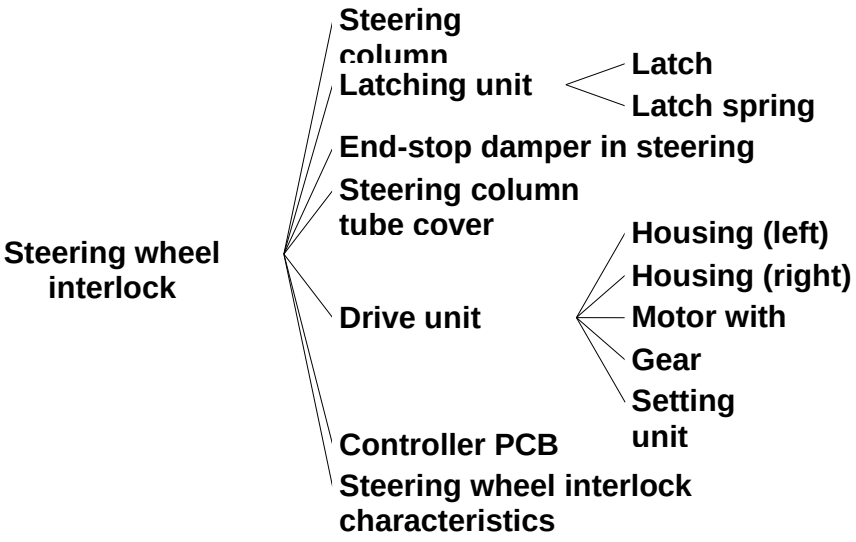
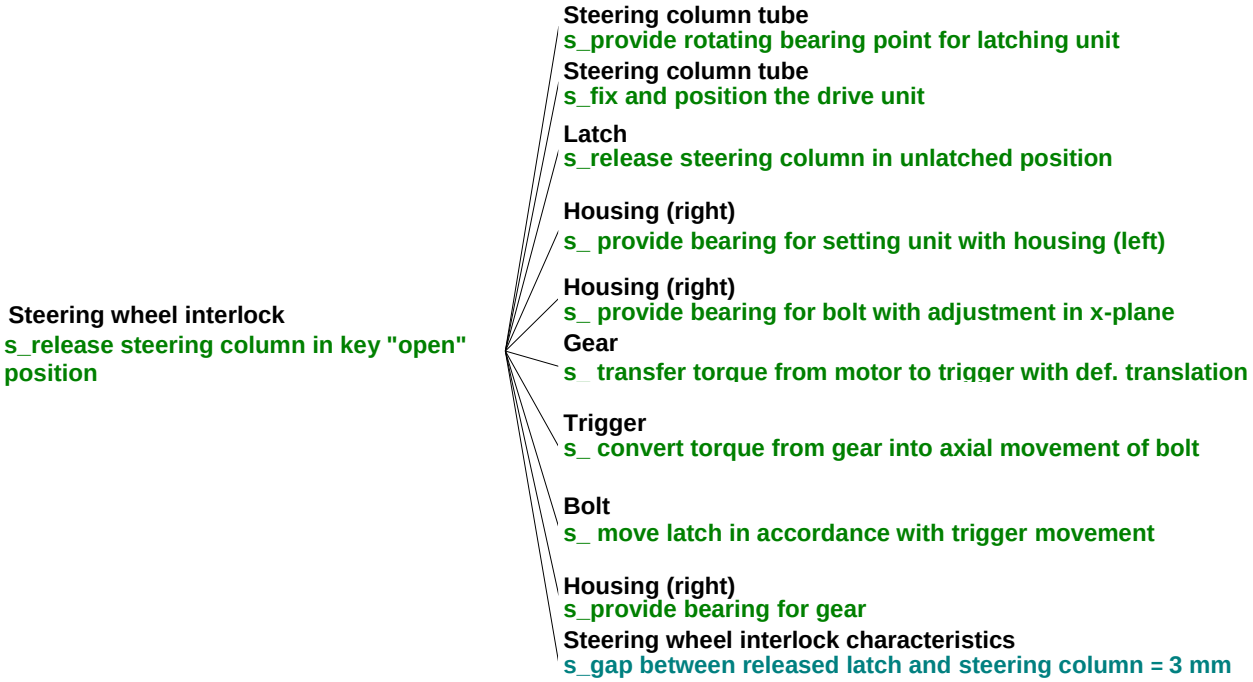
System structure of the steering wheel interlock:



Function network in the steering wheel interlock system:



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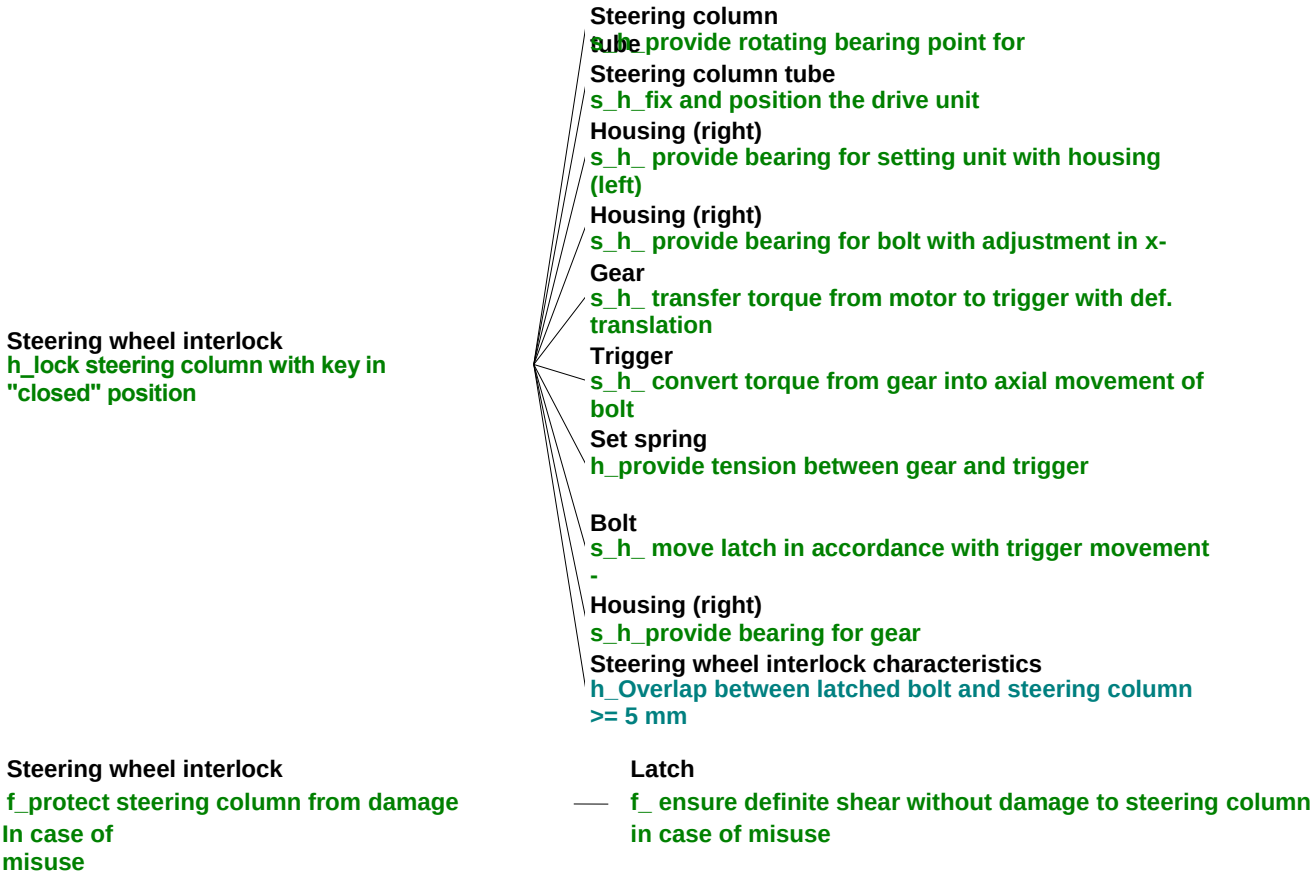

A.5.2.2 Risk analysis at concept level

Steering wheel interlock
h_lock the steering column with the key in the "closed" position
Steering column not locked with key in the "closed" position

Steering wheel interlock
s_ensure steering column is released with key in the "open" position
Steering column is blocked with the key in the "open" position

Controller PCB
s_h_provide current based on control signals from vehicle ECU
Motor incorrectly supplied with current

Following recognition of the risk in the controller PCB (**motor incorrectly supplied with current**) the concept was expanded by a function at system level, which secures against the risk.
New: s_secure the latched positions.
This action removes the PCB functions from the concept filter and need not be considered further with regard to special characteristics!

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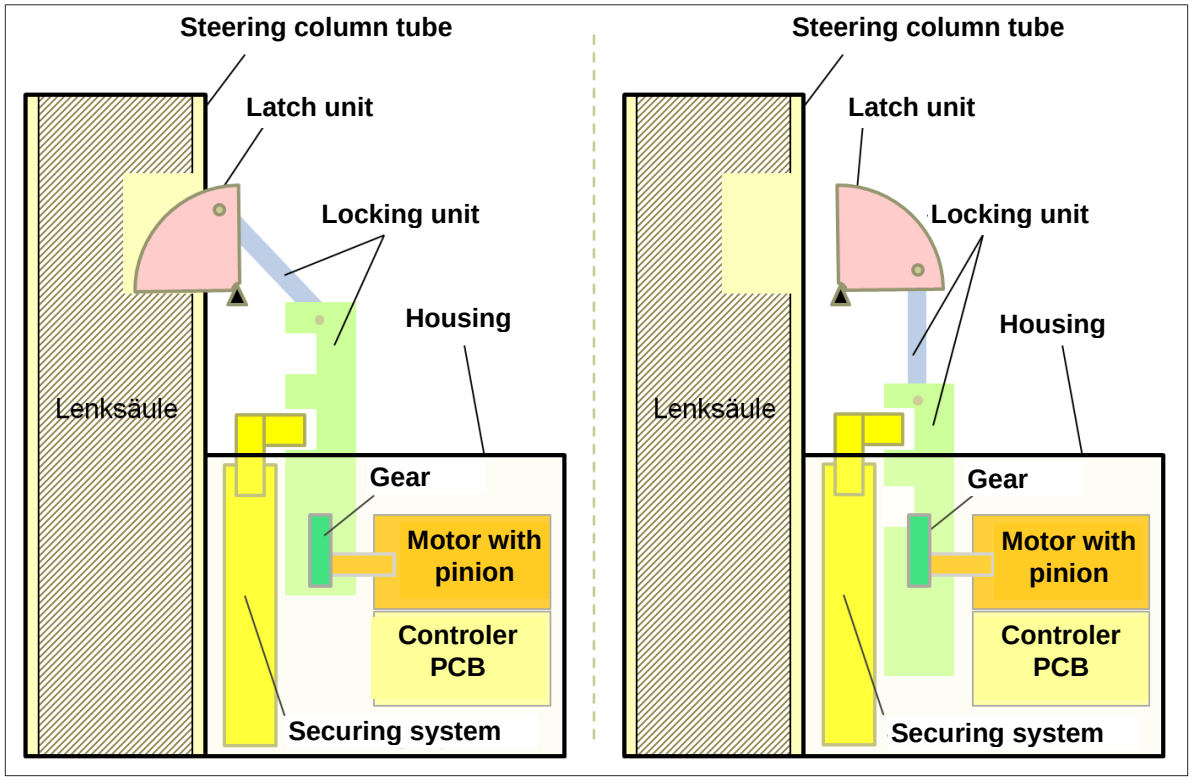
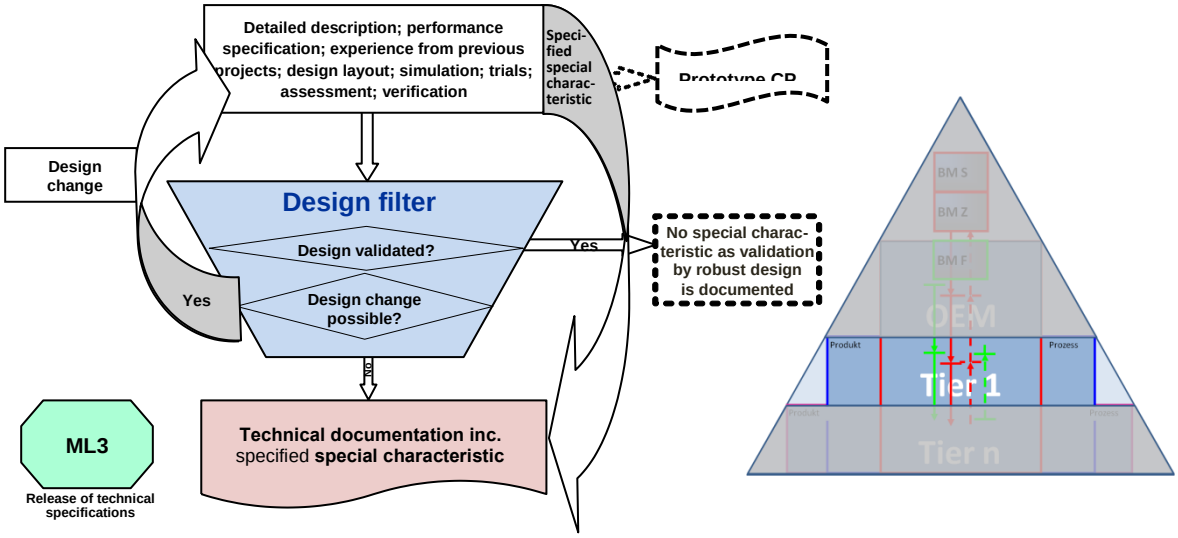


A.5.3 Process stages at Tier 1 level (ML2 and ML3)



A.5.3.1 Taking s , h and f functions to the design characteristics level and adopting the specified characteristic for the interlock characteristic for the interlock component (latch): Special characteristic f1 E_material hardness 268HB

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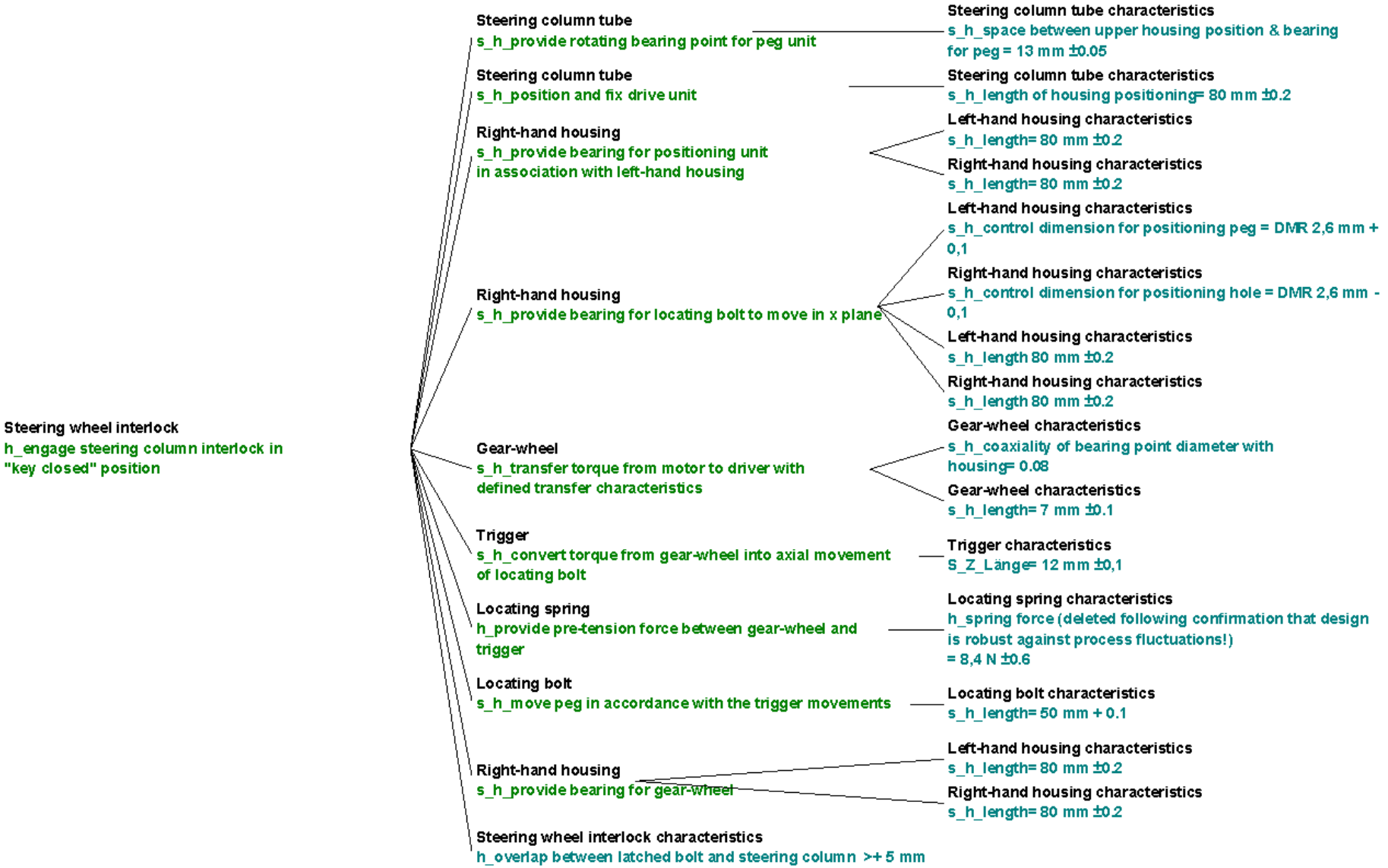

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A.5.3.2 Carrying out the design filter:

The characteristic cc/h is shown in the development stage to be robust against process fluctuations (DoE trials). Certification is described in the technical documentation covering the development and the characteristic is then eliminated.

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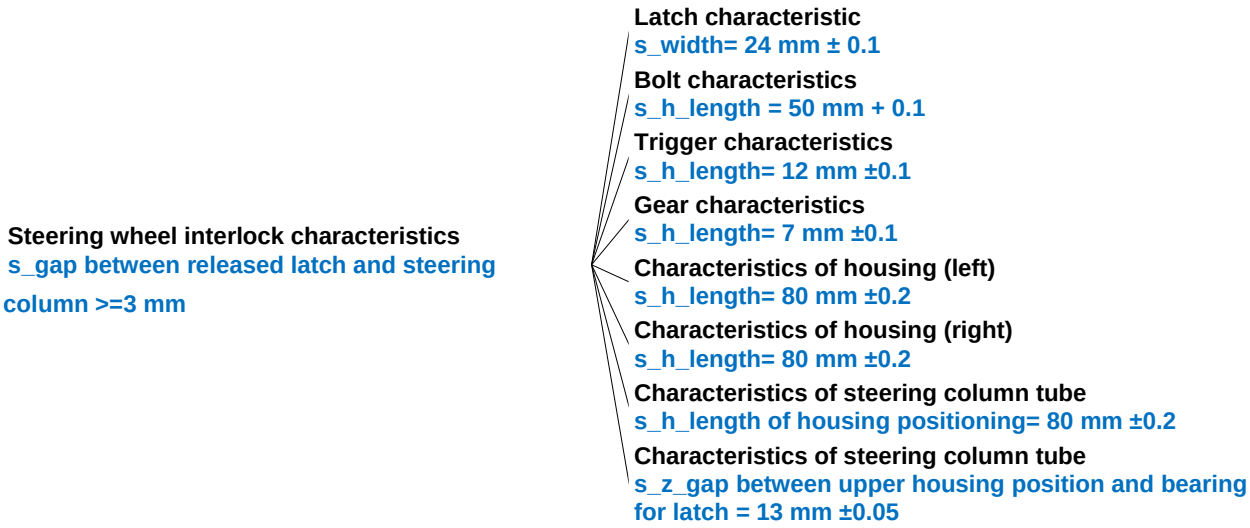
A.5.3.3 Including the sc/cc in the technical documentation:

The characteristics of the chain of dimensions covering the gap between the unlatched bolt and the steering column are not considered as separate items. Instead, the complete dimensional chain is considered as a single cc/s characteristic. This is documented in the assembly drawing (s1).



s1: Gap between released latch and steering column [steering wheel interlock] >=3 mm

All other dimensions are identified as individual dimensions in the component drawing:

s2: control dimension for positioning peg = DMR 2.6 mm + 0.1 [left-hand housing]
s3: control dimension for positioning hole = DMR 2.6 mm - 0,1 [right-hand housing]
s4: coaxiality of bearing point diameter with housing = 0.08 [gear]
f1 E: Material hardness [barrier latch]= 268 HB

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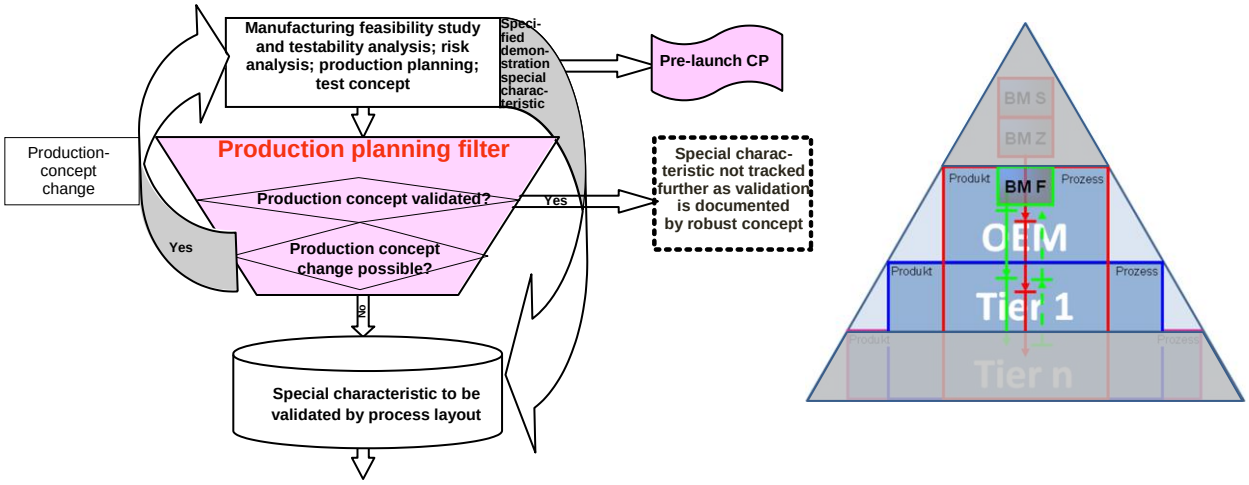
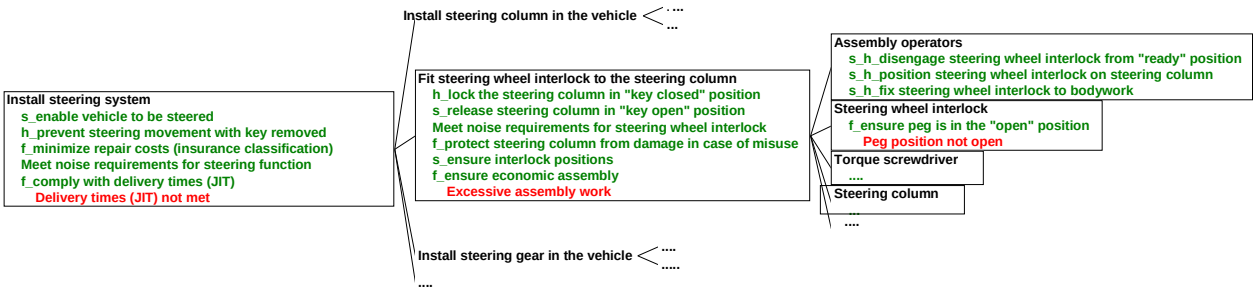
A.5.4 Process stages at OEM and Tier 1 level (ML3)



A.5.4.1 Deriving special characteristics on the basis of the OEM's Process FMEA

Compliance with delivery times is identified as a "function" which is relevant in terms of special characteristics.



Process F M E A										Number: 1.2 Page:
Type / Model / Production / Batch: Steering system assembly			Work-process number: L2 Action level:		Responsible: xxx Company: xxx					Issued: 15.01.2011
FMEA / System element: Assembly the steering wheel interlock to the steering column			Work-process number: L222 Action level:		Responsible: xxx Company: xxx					Issued: 15.01.2011 Modified: 02.09.2010
Effects of failure	S	Failure	C	Cause of failure	Preventive action	O	Detection action	D	RPN	R/DL Status
System element: Assemble the steering wheel interlock to the steering column										
Function: f_ensure efficient assembly										
[Assembly of steering system] JIT deliveries not maintained	7	Extra effort needed for assembly	F	[Steering wheel interlock] Latch position not open	Action status - Start: 15.Jan.2011 The latch position when received is recorded as a special characteristic sc/f2 in the assembly drawing Meier, 23.02.2011 unprocessed	1	Assembly template is provided at sampling location Müller 23.Mar.2011	1	(7)	Müller, Meier 23.02.2011 - 23.03. 2011 unprocessed

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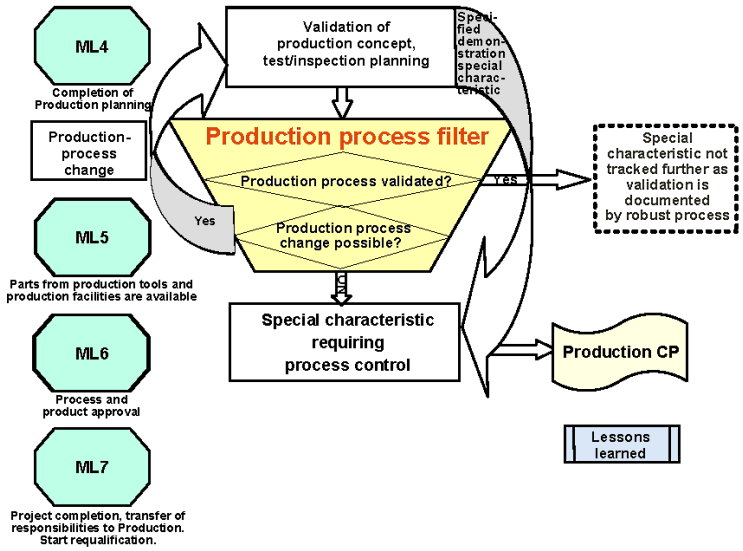
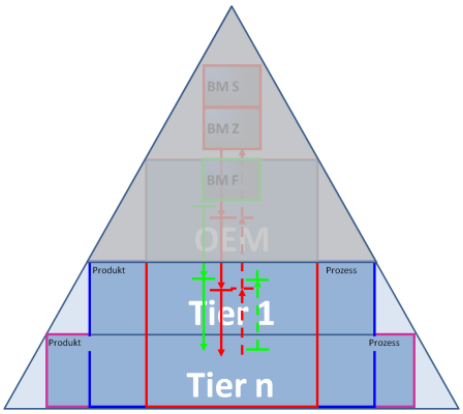
The latch position when received" is recorded in the assembly drawing as an action from the Process FMEA (sc/f2) and forwarded to the supplier.
sc/f2: Latch position when received [steering wheel interlock] = open

A.5.4.2 Carrying out the production planning filter by the Tier 1 supplier

The characteristic **s4: coaxiality of the bearing point diameter with the housing = 0.08 [gear]** is eliminated because the two diameters are produced when gripped in a machine and therefore, as a concept, no error can occur in terms of coaxiality. The machine capability is demonstrated and documented.

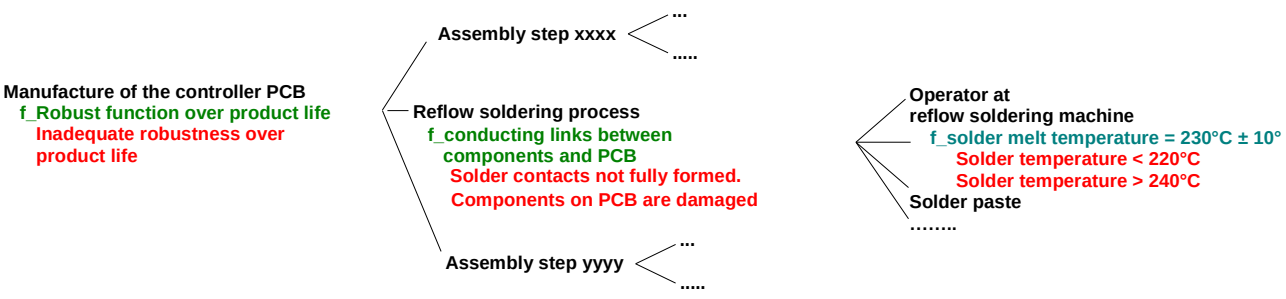
A.5.5 Process stages at Tier 1 and Tier "n" levels





A.5.5.1 Deriving special characteristics on the basis of the Process FMEA by the Tier 2 (n) supplier

Process-related robustness over the product life is identified and a "function" which is relevant in terms of special characteristics.



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	Process F M E A		Number: 1.2 Page:
Type / Model / Production / Batch: Manufacture controller PCB	Work process number: rr Action level:	Responsible: Company: Tier 2	Issued: 14 Mar.2011
FMEA / System element: Reflow soldering process	Work process number: rr Action level:	Responsible: Company: Tier 2	Issued: 14.Mar.2011 Modified: 02.Sept.2010

Effects of failure	S	Failure	C	Cause of failure	Preventive action	O	Detection action	D	RPN	R/DL Status
System element: Reflow soldering process										
Function: f_provide electrically conducting links between components and PCB										
[Manufacture controller PCB] Inadequate robustness over product life Not a critical situation for the steering functions as these are blocked mechanically by ensuring the inter-lock positions.	8	Solder contacts not fully formed	F	[Reflow soldering Machine]. Solder temperature <220°C	Action status - Start: 14.Mar.2011 Solder temperature is Identified as sc/f1. Meier 26.Mar.2011 unprocessed If temperature is not correct, soldering process is stopped by machine controls with error message Becker 28.04.2011 unprocessed	1	Temperature monitoring with PTC in the reflow soldering machine 31.Mar.2011 unprocessed	2	(20)	Becker, Meier, Schmidt 26.Mar.2011 - 28.Apr.2011 unprocessed
[Manufacture controller PCB] Inadequate robustness over product life Not a critical situation for the steering functions as these are blocked mechanically by ensuring the inter-lock positions.	8	Early damage to components on PCB	F	[Reflow soldering Machine]. Solder temperature > 240°C	Action status - Start: 14.Mar.2011 Solder temperature is Identified as sc/f1 Meier 26.03.2011 unprocessed If temperature is not correct, soldering process is stopped by machine controls with error message Becker 28.04.2011 unprocessed	1	Temperature monitoring with PTC in the reflow soldering machine Schmidt 31.03.2011 unprocessed	2	(20)	Becker, Meier, Schmidt 26.Mat.2011 - 28.Apr.2011 unprocessed

The "solder melt temperature" is documented in the production control plan as an action from the Process FMEA.

f1: solder melt temperature [reflow soldering machine] = 230°C ± 10°

Production control plan of the Tier 2 supplier:

Parts/ Process No.	Process title / description of operation	Machine, device, rig, production tool	Characteristics			Classific-ation of special character-istics	Methods					Reaction plan
			No.	Product	Process		Product/ process specification/ tolerances	Test system used	Random sample		Control method	
									Sample size	Frequency		
7	Reflow soldering process	Reflow soldering machine	sc/f1	Transfer resistance of the soldered connection	Solder melt temper-ature	sc/f	230° C ± 10°	Temperature measure-ment sensor TS12_f	3	All heating cycles	Test document PD18	Quarantine the soldering process. Inform the supervisor

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A.5.5.2 Carrying out the production process filter at Tier 1 level

The production process filter at Tier 1 level does not eliminate any further characteristic. The characteristics are included in the Tier 1 supplier's production control plan.

The Tier 1 supplier's production control plan:

Part / Process No.	Process name/ description of work-process	Machine, device, rig, production tool	Characteristics			Special charac-terristics classify-cation	Methods					Reaction Plan
			No.	Product	Pro-cess		Product/ process specification/ tolerances	Checking system used	Sampling details		Control method	
									Size	Frequency		
1	Receive material	Parts for latching bolt	sc/f 1E	Material hardness		sc/f	<=268 HB	Check mat'l specification MS8_L2	100%	Each batch	Material docket M87	Hold in quarantine stores until return to sender. Supervisor
4	Housing assembly	Assembly area	cc/s2	Check dimension of positioning peg (left housing)		cc/s	= DMR 2.6 mm + 0.1	Checking gauge PL317/g	5	1 x shift	Control chart R38	Measure back to last random sample. Supervisor
4	Housing assembly	Assembly area	cc/s3	Check dimension of positioning peg (left housing)		cc/s	= DMR 2.6 mm + 0.1	Checking gauge PL318/g	5	1 x shift	Control chart R39	Measure back to last random sample. Supervisor
34	Function test	Test device	cc/s1	Gap between released latch & steering column (steering wheel interlock)		cc/s	>= 3 mm	Test mandrel PD71/g	100%	Contin-uous		Identify as scrap. Transport to quarantine store. Supervisor
34	Function test	Test device	sc/f 2E	Latch position when delivered (steering wheel interlock)		sc/f	= open		100%	Contin-uous		Identify for rework. Supervisor

Note: For illustration reasons this example does not show the process of determining special characteristics in its entirety. It makes no claim to completeness or the accuracy of the contents.

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A.6 Electric parking brake

Electric parking brake
EPB
Special characteristics
Examples for decision-making
(extracts)

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A.6 Electric parking brake – special characteristic

An initial manufacturing feasibility study and risk analysis in the concept phase covering this product resulted in a total of 1585 special characteristics relating to safety and function. Such a number causes the characteristics to lose their significance and makes the process impossible to handle.

A reduction in the number of special characteristic is essential.
To do so, filters were used in the
concept phase
design phase
production planning phase
in full production

In drawing up the analysis it was assumed that all characteristics, whether presently regarded as secure or not, must be tracked by the development function, through to full production

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A.6 Possible means of reducing the numbers

Concept filter

- In specifying special characteristic, general design considerations were backed up by experience from products already in production and subject to the same demands (field observations and quality statistics)

Design filter

- In addition, information was gained from laboratory investigations against specifications and tests under extreme conditions, as well as the associated, detailed results. Information from tolerance studies and failure analyses was also used. Where appropriate, results and findings from in-vehicle validations (e.g., winter and summer tests) can also be called on.

Production planning filter

- Use was made of findings from process studies on current production lines (types and frequency of failures, MFU, PFU, MSA) and
- by taking account of proven manufacturing technologies and
- the planning and shaping of robust production processes.

Production process filter

- Additional important information was gained from careful analysis of machines and processes used in similar large-scale production and assembly , as well as
- the analysis of known product data such as ppm and events at customers' premises and in the field

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A.6 Possible means of reducing the numbers

Ways of reducing the number of special characteristics
were examined by studying the following parts and sub-assemblies of the electric parking brake.

- Axial bearings
- Motor assembly
- Torque support
- Shaft / nut / lubrication system
- Slipping clutch
- Force sensor
- ECU

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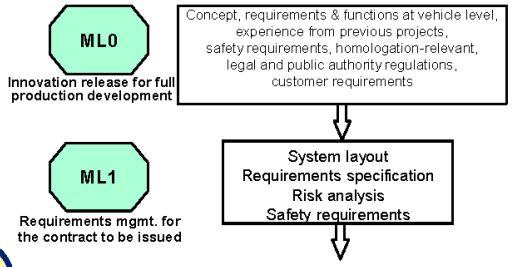
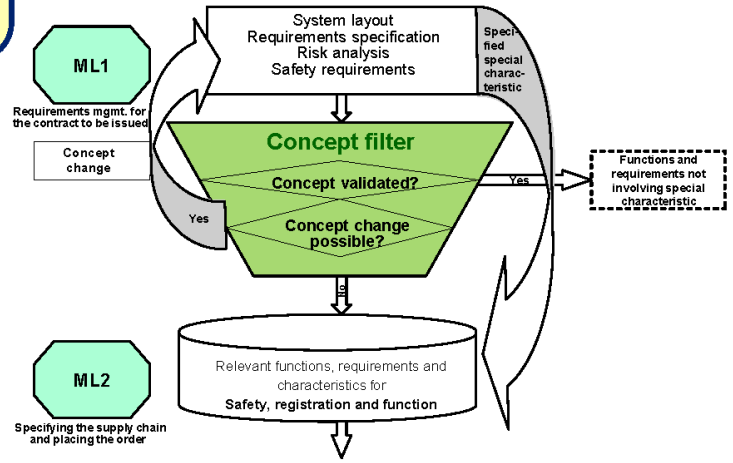
A.6 Axial bearings

- **FMEA for the EPB axial bearing**

  The FMEA results in severity figures of 8, 9 or 10 for the risk areas of
  - friction, wear
  - type and quantity of grease
  - type of bearing (ball, roller, ….)
  - bearing ventilation
  - residual magnetism
  - …

In today's thinking a figure of 9 or 10 does not automatically result in a special characteristic sc/f or a critical characteristic cc/h or cc/s





- **Concept filter**
- Use a similar, proven design: axial bearings in ca. 12 million units in use with no known problems
- In designing the bearing layout a larger-dimension bearing was selected, giving a bearing static performance figure of 40 kN, ca. 20 times the safety margin

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A.6 Axial bearing

- **Design filter**
- Results from laboratory investigations
  - Preliminary trials with 3-part bearing OK. (ca 20 units < 100 000 cycles)
  - No wear, grooves or rifling .....
  - Trials with production bearings also OK. (ca 40 units, some achieving 2 x life)
  - Manufacturer's findings OK.

From the design and quality stand-points the axial bearing is seen as a robust design.

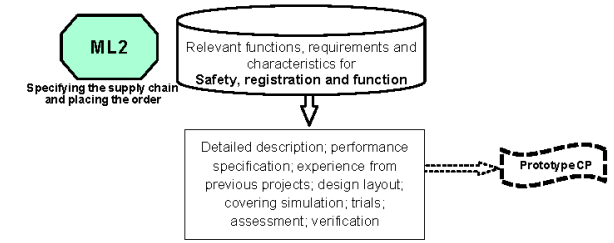
No sc or cc are taken from the FMEA and included in drawings or the list of sc / cc.

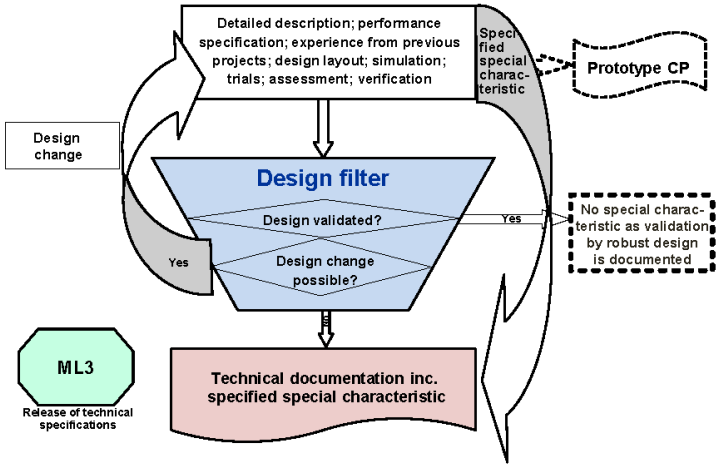
However: Information from the supplier regarding the evaluation of individual risks in our FMEA, to be included in his risk analysis.

If additional risks are detected, further discussion is required with the supplier.

- **Production planning filter**
  Not relevant

- **Production process filter**
  Not relevant





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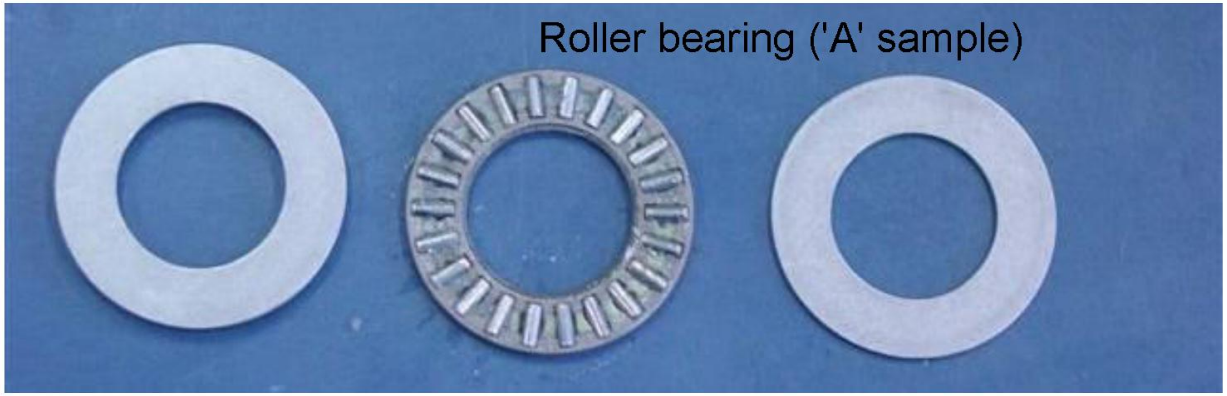
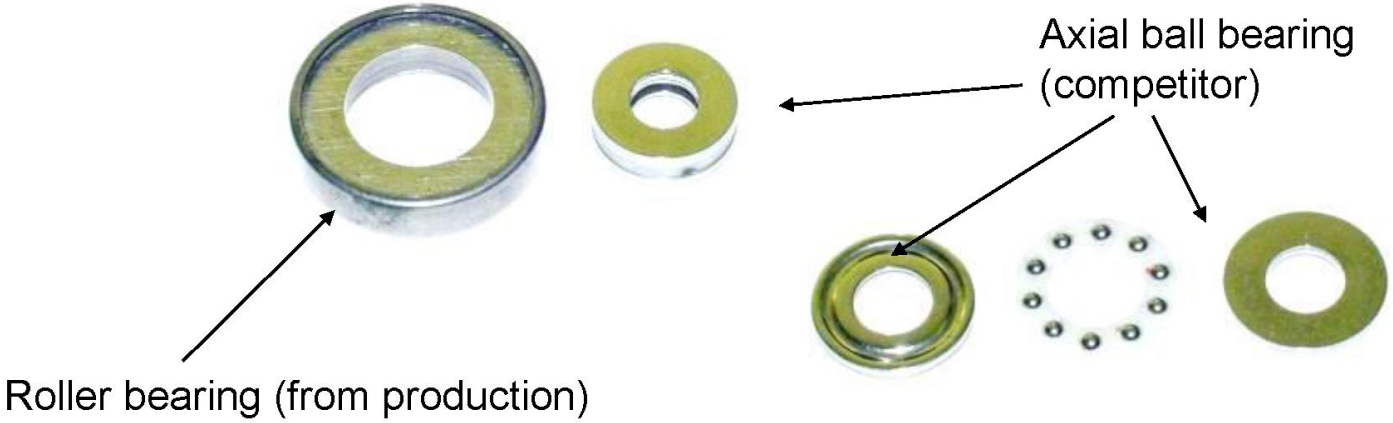
A.6 Axial bearing





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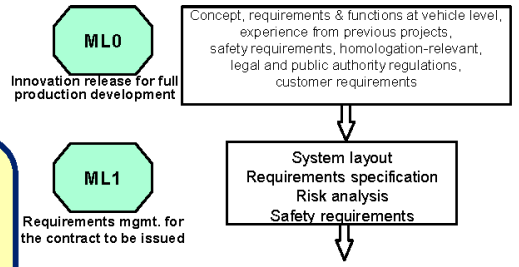
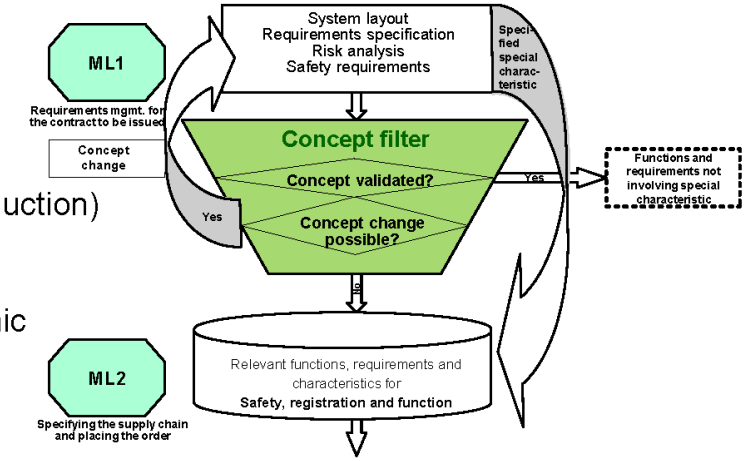
A.6 Motor assembly

- **FMEA for electric parking brake motor assembly**
  The FMEA results in severity figures of 8, 9 or 10 for the risk areas of
  - shaft parallelism
  - rectangularity
  - life of 100 000 cycles (brush; commutator....)
  - performance graph
  - sealing function
  - jammed motor (magnets, gearing, cup, air-gap, ...)
  - rotation detection
  - EMC
  - over-heating

In today's thinking a figure of 9 or 10 does not automatically result in a special characteristic sc/f or a critical characteristic cc/h or ss/s





- **Concept filter**
- Design layout as for window-lift drive (large-scale production)
  - the difference is in gearing and winding
  Newly developed ECU checks motor operation (thermal protection; reduced supply voltage if a dynamic block occurs).
  New sealing concept

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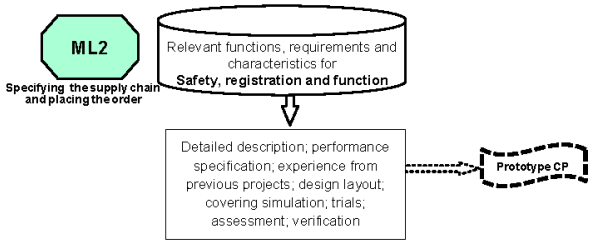
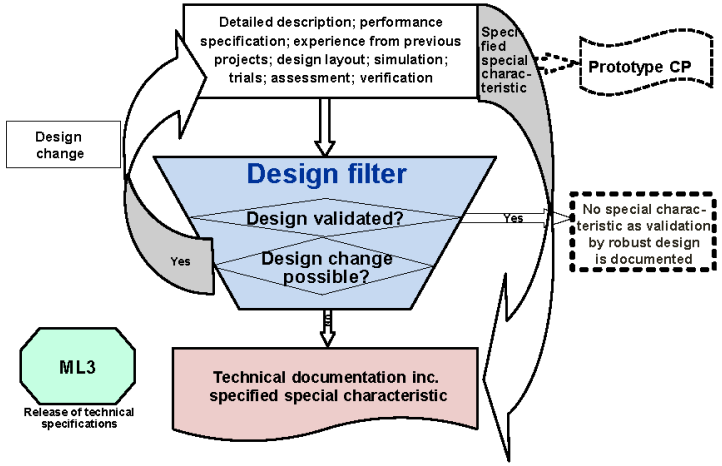
A.6 Motor assembly

- **Design filter**

  Laboratory investigations (60 units) up to twice the specified life. Carbon brushes show wear at the edges



- **Special characteristics in the drawings**
  - 5 cc/s and 83 sc/f



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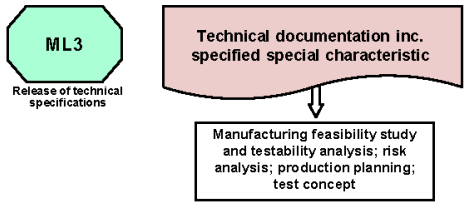
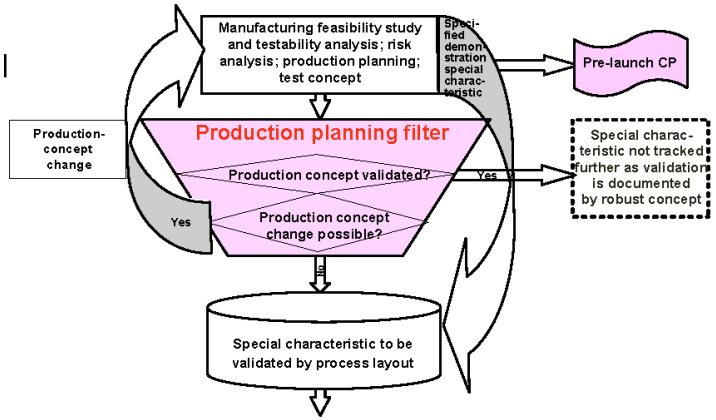
A.6 Motor assembly



- **Production planning filter**
  The use of proven manufacturing methods for mechanical parts with capability indices (Cpk) between 1.85 & 2.11 mean that no further sc / cc are generated.
  15 sc/f from the drawings need not be tracked further, because it is possible to demonstrate the robustness of the manufacturing processes.
  Checks on the supplier's production planning for electronics
  result in 5 more cc/s and 3 more sc/f



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A.6 Motor assembly

- **Production process filter**

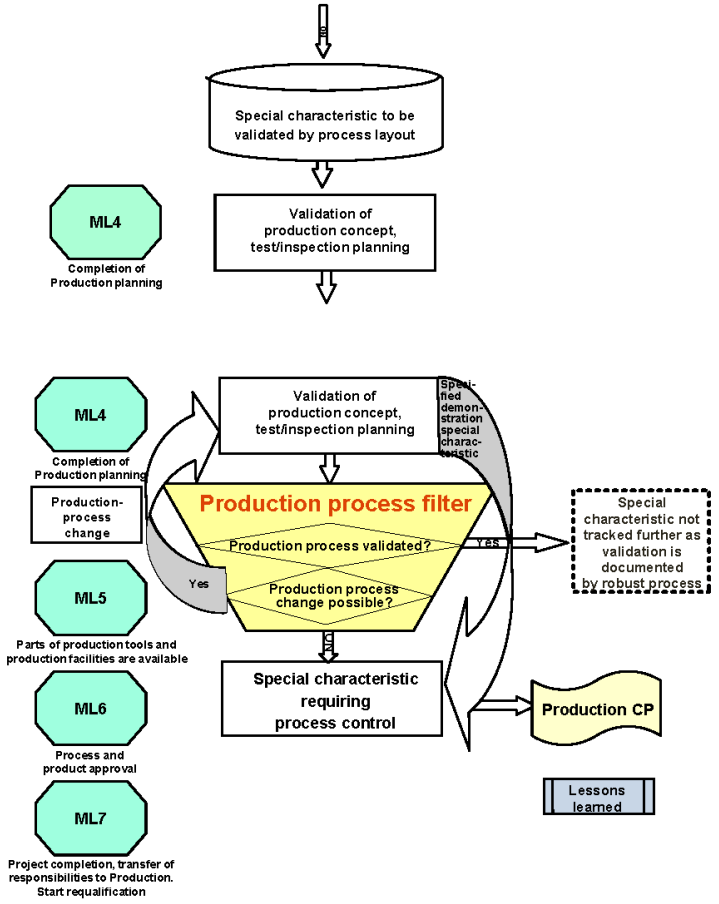
  120 million units delivered to date.

  No known problems with shaft, sheet package, housing, commutator, insulation, magnets, magnet ring, brush system, throttle and capacitor. This permits the elimination of 3 sc/f.

  Data from experience reveal 4 more sc/f and one cc/s for the cup, wiring and winding.

  The ECU must be considered and further special characteristics will probably be added

.



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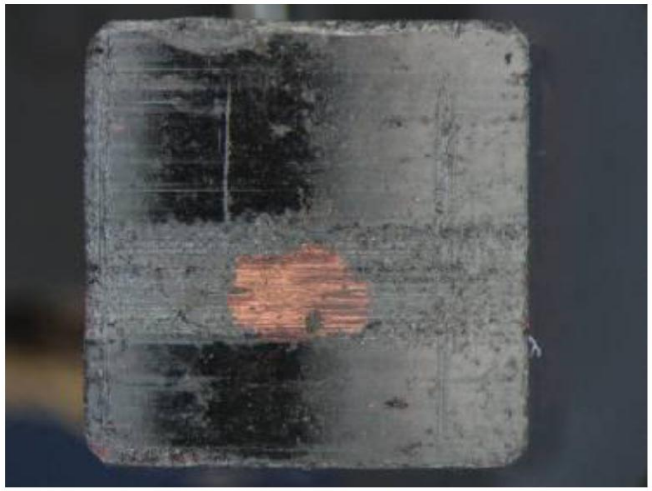
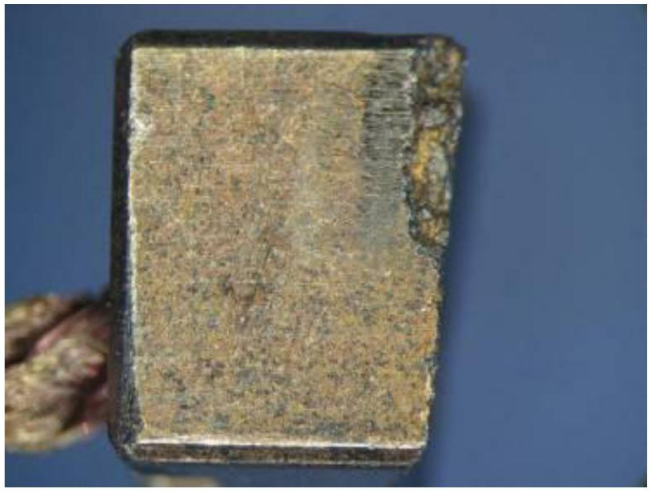
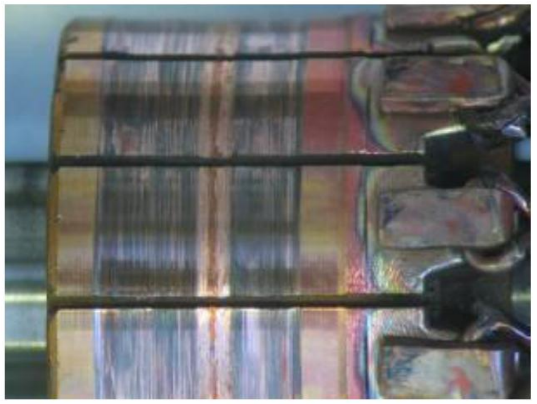
A.6 Brush / commutator





Brush / commutator after 2 x life cycle



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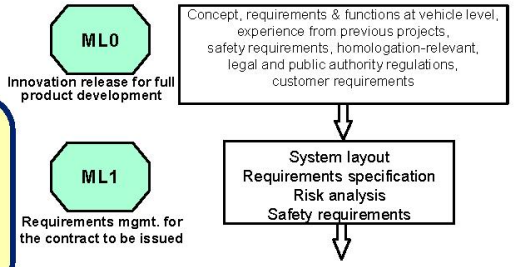
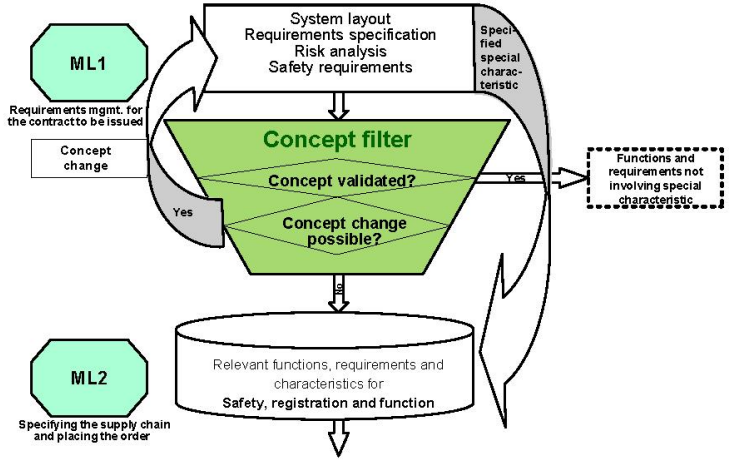
A.6 Torque support BBF-23456-A

- **FMEA for electric parking brake torque support**
- The FMEA results in severity figures of 8, 9 or 10 for
  - press fastening
  - material strength
  - notching effect
  - Bowden cable interface (dimensional)
  - tolerances on form & position
  - geometry

In today's thinking a figure of 9 or 10 does not automatically result in a significant characteristic sc/f or a critical characteristic cc/h or cc/s



- **Concept filter**
  Multiple safety level for tensile & torsion resistance in the layout
  - problematic design with stamped form part rejected
  - change to stable design with cold-formed part



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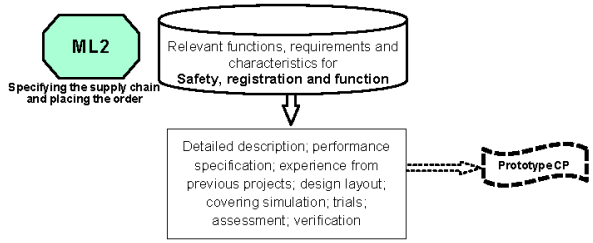
A.6 Torque support BBF-23456-A

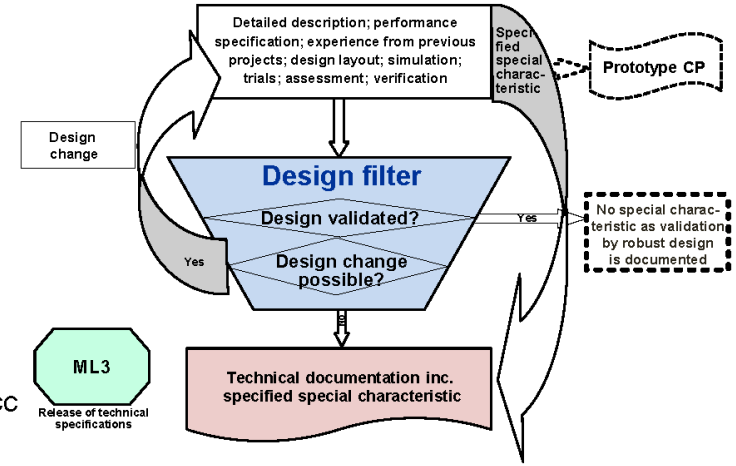
- **Design filter**
  60 units operated to 2 x life ➔ OK.
  Pressure marks visible on Bowden cable location.
  1 million load changes on separate test-rig ➔ OK.
  Pull-off force and torsional moment documented with a safety factor of 10



- **Drawings**
  - 2 cc/s ➔ material and pull-off force in the shaft assembly drawing
  - 2 sc/f ➔ guide surface dimension and Bowden cable dimension

- **Production planning filter**
  No experience from earlier designs ➔ maintain sc / cc

- **Production process filter**
  No experience from previous production ➔ maintain sc / cc



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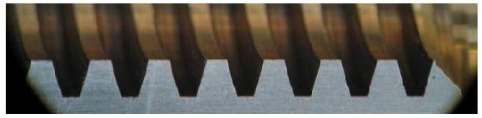
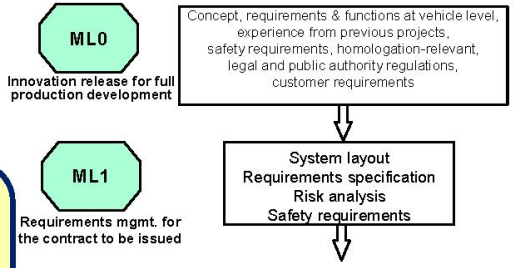
A.6 Shaft / nut / lubrication system

- **The FMEA for the shaft/nut/lubrication system shows severity figures of 8, 9 or 10 for**
  - Material strength
  - Surface quality
  - Lubrication



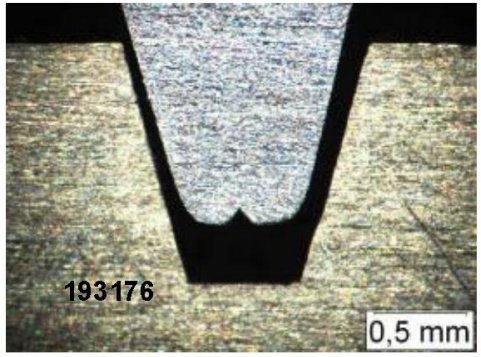
In today's thinking a figure of 9 or 10 does not automatically result in a special characteristic sc/f or a critical characteristic cc/h or cc/s

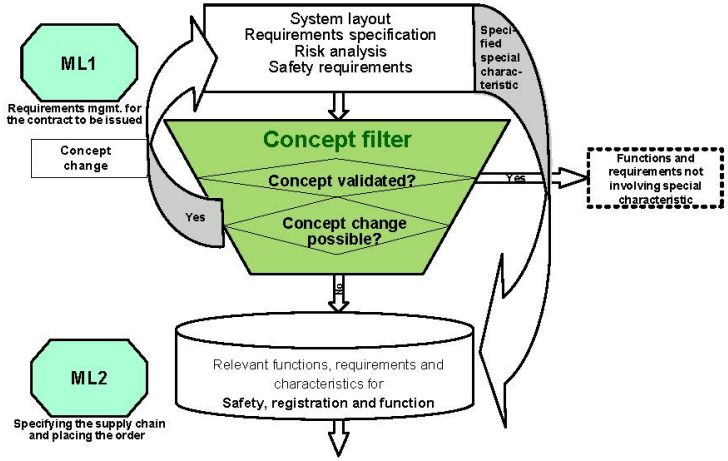


- **Concept filter**

  Design:
  Steel/brass/AG 633 combination with lubrication

  Design:
  Steel/bronze with L32 rejected (wear)





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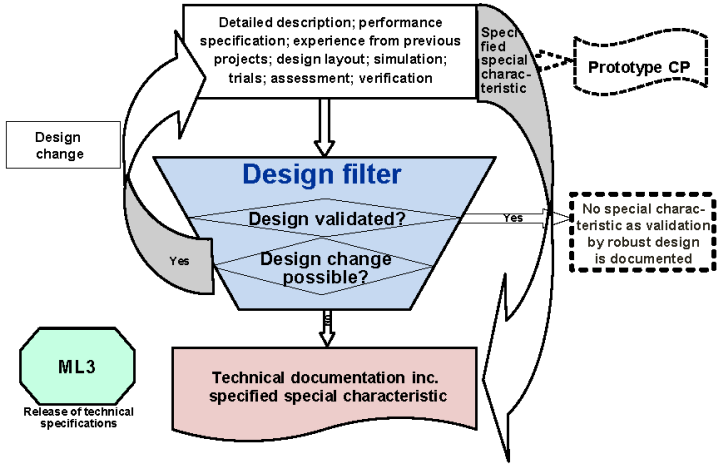
A.6 Shaft / nut / lubrication system

- **Design filter**
  20 steel/brass units tested to 2 x life.
  Practically no wear detected ➔ OK.
  Test on 20 x steel/bronze units broken off
  because of extensive wear

- **Drawings**
  4 x sc/f and 1 x cc/s (material) each for shaft and nut
  Also 1 x sc/f and 4 x cc/s for sub-assembly
  with lubrication



- **Production planning filter**
  Initial process trials indicate that the steel/brass/AG633
  combination has the capacity to absorb process
  fluctuations such as flaking and layering during rolling.
  Further investigations required ➔ maintain the sc / cc

- **Production process filter**
  Very different manufacturing process compared with previous production ➔ maintain the sc / cc

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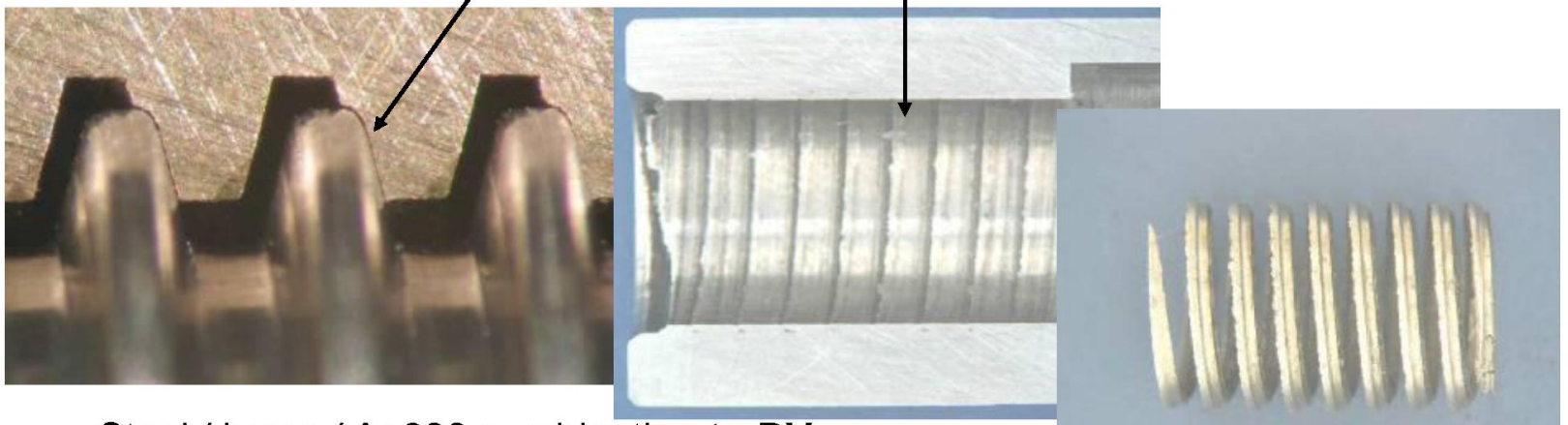
A.6 Wear on nut / shaft

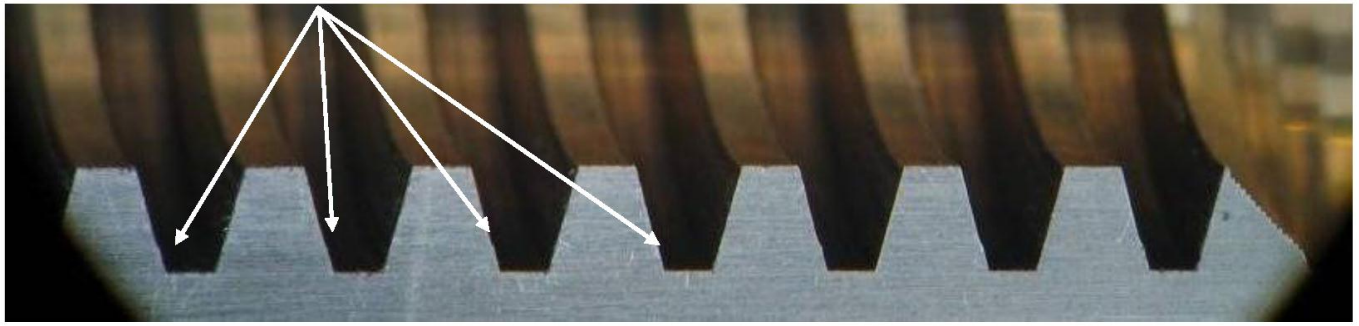
Steel / bronze / L32 combination **to DV**

Result: Massive wear, finally destroying the thread



Steel / brass / Ag633 combination **to DV**

Result: Very slight traces of wear



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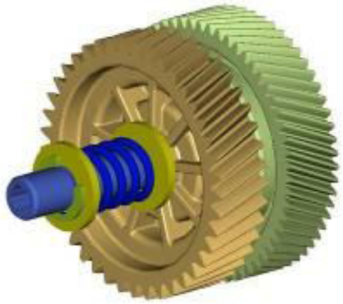
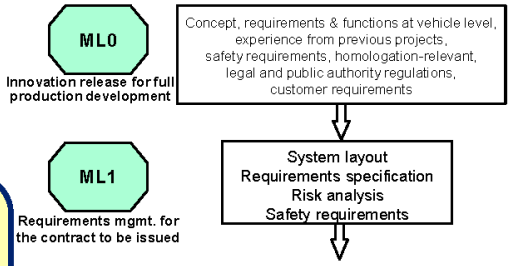
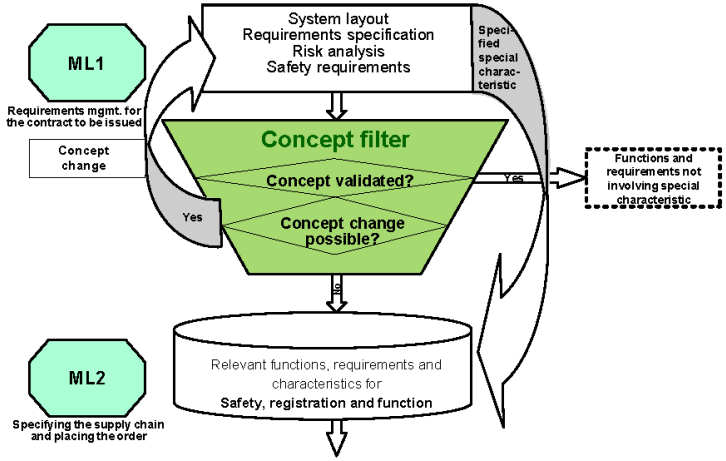
A.6 Slipping clutch

- **The FMEA for the slipping clutch ABC-654002 shows severity figures of 8, 9 or 10 for**
  - Torque transfer
  - Firm retention on the shaft
  - Wear



In today's thinking a figure of 9 or 10 does not automatically result in a special characteristic sc/f or a critical characteristic cc/h or cc/s





- **Concept filter**
  Technical design layout by plastics and mechanical experts, using a plastic material (XZ 100) shown as suitable in comparable applications.
  Use a known gear shape and axial spacings known to be appropriate.
  Firm axial / radial retention ensured by knurling and tight over-moulding

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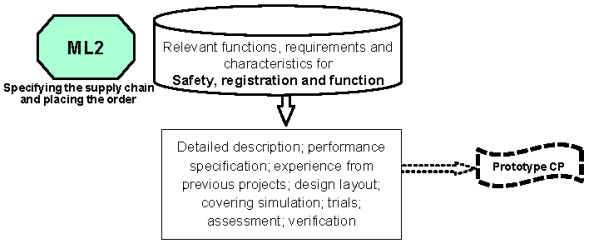
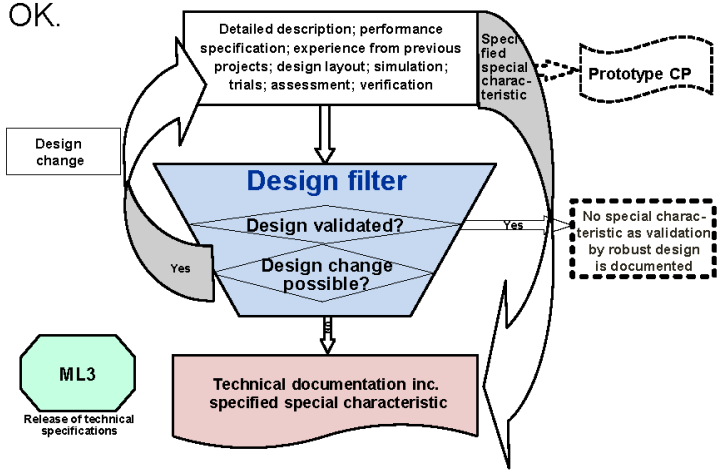
A.6 Slipping clutch



- **Design filter**
  60 units tested to 2 x life. No wear detected ➔ OK.
  Displacement force and torque tested under higher temperature stress ➔ OK.

- **Drawings**
  16 x sc/f and 2 x cc/s



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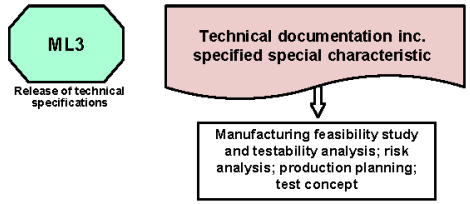
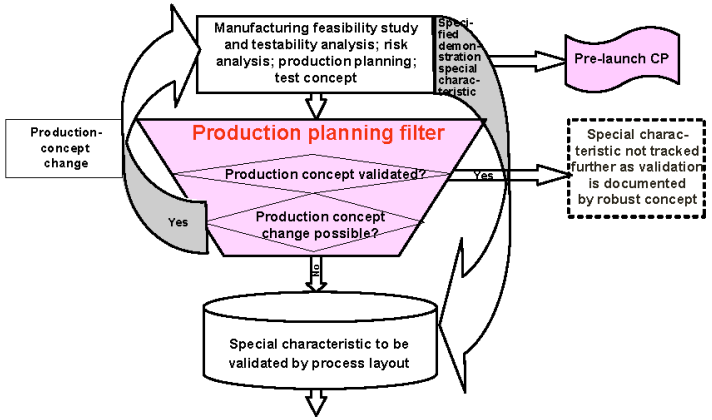
A.6 Slipping clutch



- **Production planning filter**
  Manufacturing process: Detailed investigation by supplier is required.
  Known assembly process; in terms of process planning the results from ca. 24 million units already delivered ➔ no further sc / cc



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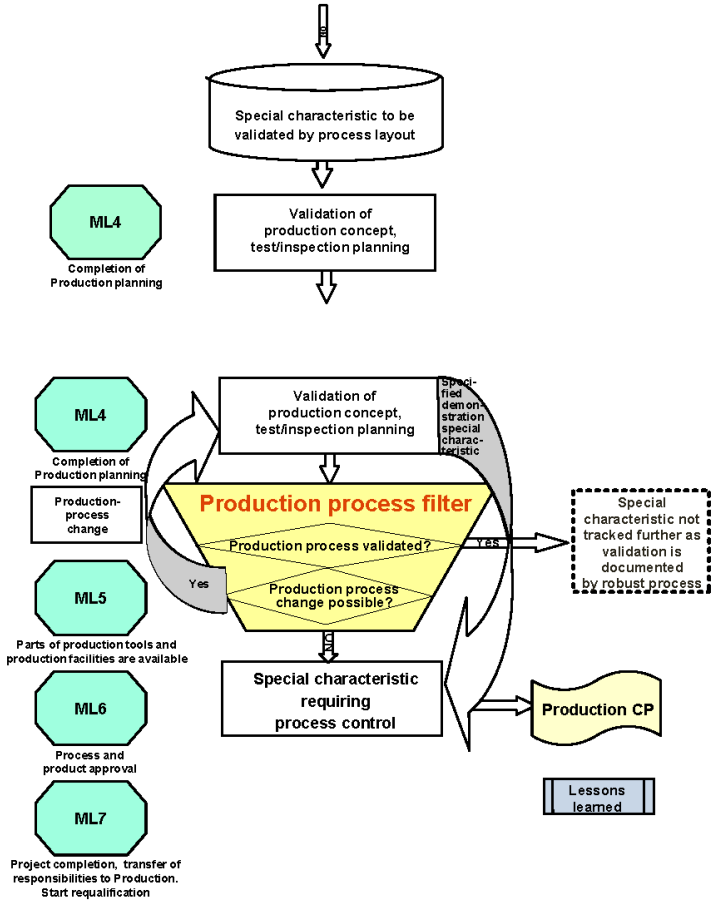
A.6 Slipping clutch

- **Production process filter**
  For technical manufacturing reasons the electric parking brake must be calibrated and during this the slipping clutch is 100% checked, including checks on forces and torques.
  It is not necessary to specify further sc / cc.



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A.6 Force sensor

- **FMEA for B58 electric parking brake**
- **Force sensor consisting of shaft, nut, spring, return spring, support washer, spring guide, leaf spring, magnet, Hall-IC, ECU and ECU for position to transmission housing**

- FMEA indicates severity levels of 10 for
  - Friction
  - Changes in magnetic conditions following calibration (changes in X and Z planes; 20 µm ca. 1% error (± 10% is the limit)
  - ➔ already > 300 items with a severity level of 10

- The problems cannot be handled by a consideration of sc and cc

- => **In the view of development and quality departments the task is not yet finally completed.**

- **=> A study based on the requirements of IEC 61508/ISO 26262 is essential**

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A.6 Results

- Overall it was possible to reduce the number of special characteristics listed and in the drawings to 271
- Of these 55 are cc/s requiring special archiving
- These 55 cc/s plus a further 27 sc/f are handled according to instructions either in production or by suppliers
- In the FMEA there are still ca. 1200 severity levels of 8, 9 or 10

In today's thinking a figure of 9 or 10 does not automatically result in a special characteristic sc/f or a critical characteristic cc/h or cc/s

- Highly complex problems require other solution methods – for example IEC 61508, ISO 26262

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A.6 Further action

- Results, experience and decisions must be documented and archived, for example :

* under C:\Projectfolder\EPB\... inc. e-mail archive EPB,
  * under L:\Labordatenbank\EPB\...,
  * In the folder Validation trials EPB design
  * in the EPB FMEA under "Comments" and in the change record
* . . .

- Decisions regarding the sc and cc which have been defined must be checked on the basis of results of product monitoring in the field. This must be carried out regularly, at least once a year, by risk analysis within the framework of the requalification checks

- The entire procedure is obligatory and described in detail in Process Instruction No. …

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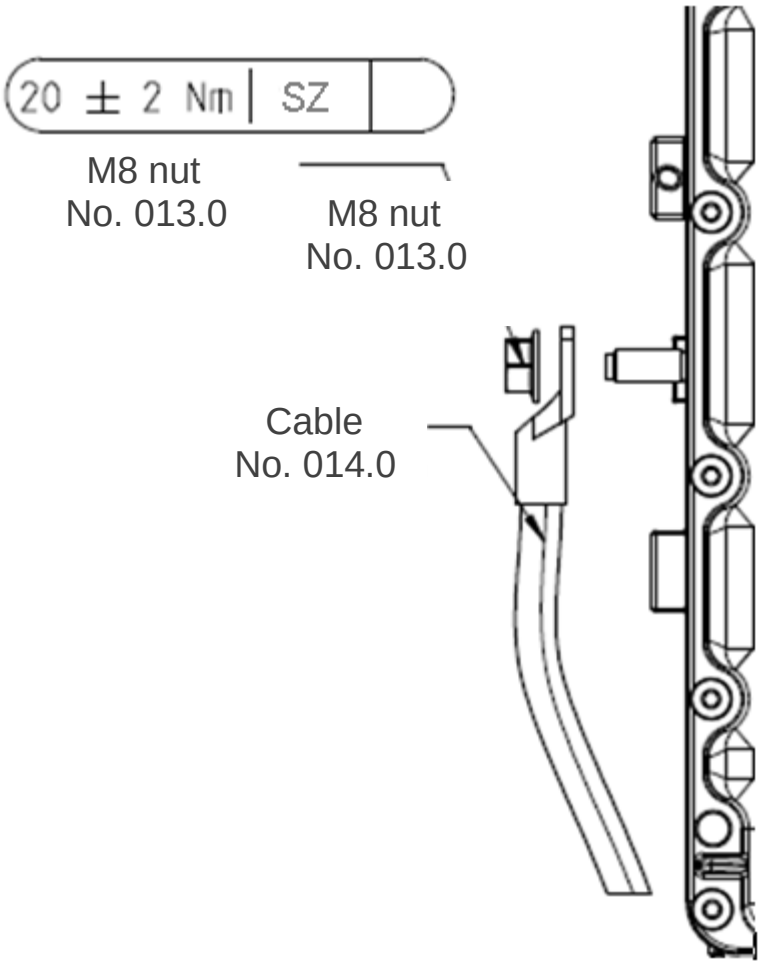
A.7 Example : Electronic control unit earthing cable



Item No. 045.0	Tightening torque
M8 nut	20 ± 2 Nm

Assembly operation : Fitting the cable

1) Insert the ECU earthing cable on the threaded bolt, position the M8 nut No. 013.0 on the threaded bolt and tighten it.

Assembly drawing showing final assembly (sections)

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Nur zur internen Verwendung für Faurecia Autositze GmbH bestimmt.

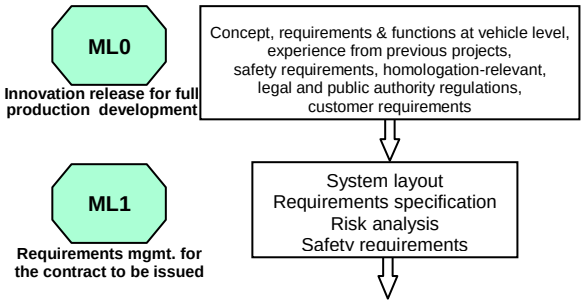
A.7.1 Description of the process sequence

a) The development process sequence

A.7.1.1 Requirements regarding the concept

Firstly the relevant requirements and functions regarding the vehicle concept are examined, with experience from previous projects.

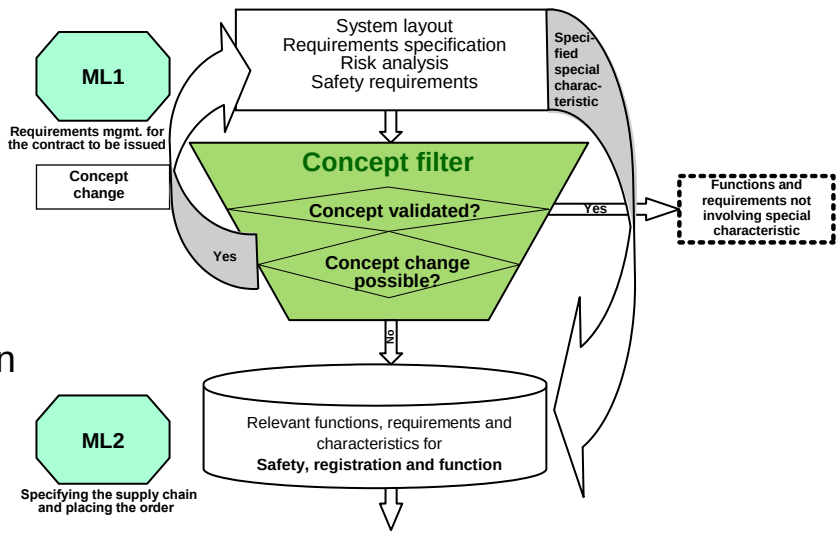
There are no customer requirements regarding the ECU which give rise to special characteristics.



The system layout, requirements specifications and safety requirements form the basis for the risk analysis. This highlights out failure modes and their consequences. These results flow into the concept filter to enable a determination of relevant requirements, functions and characteristics. One of the important requirements is set out in the requirements specification and demands compliance with EMC (electromagnetic compatibility) limits.

A.7.1.2 Concept filter

The concept is examined. Compliance with the EMC requirements is assessed critically.
The requirement cannot Be changed by a modification of the concept.
It is therefore regarded as a relevant homologation requirement and is carried forward to the design phase for further examination.



Other functions and requirements which were secured at the concept phase have been confirmed by tests and are not forwarded to the design phase as relevant functions and requirements. The associated tests and their results are documented in the development report EB14-2010.

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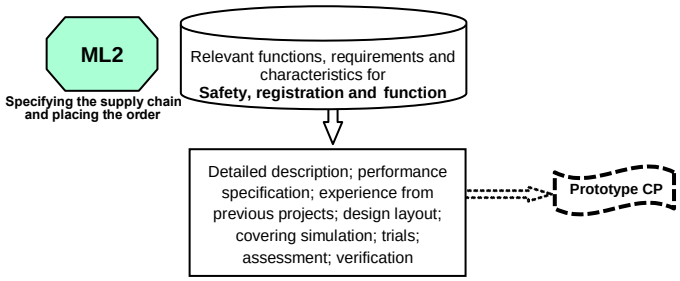
A.7.1.3 Requirements regarding the design

The ECU is laid out in detail. Appropriate actions are specified in the layout to ensure compliance with homologation requirements regarding outward radiation and resistance to inward radiation.
Experience regarding EMC from previous projects is taken into account.



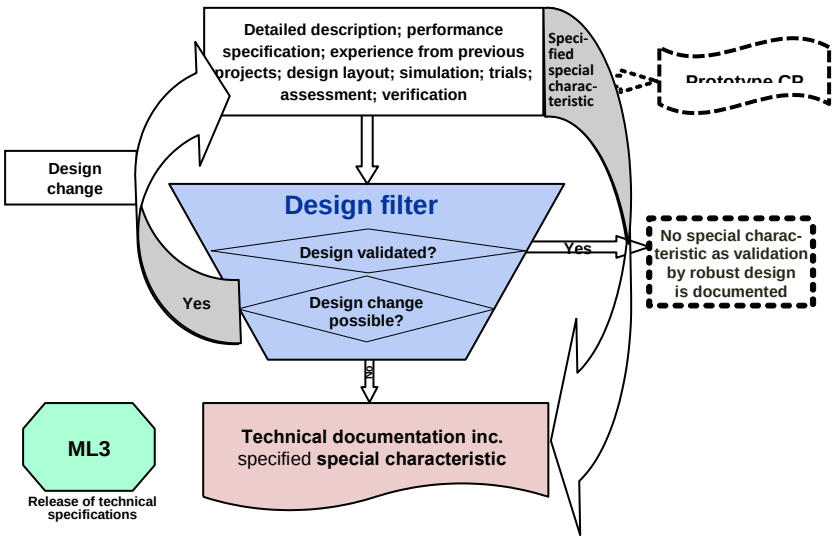
Following measurements in the EMC laboratory, the layout, components and housing are optimized. The changes made are verified by further measurements with the ECU (test report PB-E 07/2010).

Final confirmation that the EMC requirements are satisfied can be obtained only by later measurements in the target vehicle.

A.7.1.4 Design filter

Measurements in the EMC building with the ECU installed in the target vehicle indicate that all requirements can be met, provided there is a satisfactory ground connection to the vehicle. However, tests with an inadequate ground connection show that the limit figures are exceeded.

The ground connection is therefore classified as a **cc/h** characteristic.



These tests also reveal that an inadequate ground connection also leads to safety-relevant functional failures of the ECU. It is therefore also classified as a **cc/s** characteristic.

No further special characteristics were noted in the design phase.

The ECU and earthing cable are pre-assembled by the supplier and delivered as a single unit to the customer. The earthing cable is installed by the OEM. The customer must be informed of these special characteristics.

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In the customer documentation (drawing issued for quotations, technical customer documentation) the ground connection for the earthing cable is identified and classified with **s and h**.

A.7.2 Consequences

In discussions between the customer and the production planning department, as well as the customer's quality assurance department, agreement is reached on the tightening torque and test/checking measures (100% test/inspection).

The customer includes the special characteristics, the associated data and the test/inspection measures in his control plan.

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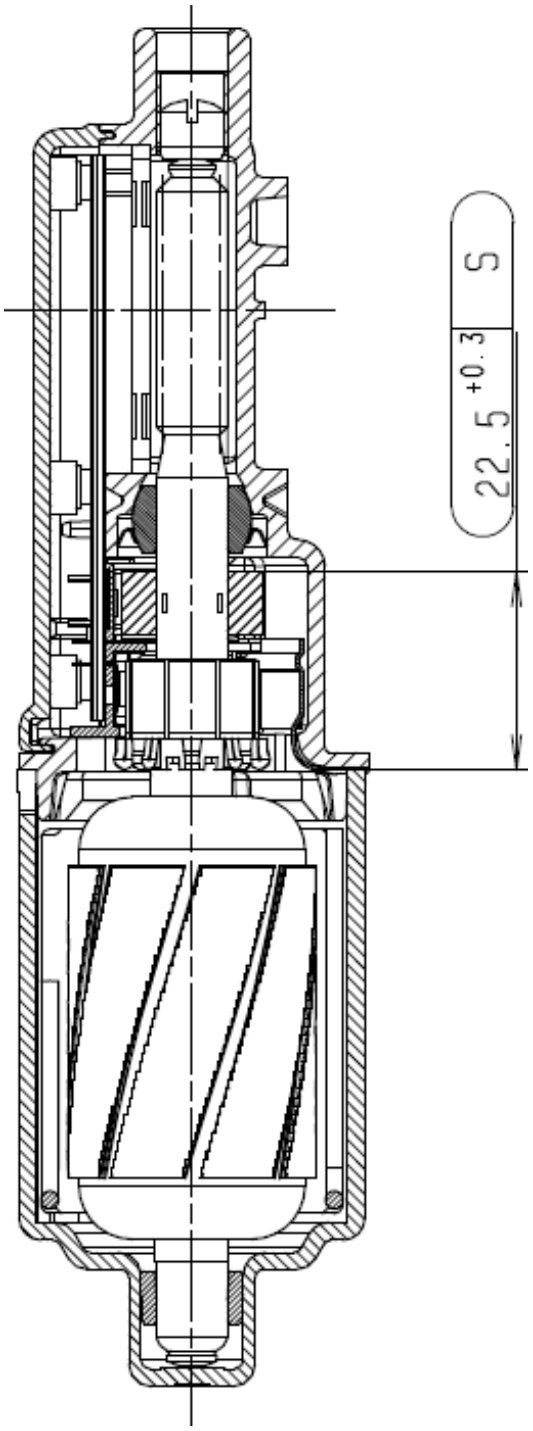
A.8 Example : Sliding roof drive motor



Design drawing (section)

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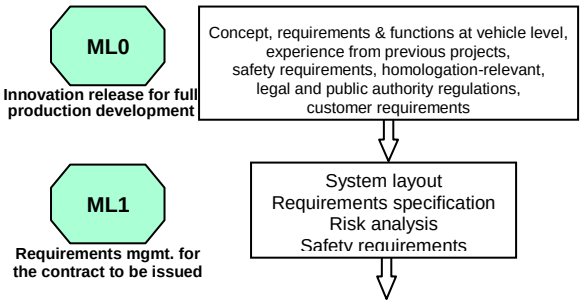
A.8.1 Description of the process sequence

a) The development process sequence

A.8.1.1 Requirements regarding the concept

Firstly the relevant requirements and functions regarding the vehicle concept are examined, with experience from previous projects.

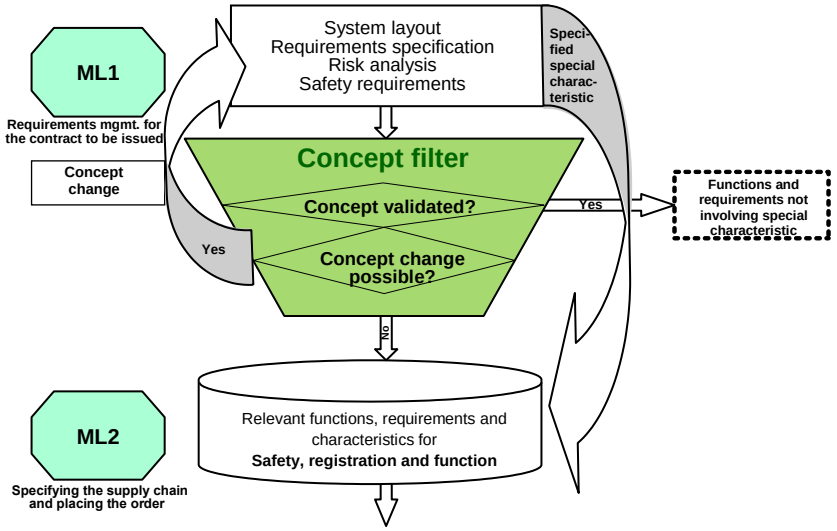


There are no customer requirements regarding the sliding roof drive motor which give rise to special characteristics.

The system layout, requirements specifications and safety requirements form the basis for the risk analysis. This highlights failure modes and their consequences. These results flow into the concept filter to enable a determination of relevant requirements, functions and characteristics. One of the important requirements is set out in the requirements specification and demands compliance with the limit figures for the closing force of the sliding roof.

A.8.1.2 Concept filter

The concept is examined. The requirements for the closing force are analysed. These requirements cannot be changed by a modification to the concept.



The closing force is examined further as a safety-relevant and homologation-relevant requirement and is carried forward to the design phase for further examination. Because of American FMVSS traffic homologation regulations there is also an homologation relevance here.

Other functions and requirements which were secured at the concept phase have been confirmed by tests and are not forwarded to the design phase as relevant functions and requirements.

Proof of compliance is documented in test report EV32/SC/2009.

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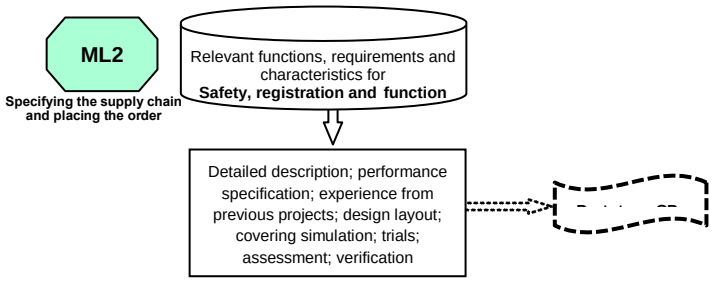
A.8.1.3 Requirements regarding the design

The functions and requirements Which have been identified are taken into account when drawing up the performance specification and the design layout.

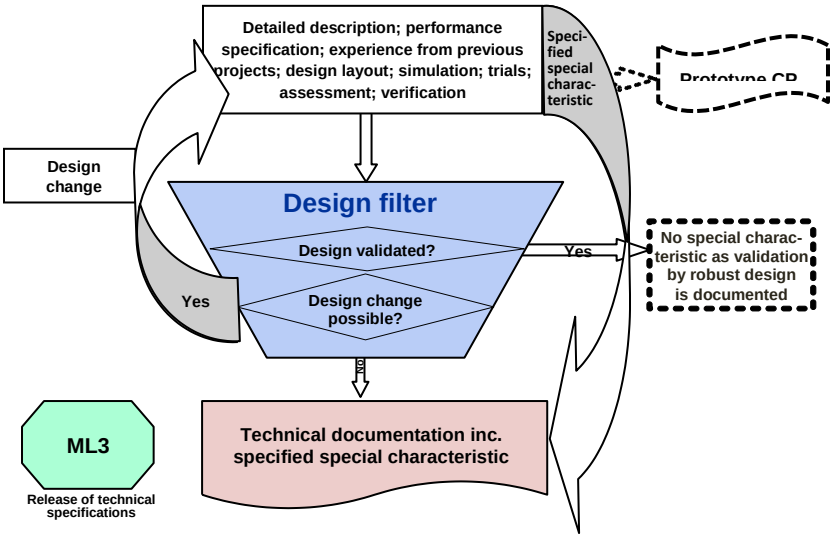


The position of the ring magnet is identified as a safety-relevant characteristic because this has a crucial influence on the closing force.

Closing force measurements on assembled samples are used to determine the optimum position of the ring magnet.

A.8.1.4 Design filter

In design discussions it determined that the position of the ring magnet cannot be secured by design measures alone. The SE team and the production department therefore agree that the position of the ring magnet must be classified as a **cc/s** to be handled as a test dimension.



No further special characteristics are determined in the design phase.

The special characteristic is specified in the technical documentation of the development phase (in particular in the drawing – see the illustration on the first page of this example) and is forwarded to the technical documentation department for production planning.

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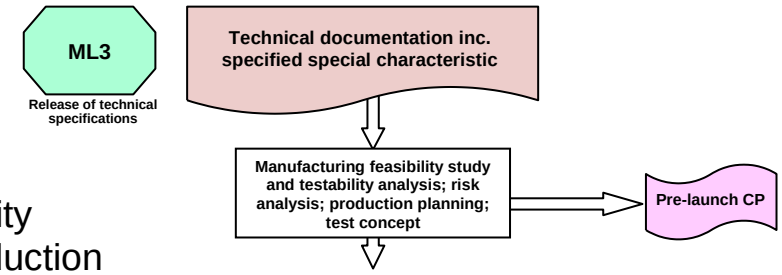
A.8.2 Description of the production process sequence

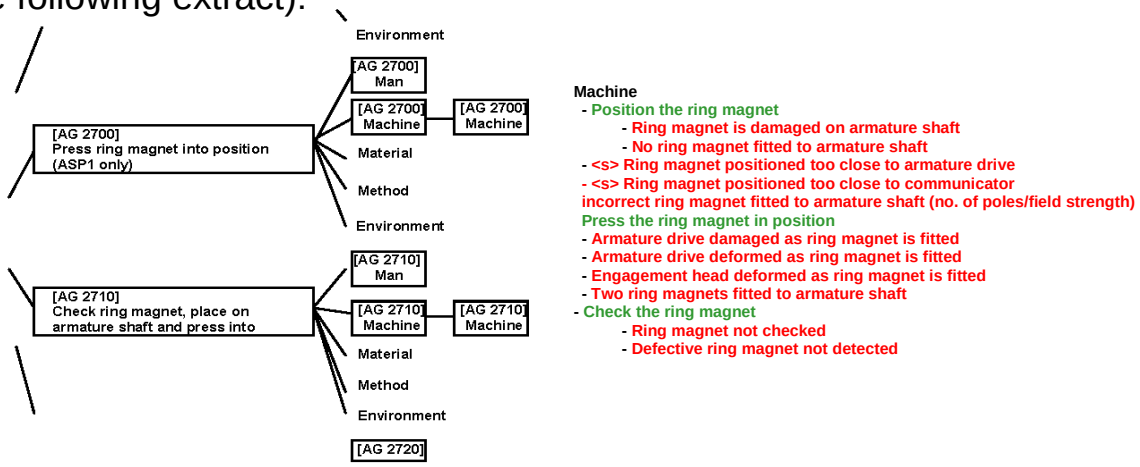
b) The production process sequence

A.8.2.1 Requirements regarding production planning



After special characteristics have been specified in the technical documentation, they must be analysed within the framework of the manufacturing feasibility and testability analysis, the risk analysis, production planning and the test/inspection concept. From this, the concept requirements for the production process are derived.

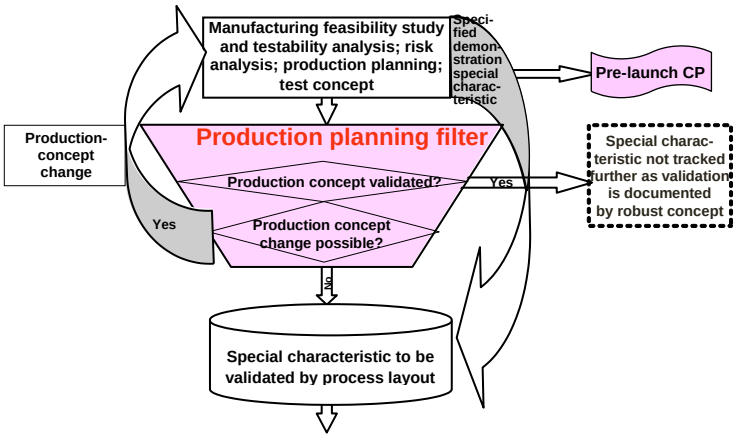
The positioning of the ring magnet is analysed in the Process FMEA (see the following extract):



The information which has been obtained flows into the production planning phase.

A.8.2.2 Production planning filter

The safety-relevant special characteristic (**cc/s –** ring magnet position) cannot be secured by the production concept alone.
A change to the production concept will not result in security.
This special characteristic is forwarded to the production process filter and the production control plan for pre-production.



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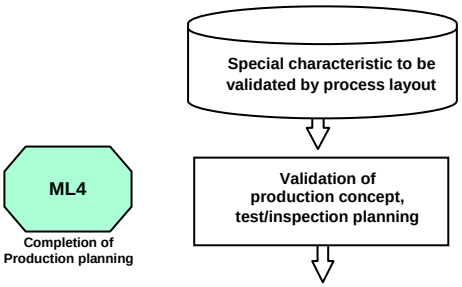
A.8.2.3 Input data for the production process filter

When securing the production planning and the test/inspection planning, it may be seen that there are further special characteristics in the process.

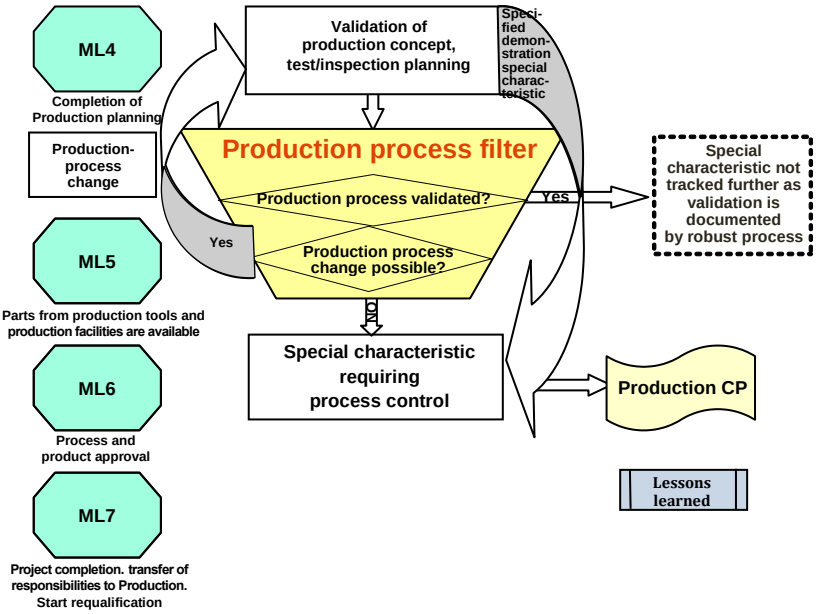
The special characteristics which have been identified are examined further.



A.8.2.4 Production process filter

In the production process filter it is clarified whether or not the special characteristic is secured by the production process.

The special characteristic cannot be secured by the production process and it is not possible to modify the production process. Te special characteristic and the specified method of monitoring (random sample checks) are carried over into the production control plan for full production.



Machine / Unit / Tool / Test/inspection equipment	Characteristics		Identific-ation	Maintenance plan	Quarantine	Prod. / process spec. tolerance (ref. document)	Records	Responsible / Test/inspection method
	Process	Product						
JMP1A11 No.8 force/travel monitoring	Monitor fitment force			PMV	Yes			100% automatic
JMK500A11 digital gauge Mitutoyo ID-F		Ring magnet fitment dimension	S	PMV			EDS	Every 8 hrs and when setting up. Machine operator / 5 parts

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