ZVEI:

Electronic Components
and Systems

Identification and Traceability in the Electrical and Electronics Industry

Guideline for the entire supply and value chain

Traceability according to EN ISO 9000:2005

"Traceability is the ability to trace the history, application or location of that which is under consideration."

COPYRIGHT:

Identification and Traceability
in the Electrical and Electronics Industry

Guideline for the entire supply and value chain

Published by:

ZVEI - German Electrical and Electronic
Manufacturers' Association e.V.
Electronic Components and Systems Division
Lyoner Strasse 9
60528 Frankfurt am Main

Phone: +49 (0) 69 6302-276
Fax: +49 (0) 69 6302-407
Mail: zvei-be@zvei.org
www.zvei.org/ecs

Author:

Working Committee "Traceability"

ZVEI contact person:

Dr. Christoph Weiß

Cover illustration:

Patricia Lutz

Photos (Cover):

Aluminiumverband Schweiz
Amphenol-Tuchel Electronics GmbH
Avago Technologies GmbH
Electrovac Hacht & Huber GmbH
Bruno Falkenstein GmbH
Deutsches Kupferinstitut Berufsverband
FELA Leiterplattentechnik GmbH
GLOBALFOUNDRIES Dresden Module One LLC & Co. KG
GÖPEL electronic GmbH
Lackwerke Peters GmbH + Co.KG
Molex Deutschland GmbH
Planet Erde
Rockwell Automation Germany GmbH & Co. KG
TQ-Systems GmbH

Translation:

Gela Dellert, Dolmetscherin und Übersetzerin

November 2009

Preface

Traceability refers to the identification and traceability of manufactured products. By means of a unique identification, the origin of the finished product can be traced along the entire supply chain down to the individual component. In the event of any defect in the finished product, this unique identification allows the source of the defect to be pinpointed quickly and targeted recalls to be initiated, thus significantly reducing the time and effort such measures require as well as minimizing financial losses. In addition, traceability provides for greater transparency in the monitoring of process-oriented costs along the value stream and allows the optimisation of in-house processes.

As a result, in May 2008, the working committee "Identification and Traceability in the Electrical and Electronics Industry" was founded under the auspices of the ZVEI (German Electrical and Electronic Manufacturers' Association) - Product Division Electronic Components and Systems. The objective of this initiative was to create a guideline which considers all aspects of the value chain in the electrical and electronics industry relating to the introduction of traceability.

More than 130 experts from over 80 companies participated in this project, covering the entire spectrum of the value chain. Participants from various business segments, ranging from medical engineering, "white goods", the automotive industry and manufacturers of subassemblies, components, electro-mechanical components, PCBs as well as distributors and software manufacturers, worked together on this recommendation. Thus, the entire supply chain of the electrical and electronics industry was represented. Furthermore, representatives of the insurance industry as well as of standardisation and certification institutes took part.

The purpose of this Guideline is to guide and assist its readers in deciding on an appropriate concept for the implementation of traceability. The main issues of this Guideline are definitions, cost-benefit-analyses, data for traceability, interface technology and practical examples.

In addition, an identification matrix for exchanging data has been developed and a recommendation for interfacing equipment has been devised. Configuration files in XML format are available for these two points and these can be linked to existing software systems.

Like any other complex system, this Guideline is subject to a permanent process of development. For this reason, a website has been created at www.zvei-traceability.de on the ZVEI homepage, providing new documents, software updates, questionnaires, presentations, information on upcoming events, etc.

We wish all users of this Guideline every success in introducing traceability and optimizing their processes!

Frankfurt am Main, November 2009

Contents

Note:
- The sections and sub-sections of the Guideline that are followed by "**" are only recommendations. No warranty is made as to the completeness of any such information.
- The terms and abbreviations defined in the appendices are written in "italics".

1 Preamble – Corporate Responsibility

This Guideline for Identification and Traceability looks at the entire range of issues regarding traceability in the electrical and electronics industry subject to the current general conditions and possibilities. It encompasses the entire supply chain and reflects the interests of the different industries. This approach therefore offers the chance to reduce costs in the longterm while minimizing risks at the same time.

What are the reasons for implementing a traceability process?

As a result of legal requirements, it is recommended that a traceability system be established and that this be kept updated. According to the Product Liability Act, every manufacturer and also supplier, is held liable, regardless of culpability, should a defective product cause per-sonal injury or damage to property.

According to the Equipment and Product Safety Act, every manufacturer is obliged to take all measures necessary to prevent any danger resulting from the product that they have put on the market.

The scope of measures ranges from warnings to cost-intensive recalls of a defective product. All these actions are based on the assumption that the products can be identified in the field and traced back.

The more the circle of defective products can be narrowed down, the better recall actions can be targeted, thus reducing the costs involved.

Apart from the obligation to recall and compensate for any damage caused, management may not be exempt from personal liability or even criminal prosecution in individual cases.

Quality assurance requirements are another reason for the implementation of a traceability system. Various norms and standards guiding the certification of companies indicate the ne-cessity to establish, control and store quality-related information and records.

This data is proof of the applied diligence and the resulting implemented safety measures. They are of equal interest to both user and company.

Apart from legal and other regulatory requirements, which may result in compensation claims, other aspects such as the loss of image or reduction in profit also have to be taken into consideration. An ineffective recall due to the lack of traceability of the manufactured product directly influences all aspects.

The introduction of a traceability system is primarily associated with investments. Due to the lower risk and correspondingly reduced reserves, funds will thus be made available. In case of any defect, less costs are incurred allowing this positive effect to be treated as a cost sav-ing. Furthermore, the collected data can be used to improve internal processes, thus quickly recouping investment costs.

These issues are described in detail later in this document providing specific calculation ex-amples.

The following sections provide information on the key issues of "traceability": necessity, set-up, implementation and application.

The level of detail contained in this document allows for a comprehensive evaluation in legal, commercial and technical terms. The latter facilitates not only the decision-making process, but also assists in finding a suitable concept for a consistent traceability system.

2 Executive Summary

The aim of *Section 2* is to summarise the essential content of this Guideline as well as to identify appropriate recipients within companies in order to facilitate the introduction of a traceability system and to ensure its effective implementation up to the final stages of the supply and value chain.

For the purpose of this Guideline, the term traceability refers to materials and products used along the supply and value chain (according to *Section 3* "Definitions").

Starting with the definition, *Section 5* specifically differentiates between the external exchange of information and data preferably kept in-house. This serves the need for communication along the supply and value chain as well as the need to protect company-internal know-how.

The general conditions deal with the difference between product and process-related traceability, the latter also focuses on process interlocking and process improvement.

In order to meet all the requirements of an international and universally applicable traceability system serving the different branches of industry, it was necessary to create different requirement levels (*Section 5.4*)

On the one hand, these different levels are necessary to define a common basis (level 1); on the other hand, they ensure flexibility by providing sufficient leeway for configuration which is requested by industries with specific requirements (level 3).

As is the case with the introduction of new processes, the costs-benefits-issue needs to be considered. For this purpose, *Section 4* provides a comprehensive overview and definitions of the individual costs of a traceability system.

It considers investments, operating costs and, in particular, the influence of the imputed risk relating to liability and entrepreneurship. This overview enables companies intending to implement a traceability system to perform a high-level cost-benefit analysis.

Section 5.5 specifies the ZVEI label standardised in this Guideline. In terms of the label classification, a distinction is made between a *packing label product** and a *packing label logistics** which is essential regarding orderless manufacturing and warehousing. The *packing label product** specifies necessary information from the processes of orderless manufacturing (according to *Appendix 2*) allowing for the tracking of information regarding the product or manufactured item. The *packing label logistics** details additional logistics information.

Consequently, a *packing label product** is required on the smallest packaging unit for all specified levels. The necessity of a *packing label logistics** and the information it contains can be derived from the definition of the levels as well as from the identification matrix according to *Appendix 2*.

Section 6 describes various international identification systems.

Following *Section 6*, *Section 8* and *Appendix 2* go into detail and explain the different technical information systems available and the framework behind them. For this reason, they also present and detail different marking methods including the respective read modes with reference to the final application as well as electronic identification systems, e.g. RFID.

Section 5.6 deals with the subject of process traceability. First, a method is presented to make the necessary traceability relationship between processes and specific process data transparent. This starts already in the design and project realisation phase and ensures the efficient and effective use of these data. This approach characterises the supposed process flow using risk assessment tools e.g. *FMEA*, DFM** or *DFT** to identify the possible process parameters required for process stability and/or evaluation. At this point, the implementation is linked to the respective in-house databases and takes place in detail in the specific technical department. Existing parallels to Robustness Validation should be taken into consideration.

Section 7 deals with the technology of the respective traceability interfaces. The focus is specifically at system level and the respective requirements and conditions for hardware/software. The detailed contents of these descriptions require an understanding of IT and allow connection to existing IT systems or the introduction of a new computer-based process data storage system.

The Appendix deals with this subject from the perspective of the relevant standards. This Guideline enables compliance with rules and standards if implemented and used properly in the defined levels. Moreover, the definitions, as well as the references given, serve as sources of additional information, as well as an opportunity to develop topics in more detail according to individual requirements.

To illustrate the situation and importance of traceability systems, *Figure 1* and *Figure 2* are provided as examples.

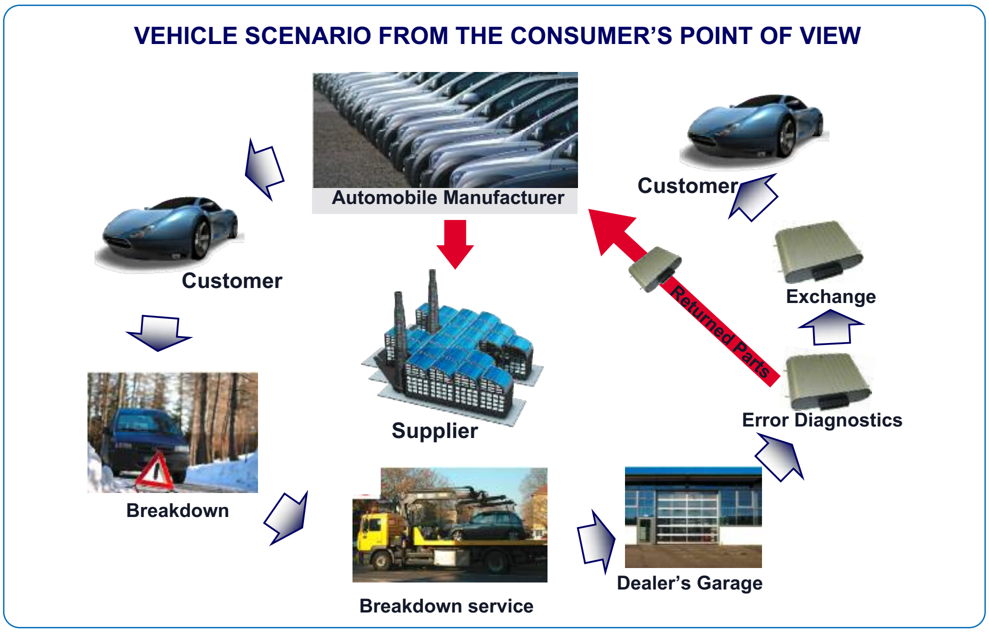


Fig. 2.1: Traceability from the consumer's point of view

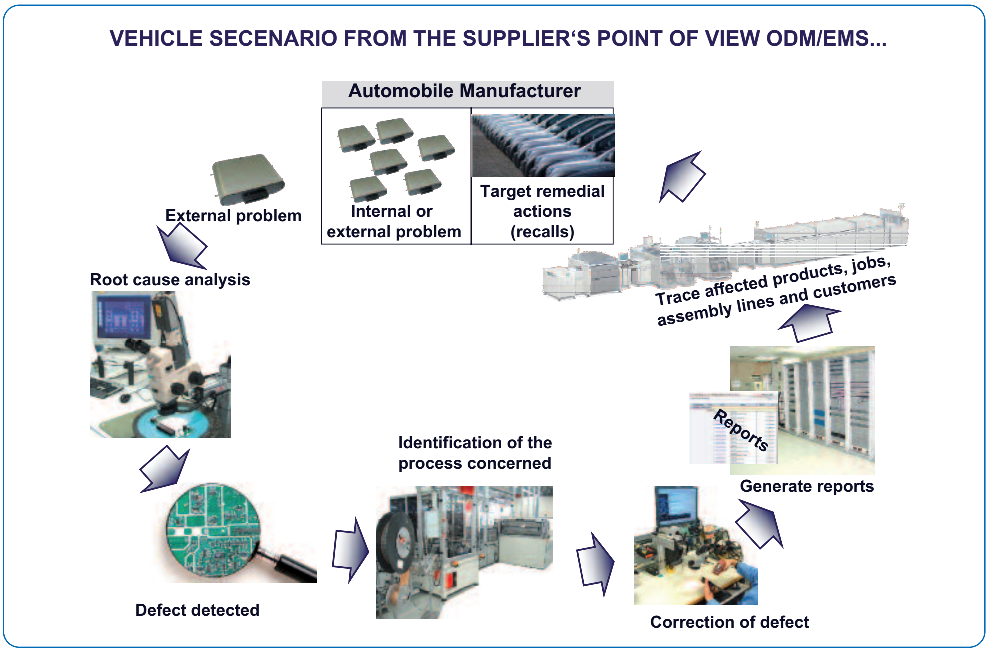


Fig. 2.2: Traceability from the supplier's point of view

3 Traceability – Definitions of the ZVEI Working Committee

Traceability allows materials and products to be traced along the entire supply and value chain and involves "*tracking**" and "*tracing**".

Traceability can be categorised into different types of traceability and the impact they have on processes. The normative requirements and definitions are explained in detail in the *Appendix* of this Guideline.

3.1 Categories of Traceability

Traceability can be implemented in different categories which can be divided into four major groups: Product, Material, Process and Logistics Traceability.

While material traceability generally records only incoming materials in the form of, e.g. product names and *batch** information (according to the table in *Appendix 2*), process traceability documents certain processing parameters and process results as well.

Product Traceability

Product traceability is a combination of material and logistics traceability along the supply and value chain.

Material Traceability

Material traceability refers to the *tracing** of material incorporated in or used for a product. This requires the recording of material data and assigning it to the respective product identification number.

Process Traceability

Process traceability refers to the *tracing** of the processes involved in the production of a product. For this purpose it is necessary to record the data relevant for the process quality and link this data with the respective product identification number. This should also include test processes.

Logistics Traceability

Logistics traceability refers to the *tracing** of logistical product data according to the level matrix of *Appendix 2*. It requires the assignment of the logistics data (*packing label logistics**) to the individual product identification number *(packing label product**).

In this context, material traceability functions as the umbrella term for the traceability of the components and can include logistics-related data as well as product-related data. In most cases, logistics traceability is connected to the product via a code or serial number as specified in the level matrix. Product traceability relates to the product irrespective of the customer and can contain external as well as internal data.

3.2 Traceability along the Supply and Value Chain

External Traceability

External traceability deals with the tracing of information between the contractor and customer. Traceability is ensured by means of a unique identification number, if possible on the product itself, or on the smallest packaging unit and/or accompanying documentation of a delivered item.

Note: Alternative customer-specific arrangements are possible as per Appendix 2.

Internal Traceability

Internal traceability refers to the customer's product and process traceability along his value chain. Scope, parameter and documentation of this traceability are subject to legal and internal rules and are generally not communicated externally. This allows for risk assessment without transferring know-how.

3.3 Traceability Relating to Processes

Passive Traceability

Passive traceability refers to the systematic collection of data regarding a product's history (*batch** data, test data, process data). In case of any defect, this approach allows the analysis and root cause determination as well as the identification of the components, *sub-assemblies** and products involved.

Active Traceability*

*Active traceability** refers to the systematic acquisition of data in order to target process interventions. For example, it provides the possibility of process interlocking in the event of a defect.

4 Cost-Benefit Analysis of a Traceability System

4.1 Integration of a Traceability System into Company Processes

It is possible to install and operate a traceability system independent of other IT systems within a company, however, its full potential cannot then be realised. In this case, it serves only to 'collect data'. The required master data has to be entered manually into the traceability system, which generally involves considerable time and effort. Machine and test data are transferred via asynchronous interfaces into the system. The benefit of such a system consists solely of the provision of offline reports for analysis purposes. This is also referred to as a passive traceability system.

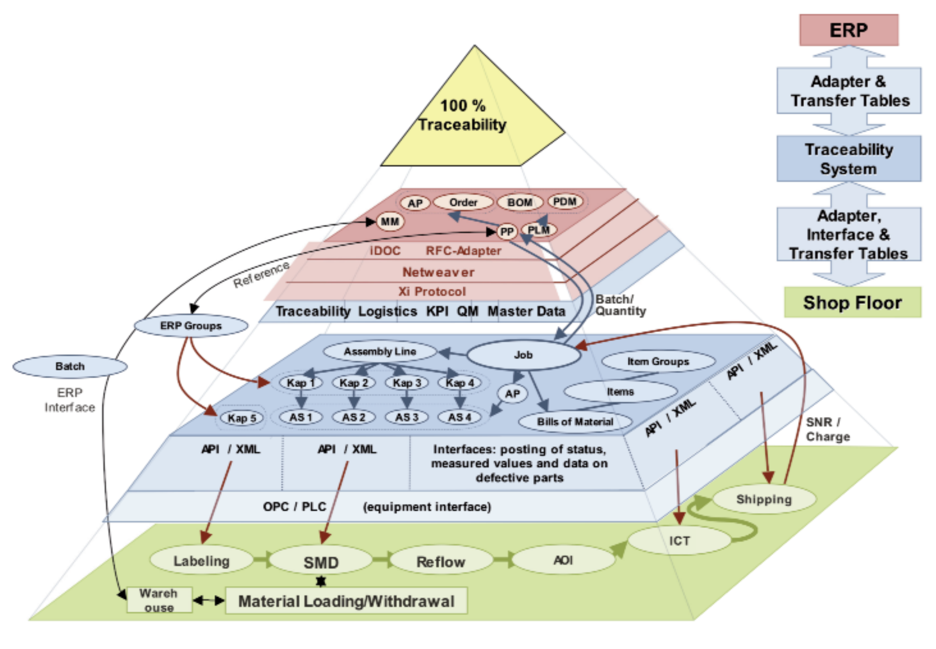


Fig. 4.1: Integration of traceability systems into company processes

If a company expects a measurable benefit from the introduction of a traceability system, such as improving product quality, reducing the number of rejects or refining the production process, then the traceability system will require effective interlocking mechanisms. This is referred to as an active traceability system.

Examples of product-specific interlocking are:

- Bills of material and assembly areas compared with (machine) setup
- Status of the mounted trading units/material *batches**
- Deviations from predefined process and test values
- Production according to the correct process flow

One of the requirements for process interlocking is the synchronous communication between the shop floor equipment and the traceability system; another requirement is consistent data (material data, bills of material, assembly areas, test plans ...) across all systems involved.

For the company this involves e.g.:

- Provision of all master data by the development department at the time of a product launch or product change prior to the production of the first sample, including the transfer of the master data to all subsequent systems
- Versioning of product changes.
- Definition of all trace-relevant production steps (including the alternatives) and realisation of the respective workstations, work plans and bills of material by industrial engineering.
- Definition of the production-step-related setup.
- Definition of test and process values to be tracked.
- Linking production systems of trace-relevant production steps to the traceability system and implementing interlocking options within defined cycle times.
- Providing for the precise recording and tracking of used components and *sub-assemblies** with regard to the trading units by the company's logistics systems

Summary: *Active traceability** is not an accessorial feature of production, like, for example, another report, but a company system with great influence on the flow of production-related information, merchandise logistics, technical equipment and organisation of a company.

It affects almost all company divisions and sectors – as illustrated in *Figure 4.1*.

The success of a traceability system and its implementation depend largely on an elaborate concept, good project management and the involvement of all participating parties as well as the provision of the necessary personnel and financial resources.

4.2 Traceability in the Production Process

The purpose of process traceability is to capture and collect all parameters which influence the process and provide these parameters for the product traceability. This means the ability to record and track individual *serial numbers**, *batches** or key performance indicators. The latter have to be defined during the project phase.

Following defined schemes, these key performance indicators are oriented on possible risks, required documentation or special requirement criteria. The objective is to create a database through suitable monitoring of processes and the related documentation which allows the support or implementation of approaches such as "Zero Defect" or "Robustness Validation".

One major advantage of process traceability is the availability of additional data from control and production processes. This data can be used for further optimisation measures in terms of continuous improvement. Traceability represents another step on the way to a "transparent factory", offering, for example, the following possibilities:

- Higher transparency of the internal value chain by linking different production data.
- Possibility of the mutual interlocking of processes. Subsequent processes can only be started upon completion of the preceding process, as specified. Risk minimization of defects through positively-controlled processes.
- Greater transparency regarding the monitoring of process costs. This can be achieved by recording and linking processing times and downtimes, for example, as well as material consumption and the process data of every product to be manufactured.
- Direct availability of the utilisation rate of machines, assembly lines and shop floors.
- Key quality indicators are produced online, allowing prompt corrective measures to be taken and thus avoiding the subsequent quality evaluation of classical quality assurance. Furthermore, these _key quality indicators can also be used for long-term analyses.
- Data acquired for traceability can be used for material management. An immediately available analysis of material stocks within production offers the same quantifiable advantages as automatic material planning by registering the material consumption of production equipment.
- The ability to provide traceability data gives companies a competitive edge or rather a unique selling advantage, distinguishing them from market competitors without a corresponding system.
- In certain industries, a consistent traceability system may be a requirement for suppliers in future.
- In the event of defects in the field, traceability allows for a qualified risk assessment.
- If there is a problem, traceability can pinpoint the source of the defect, thus avoiding cost-intensive recalls. Apart from the financial aspect, the fact that a company's public reputation is also protected by the possibility of targeting recalls of defective products, should be mentioned.
- Traceability systems allow savings in insurance costs.
- Traceability systems provide an important basis for protection against product piracy by supplying customers and dealers with unique identification criteria.
- Captured process data provides for the early planning of service and maintenance work.
- Guiding and monitoring setup processes and setup changes by means of a traceability system often accelerates these processes considerably. For example, the system is able to display current data as well as the mounting stations of a scanned *batch** or locate the *batches** designated for a scanned mounting station.

Section 5.6 and *Section 7*, as well as *Appendix 4*, present examples of a suitable method for collecting data for a traceability process.

The circulation of this internal process data is subject to restrictions such as the protection of company know-how or non-disclosure agreements.

4.3 Decision Criteria for a Traceability System

The introduction of a traceability system affects almost all company sectors and divisions. The time and effort associated with such a system as well as the resulting benefits depend largely on a few fundamental decisions that need to be made first. The following questions should be considered:

- **What type of traceability system (active or passive) should be installed?**

A passive system collects data regarding the process history (*batch** data, test data, process data) and in the event of a defect, this approach supports the analysis and root cause determination as well as the identification of components, *sub-assemblies** and products involved. An active system also collects these data. However, it also provides the option of interlocking systems against master data (e.g. bills of material, work plans, test plans) and process parameters in real time which helps avoid mistakes.

- **Which approach is preferred: product-specific, division related or a corporate solution?**

In this case, the impact of changing the operating mode of machines to the "traceability operating mode" has to be analysed.

  - Is it necessary to manufacture all produced products "in compliance with traceability" as a result of this changeover, or
  - is it possible to operate the production facility on a product-related basis with or without traceability?

- **What is the planned extent of adjustment of material logistics to meet traceability requirements?**
- **Will traceability information only be required for specified purchased parts or will material logistics be completely reorganised?**
- **Is the traceability system to operate on a stand-alone basis or is it be connected to an existing system environment, (e.g. ERP system, MES)?**

Relevant for Active Traceability	Relevant for Passive Traceability	Reference to Section		Year 1	...	Year s
		4.1.	**Potential Savings**			
x	x	4.1.1.	Reduction of External Defect Costs			
x		4.4.2.	Reduction of Internal Defect Costs			
x	x	4.4.3.	Reduction of Quality-Related Downtimes in %			
x		4.1.4.	Increase of the Overall System Efficiency in %			
x		4.1.5.	Improved First-Pass-Yield in %			
x		...	Others			
		4.5.	**Expenses**			
x	x	4.5.1.	Investments in Infrastructure and Manufacturing Resources			
x	x	4.5.2.	Maintenance and Repair Coss			
x	x	4.5.3.	Support			
x	x	4.5.4.	Training			
x	x	4.5.5.	Operating Costs			
x	x	4.5.6.	Product Costs			
			ROI			
			Sum of Total Savings			
			Sum of Total Expenses			
			Balance +/-			

Fig. 4.2: Calculation overview on traceability systems

A stand-alone system requires the manual acquisition of master data in the traceability system. Connection to existing systems necessitates the provision of appropriate interfaces.

The answers to the above-mentioned questions determine the ways and means of implementing a traceability system as well as the costs involved. Potential savings largely depend on the decision for an active or passive system and can be ascertained according to *Figure 4.2*.

4.4 Potential Savings

4.4.1 Reduction of External Defect Costs in case of Recalls / Claims for Damages

In the event of a defect, the records of components used in a product and the capture of process parameters during production allow the affected products to be pinpointed.

These products can thus be systematically identified for reworking or scrapping

If the products have already been delivered to the customer, it is possible to target recalls according to the respective *serial numbers** or *batches**.

In this way, the costs for scrapping, reworking and warranty, as well as goodwill claims and manufacturer's liability can be reduced.

4.4.2 Reduction of Internal Defect Costs

By verifying the data of the production facility with against job data prior to the production start, it is possible to largely eliminate the production of defective products. Consequently, the costs for scrapping or reworking can be reduced.

When errors are detected in the production, for legal or image reasons, it might be necessary to carry out corrective actions in the field or to target recalls. The following actions should be taken:

- **Identify and pinpoint affected products**
- **Identify regions and customers that are concerned**
- **Link internal and external expenses and costs with the corrective actions**

Sample calculation: k_{log} = **Logistics costs and expenses = 1000€**
k_{part} = **Spare parts costs = 200€**

Costs without Traceability:	Costs with Traceability:
$K_{w/o\ Traceability} = n_o * (k_{log} + k_{part})$	$K_{with\ Traceability} = n_1 * (k_{log} + k_{part})$
n_o = Number of recalled units = 500, 1000	n_1 = Number of recalled units = 50
$K_{w/o\ Traceability}$ = 500 * (1000€ + 200€) = **600.000 €**	$K_{with\ Traceability}$ = 50 * (1000€ + 200€) = **60.000 €**
= 1000 * (1000€ + 200€) = 1.200.000 €	
(plus internal expenses required for the identification of the customer, loss in sales, image loss, etc.)	

Benefit = 540.000€ per recall action

Benefit = 1.140.000€ per recall action

The following data can be verified, for example:

- Setup of production facility against job BOM
- Production sequence against work plan
- Machine program against placement or test program
- Production status in terms of unique specimens

Fig. 4.3: Example of a cost-benefit calculation of traceability systems

4.4.3 Reduction of Quality-Related Downtimes

In the event of a defect, the detailed depth of the recorded traceability data allows for speedy analysis of the root cause.

On the one hand, the production equipment concerned can be put back into operation in the shortest time. On the other hand, the affected products/materials can be put to further use after being reworked accordingly.

4.4.4 Increase in Overall System Efficiency

The factors described in *Section 4.4.2 - 4.4.3* prevent the production of defective items. If cycle times are not negatively influenced by interlocking mechanisms, overall system efficiency will increase.

4.4.5 Improved First-Pass-Yield

The system-based monitoring of key quality indicators allows prompt corrective measures to be taken even before limiting values are exceeded, thus avoiding the subsequent quality evaluation of classical quality assurance. Furthermore, the key quality indicators captured can also be used for long-term analysis.

4.4.6 Increase in Production Process Transparency

The prompt feedback of production data relating to a job provides precise information on the job progress at all times.

The utilisation rate of machines, assembly lines and shop floors can be made available directly.

4.4.7 Optimisation of Material Logistics/Stock Reduction

The figures on material consumption provided by the production facilities allow up-to-date inventory information at all times; this can be used to control replenishment. Furthermore, sensitive parameters (e.g. stability, processability) support automatic monitoring.

4.4.8 Possibility to Review the Calculation Bases

The system data transmitted (material consumption, processing times, downtimes) allows the calculation of sub-assemblies to be verified. It is also possible to compare the costs of different assembly lines.

4.4.9 Insurance Costs

A functioning traceability system results in targeted recalls of only those products showing defects. Without a traceability system and as a preventive measure, a higher number of products - presumably not defective - are targeted for recalls or at least have to be checked, as no unique identification is possible.

If the option of localising defective products is provided, the expense of damage claims can be decreased. This could possibly lower the liability limits needed for the insured, possibly leading to the agreement of lower deductibles and insurance premiums.

4.5 Expenses

4.5.1 Investments in Infrastructure and Manufacturing Resources

Investments can consist of the following:

- Planning costs/project costs
- Server hardware (database/application/archive server)
- Centralised or decentralised database structure (ERP, MES)
- Network (LAN; WLAN, dedicated lines, production networks)
- Software licences (database/application/archive)
- Interfaces to neighbouring systems (e.g. ERP systems, production systems)
- Installing traceability-compliant hardware components to manufacturing equipment (e.g. scanner)
- Traceability compliant design of production processes (material logistics, product master data, etc.)
- Interface to "external" traceability for the exchange of traceability data with suppliers and customers

4.5.2 Maintenance and Repair Costs

Maintenance costs and reinvestment cycles have to be taken into account for hard and software.

4.5.3 Support

Internal and external support must be assured for the entire duration of production. With interlocked production, a breakdown of the traceability systems may entail the shut down of production at the same time. In extreme cases, a 24 hour support service is necessary.

4.5.4 Training

User-oriented training courses on traceability processes for all employees involved at all company levels are strongly recommended.

4.5.5 Operating Costs

The implementation of traceability in the company processes can lead to additional time and effort and higher costs. Possible reasons for this are, for example:

* Marking, storing and commissioning of material down to the package units

* Increased time and effort for master data maintenance and data provision

4.5.6 Product Costs

Aspects to be considered are, for example:

* Unique identification of *sub-assemblies** and products

* Possible increase in cycle times due to bilateral data communication and interlocking of processes

5 General Conditions for Identification and Traceability

A traceability system requires the assignment of material data, process data and logistics data to the products. Assignment based on the time of processing is a simple method. However, this does not always allow for the assignment of used materials or deployed processes, (e.g. single-piece or multi-panel production).

For this reason, the direct assignment of material, process and logistics data should be preferred to a time-based allocation. A batch number* or serial number* has to be assigned to the product as a unique identification. Based on this identification, all product-relevant material, process and logistics data can be assigned to the product and stored in the databases.

The less data available for a product (e.g. new product) and for the value-adding-process, the greater the depth of the traceability data to be captured.

As levels of information and experience increase, the depth of data can be reduced if necessary.

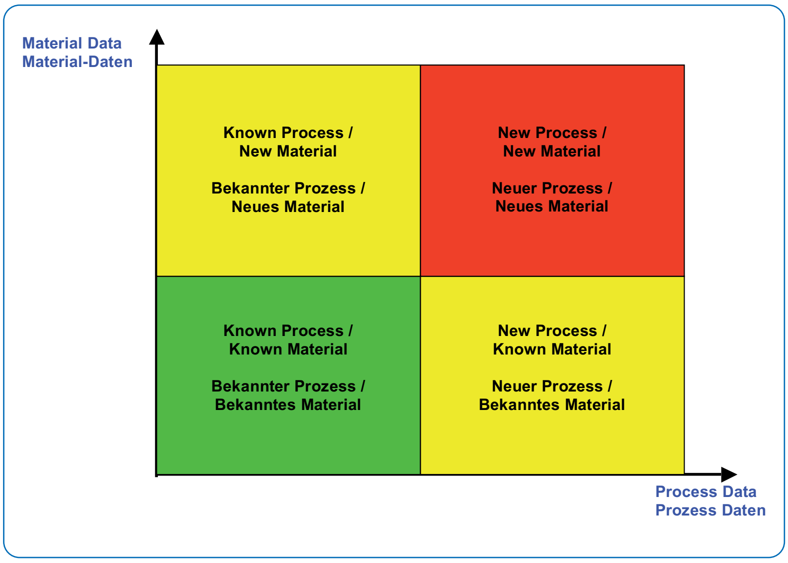


Fig. 5.1: Analysis matrix for selecting the depth of traceability data

Figure 5.1 provides a general overview of the positioning of traceability requirements. This two-dimensional illustration specifically sets used material against the internal process flow. True to the motto "Never change a winning team", the green field indicates a low level of data detail, as the information and contents regarding materials or process levels are already known. .As soon as new parameters are introduced for either or both processes, the amount of data for the respective traceability should be increased in order to safeguard the processes.

When taking the ZVEI label into account, the level should be increased in line with the increasing number of unknown parameters.

The following four scenarios with the parameters "material" and "process" are analysed:

- Known Process/Known Material –> low data depth of material and process data
- Known Process/Unknown Material –> high depth of material data and low depth of process data
- Unknown Process/Known Material –> low depth of material data and high depth of process data
- Unknown Process/Unknown Material –> high depth of material and process data

5.1 Identification and Traceability in the Supply and Value Chain

Traceability data can only be exchanged on the basis of the contractual relationship between contractor and customer. The circulation of a unique tracing identification from raw material through to the finished product and vice-versa, can only be realised with considerable effort and is not recommended due to the complexity of such processes and considerable investments.

The approach of "external traceability" indirectly meets this requirement as the system allows the acquisition of data as defined in *Appendix 2*. In this way it is possible to access the traceability data.

"Internal traceability" should be linked with "external traceability", using an internal key and thus providing in-depth information if required.

The individual organisation is responsible for data archiving which – subject to individual requirements – is based on legal requirements, technical standards and customer agreements

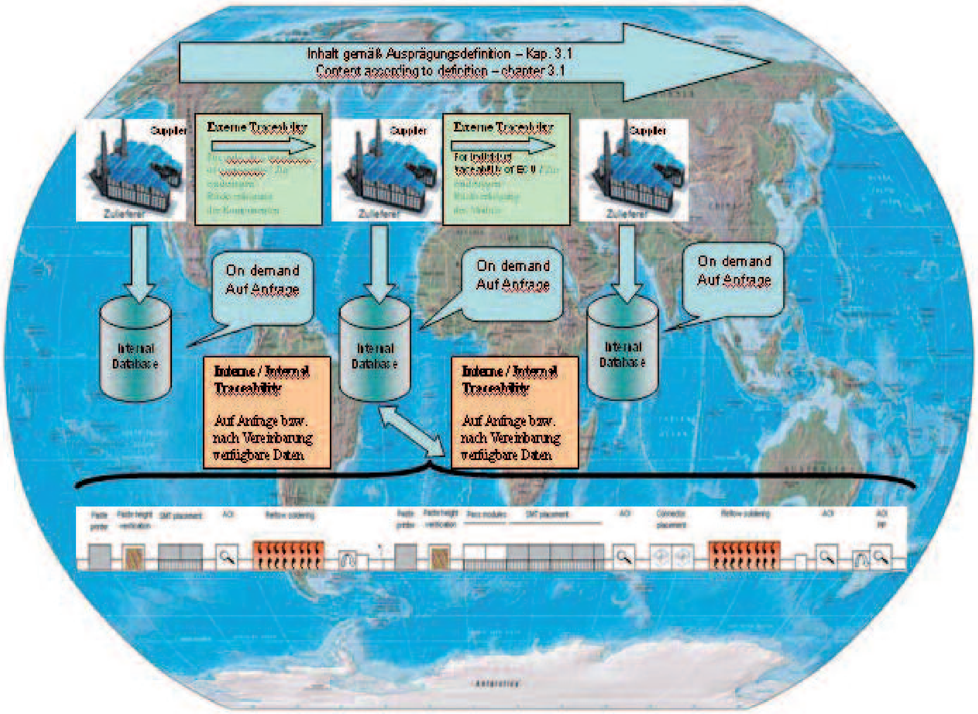


Fig. 5.2: Principle of identification and traceability in the delivery and value chain

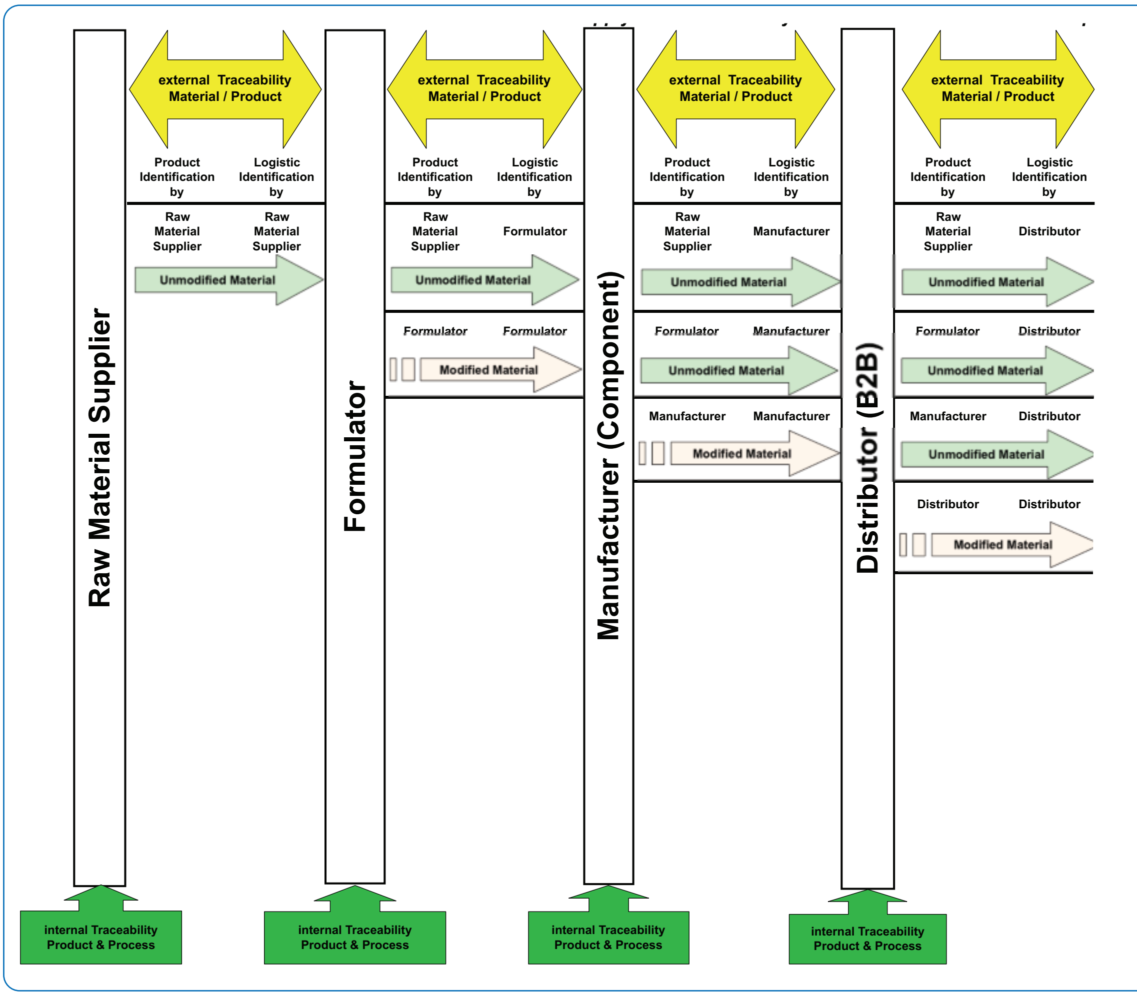
Figure 5.3 (page 16) details traceability along the supply chain as well as the flow of information as part of the external traceability.

With external traceability, customer-independent information (see ZVEI *packing label product**) is forwarded unchanged until the product advances to the next processing/refinement level. All other customer-specific information is exchanged between the contractual partners completing the product information.

Subject to the processes implemented, internal product or material traceability varies in terms of the role and function of the contractual partners, which may result in differing data availability. For example: internal traceability of an EMS (Electronic Manufacturing Service) in contrast to distribution.

5.2 Transition between External and Internal Traceability

The combination of product and logistics data originally transmitted as part of external traceability enables the initialisation and assignment of the respective relevant internal traceability data also linked to the processes within the company.



External and internal traceability systems are linked in the incoming goods department. Internal traceability is linked to external traceability at the packing station (product-related) as well as at the dispatch station (logistics-related).

The following diagram depicts the points of transition:

5.2.1 Transition of External to Internal traceability

The incoming goods department collects the data by recording the information on the *packing label product** and the *packing label logistics**. This is required for the initialisation of in-house internal traceability and is achieved by assigning the provided information to an in-house unique trace number which is then carried along the entire in-house traceability chain.

The incoming goods department receives the ordered material. In addition to the commercial material entry:

- the material data is captured.

  –> if possible, on the basis of a standardised data carrier

  –> if possible, on the basis of the smallest packaging unit
  (of the logistic size which is supplied to the machine in production)

- the material should be stored in a defined storage location

  –> if possible, per material number all from the same batch*

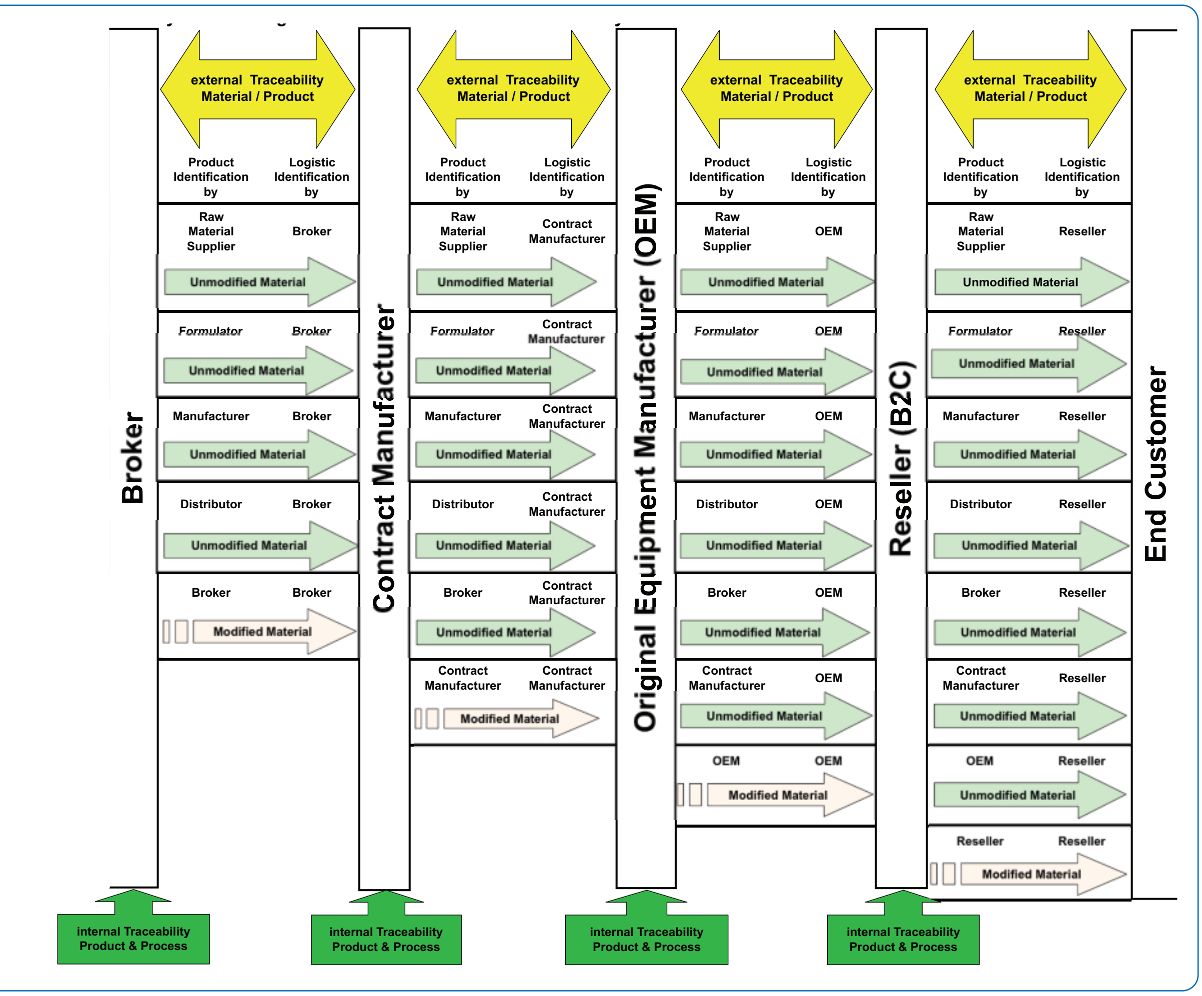


Fig. 5.3: Traceability along the supply chain

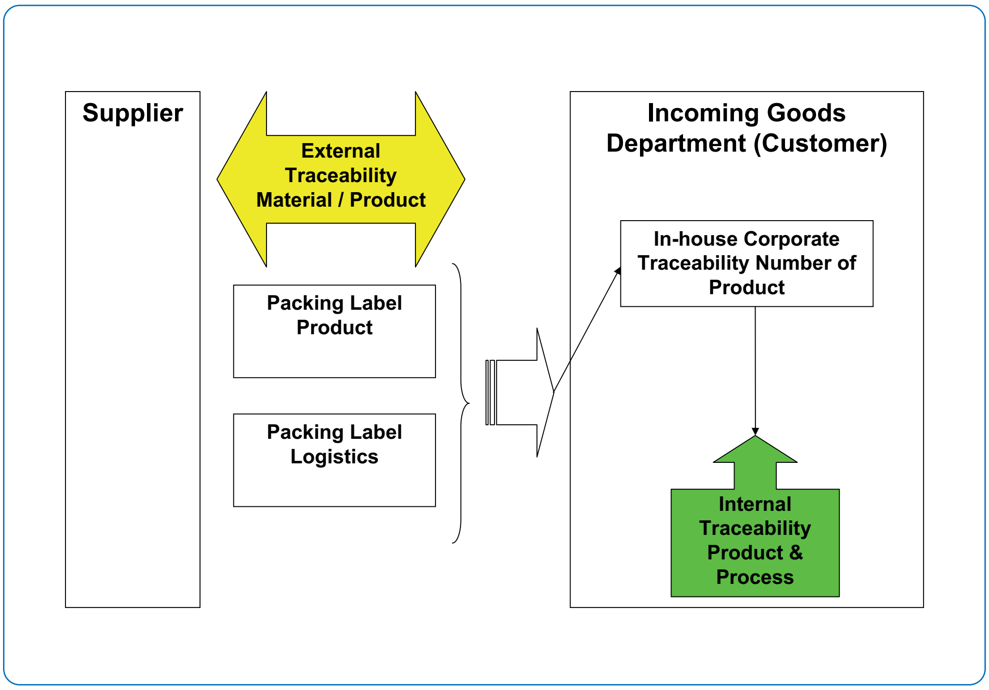


Fig. 5.4: Transition from external to internal traceability

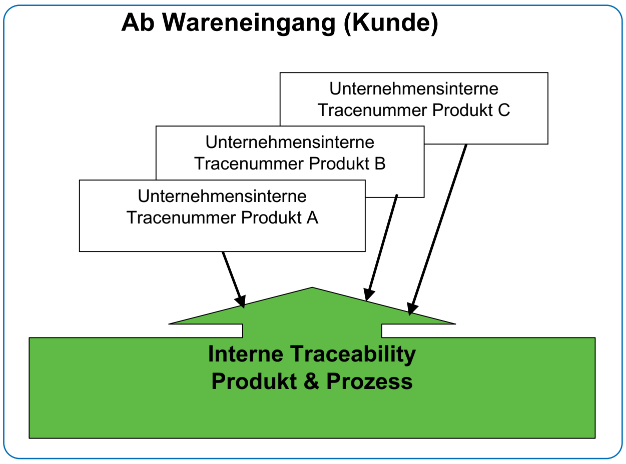


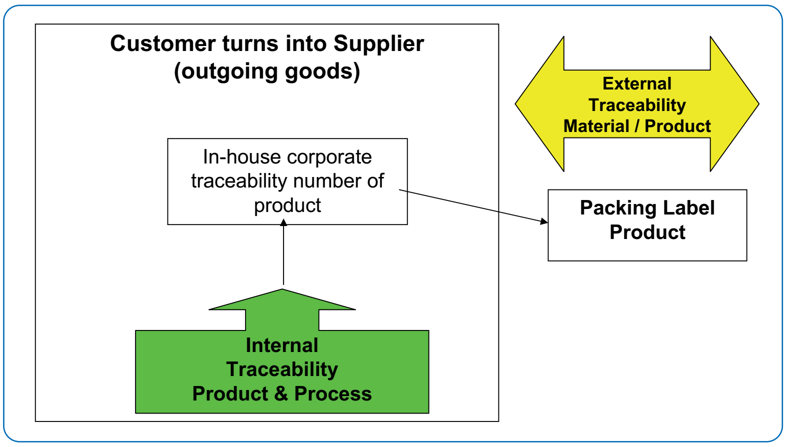
Fig. 5.5:
Internal traceability via trace number

5.2.2 Internal Traceability

This process (*Fig. 5.5*) uses an internally assigned trace number to link the supplied information with the process data accrued during production and necessary at delivery. This is also referred to as product traceability.

5.2.3 Transition from Internal to External Product Traceability

If a product is processed or refined, all information relevant for the *packing label product** will be provided in a new packing label during this process.



If there is no refinement process, the *packing label product** of the upstream supplier can be passed on unchanged.

Fig. 5.6:
Traceability in the packing process

5.2.4 Transition from Internal to External Logistics Traceability

In this process, the customer-related information (ZVEI *packing label logistics**) is gathered at the time it is actually assigned to a customer by logistics.

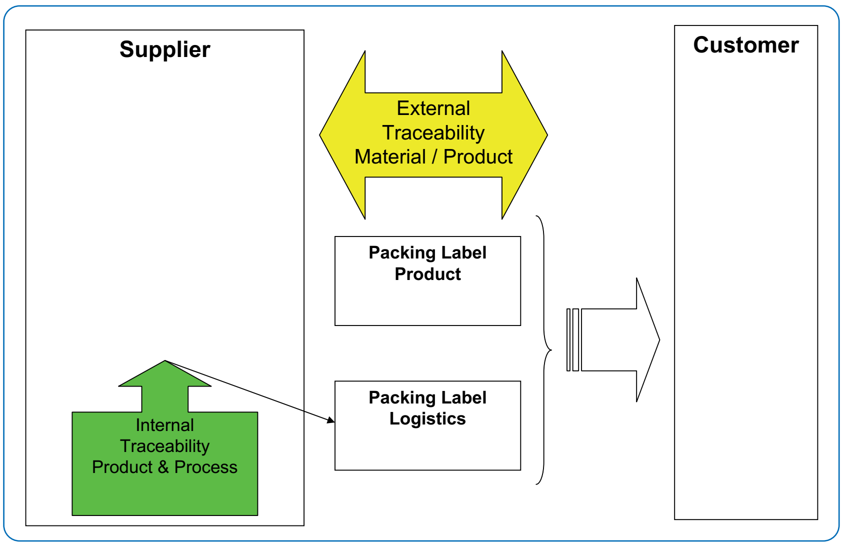


Fig. 5.7:
Transition from internal to external traceability of logistics product identification

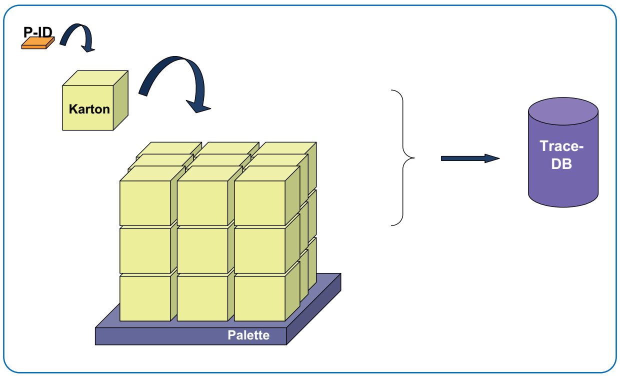


Fig. 5.8: Transition from internal to external traceability in the packing process

Internal traceability systems assign the following data to the product identification (product ID) and store this data in a traceability database (trace DB):

- Identification of the packaging unit, (e.g. box with identification number)
- Identification of the secondary packaging unit, (e.g. pallet with identification number)

The despatching procedures of all internal or external despatch stations can be recorded and assigned to the product in the traceability database of the respective supplier.

5.3 Application of Identification Criteria and Traceability

The objective of internal and external traceability is to ensure the unique identification of potentially defective products and allow them to be traced along the supply and value chain. The precision required for pinpointing (individual components or grey area as a result of bordering time range/*batch**) is subject to the product and the individual agreement between contractor and customer.

If the contractor and customer opt for the identification method specified in <u>*Appendix 2*</u>, it is mandatory to implement the individually agreed level requirement according to <u>*Appendix 2*</u>.

5.4 External Traceability

5.4.1 Identification and Traceability System Levels of External Traceability

Traceability levels of a product are geared to its intended use or the market in which the product is circulated (see *Figure 5.9*).

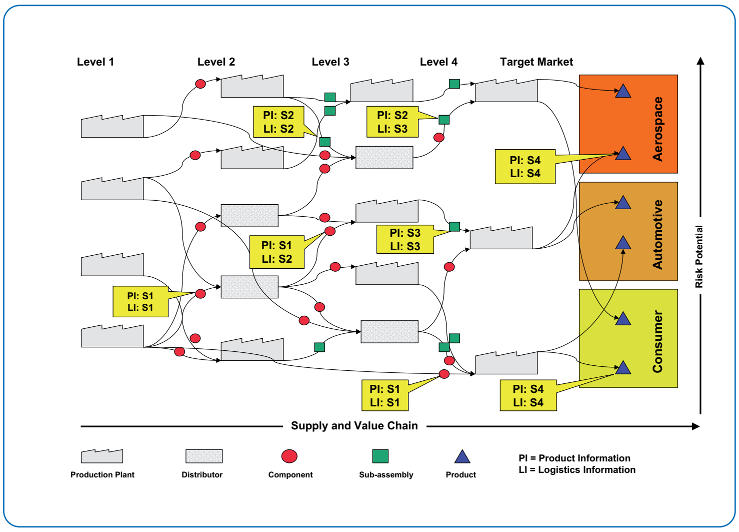


Fig. 5.9: Material supply along the supply chain

When deciding on the depth of the traceability data, the economic aspects are important criteria. An increasing level of detail also involves rising costs for the product marking and identification.

In any case, the category or precision of the traceability system has to be closely agreed between the contractor and customer. The recording and administration of data that is not required has to be avoided. As part of the contractor's internal traceability system, the contractor is obliged to record and keep at hand the external traceability data of the customer and vice-versa.

5.4.2 Level Definition of the ZVEI Label Data Record for External Traceability

The data records are transferred to the packing label product and the packing label logistics. The type of label and format are optional.

The level definitions ensure solely external traceability and its identification.

- ***Packing label product**:** record of all technical product data, information of which is placed by the manufacturer directly on the smallest packing unit.
- ***Packing label logistics**:** record containing information on the product data and, if required, on customer data with regard to the handling of the logistics.

5.4.2.1 Level Definitions of the ZVEI Packing Label Product Data Record (ZVEI-PL)

Definition of Level 1A:

This level specifies the identification required to ensure the external traceability of products using plain text and bar codes, (e.g. Code 39 or Code 128). It applies to products which are not critical for processing and are not subject to any restrictions in terms of storage and expiration date.

Definition of Level 1B:

This level specifies the identification required to ensure the external traceability of products using plain text and 2D-Codes, (e.g. ECC200). It applies to products which are not critical for processing and are not subject to any restrictions in terms of storage and expiration date.

Definition of Level 2A:

This level specifies the identification required to ensure the external traceability of products using plain text and bar codes, (e.g. Code 39 or Code 128). It applies to products which are critical for processing and are subject to restrictions in terms of their storage and/or expiration date.

Definition of Level 2B:

This level specifies the identification required to ensure the external traceability of products using plain text and 2D-Codes, (e.g. ECC200). It applies to products which are critical for processing and are subject to restrictions in terms of storage and expiration date.

Definition of Level 3:

This level specifies the identification and traceability requirements between contractor and customer. It includes the customer-specific requirements that are not mapped in the preceding levels and which are subject to individual agreement. All of this information is optional. It is imperative that the maximum number of level fields not be exceeded.

5.4.2.2 Level Definition of the ZVEI Packing Label Logistics Data Record (ZVEI-LL)

Definition of Level A:

This level specifies the minimum identification requirements of the external logistics traceability on the smallest packaging unit, using plain text, bar codes, (e.g. Code 39 or Code 128) and 2D-Codes.

Definition of Level B:

This level specifies the maximum identification requirements of the external logistics traceability on the smallest packaging unit, using plain text, bar codes, (e.g. Code 39 or Code 128) and 2D-Codes.

Definition of Level C:

This level specifies the identification of the external logistics traceability on secondary packaging units, using plain text, bar codes, (e.g. Code 39 or Code 128) and 2D-Codes.

Definition of Level D:

This level specifies the logistic identification and traceability between contractor and customer. All of this information is optional. It is imperative that the maximum number of level fields not be exceeded.

5.5 Identification Systems along the Supply and Value Chain

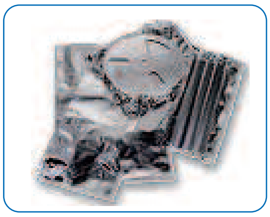
5.5.1 ZVEI Material Label (ZVEI Label)

The ZVEI material label is virtually divided into a data record for the *packing label product** (ZVEI-PL) and a data record for the *packing label logistics** (ZVEI-LL). Its format may vary but it is the content that is relevant, not the format. These codes according to <u>*Appendix 2*</u> must be complied with. Using the information within the cell, it should be possible to create a table comparing the cell information from other systems. Electronic order processing systems should be taken into consideration with regard to the respective exchange of data.

Process and declaration data as well as technical data cannot be transmitted using the ZVEI label. Via the ZVEI label, the contractor receives the trigger impulse to actively request this data. The transmission of any process data (protection of know-how, misinterpretation...) is excluded. The preferred format for the electronic transmission of this data is XML.

Fig. 5.10: Classification of identification at different packing levels

5.5.2 Classification of Identification at Different Packing Levels



1. Level

product packing data record
+
logistics packing data record of level A or level B

2. Level

Homogeneous products

product packing data record
+
logistics packing data record of level C

Mixed products:
logistics packing data record of level C

3. Level

Homogeneous products:

product packing data record
+
logistics packing data record of level C

Mixed products:
logistics packing data record of level C or level D

4. Level

Homogeneous products:

product packing data record
+
logistics packing data record of level C

Mixed products:
logistics packing data record of level C or level D

ZVEI FIELD DEFINITIONS													
		Data Identifier							Level 1A				
ZVEI No.	ZVEI- Track & Trace Information	1D-EAN 8	1D-EAN 13	1D-Code 39	1D-2/5 Interleaved	1D-Code 128	2D-ECC200	Character Length (max.)	Marking	Logo	Plain Text	Bar Code Identification	
1	Unique External Code (Supplier/Manufacturer)												
2	Supplier ID												
3	Purchase Order Number												
4	Item												
5	Customer Part Number												
6	Manufacturer's Name												
7	Manufacturer's Part Number												
8	Revision Level of the Part (Manufacturer)												
9	Part ID Manufacturer or Supplier												
10	Logistics Package ID (Supplier/Customer)												
11	Quantity												
12	Delivery Note Number												
13	Batch ID												
14	Information on the Origin												
15	Best Before Date *												
16	Moisture Sensitive Level (MSL)												
17	Environmental Compliance												
18	Product Approval *												
19	ZVEI Label Type, Level and Bar Code Revision												
20	Additional Information												
21	Kanban Number												
22	Delivery Address (unloading point)												
23	Supplier-Specific Field (free text)												

Fig. 5.11: Example illustrating an identification matrix of the ZVEI label data record

5.5.3 Identification Matrix of the ZVEI Label Data Record (general)

The identification matrix specifies the identification of the smallest packaging unit of a product or material. This identification matrix can be found in *Appendix 2* of this Guideline.

5.6 Internal Traceability: "Best Practice" Example used in the EMS Industry

This Section details internal traceability, using the "Best Practice" example of the EMS industry.

ZVEI Traceability Level Classification - External Traceability																														
ZVEI-PL Packaging Label Product																ZVEI-LL Packaging Label Logistics											Delivery Note			
Level 2A				Level 1B				Level 2B				Level 3				Level A und Level B					Level C			Level D						
Marking	Logo	Plain Text	Bar Code Identification	Marking	Logo	Plain Text	Bar Code Identification	Marking	Logo	Plain Text	Bar Code Identification	Marking	Logo **	Plain Text **	Bar Code Identification	Marking A	Marking B	Plain Text	1D-Code Identification	2D-Code Identification	Marking C	Plain Text	Bar Code Identification	Marking D	Plain Text	Bar Code Identification	Marking	Plain Text	1D-Code Identification	2D-Code Identification

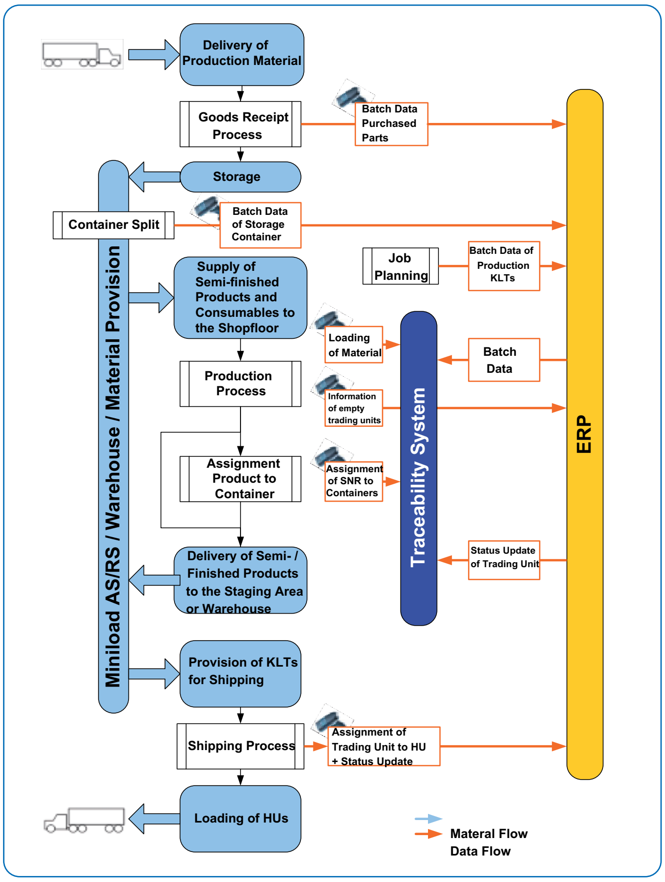


Fig. 5.12: Example: Internal traceability within a company process (EMS

5.6.1 Traceability System Levels

The project team provides the classification of levels on the basis of customer specifications and risk analysis. If requested by the customer, this classification has to be documented in the technical specifications and in the requirements for manufacturing resources.

5.6.1.1 Flow Chart of the Classification of Internal Traceability Specifications in Electronics Productio

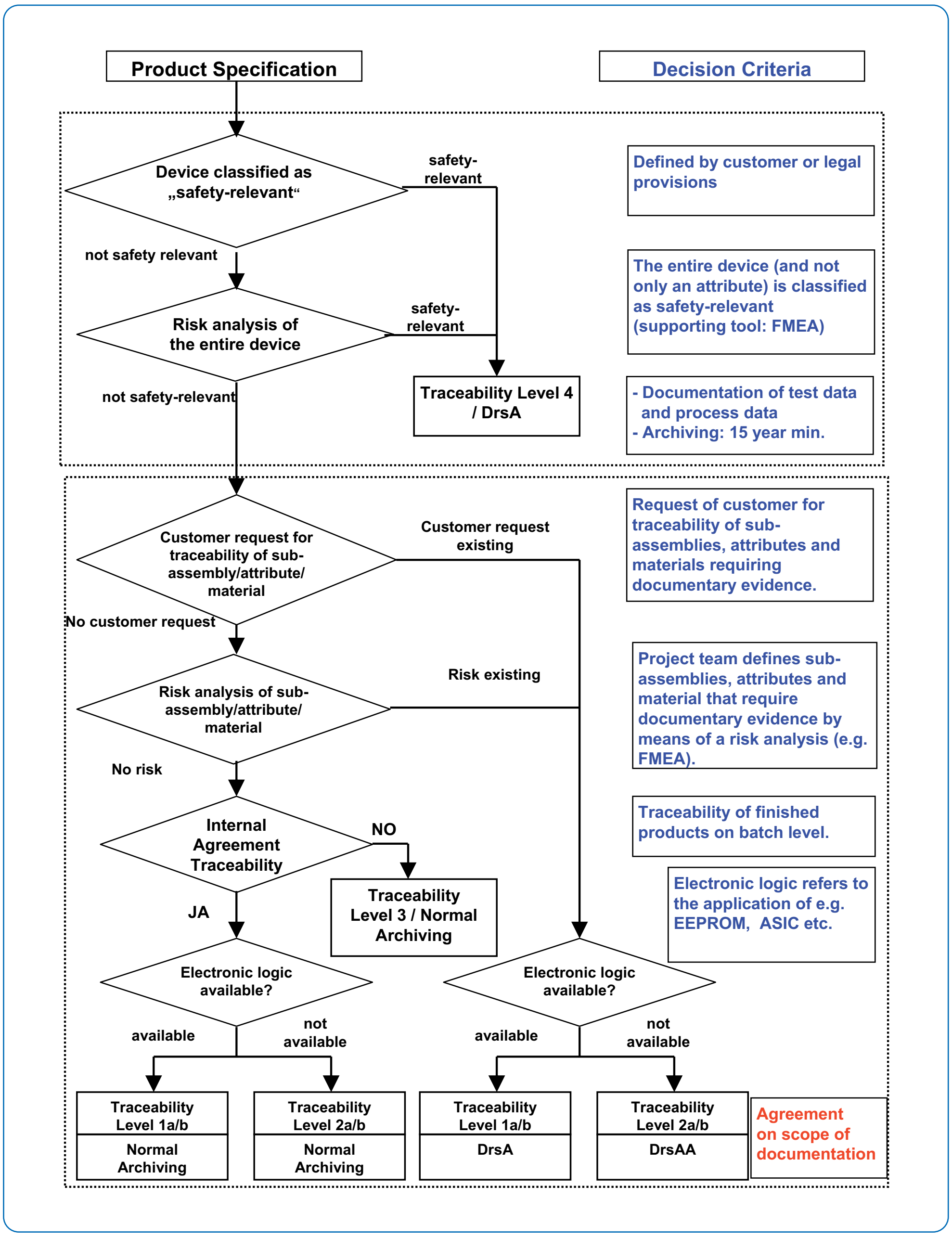


Fig. 5.13: Internal traceability in electronics production

Level 1: Traceability of finished products at *batch** level according to the production date (week) or date code. Storage of job data in the respective trace system.

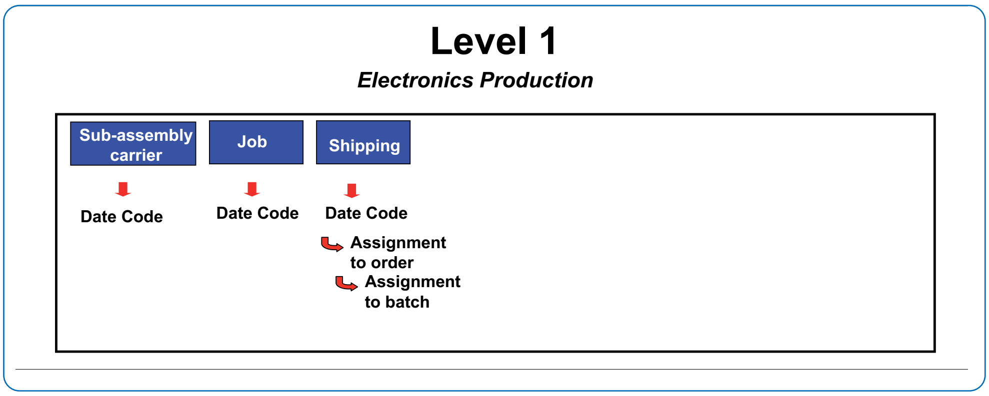


Fig. 5.14: Internal traceability at batch level*

Level 2: *Sub-assemblies** that have no electronic logic and require documentary evidence of specified attributes are traced via documentation. The job data is transferred from the respective systems.

2a: Documentation of test data and interlocking must be defined; the traceability of *sub-assemblies** and interlocking of different versions must be specified.

2b: Documentation of interlocking and test data must be defined; the traceability of *sub-assemblies** and interlocking of different versions must be specified; component traceability (supplier - *batch** level).

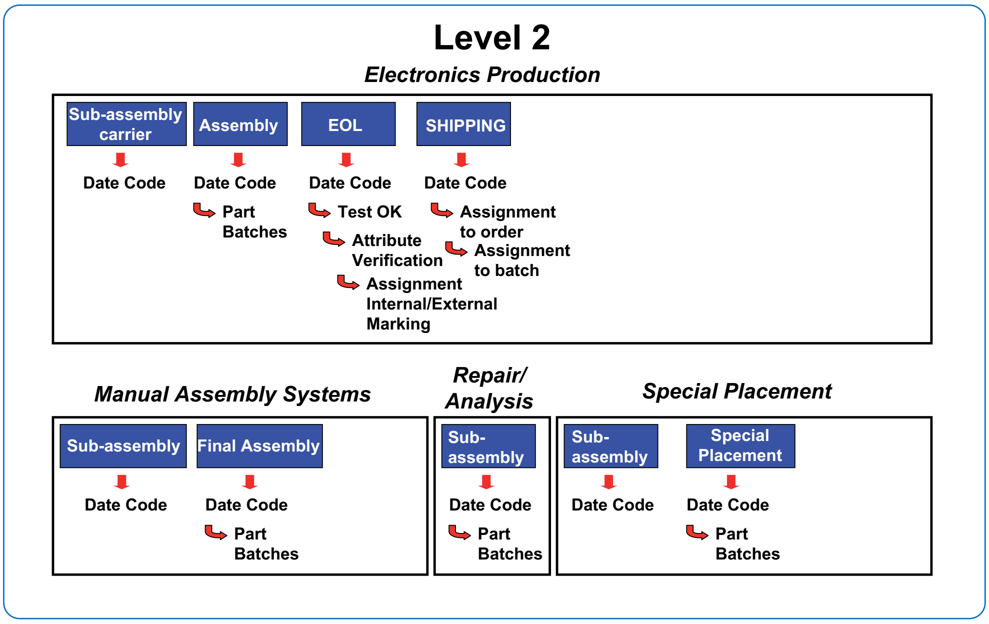


Fig. 5.15: Internal traceability on test data level

Level 3: *Sub-assemblies** requiring documentary evidence of specified attributes and with electronic logic can be traced via this documentation and, if required, via additional documentation. The job data is transferred from the respective system.

3a: Documentation of interlocking and test data must be defined; the traceability of *sub-assemblies** and interlocking of different versions must be specified; transfer of product data.

3b: Documentation of interlocking and test data must be defined; the traceability of *sub-assemblies** and interlocking of different versions must be specified; transfer of product data, component traceability (suppliers - *batch** level).

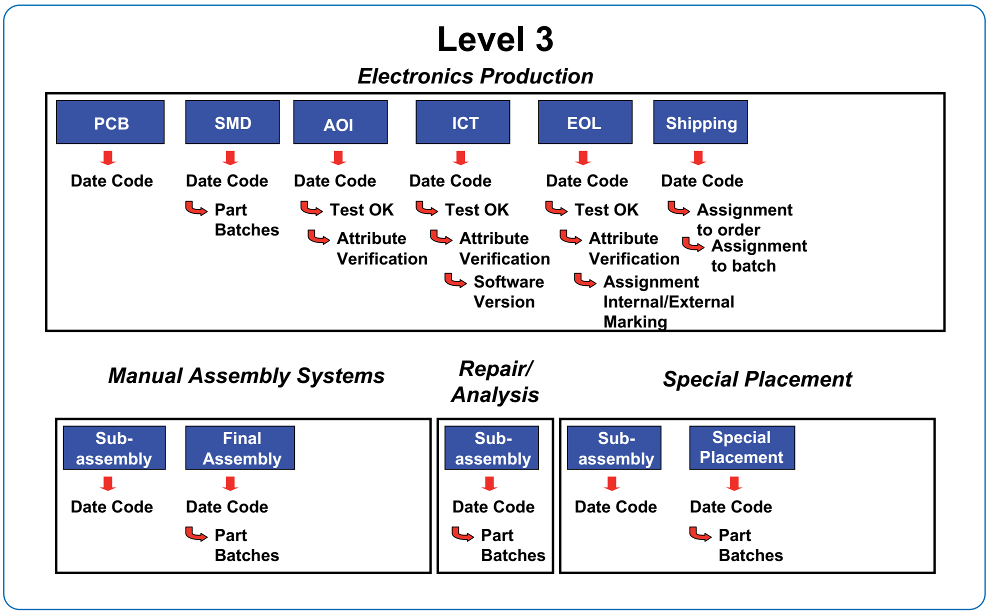


Fig. 5.16: Internal traceability at test data and sub-assembly levels

Level 4: *Sub-assemblies** and equipment classified as safety-relevant. The final product is classified as safety-relevant as soon as a *sub-assembly** or component carries a safety-relevant attribute. The job data is transferred from the respective system.

Documentation of test and process data, interlocking systems, traceability of *sub-assemblies**, interlocking of different versions, transfer of product data, component traceability (at *batch** level and/or unique identification of a component), documentation of all safety relevant components and attributes.

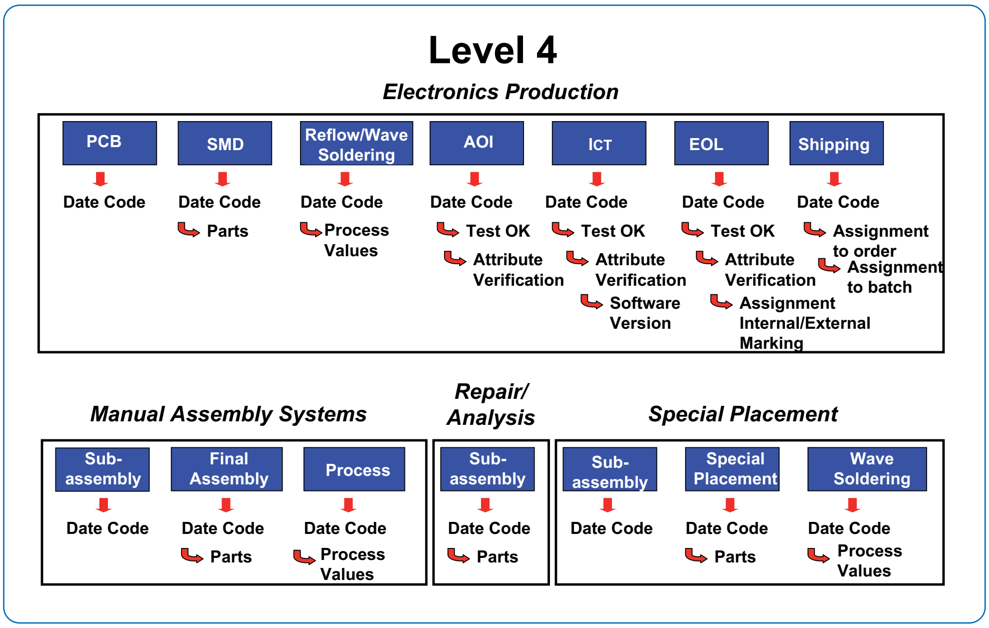


Fig. 5.17: Internal traceability at test data, sub-assembly and product levels

5.6.1.2 Specification of Requirements regarding Internal Traceability for Different Levels

	Requirement	Level 1	Level 2	Level 3	Level 4
1.	Consecutive marking of products		X	X	X
2.	Recording/Saving/Marking of delivered goods in the incoming goods department			X	X
3.	Assignment of material *batches** to sub-assemblies		X	X	X
3a.	Time-based assignment of material *batches** to sub-assemblies	X			
4.	Clear assignment of material to a sub-assembly				X
5.	Interlocking in the production process		X	X	X
6.	Database entry for traceability		X	X	X
7.	Storage of test data OK/NOK		X	X	X
7a.	Storage of attributes requiring documentary evidence		X	X	X
8.	Storage of critical process values				X
9.	Data storage in EEPROM (if available)			X	X
10.	Assignment of a product to a trading unit		X	X	X
11.	Data storage according to the respective agreement after transfer of risk		X	X	X
12.	Storage of repair data		X	X	X
13.	Storage of data on scrapped items				X
14.	etc.				

5.6.2 Process Interlocking

"Process interlocking" has to be considered from the same angle as the previously described "process traceability".

On the basis of process traceability, process interlocking provides the advantage of achieving high quality in every single step of the process

Process interlocking prevents the execution of a subsequent process step for a product or sub-assembly if the qualification results of the product and process are not satisfied. The required qualification criteria and respective results are determined by the process qualification reviewing process capabilities, process stability and tests.

This basic function of process interlocking can be extended. For example, it is possible to use trends and noticeable problems in processes or in test results for process interlocking or to add warnings relating to process interlocking.

In order to use this function, the following requirements have to be met:

- Unique identification of the product or at least of the job prior to production start
- Recording devices at specified locations that are either integrated or manually operated
- Definition of process steps as well as test and decision criteria in the process planning stages

The last point, in particular, requires an in-depth and detailed study of the process technology and/or the respective product and process specifications. Thus "advanced quality planning" is an essential requirement.

With regard to the course of action, the following concept can be taken as a basis (example: automotive environment):

Figure 5.18 shows a production process for electronic sub-assemblies with scan systems at different positions (special parameters) to allow identification and thus process interlocking. In this way, it is ensured that a sub-assembly has successfully passed the preceding process step before being forwarded to the next process step. The criteria for an "OK"-test are stored in the system and depend on the respective requirements or the result of the planning process.

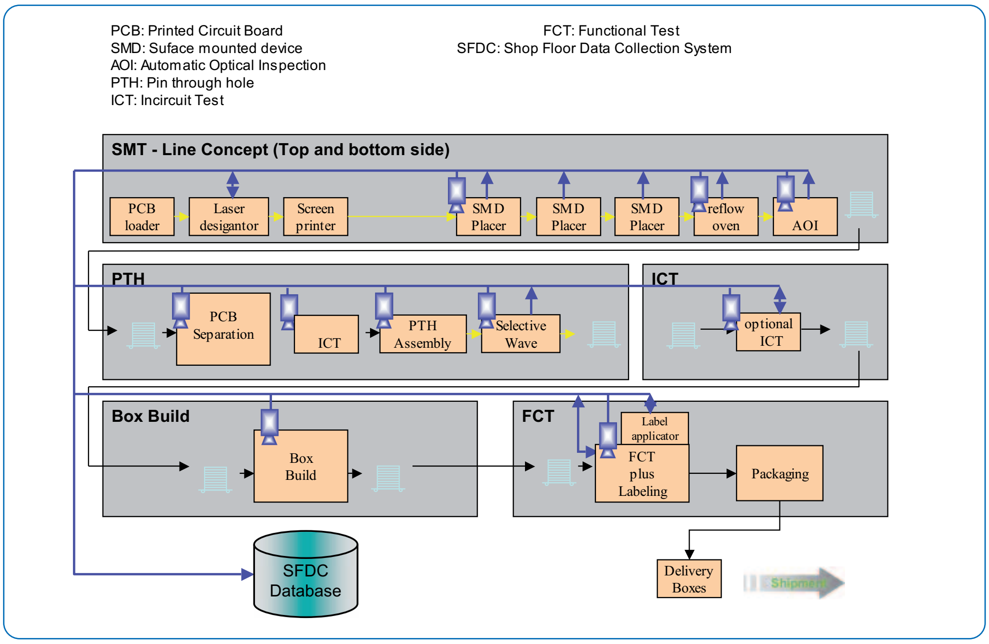


Fig. 5.18: Example of process interlocking in the automotive industry

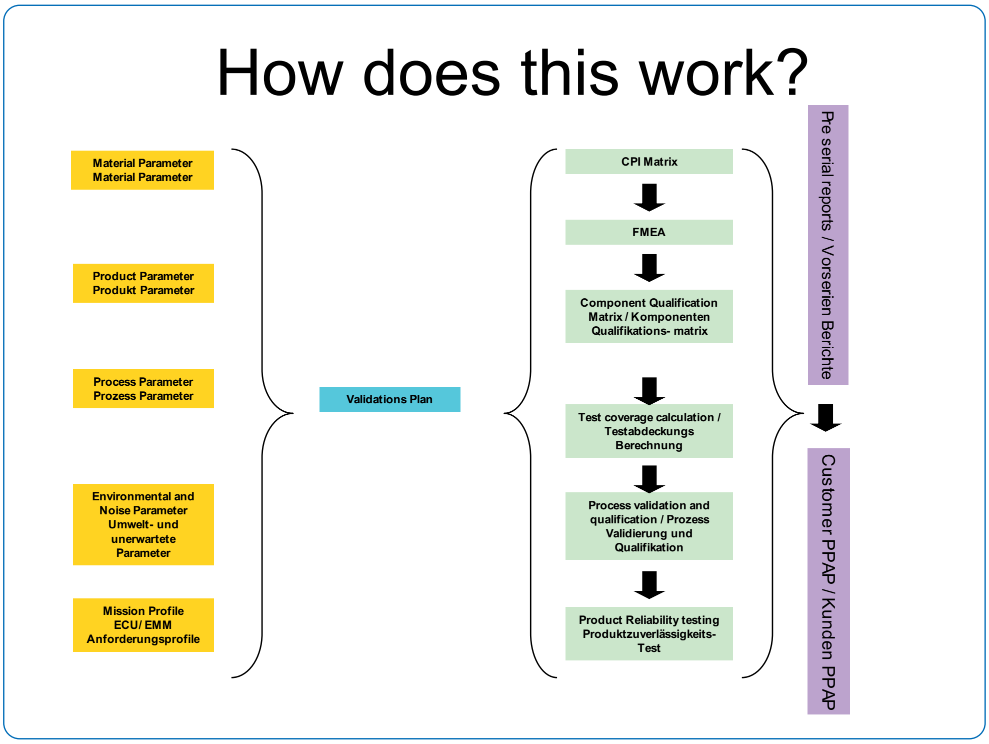


Fig. 5.19: Example of Process interlocking in the automotive industry

Figure 5.19 illustrates a possible advanced planning concept and the relevant input to be considered.

The left-hand side considers the respective parameters and consolidates all values and specifications in a validation plan. On the right-hand side, the "CPI Matrix" reviews and evaluates the interactions of individual parameters of the components with regard to the process. This approach has been described in the handbook "Robustness Validation ECU - ZVEI April 2008 issue". The resulting measured data (see *Appendix 4*) is used to decide on interlocks in individual cases.

The serial process sequence obtained is then guided through specified test gates. The product manufactured "OK" always requires all defined process steps and tests to be completed and to be positively evaluated as specified.

5.6.3 Traceability as an Opportunity for Process Improvement

Following the activities described in the previous chapter, the next step is improvement of the process on the basis of the knowledge and data gained. Process improvement is not directly linked with the interlocking function; however, this function allows timely improvement, thus reducing the number of rejected or defective products.

In general, the term "improvement" represents a broad concept, however it primarily concentrates on the technology or properties of the product to be manufactured. A more detailed account can be found in the ZVEI handbook "Zero Defect" which describes the course of action in detail.

Furthermore, improvement of the process in terms of effectiveness and efficiency has to be verified. This can mean, e.g. the reduction or omission of tests due to the high stability and capabilities of preceding process steps, assuming that data is readily available.

However, quite often it is not sufficient to analyse data trends which, to some extent, used to be the original idea behind traceability. One important restriction is the missing internal *serial number**, thus limiting the analysis to *batch** sizes with no specific results and the data not readily available for reference.

In this connection, it is important to mention the distinction between product traceability as a mere information loop along the supply chain (= external traceability) and the true process traceability (= internal traceability) as a detailed source of data. Expectations of a correspondingly sustainable "improvement" with reference to the "Zero Defect" approach, can only be met if, during processing and based on the results of the *FMEA*, DFM*, DFT**, etc., data is captured, prepared and analysed in a timely manner with the option of a feedback loop.

Figure 5.20 illustrates the possible steps of a process interlocking system along the process value chain in general. The final objective of ensuring the integrity of data captured, featuring interlocking attributes, is improvement of the process to combine "real-time data capture" with the process flow and thus contribute to zero defect production.

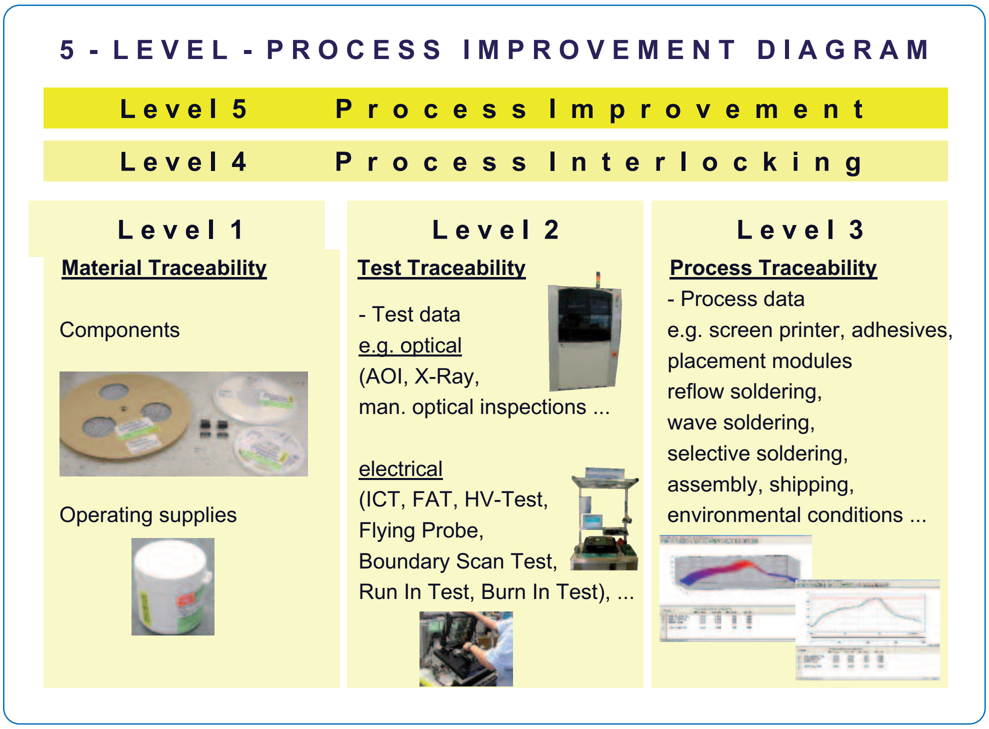


Fig. 5.20: Process improvement diagram

5.6.4 Process Matrix

The process data matrix is a kind of tool, particularly used for product and process traceability. In this context, the entire process flow is compared to a quantity of potential data. Preceding results from *FMEA**, Design for Manufacturability and Design for Test are decisive in the analysis.

The principle of the process matrix is explained in *Figure 5.21*:

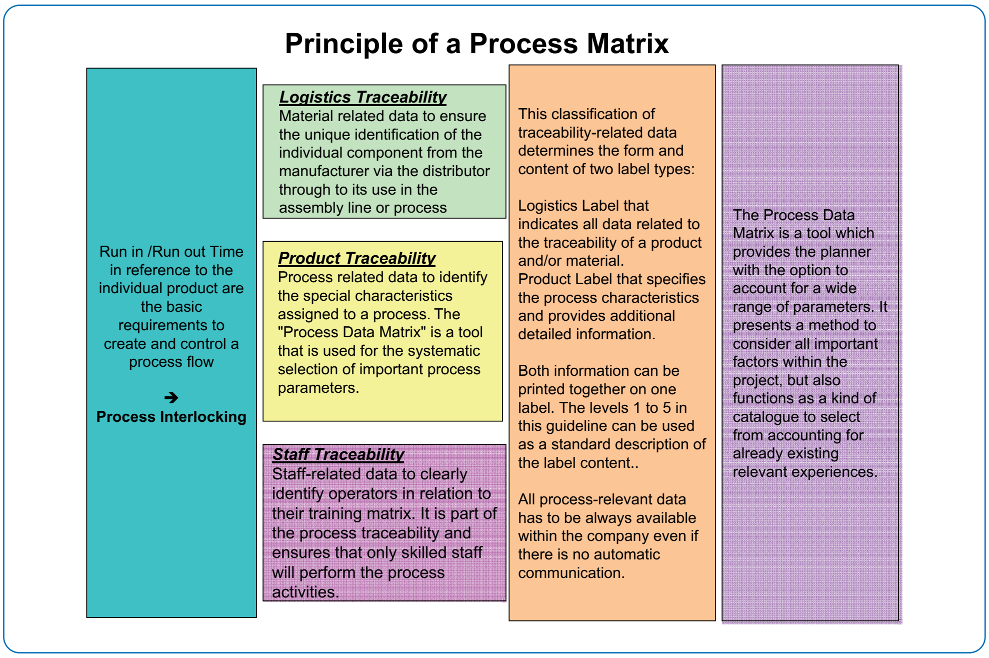


Fig. 5.21: Principle of a process matrix

5.6.4.1 Example of a Process Matrix **

Prozess-Schritt / Process Step	Prozess-Aktivität / Process Activity	Prozess- Charakteristik / Process Characteristics	Wichtigkeit Importance 0 to/bis 3	Messbare Daten / Measurable Data Numerisch Numeric	Messbare Daten / Measurable Data Attributiv Attribute
1	Pasten Druck / Paste Printing	Volumen	3		
2	Reflow Löten / Reflow Soldering	Delta T	2		
3	Nutzentrennen / Depanelization	Stress	3		
4	ICT	Grounding	2		
5	Etc.	Etc.			

Fig. 5.22: Example of a process analysis for solder paste printing

Description of Process Matrix

The column with the process steps contains all the production steps within an organisation. Any indirect production steps, as well as preparatory or follow-up actions, also have to be accounted for. With regard to the process activity, all sub-steps of a machine or functional unit have to be taken into account. The process characteristic then represents the respective individual values or can be used as another sub-group for characterisation. Reference to the storage medium or referral to the information content is also possible here.

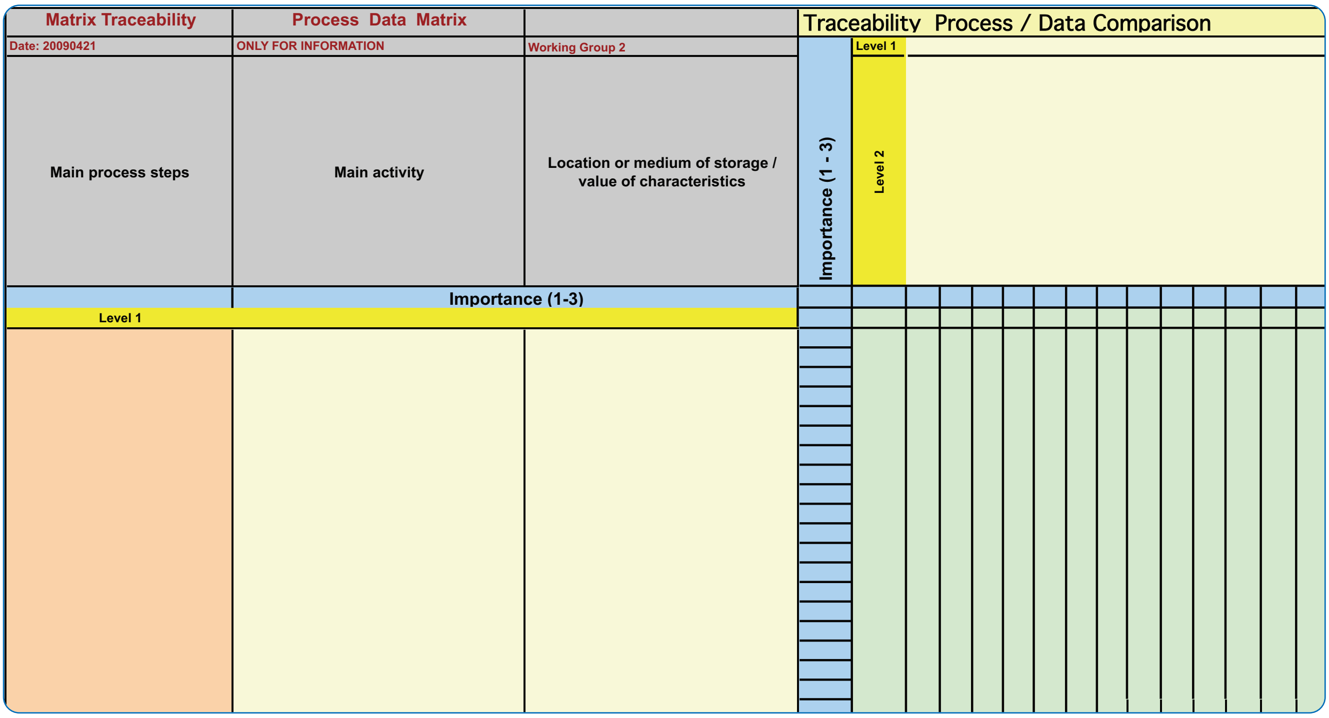


Fig. 5.23: Example of a process matrix for solder past printing

All data types which may influence the product to be manufactured in any way, directly or indirectly, are entered in the horizontal rows.

The relationship to the individual process steps is established later, thus requiring no pre-selection at this point.

The challenge is to use the available results of, e.g. *DFM*, DFT** and *FMEA*,* to create a basis for analysis which provides a basic weighting for any possible combination. In a second step, the individual reference line between process and data character is then evaluated.

As a result of the number of individual evaluations, this structured approach to the process matrix is deliberately used to neutralize all existing streams of thought and evaluations in order to obtain in the end a neutral analysis of the process.

By creating column and row totals and using the weighting as a multiplying factor, it is possible to objectively highlight the most important data for acquisition.

6 International Identification Systems**

6.1 International Standards for Identification Systems**

Appendix 1 provides a list of the international standards referring to identification systems. The purpose of this list is to assist the user in deciding on the necessary and proper systems for his company.

6.2 GS1 Identification Systems**

The GS1 system provides several types of international numeration with three of these identifiers being particularly important for traceability systems:

- The Global Identification Number (GLN, formerly ILN) for the unique, globally exclusive identification of all companies, enterprises and sites
- The Global Trade Item Number (GTIN, formerly EAN) for the unique, globally exclusive identification of articles, sales and trade units as well as services
- The number of the shipping unit (NVE/SSCC, formerly NVE) for the unique, globally exclusive identification of logistics units (international term: Serial Shipping Container Code, SSCC).

6.2.1 Global Location Number GLN

The Global Location Number (GLN) provides a standard means of clearly identifying physical and electronic addresses of companies and organisations, subsidiaries, branches as well as company function-oriented or process-oriented entities within a company, (e.g. warehouse, departments, assembly lines, delivery location). In all applications, this number functions as an access key to the master data stored in the computer system under this code. Its global uniqueness allows a reduction in administrative work, simplifies the information flow and increases the accuracy and speed of administrative processes and data processing. At the same time it provides the prerequisites for efficient shipping, sorting and tracking of goods.

6.2.2 Global Trade Item Number GTIN

The GTIN is a universally unique, exclusive identification number identifying the specific characteristics of an item. It does not contain any "self-explanatory" attributes. Due to its exclusiveness, the GTIN enables the unique marking and identification of trade items and services in data and goods traffic across all business sectors. It refers to the master data of an article (description, weight, size of trading unit, commodity group, etc.) stored in the databases.

The GTIN can be used on all GS1 data carriers (see *Appendix 1, Section 4*) and thus be read automatically. For the purpose of traceability, additional information such as *serial number** or *batch** number, can be encoded, for example, using the GS1 Data Matrix. Linking the GTIN and *serial number*/batch** enables the individual item or *batch** to be identified.

6.2.3 Unique Number of Shipping Unit NVE (SSCC)

In order to track goods, initiate recalls or simply establish a quality management system, the sender, service provider and recipient require a unique identification system identifying every trading unit along the logistics chain. Ideally, this identifier can be applied in the form of a bar code that can be read automatically. All these requirements are met by the unique shipping unit number (NVE/SSCC). It is the prerequisite for the consistent documentation of the manifold functions in terms of storage, stock removal, delivery and acceptance of goods at low personnel cost and provides highly reliable data that is automatically captured. Furthermore, traceability of trade units and consignment trakking of transport units is of great relevance across all industries. This development has been strengthened by numerous legislation.

At the receiving or shipping location, in the material flow control as well as at all other inter- and extra-company points of transfer, (e.g. delivery of goods), the NVE/SSCC supports the traceability of logistics units in conjunction with the automatic data capture using GS1 shipping labels or EPC/RFID. In electronic data exchange, it also serves as reference criteria in many logistics messages, e.g. electronic dispatch advice (DESADV).

7 Traceability Interface Technology in Electronics Production**

7.1 Introduction

This section discusses in detail the actual implementation of traceability according to the recommendations of the ZVEI (hereinafter referred to as ZVEI Recommendations). It is divided into two parts: The Section **Concept and its Explanatory Statements** determines the required interfaces, including the respective criteria, in order to comply with the ZVEI Recommendations in terms of set-up and semantics.

The section dealing with **Practical Implementation** then specifies the concept for connecting processes (machines, manual workstations, etc.). In general, configuration files should be used directly for programming and are thus subject to permanent development. For this reason, they are available as a separate download to this Guideline at www.zvei-traceability.de. The files stored in the download section, as well as the respective documentation detailing the semantics of the individual data fields, provide the basis for the ZVEI Recommendations. The respective samples are from actual industrial applications and are provided as XML files.

Upon reading the recommendations, the programmer should be in a position to implement one of the deployment-ready interfaces for current devices or for the communication between customer and supplier as well as to use the extensions provided allowing for adjustments to meet individual requirements.

7.2 Concept and Justification

In conjunction with the respective software, all production facilities as well as manual workstations and manufacturing cells, etc. are to be referred to as *Equipment* (without loss of generality). Any relevant software components not included in this equipment are to be referred to as *Traceability System*. In this context, it is of no importance whether one or several modules (ERP, MES with or without external traceability software) are actually implemented, as this is characterised by the interfaces below:

- The label described in *Section 5.5ff*.
- The interface **TraceQuery** for internal traceability, as defined in *Section 3.2*, to illustrate, for example, data relating to a specific *serial number**.
- **Equipment Interfaces.** They are the focus of this documentation describing the actual data exchange between production facilities, manual workstations, manufacturing cells, etc. and the traceability system. The processes are monitored and controlled before and after assembling a multipanel using the **control** interface with the relevant protocol being transferred using the **unit_data** interface.

Figure 7.1 illustrates the role of these interfaces. The individual concepts are based on the requirements specified below. This list does not constitute a checklist to be used for the implementation of the ZVEI Recommendations, but rather conveys the principles it is based on.

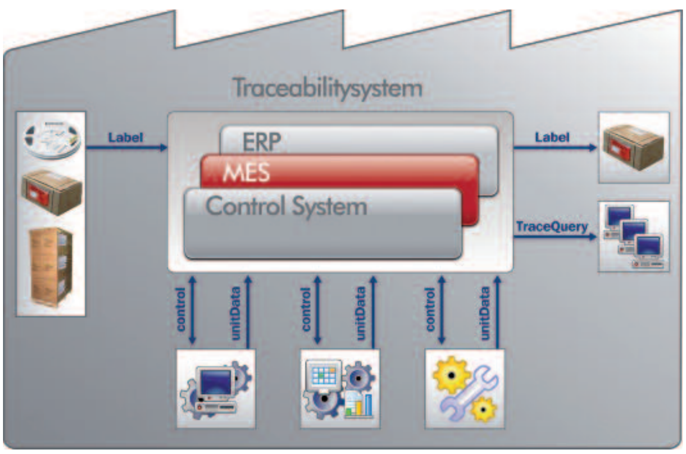


Fig. 7.1: The role of interfaces in a central traceability system

7.2.1 TraceQuery Interface

This interface is used to display the internal traceability data according to *Section 3.2* whereby its implementation is not necessarily limited to a location area or software system. In fact, it might become necessary to exchange data with cooperating companies (so-called "extended workbenches" [subcontractors]) or other company locations. In general, the respective details are then specified according to the individual situation and requirements. At this point, all that has to be considered is that a data exchange over long-distances and between different systems is possible.

The display of all production data relating to an individual *serial number** is a typical example of this interface application. The draft of the ZVEI Recommendations took into account the following requirements:

- The interface must be synchronous.

  Reason: In the event of rework being performed on an assembled panel, it is necessary to perform an online query on the status without losing any time.

- The optional use of this interface by closely cooperating companies should also be provided for, i.e. allow data to be called up in lesser or greater detail via a filter tool.
- The interface must use a tamper-proof protocol.
- The interface must allow for the application of hypermedia systems.
- The interface should use a RESTful [fielding] architecture with particular focus on the following:
- Query option for every batch* or material ID, serial number*, etc. via the individual URI which can be determined on the basis of the supplied data (label, RFID...).
- The protocol must be stateless in nature, (e.g. no cookies or sessions).
- Applications should allow for late binding or loose coupling via hypermedia, i.e. reference to resources without any registration database.
- Smaller enterprises should also be in a position to implement this interface with a minimum of technical equipment required for the interface query.

Implementation can best be accomplished with HTTP, if necessary on SSL (https://...) as a reliable and well-established technology, the more so as these interfaces are generally realised as web interfaces. It should be possible to display this data on current web browsers. The ZVEI Recommendations are limited to the following conditions:

ZVEI Recommendations for TraceQuery

- The entry of the *serial number** MUST provide all processes including the relevant traceability data that have been processed using this *serial number**.
- If the *serial numbers** are aligned due to the product being assembled, packed or the like, the data output MUST also account for the alignment.
- Upon entry of the *batch** number, it MUST be possible to determine the *serial numbers** of all multi-panels which have been populated with components of this *batch** or would have been populated as a result of the GREY AREAS.
- Upon the entry of a *serial number** and allowing for the GREY AREA, it MUST be possible to determine all *batches** which have been used for this *serial number**.
- Upon the entry of a *serial number**, it MUST be possible to determine all processes involved in the production of this *serial number** including the OK/NOK information.
- It MUST be possible to determine all *serial numbers** for predefined process or test characteristics whose values meet the specified conditions.

7.2.2 Equipment Interface Requirements

At present, data is exchanged between shop floor equipment and the traceability system mostly using proprietary protocols. When introducing new equipment, this has to be integrated in the traceability system before use. In the case of similar equipment from different manufacturers, it is possible that data already stored may differ in terms of semantics.

The introduction of the interface presented in this paper should help to improve this situation. The intention is to implement it on an optional basis rather than it being a mandatory feature. Apart from being another step towards the uniformity of data exchange, the interface also presents a communication basis between the manufacturer of the equipment and his respective counterpart. The explicitly predefined files should help to reduce multiple implementations and misunderstandings to a minimum. Furthermore, the specification of a proprietary protocol (including customer-specific adjustments) should be taken out of the hands of the equipment supplier.

ZVEI Recommendations with regard to the semantics of exchanged data for established processes can be found in the download area of www.zvei-traceability.de. An oven, for example, has to provide certain temperature information. It is merely a suggestion that this information be given in degrees Celsius, a special decimal format, with a special coding and written at a certain point in the XML file.

When defining the format, the following requirements were taken into consideration:

- Direct readability of reference data in order to allow for immediate action in the event of breakdowns.
- Possibility to specifically determine and test reference data in terms of form and content.
- Compliance with different industry requirements as well as the possibility of implementation at several levels of detail.
- Product Traceability
  (Transmission of components and used material for the verification and storage of material information).
- Process Traceability including tests, repairs, packaging, shipping, etc.
  (Transmission of process data for verification and storage).
- Traceability for peripheral processes such as the setup of production equipment.
- Expandability to accommodate individual requirements, e.g. placement pressure in assembly processes, which might imply "loose coupling", i.e. avoiding a fixed data scheme with specified function declarations.
- Expandability to include other processes not yet established.
- Expandability to other areas outside the electronics production e.g. mechanical production (milling, non-milling, injection moulding ...).
- Ability to explicitly restrict the capture of data to traceability in order to prevent the mixing of data from different sources, e.g. industrial data acquisition without direct access to process data.
- Breakdown of data according to semantic relations, e.g. processing data of a product with regard to assembly information and process data.
- Ability to use an international character set.
- Performance capability to allow for data exchange at 1/10 seconds per cycle.
- Implementation of a multi-step data exchange, e.g. specification of process parameters or *serial numbers** required for multi-panels, but also for complex dialogues with an arbitrary number of steps, e.g. at repair workstations. The communication direction "traceability system to machine" should replace the operator's input. This requires the bi-directional and synchronous functioning of the interface.
- Process interlocking option, i.e. temporary or final blocking of the product from further processing. The process interlocking forms an integral part of traceability, ensuring the traceability steps from the list above are performed in a specified order and completed with positive results.
- Conformity of expectations, i.e. similar technical approach for similar tasks of successfully established interfaces.

In order to meet all these requirements, the interface has been designed in XSD. The ZVEI Recommendations are: use of XML-compliant format for reference data, thus requiring minimum effort for the control of form and content using existing libraries.

For control purposes, it should be made possible to provide single files of the transferred data. If the equipment control systems do not use XML for data transmission, e.g. due to low resources, it should be made possible for this data to be converted into XML by the target host and for the files to be stored there. There is no mandatory specification regarding the transmission itself. In practice, implementation ranges from the storage of files through to service-oriented architectures across several company locations.

ZVEI Recommendations for control and unit_data

- The interfaces are designed in XML format and are available for download from the website www.zvei-traceability.de. Schemes and examples CAN be used as a basic reference for technical implementation.
- The incorporated data MUST comply with the semantics specified therein.

7.3 Practical Implementation

The equipment interface is divided into two areas which are referred to as control and unit_data: Communication first takes place using control for the purpose of the process control, i.e. transmission of inquiries and replies before and during product processing.

Then the equipment sends the product processing information to the next step up, using unit_data protocol. The details depend on the individual application. In general, the following production types are to be distinguished:

1. Job-related production without serial numbers*.

   Only products of the released job are manufactured.
   The products have no individual *serial number**.

   - Set-up of main equipment (production equipment, manual workstations, assembly lines or manufacturing cells) for a job.
   - Process release for the job.
   - Process interlocking effective for the duration of the job.

2. Job-related production with *serial numbers**:

   As specified in point 1, with the exception of products with individual *serial numbers**.

   - Only products (*serial numbers**) of the released job are manufactured.
   - Set-up of main equipment (production equipment, manual work stations, assembly lines or manufacturing cells) for a job.
   - Process release for a job.
   - Process interlocking effective for the duration of the job and for the valid *serial number**.

3. *Serial number**-related production.

   - Irrespective of their sequence, products (*serial numbers**) that do not necessarily belong to one job are manufactured.
   - Every *serial number** might require the individual set-up of the main equipment (production equipment, manual workstations, assembly lines or manufacturing cells).

Every *serial number** might require the verification of the production processing regulations in the event of process interlocking.

Data is often exchanged in three steps

control (inquiry).

The equipment (or workstation) identifies the product to be processed, e.g. a PCB on the basis of the serial number* or bulk material on the basis of the product number. Then, it sends an inquiry to the traceability system as to whether the product is available for processing or has already been blocked.

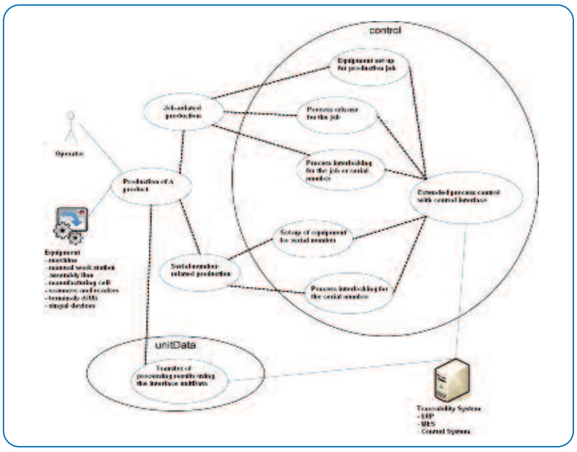


Fig. 7.2: Various production types illustrated as Use Cases.

control (reply).

By means of this data, the traceability system is able to identify the product processing regulations and return them. The reply is issued in the same data format complemented with the processing information. This can also be an interlocking request if the product has not been released for further processing due to a failed test or a missing work step, (e.g. washing). However, the process, too, can request interlocks and their release if the local conditions do not yet comply with the data sent; for example if the oven has not yet reached the specified temperature or a component *batch** is still missing or has not been released for the process.

unit_data.

Upon completion of the processing activities, the protocol data is transmitted:

Examples detailing the data exchange for different equipment types can be found in the download section of www.zvei-traceability.de.

7.3.1 Data Structure

This section explains the structure of the traceability data. The structure of control data as well as unit_data consists of header and equipment data. Header data is similar to the cover sheet of a production job using the same format for all processes. This also includes complex dialogues, e.g. at repair workstations. The data format will be the same, thus allowing for the implementation of numerous workflows which are yet unknown. *Figure 7.3* provides an example of the data structure detailing the data definitions:

Definitions:

- name: depending on the level of precision of the required traceability, this can be either a *serial number** but also a job or job lot.
- equipment: name or unique description of the production facility, manual workstation or manufacturing cell.

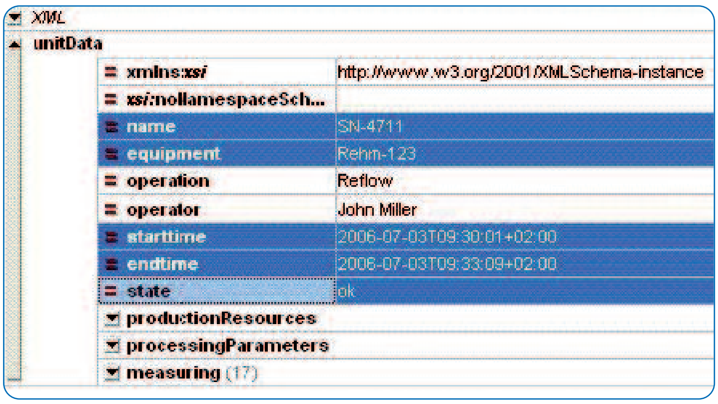


Figure 7.3:

- starttime, endtime: point of time specifying the start or end of the processing activities.
- state: OK or NOK processing status.
- Optional supplementary information, (e.g. plant, operation, material)

Process-specific data is stored in the optional equipment data.

Examples are:

- ProductionResources: tools and additional production resources
- ProcessingParameters: parameters and target values
- Properties: additional properties
- Assembly, disassembly: material consumption, assembly and disassembly information
- Measuring: general measuring data
- Test, diagnosis, repair data
- SubUnit_data: information about workpiece carriers
- Additionalld: additional *serial numbers**
- Actions: activities to be performed
- Setups: target and actual data on setups, material to be assembled

As a result of the consistent data between different processes, this structure provides the user with a clear picture. Furthermore, the same protocol types are used for the data exchange between the traceability system and the machine.

The machine software fills the empty data fields received from the MES and returns a completed form. Normally, the data exchange consists of the following three steps as illustrated in the example of the reflow oven.

7.3.1.1 *Serial numbers**

There are several possibilities to identify multi-panels and their sub-panels. It can occur that these identification numbers cannot be read in some processes. In this case, the *serial number** of the individual sub-panel to be assembled has to be determined using the *serial number** on the panel edge and information from rows and columns. Normally this is done by the traceability system which matches the data sent by the equipment to the *serial numbers**. Another option is for the individual equipment to assign the number, provided it receives the following information for every sub-panel:

- *Serial number**
- The respective identification characteristics of the sub-panel that are recognisable for the equipment. This is normally the position in the processing sequence or its relative position within the multi-panel which requires specification in terms of "front" and "top".

If every piece of equipment processes the sub-panel always in the same order or at least unchanging order, it is possible to administer the technical index together with the respective *serial number**. One advantage is the highly general nature of this approach, allowing for the unique assignment of sub-panels even if these are arranged in an irregular order (similar to a natural stone wall). Relevant work instructions must ensure that the settings of the involved equipment provide for consistent processing sequences: if the traceability system only receives data relating to the processing sequence, it will not change the data assignment, e.g. if the equipment has changed the processing sequence from N-shape to Z-shape.

In the case of several multi-panels, the sub-panels are arranged in a matrix providing for the assignment of every panel to a row and column. In this case, this data should be used for the identification instead for the processing sequence. In line with the processing sequence, the numbering method as well as the definition of "front" and "top" have to be determined.

7.3.2 Grey Areas relating to *Batches**

Depending on the production process, it is not always possible, and in many cases not necessary, to exactly identify the processed *batches** with regard to the specific reference and sub-panel. The decisive factor is rather the exact determination of the number of possibly used *batches**, which usually comprises one *batch**, or, for a short period of time, even two *batches**. In the event of a faulty *batch**, the relevant data allows for the identification of all affected multi-panels, which may include (some) multi-panels assembled with other (OK) *batches**. These issues may arise in the following situations:

- For example, the operator splices SMD (*batch**) carriers or several *batches** are on one component reel, but the location of the splicing point is either imprecise or impossible to detect.
- Pick-and-place data do not match exactly. This does not refer to the rejection of components but the machine "stores" the components and places them on the next multi-panel.
- Autolink - The machine changes the used *batch** automatically if the same item has been mounted at several workstations with the mounting process providing the data.
- Only the data of the mounting process (with or without assignment of loading point <-> reference, i.e. without any bill of material in worst case) is available, no protocol per PCB. This can be the case with old machines or manual workstations.
- Configuration errors, e.g. in the event of equipment with multiple tracks, multi-panels, top and bottom placements, the "well" intended, exact tracking might be even more fatal than the simple tracking using the mounting data and the grey area of a few panels.

The requested accuracy can refer to the *batch** (pick) and the multi-panel (place) and thus requires the following specification:

Specification of the Assignment Accuracy of *Batches**

- What grey areas are possible, i.e. is it possible for a certain component (for a limited period of time) to originate from several *batches**?
- Which processes require a break-down into sub-panels and/or reference data?

8 Technical Identification Systems**

8.1 Information Content for Material Identification

The following information is required for the identification of material and/or the smallest packaging unit:

The trace information must be machine-readable and positioned so that it can be recognised. The information that has been defined and identified for the respective level should also be displayed in human-readable form according to the table in *Appendix 2*. This will ensure the visual identification in case the bar code is damaged. Further information on the respective technical identification systems can be found in *Appendix 2*.

8.2 Identification Codes

8.2.1 Bar Code Symbology

Figure 8.1 and *Figure 8.2* illustrate the difference between the different bar codes:

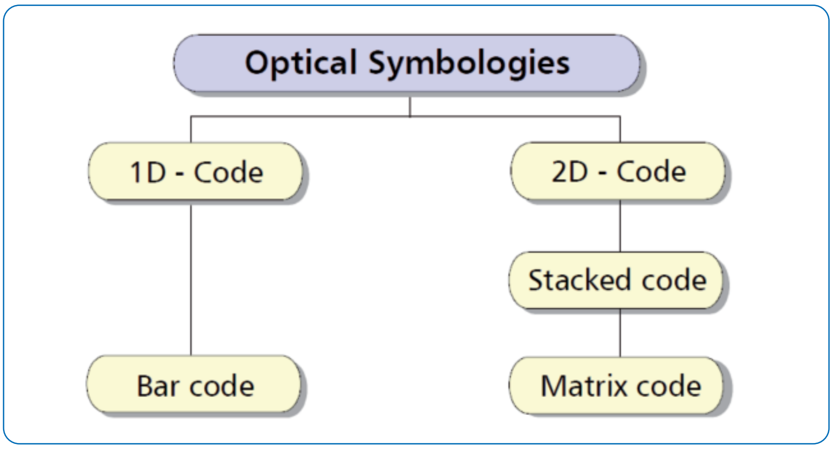


Fig. 8.1: Classification of bar codes

8.3 Printing Methods

8.3.1 Thermal Transfer Printing

Thermal transfer printers are suitable for label printing, providing strong colour contrast against white label paper and allowing plain texts to be read easily.

Selecting the right label material and appropriate thermal transfer ribbon is imperative for the successful application of this printing method, as the label will have to pass undamaged through all processing steps, e.g. reflow and wave soldering or mechanical cleaning.

8.3.2 Direct Laser Printing

Direct laser printing enables the permanent and direct marking of material. The costs of this technology depend on a combination of various factors including the original purchase costs as well as costs for operating the printer. One disadvantage is the difficult production of contrast ratios requiring the application of appropriate reading systems.

In the meantime, two different marking methods have established themselves: the CO_2 laser for changing the colour of the solder mask or other suitable surfaces; the YAG laser for the application of markings using the engraving technology.

8.3.3 Inkjet Technology

Markings are applied with the so-called continuous inkjet technology that uses black or colour pigment inks, e.g. white in combination with the appropriate solvents. With single-colour printing and subject to the colour combination, the production of contrast ratio is also difficult, requiring suitable reading systems. Two-colour inkjet printing, e.g. black print on white field markings considerably improves the contrast ratio and the readability with standard readers.

	Manufacturing	Couriers	Food & Beverage	Retail	Electronic Industry	Automotive Industry	Pharma-ceutical Industry	Transport and Logistics
1D-Codes	Yes	Yes	Yes	Yes	Yes	Odette	Yes	Yes
2/5 Interleaved	✓	✓	✓	–	✓	–	✓	✓
Code 39	✓	✓	–	–	✓	✓	–	✓
Code 128	✓	✓	–	–	✓	–	✓	✓
EAN 128	✓	✓	✓	✓	✓	–	–	✓
EAN	✓	–	✓	✓	✓	–	–	✓
RSS	–	–	✓	✓	✓	–	✓	–
2D-Codes	Yes	Yes	No	No	Yes	No	Yes	Yes
Stacked Codes	No	No	–	–	No	–	Yes	Yes
Code 16K	–	–	–	–	–	–	–	
Code 49	–	–	–	–	–	–	–	–
Codablock	–	–	–	–	–	–	✓	–
PDF 417	–	–	–	–	–	–	–	✓
Matrix Codes	Yes	Yes	–	–	Yes	–	Yes	Yes
Data Matrix	✓	–	–	–	✓	–	✓	–
Maxi Code	–	✓	–	–	–	–	–	✓

Fig. 8.2: Survey of bar code types

8.4 Readers

8.4.1 CCD Scanner or Laser Scanner

In comparison with camera systems, this type of reading system is less expensive but in most cases only suitable for reading one-dimensional (high-contrast) bar codes.

8.4.2 Camera Systems

Depending on the chosen device, these reading systems normally require higher investments. Camera systems are universally used for reading 1D bar codes as well as recognising 2D bar codes. The print contrast ratio is less important as it can be adjusted using different lighting techniques.

8.5 Interactions of Marking Methods and Reading Systems

The choice of marking method inevitably influences the choice of reading system. A low-contrast marking method must be compensated for by a high-quality reading system.

One prerequisite for the choice of marking methods is the stability of the material used during the different processing steps, e.g. reflow or wave soldering, cleaning as well as possible coating processes.

Process reliability is decisive for the combination of these systems.

8.6 Electronic Systems

8.6.1 RFID

The application of RFID (Radio Frequency Identification) allows to be stored storing of data on an electronic data carrier. The data is exchanged between the data carrier and reading device using electromagnetic fields. The RFID tag contains two parts, i.e. an electronic circuit and an antenna. The energy required is either

- transmitted by on-board batteries for active and semi-active tags or
- generated by the electromagnetic fields of the reader.

RFID tags are relatively resistant to any damage or contamination and have the advantage of being fairly unsusceptible to other interferences such as water, temperature or humidity. There are two different types of tags:

- Read-only tags
- Read/Write tags

8.6.2 Current Storage Media

One option is to write traceability-relevant data in memory components, (e.g. EEPROM or flash memories). Memory components may also be used for the identification of printed circuit boards marked with a unique identification number by the manufacturer. This kind of identification is used if the original marking is no longer visible or if an additional safety feature is required.

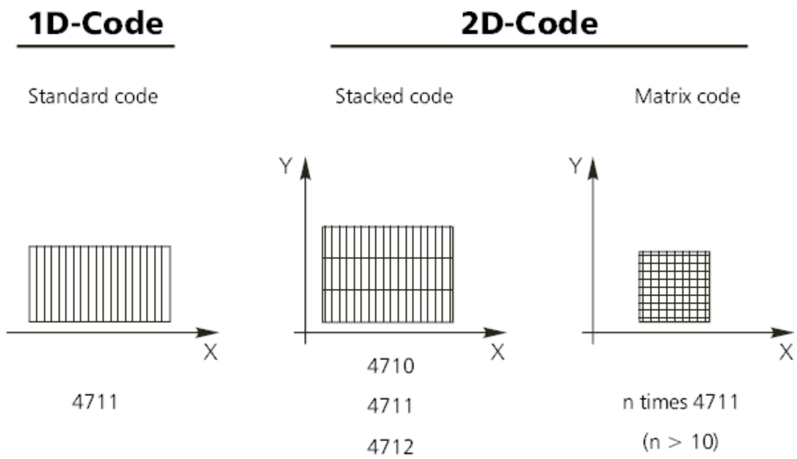
9 Bibliography

- Reference to the Handbook of Distribution
- Handbook "Robustness Validation"
- Brochure on "Zero Defect Strategy" (ZVEI)
- JEDEC Standard JSTD-020

Appendix 1 – International Identification Systems and Codes**

Reproduction of the following texts and illustrations by courtesy of Datalogic GmbH.

1. Optical Symbologies



The contents of the code are to be considered as examples

1.1 Bar Code

The bar code is a binary code comprising a field of bars and gaps arranged in parallel configuration. The sequence, made up of wide and narrow bars and gaps, can be interpreted numerically and alphanumerically using a code table. It is read by optical laser scanning (CCD line or laser diode), i.e. by the different reflection of a laser beam from the black bars and white gaps. Therefore, current reading systems require a high contrast ratio in order to ensure the process-reliable reading of the code. Even partial damage to this code, e.g. one bar missing, will render the bar code unreadable for the reading systems.

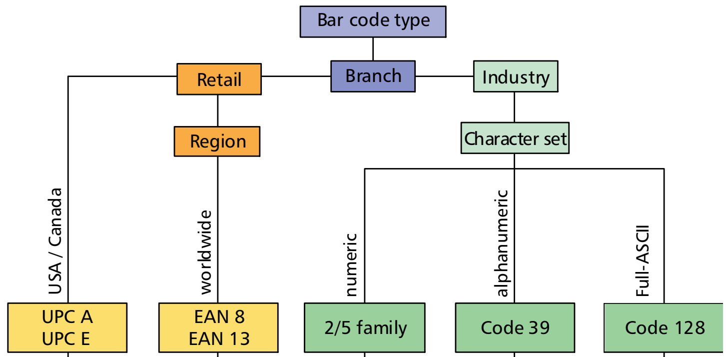
1.1.1 Terminology - 1D-Code

Terminology - 1D-Code

Bar	The dark element in a bar code symbol.
Space	The light element between two bars in a bar code symbol.
Intercharacter gap	In a discrete code, the space between the last bar of a character and the first bar of the following character.
Element	A bar or space in a bar code symbol.
Module	The narrowest element in a bar code. Wide bars or spaces are expressed in multiples of modules.
X Dimension	The width of the narrowest element.
Quiet zone	Also called light margin or clear area. It is the blank area before and after the bar code. The quiet zone Q is necessary for setting the reading direction of the bar code symbol. The quiet zone must be at least 10 times the X dimension with anyway a minimum width of 2.5 mm. In scanner applications involving a large depth of field, the quiet zone must be wider: Q = 15 times the X dimension with a minimum width of 6.5 mm.
Bar Code Symbol	The bar code symbol consists of a bar code, two quiet zones and an interpretation line. The bar code includes encoded data, which consists of coloured bars and blank spaces. The quiet zone precedes and follows the bar code and helps to identify the object to decode. The interpretation line is positioned below the bar code and translates all of the encoded information into readable characters.

1.1.2 Criteria for Choosing 1D-Codes

Criteria for Choosing 1D-Codes



	UPC A / UPC E	EAN 8 / EAN 13	2/5 family	Code 39	Code 128
Number of characters	10 digits	10 digits	10 digits	43 digits	128 ASCII
Self-checking	Yes	Yes	Yes	Yes	Yes
Variable code length	No (6, 12)	No (8, 13)	Yes/No, only even numbers	Yes	Yes
Ex. of application	Trade (POS)	Trade (POS)	Transport	Electronics	Logistics

1.1.2.1 Interleaved 2 of 5

Bar Codes — Code 2/5 Interleaved

General Numeric code consisting of the digits 0 to 9. The code contains two wide bars and three narrow bars, two wide spaces and three narrow spaces.
Code Ratio n: narrow element: wide element n = 1 : 2 to 1 : 3.
Where the narrow element measures less than 0.5 mm, the ratio between the narrow and the wide element is as follows n = 1 : 2.25, to max. n = 1 : 3.
The first digit is represented by 5 bars, the second by the spaces immediately following the bars of the first digit.

Advantages High information density.
Example: 2.7 mm per digit with minimum bar width
X = 0.3 mm and Code Ratio n = 1 : 3.
Self-test capability.

Disadvantages All the spaces contain information and therefore the print tolerance is low, i.e. ± 10%.

Printable with Offset, typographical and copperplate, flexography, computer-controlled printing and phototypesetting.

Code Chart	*Character*	*B1*	*B2*	*B3*	*B4*	*B5*
	1	1	0	0	0	1
	2	0	1	0	0	1
	3	1	1	0	0	0
	4	0	0	1	0	1
	5	1	0	1	0	0
	6	0	1	1	0	0
	7	0	0	0	1	1
	8	1	0	0	1	0
	9	0	1	0	1	0
	0	0	0	1	1	0
	Start	0	0			
	Stop	1	0			
	B1 - B5	= Bars/Spaces 1 - 5				
	1	= Wide bar/Space				
	0	= Narrow bar/Space				

1.1.2.2 Code 39:

Bar Codes — **Code 39**

General Alphanumeric code consisting of the digits 0 to 9, 26 letters, and 7 special characters. Each character contains 9 elements, 5 bars and 4 spaces. 3 elements are wide and 6 are narrow, except for the display of the special characters. The space between the characters does not contain information.
Code Ratio n: narrow element : wide element
n = 1 : 2 to 1 : 3.
Where the narrow element measures less than 0.5 mm, the ratio between the narrow and the wide element is as follows:
narrow element : wide element
n = 1 : 2.25, max. n = 1 : 3.

Advantages Alphanumeric representation.

Disadvantages Low information density.
Example: 4.8 mm per digit with the following minimum bar width
X = 0.3 mm and Code Ratio n = 1 : 3.
Low information density (± 10%).

Printable with Offset, typographical and copperplate printing, flexography, computer-controlled printing and phototypesetting.

Code Chart	*Character*	*B1*	*S1*	*B2*	*S2*	*B3*	*S3*	*B4*	*S4*	*B5*
	1	1	0	0	1	0	0	0	0	1
	2	0	0	1	1	0	0	0	0	1
	3	1	0	1	1	0	0	0	0	0
	4	0	0	0	1	1	0	0	0	1
	5	1	0	0	1	1	0	0	0	0
	6	0	0	1	1	1	0	0	0	0
	7	0	0	0	1	0	0	1	0	1
	8	1	0	0	1	0	0	1	0	0
	9	0	0	1	1	0	0	1	0	0
	0	0	0	0	1	1	0	1	0	0
	A	1	0	0	0	0	1	0	0	1
	B	0	0	1	0	0	1	0	0	1
	C	1	0	1	0	0	1	0	0	0
	D	0	0	0	0	1	1	0	0	1
	E	1	0	0	0	1	1	0	0	0
	F	0	0	1	0	1	1	0	0	0
	G	0	0	0	0	0	1	1	0	1
	H	1	0	0	0	0	1	1	0	0
	I	0	0	1	0	0	1	1	0	0
	J	0	0	0	0	1	1	1	0	0
	$	0	1	0	1	0	1	0	0	0
	/	1	1	0	1	0	0	0	1	0
	K	1	0	0	0	0	0	0	1	1
	L	0	0	1	0	0	0	0	1	1

1.1.2.3 Code 128:

Bar Codes — **Code 128**

General Code 128 is able to encode the complete set of ASCII characters without using combinations of characters (see Code 39 and 93). However, this does not mean that Code 128 can directly represent the complete set of ASCII-characters. This is only possible by utilising 3 character subsets, A, B and C, which are used according to the problem to be solved. The different subsets can also be mixed. In order to encode the complete set of ASCII characters, the start characters A or B must be used in connection with the special characters of Code 128.
Each character consists of 11 modules, divided into 3 bars and 3 spaces. Bars always comprise an even number of modules (even parity), while spaces contain an odd number of modules. The stop character is an exception as it includes 13 modules, i.e. 11 modules and one 2-module boundary bar.

Advantages Representation of the complete set of ASCII characters. High information density.

Disadvantages Low print tolerance. The code uses four different bar or space widths. The complete set of ASCII characters cannot be represented with one character set.

Printable with Offset, typographical, copperplate, thermal transfer printing and phototypesetting.

EAN 128

Logistics code used in trade applications. Differently from Code 128, the start character consists of the combination of Start A, Start B or Start C with the character FNC1. (For any further information, please address yourself to the National EAN organizations and their local associations).

1.2 EAN Bar Code:

Bar Codes — **EAN**

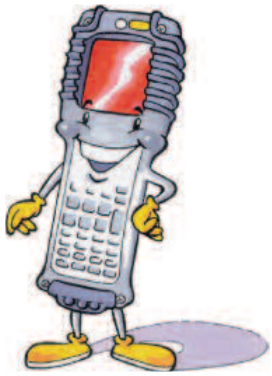
General Numeric code consisting of the digits 0 to 9. Each character includes 11 elements. All bars and spaces contain information. Only 8 or 13 characters can be represented.

Advantages High information density in 10 different sizes.

Disadvantages Very low tolerance.

Printable with Offset, typographical, copperplate and laser printing, thermal printing starting from one set size only, phototypesetting.

Code Chart Full details about EAN and EAN 128 are available at the National EAN organizations and their local associations.



1.2.1 EAN 128 General Information

Bar Codes — **EAN128**

General

All application Identifiers and their data contents can be represented with the UCC/EAN 128 bar code. A subset of Code 128, EAN 128 is characterised by the use of a special character, i.e. the function character 1 (FNC 1)1), which directly follows the start character at the beginning of the bar code symbol. The use of this combination of characters is reserved to the International Article Numbering Organization, EAN, and to the American Uniform Code Council, UCC.

Three parameters have to be taken into consideration when defining the maximum length of an EAN 128 symbol: the number of encoded characters, the physical length of the code, which depends on the enlargement factor, the number of data characters encoded excluding auxiliary and symbol characters.

The maximum length of any EAN 128 symbol must respect the following limits:

- The physical length cannot exceed 165 mm including quiet zones.
- The maximum number of encoded data, including application identifiers, is 48, excluding auxiliary and symbol check characters. 1) If FNC1 characters are used as separator characters, they can be considered as data characters.

Including all auxiliary and symbol check characters, the EAN 128 symbol should not exceed 35 symbol characters. Otherwise, there is the risk that an inadequate enlargement factor must be chosen for major company applications.

Moreover, it has to be considered that in code set C a certain number of data characters can be encoded using a smaller number of symbol characters.

1.3 Stacked Code PDF 417

Stacked Codes — PDF 417

General PDF 417 is a version of the stacked code based on its own structure. Characters are encoded in so-called "codewords". Each codeword consists of 17 modules each containing 4 bars and 4 spaces. The code can contain up to 1,108 bytes and can use between 3 and 90 rows. Each row contains two row indicators, which show the position of the row on the symbol. At least two codewords are used as check characters, which guarantee the reliability of the whole message. Error correction can be carried out by means of further codewords (up to 512) and takes place in different steps.

Advantages Very compact code. Flexibility in adapting information to a given area thanks to variable height, width and information density. All the reading devices on the market can be used. Only the decoder must be expanded, as PDF 417 is based on its own very complex structure. However, the decoder must read the whole code before transmitting the contents of the code to the central computer system.

Disadvantages The stacked structure must be respected during the reading.

Printable with Printing methods using the necessary driver software.

Stacked Codes — PDF 417

Principle PDF 417 usually has the following structure:

	R1						R1	
	R2						R2	
Start	R3						R3	Stop
	Rn					C1	Rn C2	

Rx = Row indicator/Left and Right
Cx = Check character/Code word

Example: PDF 417

2. Two-dimensional Codes

The demand for more information in less space has led to the development, standardisation and increasing use of two-dimensional bar codes. These can be either a series of stacked one-dimensional codes (stacked codes) or a matrix of black dots. Matrix codes offer a much higher data density in the marking area than one-dimensional codes

In general, these codes are read by camera-based systems and decoded by software. In contrast to hardware-based 1D readers, camera-based systems provide more options in terms of image processing. The optical requirements for the bar code, for example, print contrast ratio or distortions, are therefore much lower than for a one-dimensional code.

As a result of the mathematical encoding, most 2D bar codes are equipped with an efficient error correction algorithm.

The reading of two-dimensional bar codes is also easier. In contrast to one-dimensional bar codes, it is not necessary to align the positions of the bar code and the reader.

2.1 Data Matrix

Matrix Code — **Data Matrix**

General Data Matrix is a version of the Matrix Code and has two main subsets, ECC 000-140 and ECC 200. ECC 200 is the latest revision recommended for use. Data Matrix has the variable square size of a matrix. Symbols can range from a size of 10 x 10 to 144 x 144, thus representing either 8x18 or 16x48 symbol elements in a squared area. Data Matrix can encode 2,334 ASCII characters (each consisting of 7 bits), 1,558 expanded ASCII characters (each consisting of 8 bits), or 3,116 digits in their largest size. A horizontal and a perpendicular border form a corner, which indicates the orientation of the reading. The opposite sides of the square present alternating light and dark square elements, used to indicate both position and size of the symbol. The information density amounts to 13 characters to 100 mm².

Advantages Very compact code. It is very reliable, as it includes a very powerful error-correction algorithm, Reed Solomon. Contents can be reconstructed by means of a minimum amount of error-correction characters even if up to 25% of the whole code is damaged.

Disadvantages Only readable with image-processing devices.

Printable with All printing methods equipped with the necessary printer drivers.

AIM International Symbology Specification - Data Matrix.

Element

- Square-shaped cell that encodes one bit of the binary data "0" or "1"
- Consistent size throughout the symbol
- Element colour depends on the colour of the finder pattern (the colour of the binary number "1" is identical to the L-pattern colour)
- The code resolution is determined through the number of elements.

Quiet Zone

- Minimum of one element width (1x) on each side of the symbol

Finder Pattern

- Timing pattern: Two borders consisting of alternating dark and light cells. These are used for synchronization in the evaluation process.
- L-Shape: Border composed of two solid adjacent lines forming a " L"

Data Region

- The area inside the finder pattern.
- Contains the data and error correction codewords.

Definiti… …ication Matrix - Appendix 2

Unique E… (Supplier/…	…o the unique identification of the s… …nber to be agreed between the sup…
Supplier I…	…o the individual supplier number ass…
Purchase…	…to the order number that has beer… …fy a purchasing transaction.
Item…	This field refers to the item in the individual purchase o…
Customer…	…the material number assigned by th…
Manufact…	…the name of the manufacturer. It ma… …go if it is suitable for the code.
Manufacturer's Number	This field refers to a number or name that is used by… the identification of the manufacturer.
Manufacturer's Part Number	This field refers to the unique identification number of…
Ordering Code	This field refers to the mutually agreed unique code… used in order transactions between customer and supp…
Revision Level of the Part (Manufacturer)	This field refers to the revision status of the part at the…
Revision Level of the Part (Customer)	This field refers to the revision level of the ordered par… end.
Part ID Manufacturer or Supplier	This field refers to the individually unique order identi… ambiguous key to be used for ordering parts with rega… specified attributes.
Logis… …plier/Cus…	This field provides information on the number of packa… …ry note.
Number…	…refers to the number of packaging units withi…
Quantity…	…refers to the quantity of the smallest packagi…
Quantity…	…refers to the quantity unit of the smallest pack…
Shipping…	
Deliver…	
Batc…	***…erm for batch identification.***
Batch N…	…o the unique identification of a batch o…
Manufac…	…to the manufacturing date on the s… …unit. The date format "YYYY-MM-DD" should be used… manufacturing date. If there are several date codes, a… printed on the smallest packaging unit.
Serial Number	This field refers to the unique, individual number that… every part. It has to be unique per supplier.
Batch Counter per Smallest Packaging Unit	----

3. RFID

The application of RFID (Radio Frequency Identification) allows data to be stored on an electronic data carrier. The data is exchanged between the data carrier and reading device using magnetic or electromagnetic fields. The RFID tag contains two parts, i.e. an electronic circuit and an antenna. The energy required is either

- transmitted by on-board batteries for active or semi-active tags or
- generated by electromagnetic fields from the reading device.

RFID tags are relatively resistant to any damage or contamination and have the advantage of being fairly unsusceptible to other interferences such as water, temperature or humidity. There are two different types of tags:

- Read-only tags
- Read/Write tags

The customer must approve the use of an RFID prior to its application. The application of RFIDs should be reviewed as part of a cost-benefit analysis.

3.1 EPC Gen2

The main characteristics of the Gen2 technology are:

- UHF operating frequency 860 - 960 MHz
- Passive transponder
- Read speed: up to 500 tags per second
- Write speed: 7 to 15 tags per second
- Password protected "KILL" function

The current version of the Gen2 Specification, Version.1.2.0, is 100% compatible to ISO 18000-6C.

4. GS1 Data Carriers

4.1 GS1 Application Identifier Concept

The GS1 system accommodates several standardised data carriers as well as the data encoding system for data carriers. The data encoding system is necessary to distinguish between GS1 Identifiers and any supplementary information. Against the background of traceability, the Application Identifier System plays a major role as it determines which data is to be encoded in the bar code as well as the encoding method.[1] This means: Regardless of the data carrier technology, the data content always has to be processed in the same way.

The Application Identifier System makes it possible to encode several layers of data, i.e. linked, in a symbol and for these to be read correctly. Each application identifier serves as an indicator of the information associated with it, i.e. the data element and the respective format, thus providing the basis for error-free information processing. The GS1 Application Identifier System provides an extremely high level of interpretation reliability and data quality thanks to the use of the ISO/IEC 15418 standard and the integration of protected GS1 bar code symbologies.

The GS1 data carrier portfolio includes linear bar code standards, 2D symbologies as well as the RFID Standard Electronic Product Code (EPC).

4.2 EAN-13 Bar Code[2]

The EAN-13 bar code is the longest-established of the GS1 data carriers and can be found on almost every consumer product. This code integrates solely the 13-digit GTIN, i.e. it does not encode any other GS1 identification key or any supplementary information of any kind. The great advantage of the EAN-13 bar code, in addition to its ubiquity, is its omni-directional scanning capability, thus rendering this bar code indispensable for items that are sold through traditional points of sale (PoS).

The key advantages of the EAN-13 bar code are as follows:

- Widely used, hence indispensable for points of sale (PoS)
- Omni-directional scanning capability, thus making it quick and efficient to scan
- Can be read using commercially available laser scanners
- Worldwide GS1 symbology protection (ISO/IEC 15420)
- Linear symbology

4.3 GS1-128 Bar Code

The GS1-128 bar code was launched in the 1990s, primarily as a logistics process automation tool. The Application Identifier System was also originally developed for the same purpose. When used in combination with the Application Identifier System, the GS1-128 standard provides greatest flexibility to this day. Together, they allow for the use of unique identification schemes such as the NVE (SSCC) and the GTIN, as well as for adding other information in a standardised manner to the packaging or product bar code.

In this context, the GS1 logistics label, which is used to identify shipping units in accordance with the GS1-128 standard, should also be mentioned. The GS1-128 bar code has gained considerable importance in recent years, particularly owing to the increasing requirements of more stringent product traceability.

[1] Owing to its specifications, the EAN-13 bar code is designed in such a way that it "only" encodes the 13 digit GTIN and does not allow for the integration of additional information.

[2] Since the EAN-8 bar code is essentially the same as the EAN-13 bar code, only the latter standard will be discussed in the following.

The main advantages of the GS1-128 bar code are as follows

- It is widely used
- Flexibly configurable data content
- Encoded alphanumerically
- Worldwide symbology protection (ISO/IEC 15417)
- Symbology more compressed compared to other linear symbologies such as code 39
- Linear symbology
- The use of a system internal check digit algorithm makes the standard extremely reliable
- Can be read using commercially available laser scanners

4.4 GS1 DataMatrix

The GS1 DataMatrix is the newest among the GS1 codes. Unlike the GS1 symbologies discussed above, the GS1 DataMatrix comprises a two-dimensional symbology that allows a large amount of information to be encoded in a very compact space. However, since the GS1 DataMatrix is a two-dimensional code, it is only compatible with applications whose reading systems support two-dimensional scanning. Based on state-of-the-art image processing technologies, these systems are also referred to as image scanners. The advantage of two-dimensional scanners is that they can read both linear and two-dimensional codes, and thus are compatible with all applications.

A particularly noteworthy feature of the GS1 DataMatrix is that it can be used to apply markings directly to products, components, or individual parts. In such cases, the code is applied to the surface by means of etching, lasing, or the like, thus creating a code that remains indelible, even under harsh operating conditions. For example, the code can be used under oily conditions in industrial applications or for long-term applications that are exposed to the elements. In other words, the GS1 DataMatrix is suitable for applications whose conditions do not allow for the use of conventional bar codes.

The main advantages of the GS1 DataMatrix are as follows:

- Extremely compact and space-saving symbology
- High data capacity (up to 3116 characters can be encoded)
- Holds up well when exposed to printing and reading processes
- Integrates the Reed Solomon auto-correction mechanism
- Resistance to harsh operating environments
- Suitable for direct marking of parts
- Worldwide GS1 symbology protection (ISO/IEC 16022)

4.5 EPC/RFID

The RFID data carrier is not a bar code but rather a transponder (a microchip connected to an antenna), which stores the relevant data and transmits it to the reader by means of electromagnetic waves. Since radio frequency waves can pass through solid materials, the transponders may be shielded in adhesive film or integrated directly into the packaging or the product. RFID tags and reader communicate without being in each other's line of sight.

The electronic product code (EPC) is a standardised serialised marking system that applies to products, packages locations or other objects. Transponders in accordance with the EPC-Standard can then be placed on the products or the other objects. The base is again the GS1 identification keys GLN, GTIN and NVE/SSCC.

EPC/RFID is GS1's offer to industry to successfully realise the "Internet of Things" based on latest-generation data carrier technologies. Toward this end, the EPC Information Service (EPCIS) has been developed and implemented simultaneously with the EPC transponder.

RFID technologies and the EPC offer the following advantages:

- Ultra-rapid time-saving reading process
- No line-of-sight connection with the reader necessary
- A highly reliable solution, even when exposed to extreme environmental conditions such as cold weather or direct sunlight
- Virtually unlimited memory capacity is achievable (albeit at the expense of reading times)
- Continuous product data entry capabilities allow continuous inventorying
- Transparent and real-time information exchange through EPCIS
- Bulk data capture capabilities allow fast capture and a high level of detail
- Exact product localisation and optimised timing for product delivery processes
- Readily expandable identification functions allow for additional functionalities such as electronic article surveillance or sensor applications

5 Standards referring to Identification Systems

Standard	Title of Standard
ISO 445	Pallets for materials handling — *Vocabulary*
ISO/IEC 646	Information processing — ISO 7-Bit coded character set for information interchange
ISO 830	Freight containers — Vocabulary
ISO 15394	Packaging — Bar code and two-dimensional symbols for shipping transport and receiving labels
ISO/IEC 15415	Information technology — Automatic identification and data capture techniques — Bar code symbol print quality test specification – Two-dimensional symbols
ISO/IEC 15416	Information technology — Automatic identification and data capture techniques — Bar code print quality test specification - Linear symbols
ISO/IEC 15417	Information technology — Automatic identification and data capture techniques — Code 128 bar code symbology specification
ISO/IEC 15418	Information technology — Automatic identification and data capture techniques — GS1 Application Identifiers and ASC MH 10 Data Identifiers and maintenance
ISO/IEC 15424	Information technology — Automatic identification and data capture techniques — Data Carrier Identifiers (including Symbology Identifiers)
ISO/IEC 15434	Information technology — Syntax for high-capacity automatic data capture (ADC) media
ISO 15394	Packaging — Bar code and two-dimensional symbols for shipping, transport and receiving labels
ISO/IEC 15459-1	Information technology — Unique identifiers — Part 1: Unique identifiers for transport units
ISO/IEC 15459-2	Information technology — Unique identifiers — Part 2: Registration procedures
ISO/IEC 15459-3	Information technology — Unique identifiers — Part 3: Common rules for unique identifiers
ISO/IEC 15459-4	Information technology — Unique identifiers — Part 4: Unique identifiers for supply chain management
ISO/IEC 15459-5	Information technology — Unique identifiers — Part 5: Unique identifiers for returnable transport items (RTIs)
ISO/IEC 15459-6	Information technology — Unique identifiers — Part 6: Unique identifiers for product groupings
ISO/IEC 15961	Information technology — Radio frequency identification (RFID) for item management — Data protocol: application interface
ISO/IEC 15962	Information technology — Radio frequency identification (RFID) for item management — Data protocol: data encoding rules and logical memory functions
ISO/IEC 15963	Information technology — Radio frequency identification for item management — Unique identification for RF tags
ISO/IEC 16022	Information technology — Automatic identification and data capture techniques —Data Matrix bar code symbology specification
ISO/IEC 16388	Information technology — Automatic identification and data capture techniques — Code 39 bar code symbology specification
ISO 17363	Supply chain application of RFID — Freight containers
ISO 17364	Supply chain application of RFID — Returnable transport items (RTIs)

Standard	Title of Standard
ISO 17365	Supply chain application of RFID — Transport units
ISO 17366	Supply chain application of RFID — Product packaging
ISO 17367	Supply chain application of RFID — Product tagging
ISO/IEC 18000-3	Information technology — Radio frequency identification for item management — Part 3: Parameters for air interface communications at 13,56 MHz
ISO/IEC 18000-6	Information technology — Radio frequency identification for item management — Part 6: Parameters for air interface communications at 860 MHz to 960 MHz
ISO/IEC 18000-7	Information technology — Radio frequency identification for item management — Part 7: Parameters for active air interface communications at 433 MHz
ISO/IEC 18004	Information technology — Automatic identification and data capture techniques — Bar code symbology– QR Code
ISO/IEC TR18046	Information technology — Automatic identification and data capture techniques — Radio frequency identification device performance test methods
ISO/IEC 19762-1	Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 1: General terms relating to AIDC
ISO/IEC 19762-2	Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 2: Optically readable media
ISO/IEC 19762-3	Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 3: Radio frequency identification (RFID)
ISO/IEC 19762-4	Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 4: General terms relating to radio communications
ISO 21067	Packaging — Vocabulary
ISO 22742	Packaging — Linear bar code and two-dimensional symbols for product packaging
ISO/IEC PRF TR24720	Information technology — Automatic identification and data capture techniques — Guidelines for direct part marking (DPM)
ISO/IEC TR24729-1	Information technology — Radio frequency identification for item management — Implementation guidelines — Part 1: RFID-enabled labels and packaging
ISO/IEC TR24729-2	Information technology — Radio frequency identification for item management — Implementation guidelines — Part 2: Recycling and RF tags
ISO 28219	Packaging — Labelling and direct product marking with linear bar code and two-dimensional symbols
ISO/IEC 29133	Information technology — Automatic identification and data capture techniques — Quality test specification for rewritable hybrid media data carriers
ISO/IEC 29158	Information technology — Automatic identification and data capture techniques — Direct Part Mark (DPM) Quality Guideline
ISO/IEC 29160	Information technology — Automatic identification and data capture techniques — RFID Emblem

Appendix 2 – Identification Matrix ZVEI Label

ZVEI FIELD DEFINITIONS												
		Data Identifier							Level 1A			
ZVEI No.	ZVEI- Track & Trace Information	1D-EAN 8	1D-EAN 13	1D-Code 39	1D-2/5 Interleaved	1D-Code 128	2D-ECC200	Character Length (max.)	Marking	Logo	Plain Text	Bar Code Identification
1	Unique External Code (Supplier/Manufacturer)						3S	30A	NA			
2	Supplier ID						V	10A				
3	Purchase Order Number						K	18A				
4	Item						4K	20A				
5	Customer Part Number						P	35A				
6	Manufacturer's Name						42P	13A	S	S-OR	S-OR	NA
6.1	Manufacturer's Number						12V	13A				
7	Manufacturer's Part Number						1P	35A	S		S	1D
7.1	Ordering Code						31P	35A				
8	Revision Level of the Part (Manufacturer)						27P	14A				
8.1	Revision Level of the Part (Customer)						2P	14A				
9	Part ID Manufacturer or Supplier						41P	30A	S		S	1D
10	Logistics Package ID (Supplier/Customer)						1J.. 2J	18A				
10.1	Number of Packages						8Q	12N				
11	Quantity						Q	18N	S		S	NA
11.1	Quantity Units						3Q	3A	S		S	NA
11.2	Shipping Weight						4Q	12N				
12	Delivery Note Number						16K	12A				
13	Batch ID								S			
13.1	Batch No. 1 / Lot No. 1						1T	17A	S-OR		S-OR	1D
13.2	Batch No. 2 / Lot No. 2						2T	17A	S+		S+	1D
13.3	Batch No. 3 / Lot No. 3						4T	17A	S+		S+	1D
13.4	Manufacturing Date 1 (Date Code 1)						16D	8N	S-OR		S-OR	1D
13.5	Manufacturing Date 2 (Date Code 2)						18D	8N	S+		S+	1D
13.6	Manufacturing Date 3 (Date Code 3)						19D	8N	S+		S+	1D
13.7	Serial Number						S	20A	S-OR		S-OR	1D
13.8	Batch Counter per Smallest Packaging Unit						20T	1N				
14	Source of Origin											
14.1	Country of Origin						10L	----	S		S	NA
14.2	Country of Final Assembly						10V	20A				
14.3	Customs Tariff Number						13K	15A				
15	Best Before Date *						12D	8N				
15.1	Expiration Date						14D	8N				
16	Moisture Sensitive Level (MSL)						Z	2A				
17	Environmental Compliance											
17.1	EU RoHS Compliance *						2E	1A	[S]	[S-OR]	[S-OR]	NA
17.2	AECEIP (CN-RoHS) ***						3E	1A				
17.3	ELV 2000/53 ***						4E	1A				
17.4	GADSL Available ***						5E	1A				
17.5	Contains SVHC						6E	1A	[S]		[S]	NA
17.6	SVHC Authorised ***						7E	1A				
17.7	CofC-Certificate of conformity ***						8E	1A				
17.8	Halogen Free						9E	1A				
18	Product Approval *											
18.1	CE						10N	2A	[S]	[S]		NA
18.2	UL						11N	10A	[S]	[S-OR]	[S-OR]	NA
18.3	AECQ 10x/200						12N	----				
18.4	AIRWORTHINESS						13N	----				
18.5	MIL qualified						14N	----				
19	ZVEI Label Type, Level and Bar Code Revision						12S	14A	[S]		[S]	1D
20	Additional Information						20P	60A				
21	Kanban Number						15K	30A				
22	Delivery Address (unloading point)						2L	12A				
23	Supplier-Specific Field (free text)						1Z	60A	[S]		[S]	[1D]

ZVEI Traceability Level Classification - External Traceability

ZVEI-PL Packaging Label Product: Level 2A				Level 1B				Level 2B				Level 3				ZVEI-LL Packaging Label Logistics: Level A und Level B					Level C			Level D			Delivery Note			
Marking	Logo	Plain Text	Bar Code Identification	Marking	Logo	Plain Text	Bar Code Identification	Marking	Logo	Plain Text	Bar Code Identification	Marking	Logo **	Plain Text **	Bar Code Identification	Marking A	Marking B	Plain Text	1D-Code Identification	2D-Code Identification	Marking C	Plain Text	Bar Code Identification	Marking D	Plain Text	Bar Code Identification	Marking	Plain Text	1D-Code Identification	2D-Code Identification
NA				NA				NA									[S]	[S]						[S]						
																S	S	S			S	S		[S]			[S]	[S]	[S]	[S]
																[S]	S	[S]						[S]			S	S	[S]	[S]
																[S]	S	[S]						[S]			S	S	[S]	[S]
																	S	S						[S]			[S]	[S]	[S]	[S]
S	S-OR	S-OR	NA	S	S-OR	S-OR	2D	S	S-OR	S-OR	2D	[S]															S	S	NA	NA
												[S]																		
S		S	1D	S		S	2D	S		S	2D	[S]									[S]	[S]		[S]			S	S	NA	NA
																					[S]									
												[S]									[S]									
												[S]									[S]									
S		S	1D	S		S	2D	S		S	2D	[S]															S	S	[S]	[S]
																					S	S		[S]						
																					S	S		[S]						
S		S	[1D]	S		S	2D	S		S	2D	[S]				[S]	[S]	[S]			S	S		[S]			S	S	[S]	[S]
S		S	[1D]	S		S	2D	S		S	2D	[S]				[S]	[S]	[S]			S	S		[S]			S	S	[S]	[S]
																											[S]			
																[S]	S	[S]			S	S		[S]			S	S	[S]	[S]
S				S				S				[S]															S	S	[S]	[S]
S-OR		S-OR	1D	S-OR		S-OR	2D	S-OR		S-OR	2D	[S]															S-OR			
S+		S+	1D	S+		S+	2D	S+		S+	2D																			
S+		S+	1D	S+		S+	2D	S+		S+	2D																			
S+		S+	1D	S-OR		S-OR	2D	S+		S+	2D	[S]															S-OR			
S+		S+	1D	S+		S+	2D	S+		S+	2D																			
S+		S+	1D	S+		S+	2D	S+		S+	2D																			
S-OR		S-OR	1D	S-OR		S-OR	2D	S-OR		S-OR	2D	[S]															S-OR			
												[S]																		
S		S	NA	S		S	NA	S		S	NA	[S]															[S]	[S]		
												[S]					[S]	[S]						[S]						
												[S]															[S]	[S]		
												[S]																		
												[S]																		
[S]		[S]	[1D]					[S]		[S]	[2D]	[S]															[S]			[S]
																											[S]	[S]		[S]
[S]	[S-OR]	[S-OR]	[1D]	[S]	[S-OR]	[S-OR]	[2D]	[S]	S-OR	S-OR	2D	[S]																		
[S]		[S]	NA	[S]		[S]	[2D]	[S]		S	2D	[S]															[S]	[S]		[S]
												[S]																		
												[S]																		
[S]	S		NA	[S]	[S]		NA	[S]	S		NA	[S]																		
[S]	[S-OR]	[S-OR]	NA	[S]	[S-OR]	[S-OR]	[2D]	[S]	[S-OR]	[S-OR]	[2D]	[S]																		
												[S]																		
[S]	[S]	[S]	NA					[S]	[S]	[S]	NA	[S]																		
[S]	[S]	[S]	NA					[S]	[S]	[S]	NA	[S]																		
[S]		[S]	1D	S		S	2D	S		S	2D	[S]																		
								[S]		[S]	[2D]	[S]					[S]	[S]						[S]			[S]	[S]		[S]
																	[S]	[S]						[S]						
																					[S]	[S]		[S]			S	S		
[S]		[S]	[1D]	[S]		[S]	[2D]	[S]		[S]	[2D]						[S]		[1D]	[2D]										

List of Abbreviations used for the Identification Matrix ZVEI Label - Appendix 2	
NA	Not Applicable
S	Standard (MANDATORY)
S-OR	Logical disjunction (OR) in the respective data group
S+	Conjunction (AND) in the respective data group
..A	Alphanumeric character length
..N	Numeric character length
*	Material-dependent
**	Individual agreement
***	Field definitions for later use
[…]	Optional fields, subject to individual agreement

- The stored data identifiers are proposals based on ANSI MH10.8.2. An application for these has been lodged with the ANSI Committee.
- The symbol size of the DMC, i.e. the sum of all required data fields, should be limited to a maximum DMC of 80x80 with a module size of at least 0.3 mm
  (e.g. 80 x 0.3 mm = 2.4 cm + 0.2 cm quiet zone adds up to a DMC module of 2.6 x 2.6 cm).
- If only the ASCII characters 0 to 255 are used, the maximum number of characters to be mapped is limited to 453 characters (see also ISO/IEC 16022, page 16).
- If only numeric ASCII characters are used, a maximum of 912 characters can be mapped.
- Special characters are not considered in this context as these are generally limited in number and can be omitted from the calculation.

DMC Example 1: Product Label 1B

Maximum number of characters set in the numeric and alphanumeric fields + identifier + separator "@" between the fields

249	A/N characters including numeric characters
45	A/N character identifier
23	A/N character separator @
317	maximum number of characters

When alphanumeric characters are used and the maximum field length of 299 characters is reached, then a 72 by 72 DCM can be used.

DMC Example 2: Logistics Label 2D

Maximum number of characters set in the numeric and alphanumeric fields + identifier + separator "@" between the fields

250	A/N characters including numeric characters
30	A/N character identifier
19	A/N character separator @
299	maximum number of characters

When using alphanumeric characters and the maximal field length of 299 characters is reached, then a 72 by 72 DCM can be used.

DMC Example 3: Combination of Product Label 1B and Logistics Label 2D

317	maximum number of characters
299	maximum number of characters
616	maximum number of characters

When numerical characters are used and the maximum field length of 616 characters is reached, then a 96 by 96 DCM can be used.

Example of 72x72 DMC

Example of 80x80 DMC

Example of 96x96 DMC

Definitions and Explanations of the Identification Matrix - Appendix 2

Unique External Code (Supplier/Manufacturer)	This field refers to the unique identification of the smallest packaging unit, with the number to be agreed between the supplier and the customer.
Supplier ID	This field refers to the individual supplier number assigned by the customer.
Purchase Order Number	This field refers to the order number that has been assigned by the customer to identify a purchasing transaction.
Item	This field refers to the item in the individual purchase order.
Customer Part Number	This field refers to the material number assigned by the customer.
Manufacturer's Name	This field refers to the name of the manufacturer. It may contain the manufacturer's logo if it is suitable for the code.
Manufacturer's Number	This field refers to a number or name that is used by the customer for the identification of the manufacturer.
Manufacturer's Part Number	This field refers to the unique identification number of the manufacturer for every product (Manufacturer Material Number).
Ordering Code	This field refers to the mutually agreed unique code for a part that is used in order transactions between customer and supplier.
Revision Level of the Part (Manufacturer)	This field refers to the revision status of the part at the supplier's end.
Revision Level of the Part (Customer)	This field refers to the revision level of the ordered part at the customer's end.
Part ID Manufacturer or Supplier	This field refers to the individually unique order identification as a non-ambiguous key to be used for ordering parts with regard to technical or specified attributes.
Logistics Package ID (Supplier/Customer)	This field provides information on the number of package units stated on the delivery note.
Number of Packages	This field refers to the number of packaging units within a delivery.
Quantity	This field refers to the quantity of the smallest packaging unit.
Quantity Units	This field refers to the quantity unit of the smallest packaging unit.
Shipping Weight	-----
Delivery Note Number	-----
Batch ID	***Generic term for batch identification.***
Batch No./Lot No.	This field refers to the unique identification of a batch or lot.
Manufacturing Date (Date code)	This field refers to the manufacturing date on the smallest packaging unit. The date format "YYYY-MM-DD" should be used for specifying the manufacturing date. If there are several date codes, all codes should be printed on the smallest packaging unit.
Serial Number	This field refers to the unique, individual number that is used to identify every part. It has to be unique per supplier.
Batch Counter per Smallest Packaging Unit	----
Source of Origin	***Generic term for details of origin***
Country of Origin	This field refers to the country of origin according to the customs declaration.
Country of Final Assembly	This field refers to the manufacturing location of the ordered part.
Customs Tariff Number	----
Best Before Date	This field refers to the marking on the smallest packaging unit using the date format: YYYYMMDD.

Definitions and Explanations of the Identification Matrix - Appendix 2

Expiration Date	Marking applied to the smallest packaging unit using the date format YYYYMMDD and plain text
MSL	Moisture Sensitivity Level
Environmental Compliance*	***Generic term for the identification of environmental requirements***
EU RoHS Compliance	Confirms the RoHS compliance of a part, valid at the time the part is put on the market. The compliance status is indicated with "Yes/No".
AECEIP (CN-RoHS)	Confirms the AECEIP (CN-RoHS) compliance of a part, valid at the time the part is put on the market. The compliance status is indicated with "Yes/No".
ELV 2000/53	Confirms the ELV 2000/53 compliance of a part, valid at the time the part is put on the market. The compliance status is indicated with "Yes/No".
GADSL Available	Confirms the compliance of a part at the time it is put on the market as well as the availability of information on the content according to the GADSL. The compliance status is indicated with "Yes/ No".
Contains SVHC	This field refers to the marking of a product containing Substances of Very High Concern (SVHC). "Yes" indicates that the product contains SVHC; an empty field indicates that the part does not contain any SVHC.
SVHC Authorised	This field refers to the use of a SVHC which has been granted authorisation. This is indicated with "Yes/No".
CofC-Certificate of Conformity	-----
Halogen Free	This field refers to a part containing no halogen using "Yes/No" for indication.
Product Approval	***Generic term for the identification of product approvals***
CE	This field refers to the CE marking on a part using "Yes/No" for indication.
UL	This field refers to the UL marking on a part using "Yes/No" for indication.
AECQ 10x/200	-----
AIRWORTHINESS	-----
MIL Qualified	This field refers to the MIL qualification of a part using "Yes/No" for indication.
ZVEI Label Type, Level and Bar Code Revision	ZVEI Label Identifier - *Packing Label Product** **ZVEI-PL LX VYY** Indicators for the label identification are X = Level No. and YY = Label Version ZVEI Label Identifier - *Packing Label Logistics** **ZVEI-LL LX VYY** Indicators for the label identification are X = Level No. and YY = Label Version
Additional Information	This field refers to the additional information on a part. This information is added to the packing label logistics and has to be specified per customer.
Kanban Number	This field refers to the Kanban number for the shipment. This information is added to the packing label logistics and has to be specified per customer.
Delivery Address (unloading point)	----
Supplier-Specific Field (free text)	This field refers to additional information which is necessary from the supplier's point of view.

Data Matrix ECC 200

Sizes and Data Capacities

Symbol Size	Data Capacity		Module Size (edge lengths)	
Row x Column	Numeric	Alphanumeric	7,5 millimetres	15 millimetres
10 x 10	6	3	1.90 mm	3.81 mm
12 x 12	10	6	2.29 mm	4.57 mm
14 x 14	16	10	2.67 mm	5.33 mm
16 x 16	24	16	3.05 mm	6.10 mm
18 x 18	36	25	3.43 mm	6.87 mm
20 x 20	44	31	3.81 mm	7.62 mm
22 x 22	60	43	4.19 mm	8.38 mm
24 x 24	72	52	4.57 mm	9.14 mm
26 x 26	88	64	4.95 mm	9.91 mm
32 x 32	124	91	6.10 mm	12.19 mm
36 x 36	172	127	6.86 mm	13.72 mm
40 x 40	228	169	7.62 mm	15.24 mm
44 x 44	288	214	8.40 mm	16.70 mm
48 x 48	348	259	9.10 mm	18.2 mm
52 x 52	408	304	9.9 mm	18.8 mm
64 x 64	560	418	12.2 mm	24.3 mm
72 x 72	736	550	13.7 mm	27.4 mm
80 x 80	912	682	15.2 mm	30.4 mm
88 x 88	1152	862	16.7 mm	33.4 mm
96 x 96	1392	1042	18.2 mm	36.5 mm
104 x 104	1632	1222	19.8 mm	39.5 mm
120 x 120	2100	1573	22.8 mm	45.6 mm
132 x 132	2608	1954	25.1 mm	50.2 mm
144 x 144	3116	2335	27.4 mm	54.7 mm
8 x 18	10	6	1.6 x 3.7 mm	3.4 x 7.7 mm
8 x 32	20	13	1.7 x 6.8 mm	3.4 x 13.5 mm
12 x 36	32	22	2.5 x 7.6 mm	5.1 x 15.2 mm
16 x 36	64	46	3.4 x 7.6 mm	6.8 x 15.2 mm
16 x 48	98	72	3.4 x 10.2 mm	6.8 x 20.3 mm

Appendix 3 – Best Practice: MAT Label Automotive (Hella, Bosch, Siemens, Continental)**

The MAT Label is a standardised label for the smallest packaging unit of purchased parts. It has been developed by the companies Bosch, Continental (including Siemens VDO), Siemens I DT MC and Hella, and is already used in the automotive industry. The MAT Label particularly meets the requirements of the automobile manufacturers regarding a traceability system along the supply chain.

In accordance with the "ZVEI Identification Matrix ZVEI Label", the MAT label is a combination of the product data record Level 3 and the logistics data record Level B. The definitions (data fields, data identifier, etc.) have been chosen to allow full compatibility of the ZVEI and MAT Labels, whereby the MAT Label does not contain all the data fields of the ZVEI label.

The MAT Label has been described in the document "Requirements on Marking of Goods and Accompanying Information for Purchased Production Parts (MAT-Label, Version 2.4). This MAT Label has been explicitly made available for free use by the companies concerned and can be downloaded from the homepage of the ZVEI at www.zvei-traceability.de.

1. MAT Label Concept

The MAT Label defines:

- The information to be contained in the label
- A 2D code containing all this information
- Data syntax, data identifier and data formats for automatic data processing

The MAT Label does not define:

- Label size, label format, label paper, etc.
- Information layout on the MAT label print-out (position of 2D codes, plain text information such as part number, quantity, etc.)

This means that MAT Labels may differ in terms of their appearance. MAT Labels can be created for different packaging types; in extreme cases reduced to a 2D matrix code minimal MAT Label. The 2D bar code is a common feature of all MAT Label layouts providing all label information in standard machine-readable codes.

The following MAT Label specifications are optional and need to be agreed between the customer and supplier:

- **2D-Code**

In general, the Data Matrix Code should be used.
A possible alternative is the PDF 417 (see *Appendix 1*).

- **Plain Text Information**

Both the customer and the supplier decide which of the information listed in *Appendix 2* should be printed on the label as plain text in addition to the 2D-Code. Preferably, this specification should provide a label format that can be used by the supplier independent of the customer and in accordance with the individual component/industry etc.

- **Bar Codes**

As an optional feature, MAT Labels may also have two bar codes containing a selection of information fields (see *Appendix 2*). This allows backward compatibility with existing equipment for a transitional period.

A supplier's customer-specific MAT label should be mutually defined and agreed with the customer.

No.	Datenfeld deutsch	Datenfeld englisch	Data Identifier	Feldlänge	Format	Beispiel	2D-Code
Informationen zum Label							
1.	Label Version	Label Version	12S	4	fester Ausdruck "0002"	0002 (fester Ausdruck)	ja
Informationen zum Bauteil							
2.	Kundenteilenummer 7	Customer Part Number	P	Max. 18	A/N	718.187-04A2C53216419	ja
3.	Herstellerteilenummer	Manufacturer Part Number	1P	Max. 35	A/N	SL105C103MAA-S	ja
4.	Bestellcode 7	Ordering Code	31P	Max. 35	A/N	SC441427CFNR2A2C53216419/02	ja
5.	Bauteilbeschreibung	Part Description	-	Max. 30	A/N	10 nF / 50 V / KerW204KLA	nein
6.	Herstellernummer	Manufacturer Number	12V	Max. 13	A/N	123456789AMD	ja
7.	Herstellungsstandort	Manufacturing Location	10V	Max. 20	A/N		ja
8.	Revisionsstand / Index des Bauteils 7	Revision Level / Index	2P	Max. 14	A/N	AA01	ja
9.	zusätzliche Teileinformatino	Additional Part Information	20P	Max. 18	A/N		ja
10.	Herstellungsdatum (Datecode)	Date of Manufacturing (Datecode)	6D	8	YYYYMMDD	20080330	ja
11.	Verfalldatum	Expiration Date	14D	8	YYYYMMDD	20081031	ja
12.	RoHS	RoHS	30P	1	A/N (Großbuchstaben)	Y	ja
13.	MS-Level	MS-Level	Z	Max. 2	A/N,"N" wenn nicht zutreffend	5	ja
Logistische Informationen							
14.	Bestellnummer 7	Purchase Order Number	K	Max. 18	A/N	753013	ja
15.	Lieferscheinnummer	Delivery Note Number	16K	Max. 12	A/N	54003333	ja
16.	Lieferantenname	Supplier Name	-	Max. 30			nein
17.	Supplier-ID	Supplier-ID	V	Max. 10	A/N	884566	ja
18.	Package-ID	Package-ID	3S	13	A/N	S123456789012erstes Zeichen reserviert für S oder M (Single/Master)	ja
19.	Liefermenge	Quantity	Q	Max.18	2D-Code: 12ISO3	2D-Code: 10KGM020Klartext: 10,02	ja
Traceability Informationen							
20.	Anzahl Batches	Batch Counter	20T	1	N	1	ja
21.	Batch-No. #1	Batch-No. #1	1T	Max. 17	A/N	750160429	ja
22.	Batch-No. #2	Batch-No. #2	2T	Max. 17	A/N	750160430	ja
Sonstiges							
23.	Lieferantendaten	Supplier Data	1Z	Max. 30	A/N		ja

[6] N = numerical, A/N = alphanumerical, D = day, M = month, Y = year

[7] Capital letter formatted analog to the order

Figure Appendix 3-1

2. Information Content

The following table lists the information fields which have to be provided on the MAT Label. It defines the data fields, data format, field length and data identifier, then provides a short description of every data field.

The field definition distinguishes strictly between the customer, supplier and manufacturer, as the customer can either purchase the part directly from the manufacturer (manufacturer = supplier) or from a distributor (manufacturer <> supplier).

Label Information

1. Label Version

The label version is a fixed entry to identify the MAT Label and its version (see Figure *Appendix 3-1*).

Part Information

2. Customer Part Number

Part number of the customer used for the identification of the part. Format and design of the customer part number have to coincide with the order.

3. Manufacturer Part Number

Part number under which the manufacturer identifies the part and which is used for the release of the part by the customer.

4. Ordering Code

The ordering code is a mutually agreed code for the part which can be used unambiguously to order it. Unlike the "Manufacturer Part Number", the Ordering Code provides a more detailed description of the part, (e.g. additional software version of microcontrollers).

5. Part Description

Description of the ordered part in plain text allowing for the identification of a part without any knowledge of the customer part number nomenclature or manufacturer part number nomenclature. It is not part of the 2D-Code.

6. Manufacturer Number

Number or name of the manufacturer used by the customer to identify the manufacturer. If available, this should be the DUNS-No.

7. Manufacturing Location

Identification of the manufacturing location of the part.

Format: "AAA-BBBBBBBBBBBBBBBB" with

- AAA = 3-character country code of the location according to ISO 3166-1 Alpha-3
- BBBBBBBBBBBBBBBB = identification of plant location, e.g. name of location.

8. Revision Level/Index

Revision level or index of the customer for the part.

9. Additional Part Information

This field can be used flexibly for additional information about the part, e.g. brightness of LED lamps. In the case of this field being used, its content has to be mutually agreed upon between the customer and the supplier.

10. Date of Manufacturing

The date of manufacturing (also called "Date Code") of the part, defined by the last production process.

Format "YYYYMMDD" without dots (separators); example for 30.03.2008: "20080330"

11. Expiration Date

Expiration date of the part up to which the manufacturer guarantees its processing capability (particularly solderability) of the part subject to the specified storage conditions. .The Expiration Date of the part is defined by the manufacturer subject to the production date. Format similar to Date of Manufacturing.

12. RoHS

In the 2D-Code:

- "Y" indicates compliance with the RoHS directive of the EU 2002/95/EC
- "N" indicates non-compliance
- "0" indicates "not relevant"

In plain text, the RoHS compliance is indicated by an RoHS symbol (see label examples) or by the text "RoHS".

13. MS-Level

If the part is moisture-sensitive, then the Moisture Sensitivity Level (MS-Level) has to be indicated according to the industrial standard IPC/JEDEC J-STD-020. If the part is not moisture-sensitive ("not applicable"), this is indicated by the letter "N".

Logistics and Traceability Information

14. Purchase Order Number

The purchase order number is assigned by the customer to identify a purchasing transaction and has to be taken from the purchase order.

15. Shipping Note Number

The shipping note number is assigned by the supplier to identify a delivery. It has to be identical to the number on the shipping documents.

16. Supplier Name

The supplier name has to be printed in plain text or as a logo on the label. It is not part of the 2D-Code.

17. Supplier-ID (Supplier Number)

The supplier number is used by the customer to identify the supplier and has to be taken from the purchase order.

18. Package-ID

The Package-ID is assigned by the supplier (e.g. component reel) to identify the package unit. It has to be universally unique for every Supplier-ID:

In combination with the Supplier-ID, the Package-ID presents a unique identifier for every package unit. The customer can use the combination of these two fields to identify and distinguish package units as part of the traceability process.

The field length of the Package-ID is fixed at 13 characters. In the case of a single label, the first character has to be an "S", for a master label it must be an "M". The remaining 12 characters can be freely assigned by the supplier.

In a 2D-Code, the fields containing the Supplier-ID and Package-ID have to be printed consecutively.

Examples:

G_SV884566G_S3SS123456789012G_S
@V884566@3SS123456789012@

19. Quantity

The quantity is the number of parts or amount contained in the smallest package unit.

Format of the 2D-Code: "12ISO3".

Maximum of 12 digits before the decimal point (do not use leading zeros if the entire string has less than 12 characters).

ISO: 3-digit code for the measuring unit according to the UN/ECE Recommendation 20 of WP 4. Example for "Number of Articles": "NAR" with exactly three digits after the decimal point (to be filled up with zeros if necessary).

In the case of components that usually have no digits after the decimal point, the string "NAR000" can simply be added to the number of components.

The format used for the printed plain text should be indicated in decimal notation including the measuring unit (if required).

Examples:

Quantity	Printed Plain Text	2D-Code
3000 components	3000	3000NAR000
12.03 Kg	12.03 Kg	12KGM030

20. Batch-Counter

A Batch Counter indicates the number of production batches in a package unit. In general, components from one batch should be in a package unit. A maximum of two batches per package unit is allowed for filling-up a package unit with the subsequent batch. Thus, the field "Batch Counter" only indicates 1" or "2".

21. Batch-No. #1

The data field "Batch-No. #1" contains an identification code for the production batch of the part in the package unit (batch number, lot number, trace code, date code ...). This number allows the supplier to retroactively provide all relevant traceability data relating to the parts (data referring to individuals, machines, materials, process parameters, production quantity...). A batch identification should be individually assigned to a batch and based on the manufacturing conditions. If any of the conditions such as individuals, machines, materials, etc. change, a new number should be assigned to the batch.

22. Batch-No. #2

If necessary, a second batch number should be indicated if the subsequent batch is used to fill-up the package unit. In this case the number "2" has to be entered into the "Batch Counter" field.

Additional Supplier Data

23. Supplier Data

This data field is for the free use of the supplier.

3. 2D-Code

The 2D-Code on the MAT Label contains all data fields that have been specified in the table. The data syntax and print parameters have been defined below:

- **Data Syntax**

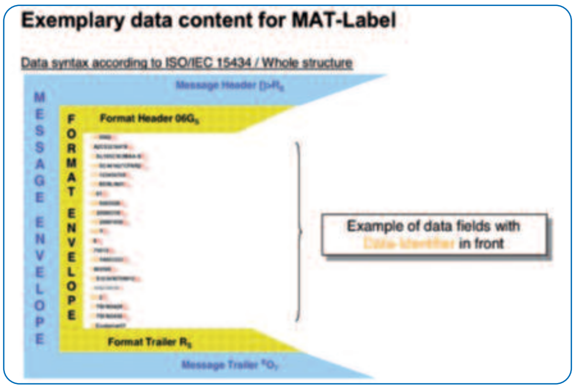
The data syntax of the information in the 2D-Code has to be created on the basis of ISO/IEC 15434, Format "06" (using data identifiers) and separators between the data fields RS, GS and EOT in accordance with ASCII/ISO 646.

(For the schematic structure, refer to Figure *Appendix 3-2*).

This means that the data syntax of a 2D-Code must consist of data fields from *Appendix 3 – Table 1* that are separated by the symbols RS, GS and EOT. The data identifiers defined in *Appendix 3 – Table 1* are used to identify the data of a data field with the data identifier heading the information in the data field.

In order to ensure compatibility with current scanning systems, the "@" sign may be used as a separating symbol for RS, GS and EOT, as these special characters cannot be printed, thus deviating from the ASCII/ISO646 Standard.

Example of 2D-Code syntax using R_S, G_S and ^EO_T:
[)>$\mathbf{R_S}$06$\mathbf{G_S}$12S0002$\mathbf{G_S}$PA2C53216419$\mathbf{G_S}$1PSL105C103MAA-S
$\mathbf{G_S}$31PSC441427CFNR2$\mathbf{G_S}$12V123456789$\mathbf{G_S}$10VBERLIN01$\mathbf{G_S}$2P01$\mathbf{G_S}$20P500
3020$\mathbf{G_S}$6D20080310$\mathbf{G_S}$14D20081030$\mathbf{G_S}$30PY$\mathbf{G_S}$Z5$\mathbf{G_S}$K753013$\mathbf{G_S}$16K54003333
$\mathbf{G_S}$V884566$\mathbf{G_S}$3SS123456789012$\mathbf{G_S}$Q10KGM020$\mathbf{G_S}$20T2$\mathbf{G_S}$1T750160429$\mathbf{G_S}$2T
750160430$\mathbf{G_S}$1ZCustomer01$\mathbf{R_S}$$\mathbf{^EO_T}$
Example of 2D-code syntax using @ instead of R_S, G_S and ^EO_T:
[)>**@**06@12S0002@PA2C53216419@[...]@1ZCustomer01**@@**
In a 2D-Code, the fields containing the Supplier-ID and Package-ID have to be printed consecutively. Examples:
$\mathbf{G_S}$V884566$\mathbf{G_S}$3SS123456789012$\mathbf{G_S}$
@V884566@3SS123456789012@



Appendix 3-2: Data syntax of 2D-Code

- **Print Parameters**

	Data Matrix Code	PDF 417
Code Type	ISO/IEC 16022	ISO/IEC15438
Error Correction	ECC200	Level 5
Printer Resolution	min. 300dpi	
Code Size	max. 64x64 (corresponds to 297 usable characters including escape characters for special characters)	max. width 70 mm max. height 35 mm
Module Size	min. 0.25 mm/module min. 3 dots/module	min. module width 0.25 mm min. module height 3X (0.75 mm)
Quiet Zone	min. of 1 mm circumferential	left/right min. 10X (2.54 mm) each; above/below min. 4x (1 mm) each

Appendix 3: –Table 1

4. 1D-Bar Codes

As an option, two additional BC128 bar codes can be printed on the label containing a specified amount of information of the 2D-Code.

The content, format and syntax of these two bar codes are defined below: Examples of the labels are provided in *Appendix 3*, *Figure 5-1* to *Figure 5-3*.

Appendix 3: Table 2

Bar Code No.	Data Content	Field Length	Format	Example
1.	CustomerPartNumber (10)@Supplier-ID(10	**fix 23**	Pxxxxxxxxxx@Vxxxxxxxxxx	P98001311641@V0000000815
2.	Batch-No.#1(19)@Delivery Quantity(5)	**fix 27**	Hxxxxxxxxxxxxxxxxxxx@Qxxxxx	H0004567890123456789@Q00200

1. CustomerPartNumber@Supplier-ID

This data field is composed of the "Customer Part Number" and "Supplier-ID" according to *Appendix 3 – Table 2*. The syntax of this bar code is:

Pxxxxxxxxxx@Vyyyyyyyyyy

with exactly 10 digits for the Customer Part Number "xxxxxxxxxx" and exactly 10 digits for the Supplier-ID "yyyyyyyyyyy" (length dimensions deviate from *Appendix 3 – Table 2*). Within the fixed defined field lengths, the information has to be flush-right and filled-up with zeros.

2. Batch-No. #1@Quantity

This data field is composed of the "Batch No. 1" and "Quantity" according to *Appendix 3 – Table 2*. The syntax of this bar code is:

Hxxxxxxxxxxxxxxxxxxx@Qyyyyy

with exactly 19 digits for the Batch-No. #1 "xxxxxxxxxxxxxxxxxxx" and exactly 5 digits for the Quantity "yyyyy" (length dimensions deviate from *Appendix 3 – Table 2*). Within the fixed defined field lengths, the information has to be flush-right and filled-up with zeros.

- **Print Parameter for BC128 Bar Codes**

Code Type	DIN/EN 799
Printer Resolution	min. 300dpi
Module Width X	min. 0.191 mm
Code Height	min. 6 mm
Quiet Zone	min. 10X (2.54 mm)

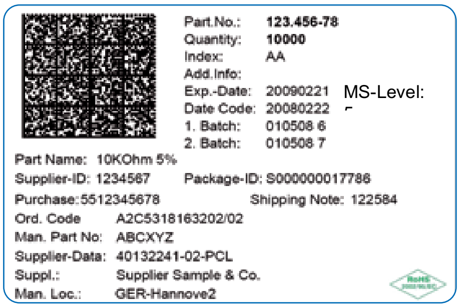
5. Sample Labels

The customer part number and the quantity have to be highlighted against the other information (large type, bold print, etc.).

Proposals for abbreviation of field names:

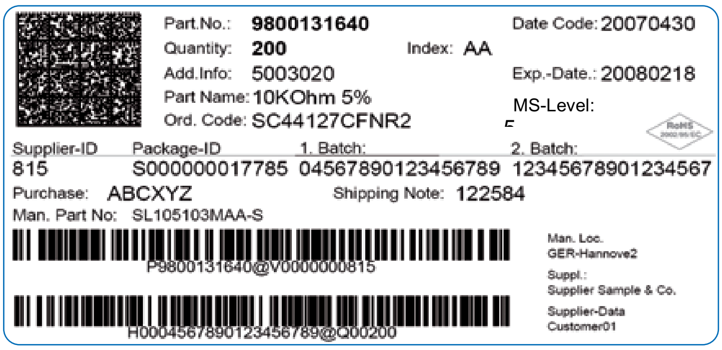
- Part No. = Customer Part Number
- Man. Part No. = Manufacturer Part Number
- Quantity = Quantity
- Add.Info = Additional Part Information
- Man.Date or Date Code = Date of Manufacturing
- Exp. Date = Expiration Date
- Suppl. = Supplier Name
- 1. Batch = Batch-No. #1
- 2. Batch = Batch-No. #2
- MSL or MS-Level = Moisture Sensitive Level
- Index = Material Revision (Part-Index)
- Purchase = Purchase Order Number
- ShippingNote = Shipping Note Number (Shipping Reference)
- Part Name = Part Description
- Ord.Code = Ordering Code
- Man.Loc. = Manufacturer Location

5.1 Sample label with Data Matrix Code (small 70 x 48 mm):



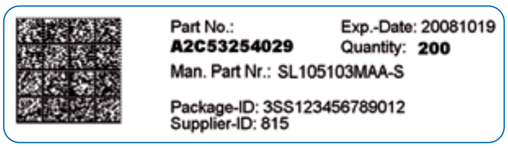
Appendix 3 – Figure 5-1

5.2 Sample label with Data Matrix Code und BC128 Codes (large, 120 x 60 mm)



Appendix 3 – Figure 5-2

5.3 Minimum label with Data Matrix Code (80 x 25 mm)



Appendix 3 – Figure 5-3

Appendix 4: Best Practice Example of a Process Matrix for Solder Paste Printing

The example of the process step "Solder Paste Printing" illustrates a process matrix that initially utilised 3D automated optical inspection (AOI) due to insufficient experience regarding the stability of the influencing parameters. Consequently, only good prints were forwarded to the assembly process. However, when considering the entire process, the cycle time was longer and the investments considerably higher.

The following examples clearly illustrate the actions required for a dedicated improvement.

1. Course of Actions

1.1 List of Attributes

Attribute	Thermal	Chemical	Mechanical	Electrical
Stability of environmental parameters (e.g. humidity, temperature)	x	x		x
Solder paste material		x		
Printing type			x	
Stencil type (Laser cut, Electro Formed,)			x	
Stencil thickness			x	
Cleaning cycle		x	x	
PCB support			x	
Printing shape			x	x
Hole filling (pin in paste)			x	x
Pad overprinting			x	x
Stencil use time			x	
Paste use time		x	x	
Pump cleaning		x	x	

Figure Appendix 4-1: Attributes relating to the process

Attribute	Thermal	Chemical	Mechanical	Electrical
PCB surface finish		x	x	x
Substrate material	x		x	
Solder mask		x	x	
Warpage			x	
Pad design			x	x
Through hole plating			x	x
Contamination		x	x	x
Delamination and track open			x	x
Via outgasing	x	x	x	
Wetability	x	x	x	x
Solderability	x	x	x	x
Etc.				

Figure Appendix 4-2: Attributes relating to the material

1.2 CPI Matrix

Component Process Interaction Matrix			Material	Process
			Subgroups	Subgroups
			Attributes	Attributes
Material	Subgroups	Attributes	x	x
Process	Subgroups	Attributes	x	x

Figure Appendix 4-3: Sample of CPI Matrix

1.3 Analysis of the direction PROCESS –> MATERIAL

Process - Data Matrix (see *Chapter 5.6.4*)

It became apparent that the focus of this measurement needed to be on the following data:

- Even surface of solder mask
- Squeegee speed
- Squeegee pressure
- Measurement of paste volume
- Derived height

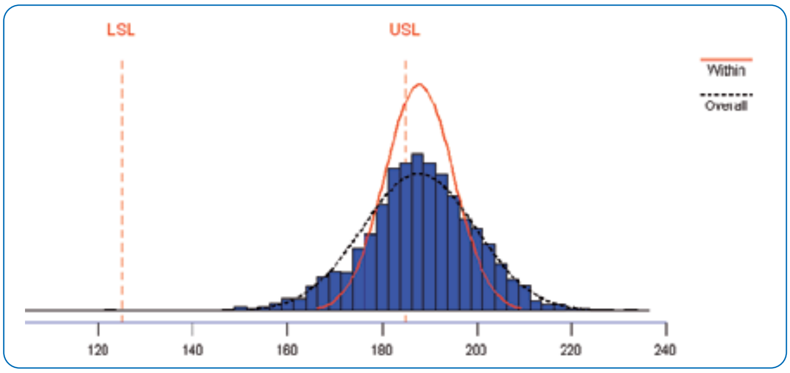


Figure Appendix 4-4

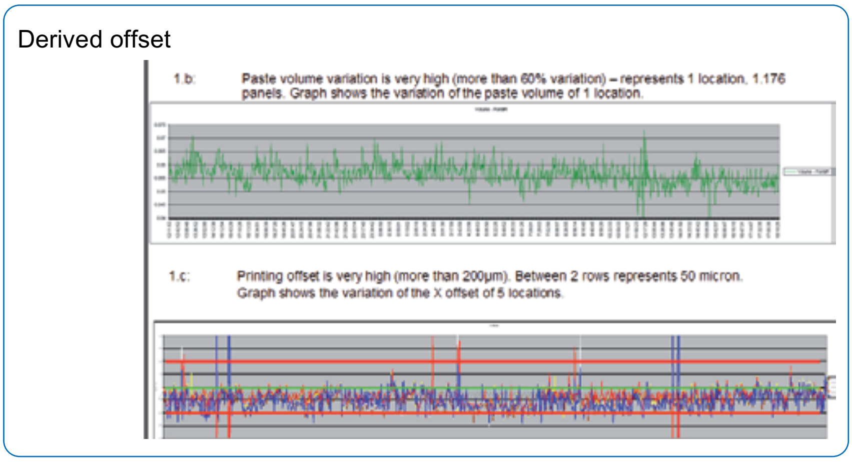


Figure Appendix 4-5

Only the measurement of real-time data allows early detection of insufficient paste print, thus preventing any negative after-effects.

1.4 Determination of the Parameters and Stabilisation –> Improvement

The main influential factors can only be identified using the real-time data from the measurements. Due to the fact that these factors are not always systematic errors but mainly the result of coincidental negative tolerances, it is imperative to determine the relation of Product/Value/Time.

Once the source of error has been identified, the individual process can focus on the decisive characteristics and, if necessary, their deviation from the standard can be reduced. This again is the prerequisite for a high Cpk value and thus for a stable process step.

Appendix - Glossary – Definitions and Abbreviations

Definitions

Note:

The definitions are intended to explain the terminology for the purpose of this Guideline allowing for possible amendments of normative term definitions or deviations therefrom.

Term	Definitions
Active Traceability	Active Traceability refers to the additional systematic capture of data in order to target process interventions. For example, it provides the possibility of process locking in case of any defect.
Active Traceability System	System for capturing active traceability data.
Additional Information	This field can be used flexibly for additional information about the part, e.g. brightness of LED lamps. In the case of this field being used, its content has to be mutually agreed upon between the customer and the supplier.
Batch	A batch represents a homogeneous unit in combination with a numbering system.
Batch Counter	A batch counter indicates the number of production batches in a packaging unit.
Batch Identification Number	Unique identification number of a batch.
Batch No.	The data field "Batch-No." contains the identification code for the production batch of the part in the package unit (batch number, lot number, trace code, date code ...).
Best Before Date	Refers to the date of the part up to which the manufacturer guarantees the processing capability (particularly solderability) of the part, subject to the specified storage conditions. It is defined by the part manufacturer subject to the production date.
CAN, OPTIONAL	CAN (or the adjective OPTIONAL) denotes specifications that can be added subject to the individual situation. An implementation that uses these specifications can interact with an implementation that does not consider these specifications.
Catalogue Products	These are orderless products that can be purchased from catalogues or data sheets. They are stored non-customer-related and are suitable for multiple applications.
control	Interface for the data exchange between a process and the traceability system before and during the processing of a product.
Customer Part Number	Part number of the customer for the ordered product used by the customer to identify the part.
Customs Tariff Number	Council Regulation (EEC) 2658/87 of 23 July 1987 on the tariff and statistical nomenclature and on the Common Customs Tariff established the "Combined Nomenclature" (CN), which is the EU's coding system for classifying products for customs and statistical purposes. The Combined Nomenclature is an 8-digit coding system. Commission Regulation (EC) 1214/2007 of 20 September 2007 is the most recent update of the CN.

Term	Definitions
	The currently valid Combined Nomenclature is published once a year in the Official Journal of the European Communities. In case of bilateral trade agreements between the EU and non-member countries, the Combined Nomenclature has been adopted by those countries and provides the basis for the tariff system.
Date Code	Encoded character set to illustrate manufacturing date.
Delivery Documents	For the purpose of this Guideline, delivery documents include: - delivery note stating the delivery positions (A, B ...) - packing list (X,Y) - bill of lading - customs declaration
Environmental Compliance	Environmental Compliance refers to the confirmation by, e.g. the responsible manufacturer or dealer, that the product meets the specified environmental requirements.
Equipment Interface	Electronic interface to _ internal traceability for the data exchange between machines and higher systems along the internal value chain.
Expiration Date	Refers to the date after which the manufacturer no longer guarantees the processing capability of the product or its defined attributes as specified in the data sheet, subject to the specified storage conditions and proper treatment of the product.
External Traceability	External traceability deals with the tracing of information between the contractor and customer. This is ensured by means of a unique identification number applied to the product, if possible, or else to the smallest packaging unit and/or accompanying documentation of a delivered item
Goods	Goods are the final production results consisting of self-contained, functioning objects (e.g. machines, equipment) of a number of groups and/or parts.
Grey Areas	In the case of continuous processing of coherent batches, it might occur, for technical reasons, that some batches can no longer be clearly assigned to the original batch. This unclear assignment is also referred to as grey area.
Internal Traceability	Internal traceability refers to the product and process traceability of the customer along the value chain. Scope, parameter and documentation of internal traceability are subject to legal and internal rules and are generally not communicated externally. This allows for a risk assessment without transferring any know-how.
Item	Refers to the item in the customer purchase order.
Kanban Number	Identification number of cards for items/materials in a Kanban system (method for optimising stock and supply requirements, e.g. in case of batch production).
Label Version	The label version is a fixed entry in order to identify the individual label data record and its versions.
Logistics Label Data Record, ZVEI	Data carrier for _ external traceability; contains data for the logistics collection/receipt of the goods by the contractor.

Term	Definitions
Marking	The marking of material allows for the assignment of quality and product data to a specific part, (e.g. manufacturing data, manufacturing location, assembly line, batch number, order lot, customers and suppliers of raw material and parts as well as test results or setup values on the assembly lines).
Manufacturer	A manufacturer is deemed to be anyone producing a final product, primary material or a part product. Also treated as a manufacturer is anyone purporting to be a manufacturer by applying the name, trademark or other distinguishing marks to the product. Importers introducing the product on the market for the purpose of selling, leasing, hire-purchase leasing or any other form of distribution for commercial reasons as part of their business activities are treated as manufacturers. A manufacturer can be a supplier simultaneously.
Manufacturing Date	Definition according to date code.
Manufacturing Location	Identification of the manufacturing locations of a material.
Manufacturer's Number	Number or name of the manufacturer used by the customer to identify the manufacturer. If available, this should be the DUNS-No.
Manufacturer's Part Identification Supplier's Part Identification	Refers to the individually unique order identification as a non ambiguous key to be used for ordering parts with regard to technical or specified attributes.
Manufacturer's Part Number	Refers to the unique identification number of the manufacturer for every product (material number of manufacturer).
Moisture Sensitivity Level (MSL)	Assignment of a product to a certain moisture class (see for example JEDEC-Standard JSTD-020).
MUST, HAS/HAVE TO, MAY NOT	MUST, HAVE/HAS TO, MAY NOT denote absolute requirements or interdictions in order to meet a requirement of the ZVEI.
Obligation to Provide Evidence Obligation to Provide Documentary Evidence	This is defined by the customer or legal provisions.
Ordering Code	The ordering code is a mutually agreed code between the customer and supplier that the customer uses for ordering a part. Unlike the "Manufacturer part Number", the Ordering Code provides a more detailed description of the part.
Package-ID	The Package-ID is assigned by the supplier (e.g. component reel) to identify the package unit.
Packing Label Logistics	Data record containing, e.g. customer data regarding the handling of the logistics.
Packing Label Product*	Data record of all technical product data with the manufacturer directly placing the information on the smallest packing unit.
Packaging Type/ Packaging Unit	– bulk, trays, tubes, tapes and reels ... – metre, piece ...

Term	Definitions
Parts	Parts (electronic), sub-parts (mechanic), sub-assemblies
Part Description	Description of the ordered part in plain text, allowing for the identification of a part without any knowledge of the customer part number nomenclature or manufacturer part number nomenclature.
Process Data	Measurement data, e.g. temperature, pressure, displacement or torque.
Process Interlocking	Process Interlocking refers to the immediate interruption or stop of the (further) processing of a product in the case that a preceding process step has not been performed or has produced a negative result, if the wrong material has been loaded into the machine or in case of the wrong process conditions. Stopping the process automatically triggers the interlocking mechanism. At manual workstations, such as repair workstations, packing or shipping workstations, interlocks are initiated by user dialogues and the computer system refusing to accept the entry of the *serial number** for the further processing, packing or shipping of the product.
Product	Product is the final good intended for consumption. There are additional specifications for the primary material or part product.
Product Data	Product data includes process data + test data + production data.
Product Label Data Record, ZVEI	Data carrier for _ external traceability; contains product data for the internal traceability system of the contractor; for the electronic interface see _ Traceability Interface
Purchase Order Number	The purchase order number is assigned by the customer to identify a purchasing transaction
Quantity	The total quantity of the delivered products.
Revision Level/Index	In technical terms, the index refers to the revision level of a document, a product or a material. When reviewing a document, product or material, the revision level is indicated by a new number and/or the effective date of the revision.
RFC Interfaces	RFC is the synonym for Remote Procedure Call (RPC) allowing a computer program to call up functions that are located in a remote server program. RFC also refers to the standard SAP protocols and interfaces for executing such function call ups including their implementation.
RoHS	The "Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC" restricts the use of hazardous substances in equipment and parts. It is often referred to as RoHS (*R*estriction of the use *o*f certain *H*azardous *S*ubstances) with each European Union member using the directive as a guide to adopt its own enforcement and implementation policies.
Serial Number	The serial number refers to the unique and individual number that is used to mark products for their identification or to provide special services to the customer.

Term	Definitions
Shipping Note Number	The number of the shipping note used for the delivery of a product. The shipping note number is assigned by the supplier to identify a delivery.
SHOULD, ARE/IS TO, RECOMMENDED, SHOULD NOT	SHOULD, ARE/IS TO (or the adjective RECOMMENDED), SHOULD NOT refer to specifications which can be ignored if there are no compelling reasons.
Smallest Packaging Unit	Refers to the package unit to which the packing label product will be attached.
Source of Origin	Refers to the country of origin.
Supplier	A supplier provides the recipient with goods or services without necessarily being the manufacturer of these goods.
Sub-assembly	A sub-assembly is a collection of parts put together as a unit, to be used in the making of a larger assembly or a final or higher item e.g. during assembly processes. An electronic sub-assembly (ESA) consists of a constructive and functional unit of integrated and/or discrete and passive components that are mechanically supported and electrically connected on a printed circuit board.
Test Data	Refers to the test steps + status as specified in the test specification.
Traceability Interface	Electronic interface to –> external traceability; for exchanging product data for the internal traceability of the contractor; in terms of the data content it is similar to the –> Packing Label Product.
Tracing **Forward Traceability**	From an element or processing parameters to the finished product –> Tracing –> Forward Traceability.
Tracking **Backward Traceability**	From the finished product to its elements or processing parameters –> Tracking.
unit_data	Interface for the data exchange between a process and the internal traceability system after the processing of a product.
ZVEI MAT Label Version	Version number of the label that has been specifically defined by the ZVEI.

Abbreviations:

Note:

The abbreviations are intended to explain a shortened form of a word or phrase for the purpose of this Guideline, allowing for possible amendments of normative abbreviations or deviations therefrom.

Acronym	Definition / Explanation
2D	two-dimensional
AAS	Automatic Assembly System
AOI	Automatic Optical Inspection
APC	Advanced Process Control
API	Application Programming Interface
ATS	Anti-Theft-System
CAQ	Computer Aided Quality Assurance
CCD	Charge Coupled Device
CIM	Computer Integrated Manufacturing
CIP	Continuous Improvement Process
CIPOS	Contactless Inductive Position Sensor
CMOS	Complementary Metal Oxide Semiconductor
CONT	CONT Contractor
CORBA	Common Object Request Broker Architecture
CU	Capacity Utilisation
CU	Control Unit
CUST	CUST Customer
DFM	Design for Manufacturing
DFT	Design for Testability
DLL	Dynamic Link Library (program code/EXE)
DMC	Data Matrix Code
DOSbox	X86 DOS emulator (especially for use with older programs on DOS basis)
DOT	Data Matrix Code (2D-Code)
DPI	Dots per inch
DrsA	Data requiring special archiving
ECC	Error Checking and Correction Algorithm
EDI	Electronic data interchange
EoL	End Of Line Function Tester
ERP Data	Acronym for Enterprise Resource Planning referring to the commercial and operational data processing e.g. SAP.
ETS	Employee Timekeeping System

Acronym	Definition / Explanation
FADB	Failure Analysis Database
FAS	Flexible Assembly System
FMEA	Failure Mode and Effects Analysis
FPY	First-Pass-Yield
FTR	Final Test Rig = EOL
FZ-Interface	Fault Notes (German: Fehlerzettel) Interface
ICT	Integrated Circuit Test
IDA	Industrial Data Acquisition
IG	Incoming Goods
IL	Information Logistics
ISIR	Initial Sample Inspection Report
IT	Information Technology
JAVA	Programming language/web-based application environment
JIT	Just in Time
KLT	VDA/KLT Small Load Carriers (German: Kleinlastraeger)
LED	Light Emitting Diode
LLC	Large Load Carrier
Manu	Tool for determining the machine capacity utilisation rate (German: Maschinen-Nutzungsgrad-Tool), Hella IT-Systems
MDA	Machine Data Acquisition
MES	Manufacturing Execution System
OEE	Overall Equipment Efficiency
OLE	Object Linking and Embedding
OPC	Operation Process Control/interface for software data
OPM	Online Process Monitor
ORACLE	ORACLE relational database management system
PAA	Part average analysis (DC statistic tool)
PCB	Printed Circuit Board
PDA	Production Data Acquisition
PDM	Predictive Maintenance; also Product Data Management = technical information system for the creation, management and publication of all product-related data
PL	Performance Level
PLC	Programmable Logic Controller
PM	Preventive Maintenance
PPM	parts per million
PPS	Production Planning and Control System

Acronym	Definition / Explanation
PR	Pilot Run
PRT	Part(s)
PU	Packaging Unit
QA	Quality Assurance
QM	Quality Management
RDBMS	Relation Database Management System (transfer tables)
REACH	Regulation on Registration, Evaluation and Authorisation of Chemicals
RFID	Radio Frequency Identification
ROVL	Robustness Validation Level
SA	Sub-assembly
SMD	Surface Mounted Device
SMT	Surface Mounted Technology
SN SNR	Serial Number/Unique Number (of the product)
SOP	Start of Production
SPA	Statistic Process Analysis
SPC	Statistical Process Control
SVHC	Substances of Very High Concern
TPM	Total Productive Maintenance
TRC	Test Retry Counter
VI	Visual Inspection
WPC	Workpiece Carrier
XML	Extensible Markup Language (TXT - data exchange model)

Appendix – Definition of Traceability according to Institutions or Standards**

NOTE:

The norms and standards cited below are reference documents for information purposes and do not replace the individual application and interpretation of these norms and standards within the companies.

–> Requirements according to ISO 9000: 2005

Traceability (Pt. 3.5.4)

"Traceability is the ability to trace the history, application or location of that which is under consideration."

NOTE 1 When considering product (3.4.2), traceability can relate to

- the origin of materials and parts
- the processing history, and
- the distribution and location of the product after delivery

NOTE 2: In the field of metrology the definition in VIM:1993, 6.10, is the accepted definition.

–> Requirements according to ISO 9001: 2008-12

Identification and Traceability (Pt. 7.5.3)

"Where appropriate, the organization shall identify the product by suitable means throughout product realization.

The organization shall identify the product status with respect to monitoring and measurement requirements throughout product realization

Where traceability is a requirement, the organization shall control the unique identification of the product and maintain records (see 4.2.4).

NOTE In some industry sectors, configuration management is a means by which identification and traceability are maintained.

–> Requirements according to EN 9100: 2003-10 (Aerospace series)

"Where appropriate, the organization shall identify the product by suitable means throughout product realization. The organization shall maintain the identification of the configuration of the product in order to identify any differences between the actual configuration and the agreed configuration.

The organization shall identify the product status with respect to monitoring and measurement requirements.

When acceptance authority media are used (e.g., stamps, electronic signatures, passwords), the organization shall establish and document controls for the media.

Where traceability is a requirement, the organization shall control and record the unique identification of the product.

According to the level of traceability required by contract, regulatory, or other established requirement, the organization's system shall provide for:

- identification to be maintained throughout the product life;
- all the products manufactured from the same batch of raw material or from the same manufacturing batch to be traced, as well as the destination (delivery, scrap) of all products of the same batch;
- for a *sub-assembly**, the identity of its components and those of the next higher *sub-assembly** to be traced;
- for a given product, a sequential record of its production (manufacture, assembly, inspection) to be retrieved."

–> Requirements according to ISO 13485:2003 / U.S. CFR 21 820 (Medical Devices – Quality System Regulation)

The requirements that are specific to manufacturers of medical devices in order to meet regulatory and statutory requirements as specified in the ISO 13485:2003, in the U.S. CFR 21 Part 820, § 160 "Distribution", § 60 "Identification, § 65 "Traceability", § 70 "Production and process controls", § 72" Inspection, measuring, and test equipment" and in the "Guidance on How to Handle Information Concerning Vigilance Reporting Related to Medical Devices provide details on

- Data acquisition to verify that product requirements have been met (product monitoring)
- Implementation of modifications of the installed device (updates, field corrections), required updates, safety-related or performance-related improvements, other improvement processes
- Issue of advisory notices in the event that it comes to the attention of the manufacturer, (e.g. as a result of customer complaints), that the fitness for use or quality of a device has deteriorated, requiring recalls or corrective actions that are mandatory for reporting
- Additional important information, e.g. planning of service resources or "End of Support"

In order to perform the above-mentioned actions in a reliable and timely manner, it is important to have a good knowledge of the products that are supplied to the customer and where they are installed, and to maintain this data:

- Structure and description of the customer system
- Confirmation of delivery and proper installation ("Proof of Delivery", "Proof of Installation" and "acceptance by the customer")
- Documentation on any modification of the installed device
- Requirements regarding updates and customer advisory notices

Sec. 820.60 Identification

Each manufacturer shall establish and maintain procedures for identifying product during all stages of receipt, production, distribution, and installation to prevent mixups.

Sec. 820.65 Traceability

Each manufacturer of a device that is intended for surgical implant into the body or to support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labelling can be reasonably expected to result in a significant injury to the user shall establish and maintain procedures for identifying with a control number each unit, lot, or of finished devices and where appropriate components. The procedures shall facilitate corrective action. Such identification shall be documented in the DHR.

Sec. 820.160 Distribution

(a) ... procedures for control and distribution of finished devices to ensure that only those devices approved for release are distributed...

Where a device's fitness for use or quality deteriorates over time, the procedures shall ensure that expired devices or devices deteriorated beyond acceptable fitness for use are not distributed.

(b) Each manufacturer shall maintain distribution records which include or refer to the location of:

- The name and address of the initial consignee;
- The identification and quantity of devices shipped;
- The date shipped; and
- Any control number(s) used.

Sec. 820.70 Production and process controls

(a) General. Each manufacturer shall develop, conduct, control, and monitor production processes to ensure that a device conforms to its specifications. Where deviations from device specifications could occur as a result of the manufacturing process, the manufacturer shall establish and maintain process control procedures that describe any process controls necessary to ensure conformance to specifications.

Where process controls are needed they shall include:

- Documented instructions, standard operating procedures (SOP's), and methods that define and control the manner of production;
- Monitoring and control of process parameters and component and
- device characteristics during production;
- Compliance with specified reference standards or codes;
- The approval of processes and process equipment; and
- Criteria for workmanship which shall be expressed in documented standards or by means of identified and approved representative samples.

(b) Production and process changes. Each manufacturer shall establish and maintain procedures for changes to a specification, method, process, or procedure. Such changes shall be verified or where appropriate validated according to 820.75, before implementation and these activities shall be documented. Changes shall be approved in accordance with 820.40.

(c) Environmental control. Where environmental conditions could reasonably be expected to have an adverse effect on product quality, the manufacturer shall establish and maintain procedures to adequately control these environmental conditions. ...

(d) Personnel. Each manufacturer shall establish and maintain requirements for the health, cleanliness, personal practices, and clothing of personnel...

(e) Contamination control. ... to prevent contamination of equipment or product by substances that...

(f) Buildings. Buildings shall be of suitable design and contain sufficient space ... assure orderly handling.

(g) Equipment. ... shall ensure that all equipment used in the manufacturing process meets specified requirements...

Sec. 820.72 Inspection, measuring, and test equipment

Control of inspection, measuring, and test equipment; calibration procedures including the evaluation of defective devices;

–> Requirements according to EN 13980: 2002 (Potentially explosive atmospheres)

Identification and Traceability (Pt. 7.5.3)

"7.5.3 of ISO 9001:2000 applies.

a) The manufacturer shall establish and maintain procedures for product identification during all stages of production, testing, final inspection and placing on the market.

b) Traceability is required with respect to the final product and its significant parts.

NOTE: Significant parts are, for example, a printed circuit board (PCB) of an intrinsically safe, circuit, but not each electronic component on a PCB."

–> Requirements according to the VDA Recommendation 5005 (1st Edition July 2005)

The VDA Recommendation 5005 "Traceability of vehicle components and identifiability of their technical design" describes processes and procedures regarding the forward and backward tracking of vehicle parts and identification of their technical construction.

"The aim of the recommendation is to define the standardised processes which are suitable throughout the entire supply chain to enable the traceability and identifiability of vehicle components. To this end, suitable documentation processes are described in accordance with possible applications and their framework conditions, and general requirements on component marking are formulated. Furthermore, fundamental aspects of using the processes, relating to customer or suppliers, are specified.

The most common documentation processes for traceability in the automotive industry are based on:

- individual component marking
- package marking
- delivery note documentation

Different levels of demarcation precision apply, depending on the alternative chosen.

The customer and supplier/manufacturer select the documentation process for their interface. This means that different documentation processes may be used over the course of the supply chain.

The content of the identification number is a reference which does not contain any quality or process data itself.

The supplier/manufacturer establishes a cross-reference to the quality and production data of the finished product via its reference/identification number. This cross-reference is documented and archived.

This customer uses the reference/identification number of the supplied product to establish a cross-reference to his end product in which it has been fitted. The cross-reference is documented and archived.

The identification number therefore forms the reference between the quality and production data, (e.g. *batch** of raw materials used, manufacturer of bought-in components, inspection results, settings, production site and equipment etc.) of the products supplied by the supplier and the customer's end product. The content of the identification number must be unique over the agreed period of the customer/supplier relationship.

The saved data should be retained by the supplier and customer in compliance with the statutory provisions in force in the various countries in which the products are sold. The data retention period is to be contractually agreed between the customer and supplier.

In the event of a claim, the customer and the supplier/manufacturer exchange the necessary references to enable the cause to be analysed and to minimise damage.

–> Requirements according to IRIS – Rev. 01 (Transportation)

Identification and Traceability (Pt. 7.3)

"ISO 9001:2000 7.5.3 "Identification and traceability" shall apply".

–> Requirements according to AQAP 2110 – Edition 2 (November 2006)

Identification and Traceability (Pt. 7.5.3)

"ISO 9001:2000 7.5.3 "Identification and traceability" shall apply".

–> Requirements according to PRI-NADCAP

Identification and Traceability

"A format of letters, numbers, symbols and patterns that are used primarily to identify component locations and orientations for convenience of assembly and maintenance operations. Additionally, to identify Supplier vendor code, Supplier vendor logo, lot traceability identification, date code of manufacture and serialization, when required by the Customer." (AC7119 Rev. D).

Appendix – List of participating authors and companies**

Group 1: Components/Suppliers

Analog Devices GmbH	Sabine Koschack
AVNET EMG GmbH	Jens Dorwarth
ELMOS Semiconductor AG	Detlev Kraus
ELMOS Semiconductor AG	Dr. Jörg Gondermann
EPCOS AG	Wolfgang Woitsch
Freudenberg Mektec Europa GmbH	Bernhard Vadehra
Infineon Technologies AG	Anja Kalmes
Infineon Technologies AG	Christoph Rippler
Marquardt GmbH	Harry Liebrecht
MSC Vertriebs GmbH	Kai Kemper
MURATA ELEKTRONIK GMBH	Reinhard Sperlich
MURATA ELEKTRONIK GMBH	Eugen Balmberger
OSRAM Opto Semiconductors GmbH	Arne Ameringer
OSRAM Opto Semiconductors GmbH	Hermann Stangl
Panasonic Electric Works Europe AG	Jochen Döring
PHOENIX CONTACT GmbH & Co. KG	Dirk Drühe
Rohde & Schwarz Messgerätebau GmbH	Dr. Franz-Josef Hartmann
Schweizer Electronic AG	Michael Nothdurft
TTI Europe Inc.	Martin Brennecke
VTI Technologies Oy Niederlassung Frankfurt	Jan Pekkola

Group 2: Production

BAUMÜLLER NÜRNBERG	Ralf Kraus
Brose Fahrzeugteile GmbH & Co. KG	William Meyer
CCS Customer Care & Solutions Holding AG	Erich Baumgartner
EADS Deutschland GmbH	Dr. Günter Jost
ELMOS Semiconductor AG	Ralf Montino
EN ElectronicNetwork Hersfeld GmbH	Karl-Heinz Knott
Funk Gruppe	Thomas Gaze
Funk Gruppe	Regina Schach
Handke Industrie Solutions GmbH	Jörg Hofmann
Hella KGaA Hueck & Co.	Karsteb Wiesner
Hella KGaA Hueck & Co.	Dr. Peter Lahl
iTAC Software AG	Martin Heinz
Jürgen Brag Unternehmens- und Technologieberatung	Jürgen Brag
Lenze Operations GmbH	Mario Lindt
Marquardt GmbH	Harry Liebrecht
Miele & Cie. KG	Bernhard Petermann
Pepperl + Fuchs GmbH	Hans-Wolfgang Aicher
Prettl Elektronik Radeberg GmbH	Marcus Viete
Prettl Elektronik Radeberg GmbH	Ingo Rückardt
riese electronic GmbH	Wolfgang Zimmer
Robert Bosch GmbH	Steffen Brockmeier
Robert Bosch GmbH	Klaus Heiber
Rohde & Schwarz Messgerätebau GmbH	Dr. Franz-Josef Hartmann
SANMINA-SCI Germany GmbH	Bernd Enser
Schlafhorst Electronics AG	Manfred Tillmann
SIEMENS AG	Georg Frank
VOGT electronic EMS GmbH	Oliver Magnus Behrendt
VOGT electronic Components GmbH	Norbert Rödel
Zollner Elektronik AG	Roland Heigl

Group 3: Technology

ATEcare Service GmbH & Co. KG	Olaf Römer
diplan GmbH	Friedrich-Wilhelm Nolting
ERSA GmbH	Michael Schäfer
Gaus Softwaretechnik GmbH	Dr. Johann Gaus
H & S Heilig und Schubert Software AG	Stephan Gehling
IBS AG	Torsten Schulz
Infor Global Solutions Deutschland AG	Wolfgang Noack
iTAC Software AG	Dieter Meuser
kratzer Automation AG	Johannes Arneth
kratzer Automation AG	Peter Erhard
kratzer Automation AG	Franz Stieber
Marquardt GmbH	Wolf-Dieter Steinhäuser
Pepperl + Fuchs GmbH	Hans-Wolfgang Aicher
rehm Anlagenbau GmbH	Markus Mittermair
Robert Bosch GmbH	Dr. Rolf Becker
Robert Bosch GmbH	Ulrich Rohrer
Robert Bosch GmbH	Michael Strack
Router Solution GmbH	Philipp Ruhemann
Siemens Product Lifecycle Management	Markus Sauter
Siemens AG	Hubert Egger
Viscom AG	Detlef Beer
WI-SYSTEME GmbH	Hanst Forster
Zollner Elektronik AG	Ernst Neppl
Zollner Elektronik AG	Rudolf Steinbauer

ANALOG DEVICES

AVNET electronics marketing

HELLA

BOSCH
Technik fürs Leben

CCS
Customer Care & Solutions
Holding Switzerland

KSG LEITERPLATTEN

PRETTL
electronics

infineon

ElectronicNetwork
SYNERGIE IN KOMPETENZ

Panasonic

SANMINA-SCI

SCHWEIZER
ELECTRONIC

s.e.t. AG
schlafhorst electronics

ROHDE&SCHWARZ

HASEC
ELEKTRONIK GMBH

VOGT
electronic
Since 1934 – we solve it

SIEMENS

zollner

MARQUARDT

VISCOM
vision technology

muRata
Innovator in Electronics

tiesle
electronic
manufacturing
service

ELMOS
Semiconductor AG

JÜRGENBRAG.
Unternehmens- und Technologieberatung

INFOR

msc.

KOSTAL

Mühlbauer
High Tech International
ROMMEL

EPCOS

iTAC
SOFTWARE

HANDKE
Industrie-Software

EADS
DEFENCE
& SECURITY

alpha-board
excellence in multiple layers

PHOENIX CONTACT
INSPIRING INNOVATIONS

TQ

Lenze

kratzer
AUTOMATION

H&S

di
plan

funk
INTERNATIONALE VERSICHERUNGSMAKLER
UND RISK CONSULTANTS

PEPPERL+FUCHS

Gaus Softwaretechnik

IBS

OSRAM
Opto Semiconductors

BAUMÜLLER

GÖPEL
electronic
Get the total Coverage!

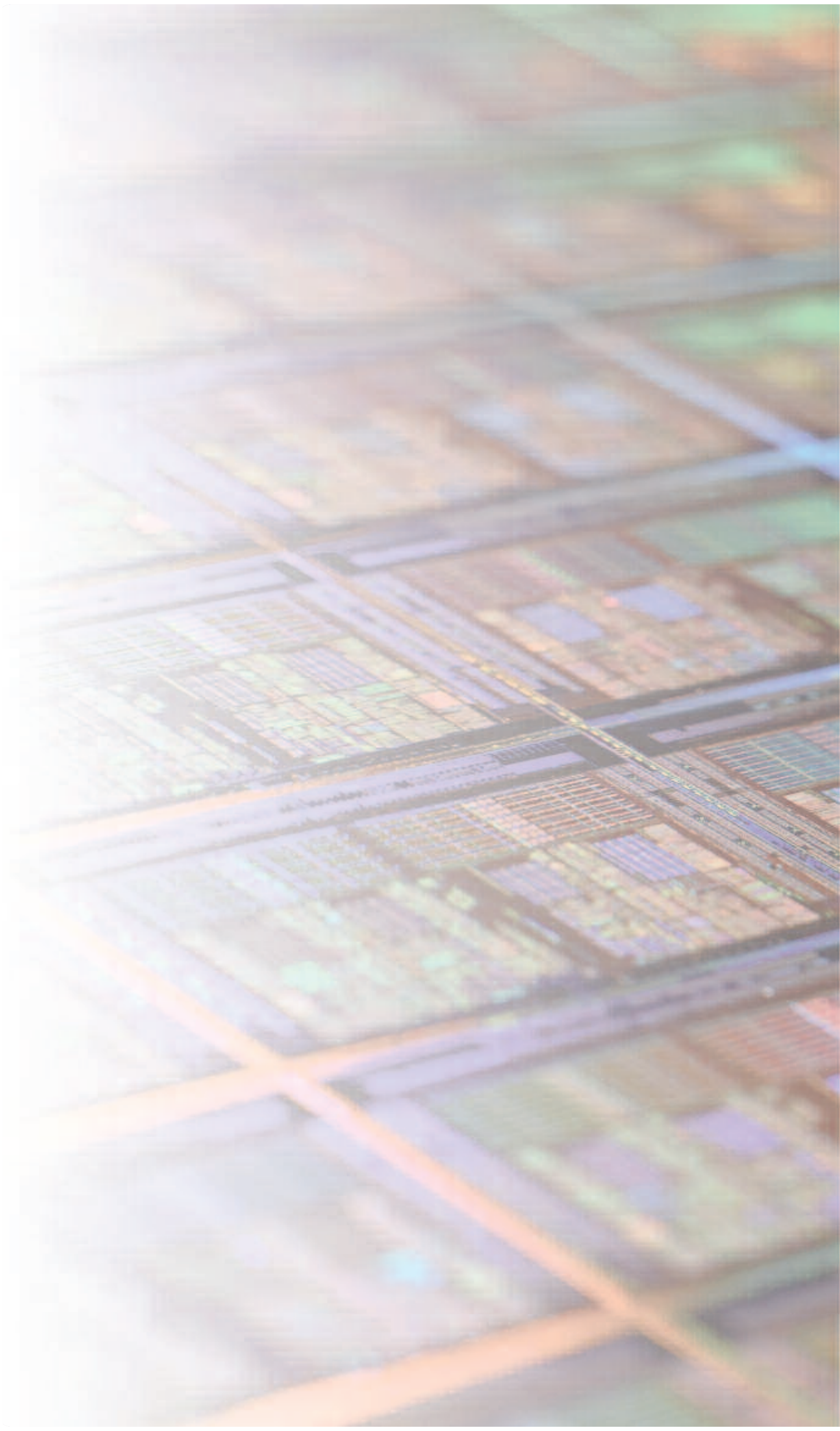
ZF

HARTING

brose
Technik für Automobile

Freudenberg
Freudenberg
Mektec Europe
Member of the Worldwide Mektec Group

ATECARE
automatic test equipment
sales & support



ZVEI - German Electrical and Electronic
Manufacturers' Association e. V.
Electronic Components
and Systems Division
Lyoner Strasse 9
60528 Frankfurt am Main

Phone: +49 (0) 69 6302 - 276
Fax: +49 (0) 69 6302 - 407
Mail: zvei-be@zvei.org
www.zvei.org/ecs