DEUTSCHER SCHRAUBENVERBAND E.V.
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DSV - Information

Technical Delivery Quality of Mechanical Fasteners

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1. Objectives

The manufacturers affiliated within the Deutsche Schraubenverband e.V., together with their partners, are committed to meeting the quality and performance requirements established by international standards and the applicable customer-specific requirements by implementation of the quality objective of a

zero defects

strategy for all mechanical fasteners, assemblies and modules. By applying this directive, they jointly contribute to limiting disruptions in processing of fasteners to the lowest possible minimum.

However, in some cases, the complexity of manufacturing processes and logistical aspects can lead to unsystematic deviations that cannot be prevented in current technological conditions.

The purpose of this document is to show the technical background of important correlations for applying the zero defects strategy as well as possibilities and limitations when applied to the process of manufacturing fasteners in order to contribute to a common perspective of manufacturers and users.

It is important to note that meeting quality requirements is not the sole responsibility of fastener manufacturers, but instead requires close coordination between manufacturer and user. The user is obliged to provide all information required for the application of the product as well as the quantified technical requirements and relevant properties. In the event of a complaint, the user must provide the rejected parts for analysis and must ensure traceability (batch assignment) within his processes. In order to assess a mechanical connection, an analysis of the system is always absolutely necessary. The elements comprising such a fastening system include the fastener itself, its specific components and the relevant assembly process of such a system.

***Note**:* This document does not cover the evaluation of logistical aspects. The methods to be used for this are to be developed and agreed to by both the manufacturer and the customer before the contract is concluded. In general, it is not viable to utilise a ppm evaluation for logistic processes (incorrect deliveries, unsuitable packaging, labelling errors, etc.).

2. Effects of manufacturing processes

The manufacturing of threaded fasteners can be divided into the following processing steps:

- Hot and cold forming
- Thread manufacturing
- Machining
- Washing/cleaning/blasting
- Tempering

- Surface coating
- Loading and unloading of containers
- Internal transport
- Sorting and packaging
- Storage and shipping

Threaded fasteners are manufactured in mass production with the potential for mixing parts or production lots. Furthermore, the conditions of external transport and local conditions at subcontractor or customer/user sites as well as bulk and handling processes can lead to unintentional mixing or contamination.

This means that despite continuous improvement of the production processes, there is always a residual probability that non-systematic events (e.g. spalling of the heads of threaded fasteners, foreign parts, intermixing, other types of damage, bending) will result in products within a production lot that do not conform to the specifications.

For this reason, in many cases the production process is completed by manual or automatic sorting, which reduces the number of occurring parts with deviations and/or foreign parts. However, in most cases mechanical properties can only be verified by destructive testing methods. The testing of mechanical properties can therefore often only be achieved by means of statistical methods.

The responsibility lies with each manufacturer to define and implement reliable processes at all stages of production. The basic requirements for these processes are described in the following international standards:

ISO 9001	Quality Management Systems - Requirements
ISO TS 16949	Quality management systems - Particular requirements for the application of ISO 9001 for automotive production and relevant service part organizations
EN ISO 16426	Fasteners - Quality assurance system

3. Definitions

Fault: Non-fulfilment of a requirement resulting in either a limited function or use or compromised usability. This also includes foreign parts/mixing.

Deviation: Non-fulfilment of a requirement (for example, exceeding or falling below a tolerance range), while the function or usability is basically retained.

ppm: Number of parts with defects in a production lot or evaluation period of fasteners per 1 million parts.

4. Requirements

In general, mechanical fasteners are described by a series of geometric and mechanical properties specified in customer specifications or standards.

For fasteners with special, especially safety-critical applications, ppm values (i.e. defective parts per million pieces) may be required. This often results in increased expenditure, which can lead to higher costs. Automatic sorting processes may be required to meet these ppm requirements.

A controlled production process is necessary for high and consistent quality of mechanical fasteners. For variable characteristics this can be verified using C_{pk} or C_{mk} key figures, provided statistical rules apply.

4. Basic information

4.1 General

- The zero defects strategy is a common goal of manufacturer and user. It is not an assurance that ppm = 0 can be achieved.
- Agreements regarding the design and quality of mechanical fasteners should be established in in close cooperation between the manufacturer and the user early during the initial concept phase leading to the final product. This cooperation includes the exchange of all necessary information regarding the function and assembly of the fasteners.
- Close cooperation is also necessary in the event of detected faults in order to minimise the costs of preventive and remedial measures.
- Even present state-of-the art sorting machines are neither capable of recording all specified characteristics of a fastener and sorting accordingly, nor detecting 100% of parts with deviations/faults (slippage!)
- The characteristics to be considered in a 100% inspection must be coordinated between manufacturer and user or customer.

4.2 Technical aspects

4.2.1 ppm requirements

- ppm requirements regarding a fastener must refer to agreed and defined characteristics of the fastener that affect its function or assembly. The agreement should include the method of fault detection. The agreement is to be specified at the time of the order.

  In the event of a claim regarding a delivery batch, the ppm number must be determined for the affected production lot. This is usually achieved by a 100 % sorting process. The ppm figures listed below, or contractually agreed upon, apply to the acceptance or rejection of the claim.

- Requests for generalised ppm values of production lots without reference to defined characteristics are devoid of any technical basis and can only be used to evaluate the general quality level of a manufacturer or supplier (supplier evaluation). Generalised ppm requirements should relate to a fixed period of time; they should not be applied to the acceptance of a single production lot.

- The determination of ppm values is primarily suitable for assessing unsystematic influences or events.

- In most cases, ppm specifications involve expensive automated sorting. For this reason, a detailed cost-benefit assessment should be compiled.

- ppm specifications are not suitable for properties or characteristics that require a destructive test method. Examples:

  - Tensile strength
  - Hardness
  - Surface discontinuities
  - Decarburization, entire and partial
  - Impact strength
  - Metallographic microstructure
  - Other similar properties

- There are a number of characteristics that can influence the quality of the entire lot in the event of deviations from requirements, because the processing method always affects the total production quota. These characteristics should not be included in a ppm evaluation. Examples:

  - Corrosion resistance
  - Appearance
  - Coefficients of friction
  - Coating thickness.

- State-of-the-art technology for attainable ppm values in relation to a <u>single</u> characteristic of cold- formed products:

  - Unsorted: 200 ppm *
    500 ppm (regarding foreign parts)
  - Manually sorted: 100 ppm *
  - Automatically sorted: 10 ppm

  *) for products with a length-diameter ratio l/d > 10, special ppm values must be agreed upon between manufacturer and customer regarding the characteristic 'straightness'.

- Characteristics suitable for automatic sorting:

  According to state-of-the-art technology, various measuring and testing methods are used, e.g. mechanical methods, optical methods (camera or laser technology) or the eddy current method. This allows for sorting of production lots by the following characteristics or sizes, among others:

Dimension specifications:

- Length (mechanical / optical)
- Thread length (optical)
- Thread diameter (mechanical / optical)
- Pitch diameter (mechanical / optical)
- Head / collar diameter (mechanical / optical)
- Shaft diameter (optical)
- Head height (mechanical / optical)
- Core diameter (optical)
- Depth internal drive (mechanical)
- Height external drive (mechanical / optical)
- Thread pitch (mechanical / optical)
- Width across flats (mechanical / optical)
- Roundness / axial alignment
- Inner / outer diameter and height of discs (mechanical / optical)

Presence of specific geometries, configurations or elements:

- Thread present yes/no (mechanical / optical)
- Internal drive present (mechanical / optical)
- External drive present (mechanical / optical)
- Clamp lock present with nut (mechanical / optical)
- Alignment tip present (mechanical / optical)
- Pre-assembled flat washer present (mechanical / optical)
- Microencapsulated adhesive present (optical)

Other characteristics:

- Foreign parts (mechanical / optical / eddy current)
- Fractures/cracks in the head/collar (eddy current)
- Fractures/cracks in the shaft (optical/eddy current)
- Functionality of driving feature (mechanical)

- In terms of cost efficiency, the customer should only select characteristics for sorting that are essential to the assembly or function of the fastener(s).
- Experience shows that the corrosion resistance of the product can be impaired or at least reduced by a sorting process.
- The number of pseudo-rejects rises significantly in the context of a rising number of sorting characteristics. Therefore, sorting by characteristics of secondary importance should be avoided.

4.2.2 Statistical Process Control (SPC)

- SPC is only suitable for properties that can be influenced by the operator or technical equipment during the manufacturing process.
- While unsystematic deviations cannot be detected by SPC, systematic deviations can usually be limited by the use of SPC (see also ISO 16426).

- In addition, the following should be noted in the case of a single characteristic: If the process is stable ($C_{pk} = C_p$) and if a C_{pK} value of 1.33 is assumed, this indicates that more than 63 ppm of the finished products may still be out of tolerance (ISO 16426). This ppm value decreases with higher C_{pk} or C_p-values (however, with such deviations, there is usually no danger of functional impairment!).

- The requirement for C_{pk} or C_p values ≥ 1.33 stipulates a limited use of the specified tolerance window. For sizes that are associated with tool wear in production, this leads to shorter tool replacement intervals and thus increased production costs.

There are a number of characteristics or specified processes that are not or only conditionally suitable for SPC control, for example:

Category	**Characteristic (Example)**
Not controllable; dependent on tool behaviour	- Radii - Angles - Thread dimensions (limited control due to pre-dimension) - Formed shank diameter - Stamped width flats - Shape and position tolerances
Characteristics produced in a single, separate and closed process	- Coating weight of the surface protection system - Corrosion resistance - Hardness (thermal treatment in chamber furnace) - Alloy composition - Coefficients of friction - Usability of thread gauges (handling damage) - Driving torques
Characteristics which are not normally distributed (Gaussian curve) (non-centric tolerance position)	- Strength (thermal treatment in continuous furnace) - Hardness (thermal treatment in continuous furnace) - Thread diameter
Characteristics with both low tolerance and low accuracy of the measuring devices	- Fit diameter for coated threaded fasteners - Coating thickness for coated threaded fasteners
Characteristics that are manufactured with automatic adjustment or exhibit a creeping trend	
Multi-part assembly process	
Processes with various inhomogeneous materials	

Previous editions
November, 1996
December, 1997
January, 1999

5. Source literature

- DIN EN ISO 16426: Fasteners -- Quality assurance system (January 2003)
- AFFIX Reference guide for quality rules and practices for fastening products, (2nd edition, October 2006)
- European Industrial Fastener Institute (EIFI) guideline
  Mechanical Fasteners – Quality of Technical Characteristics (April 2009).