

Master Document: Identification and Documentation of Special Characteristics

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Most recent change history:

Revision	Description of Change
E to F	“Zero Defects” changed to “Error Proof” in the CIT table on page 10.

Changes in relation to previous issue are written with red, alternatively for figures and tables with a red frame around

Identification and Documentation of Special Characteristics

1 SCOPE AND APPLICATION

This standard defines the requirements for the selection, identification, documentation and manufacturing controls of design and process related special characteristics.

This standard applies to Sauer-Danfoss, Globally.

2 PURPOSE

The purpose of this standard is to define the Sauer-Danfoss system for classifying the characteristics most important for our customer's safety and satisfaction as special characteristics.

The classification system ensures extra attention and manufacturing process controls are focused on those "vital few" characteristics during the product and process design, PPAP Validation, and on-going production.

3 DEFINITIONS

The special characteristic designations to be used as part of the Sauer-Danfoss system are:

Safety Characteristics – Safety characteristics are those characteristics/features which have the potential to affect safety.

When defining safety characteristics the safety of all personnel involved in the manufacture, test, commissioning, and end use of the product need to be considered.

Safety characteristics are best controlled through well-understood and maintained design margins coupled with manufacturing error-proofs that prevent or detect abnormal process variations which could significantly reduce operating margins.

Safety critical items will be identified on the engineering drawing with a pentagon with an 'S' inside it.

Key Characteristics - Key characteristics are defined to be those characteristics for which the normally expected process variation affects product function/customer satisfaction.

Stated another way, the end customer can distinguish product differences due to the variation of a key characteristic *within* specification. The customer's satisfaction is increased when these characteristics are maintained on target with minimum variation.

Key Characteristics will be identified on the engineering drawing with a pentagon with a 'K' inside it.

Process Characteristics – Process Characteristics are characteristics which do not directly affect the function of a product but are important for success of downstream manufacturing processes such as an automated assembly.

Process characteristics will be identified on the engineering drawing with a pentagon with a 'P' inside it.

Characteristics with Multiple Designations – In rare cases characteristics could be *both* "Safety" and "Key". This would designate that the feature needs to be statistically maintained "on target with minimum variation" for customer satisfaction as well as being error-proofed to ensure the prevention or detection of any abnormal process variations which could significantly reduce operating margins.

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Standard Characteristics - The majority of characteristics are standard characteristics. Standard characteristics must be maintained within specified limits.

Standard Features are those for which reasonably anticipated manufacturing variation is unlikely to significantly affect a product's safety or function.

Standard Features do not have a symbol.

4 RESPONSIBILITY

Product Engineering is responsible for classifying Safety and Key special characteristics.

Process characteristics, if required, are to be classified by Process Engineering and communicated to Product Engineering for inclusion on the drawing/specification.

Product Engineering managers in the individual areas shall be responsible for ensuring compliance with the requirements contained in this standard.

Efforts should be taken by Product Engineering to minimize the number of special characteristics through design activities focused on reducing the severity and/or occurrence rankings from the Design FMEA (DFMEA).

Typically, this can be achieved by making design changes that eliminate failure modes with high severity rankings, by adopting a design that has a large design margin, or by improving the engineering organization's fundamental knowledge of the causes of failure.

5 GENERAL

Characteristics are divided into four classifications (Safety, Key, Process, Standard) based on a Design FMEA assessment of failure mode severity and occurrence ratings and/or a Quality Loss Function Analysis.

Each classification has process capability and control requirements and also serves to indicate to the process/service operators the level of importance of the operation they are performing.

6 IDENTIFICATION AND CLASSIFICATION METHOD

Potential Special Characteristics shall be determined by the DFMEA occurrence and severity rankings as shown in Table 1.

The Occurrence and Severity rankings shall originate from a Design FMEA conducted per the Sauer-Danfoss standard, GS-0002.







If the severity is ≥ 9 , then the characteristic is a safety characteristic, independent of its status as a key characteristic. Any severity ≥ 9 occurring in the product, which cannot be reduced through re-design, requires steps to mitigate the risk in the manufacturing process.

If severity is ≥ 5 *and* occurrence ≥ 4 , the characteristic is classified as a key characteristic.

Characteristics may be classified with more than one special characteristic. For example, characteristics with a severity of ≥ 9 and the occurrence ≥ 4 are classified as Safety *and* Key characteristics.

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Table 1

		Design Occurrence											
		1	2	3	4	5	6	7	8	9	10		
		Failure Mode Severity											
		1	2	3	4	5	6	7	8	9	10		
Legend  Key Characteristics for Function   Safety Characteristic   Safety and Key Characteristic 	None	Very Minor	Minor	Very low	Low	Moderate	High	Very high	Hazardous with warning	Hazardous without warning			
	Calculation and Analysis	Not possible	Possible, with low correlation to test results	Possible with generally acceptable correlation to test results	Possible, with high level of correlation to test results	Unknown	Small, not well established or understood	Small	Similar designs in similar applications frequently show problems	Typically is Not Approved	Typically approved for small differences, <33% of tolerance range		
	Design Margin	Unknown	Small, not well established or understood	Small	Somewhat established and understood	Large, established and understood	Similar designs in similar applications sometimes have problems	Some problems detected in first round of testing, but easy to overcome with help of analysis	Proven design which typically passes first round of testing; similar designs in similar applications have no problems	Typically is Not Approved	Typically approved for larger differences, up to 100% of tolerance range		
	Lab and Field Test Results	Similar designs in similar applications frequently show problems	Similar designs in similar applications sometimes have problems	Some problems detected in first round of testing, but easy to overcome with help of analysis	Proven design which typically passes first round of testing; similar designs in similar applications have no problems	Unknown	Similar designs in similar applications	Some problems have problems	Similar designs in similar applications frequently show problems	Typically is Not Approved	Typically approved for small differences, <33% of tolerance range		
	Deviations	Typically is Not Approved	Typically approved for small differences, <33% of tolerance range	Typically approved for larger differences, up to 100% of tolerance range									

Reference GS-0002 for Design FMEA Occurrence and Severity descriptions.

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In addition to the use of DFMEA Severity and Occurrence, *Key* characteristics can be determined using the quality loss function logic defined in Appendix ‘C’.

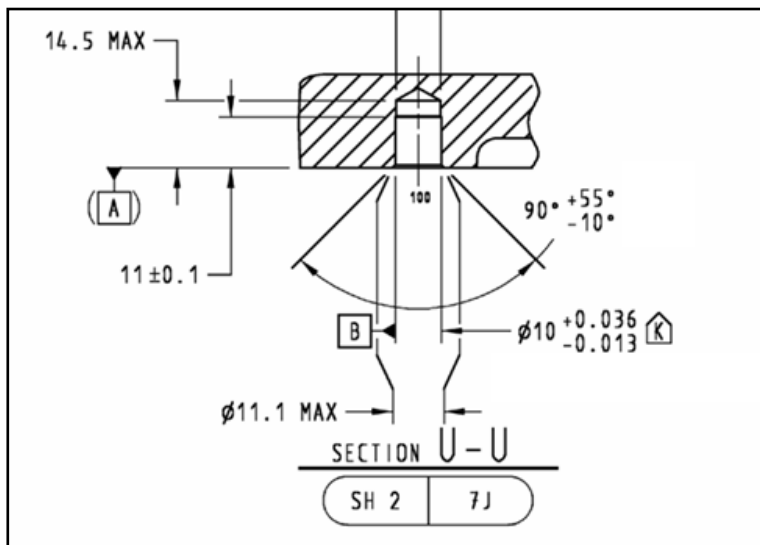
Quality Loss Function logic can be an effective way to assess “border” cases from the “S x O” method (i.e. Occurrences of 5 & 6 and Severities of 5 and 6) to determine if classification as a “Key” characteristic is really warranted.

DOCUMENTATION REQUIREMENTS

Product Engineering is responsible for recording on the technical document (e.g. drawing, assembly specification, test specification, material specification etc.) any special characteristics.

A pentagon with an ‘S’ for Safety, a pentagon with a ‘K’ for Key, a pentagon with a ‘P’ for Process shall be placed on the technical document by each characteristic designated as a special characteristic. See Figure 1.

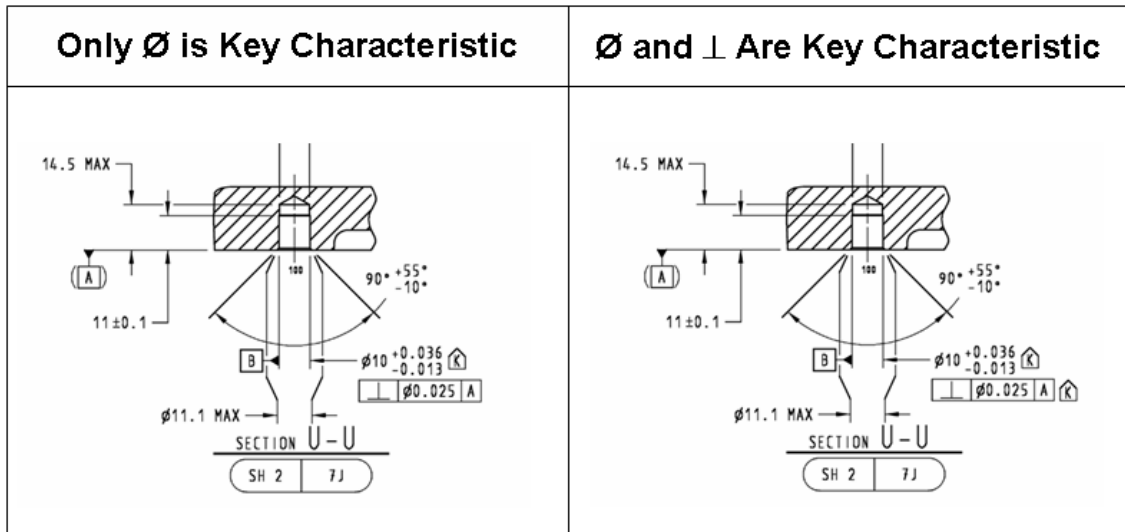
Figure 1



In the case that a feature is described by multiple callouts, a special characteristic designation is required for each callout. See Figure 2.

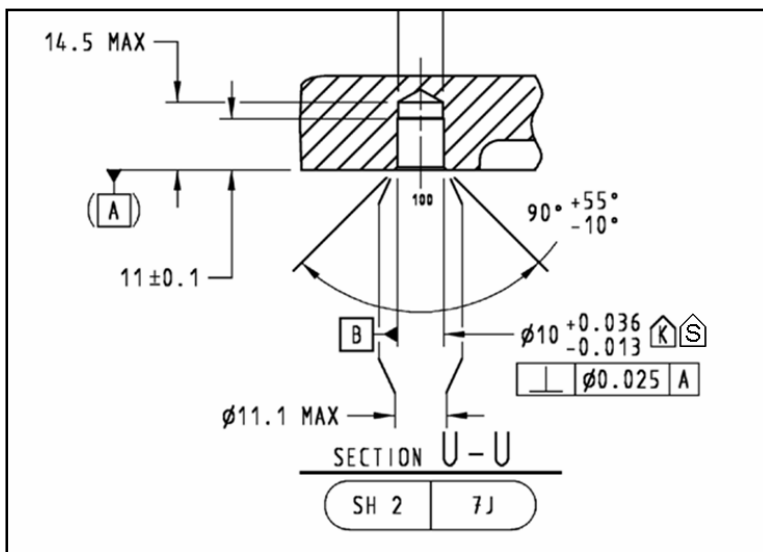
Identification and Documentation of Special Characteristics

Figure 2



In cases where a characteristic is both a safety and a key, the special characteristics are to be designated as shown in Fig 3. The order (K first or S first) is not important.

Figure 3.



Product Engineering shall include on all drawings and relevant specifications, as early as possible in the design process, a Customer Importance Table (CIT) summarizing special characteristics.

Standard Characteristics may also be included, but they are not required in the CIT unless deemed necessary by the team during the Design for Manufacturability/Assembly/Test (DFM/A/T) process.

Typical drawing and specification CIT formats, as well as guidelines for completing the CIT, can be found in Appendix A. The Customer Importance Table is always located on the first sheet.

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It is optional to include a table indicating the location and quantity of special characteristics placed on the drawing (see Appendix A).

Technical documentation that has undergone an FMEA process with no resulting special characteristics identified, must either include a blank CIT (see Appendix A), or the text “Special Characteristics per GS-0004” must be shown in the drawing/specification indicating the process for identifying special characteristics has been completed but no special characteristics were found.

Special Characteristics can also for other reasons be denoted in the documentation even though the FMEA process did not identify any Characteristics per Table 1.

6.1 Sauer-Danfoss drawings and specifications created prior to GS-0004Rev E

Special characteristics created prior to GS-0004 Rev. E followed a different classification system. The system defined Quality Characteristics as Critical and Key characteristics and did not have Safety or Process characteristics. Critical and Key characteristics (prior to revision E) are to be interpreted as Key Characteristics under the New System.

Characteristic Type	GS-0004 Before Rev E	GS-0004 Rev E & After
Safety	Not Part of Standard	Safety Characteristic 
Quality	Critical 	Key Characteristic 
	Key 	
Process	Not Part of Standard	Process Characteristic 

7 PPAP AND PROCESS CONTROL REQUIREMENTS

Process FMEA

Special characteristics also serve as the method for conveying Severity from the Design FMEA to Process FMEA (PFMEA). This provides a robust method of communicating the appropriate severities without providing a DFMEA. Unless otherwise specified, PFMEA severities shall be assigned based on the type of special characteristics as shown below.

- Safety = Severity of 10
- Key = Severity of 8
- Safety + Key = Severity 10
- Process = Severity of 4
- Standard (no Symbol) = Severity of 4

Identification and Documentation of Special Characteristics

Capability

The process capability requirements shall be satisfied for each special characteristic per Table 2.

Table 2

Classification	Minimum Cp Requirement	Minimum Cpk Requirement	Equivalent PPM Level
Safety	Error Proof		
Key	≥1.83	≥1.33	≤32
Process	≥1.0	≥1.0	≤2700
Safety + Key	≥1.83	≥1.33	Error Proof
Standard	≥1.0	≥1.0	≤2700

Process capability studies shall be completed for Key and Process characteristics and submitted as part of the PPAP process. Reference Sauer-Danfoss standard GS-0007.

If the process capability requirements are not met, then Product and Process Engineering must work to resolve the issue.

Typically, resolution can be achieved by changing the design concept, testing/analysis to determine if design tolerance can be increased, and/or implementing process improvements.

In the cases where these activities do not achieve the desired capability a more restrictive control plan such as 100% inspection to reduced limits can be used.

Measurement

Production Gauging shall be selected for each special characteristic per Table 3.

Table 3

Classification	Gauging	GR&R
Safety	Error Proof	Not Applicable
Key	Variable	≤20% Required
Safety + Key	Error Proof + Variable	≤20% Required
Process	Variable or Attribute	≤30% is recommended for all measurement systems
Standard	Variable or Attribute	

Key Characteristics must have Gage Repeatability and Reproducibility (GR&R) studies completed and submitted as part of the PPAP process. Reference Sauer-Danfoss standard GS-0010.

If GR&R requirements are not met, work must be done to resolve the issue.

For key characteristics with DFMEA occurrences ≥8 continuing efforts to achieve ≤ 20% GR&R should be undertaken.

For key characteristics with DFMEA occurrences ≤ 7 more restrictive control plans such guard banding (reducing tolerance by the GR&R) or attribute gauging can be employed to mitigate a GR&R > 20%.

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Control Plan

The production control plan shall identify each special characteristic (S, K, or P) and define the production process controls. Reference Sauer-Danfoss standard GS-0012.

The production process control method for special characteristics shall be selected for each special characteristic per Table 4.

Table 4

Classification	Production Control Method	Examples for Reference Only
Safety	Error Proof	Poke-Yoke
Key	Statistically based charted method	Statistical Process Control with Cpk>1.33 Pre-Control at 50% Green Zone Other Statistically Proven Controls
Safety + Key	Error Proof + Statistically based charted method	Poke-Yoke plus Pre-Control at 50% Green Zone
Process	Samples to Print	Check 1/10 to print limits

The control plan must be submitted as part of the PPAP process.

In cases where other production control methods are chosen they must statistically demonstrate an equivalent PPM less than requirements shown in Table 2.

8 REFERENCES:

Sauer-Danfoss Global Standards:

- Design FMEA GS-0002
- Capability Study GS-0007
- Gage R&R GS-0010
- Control Plan Requirements GS-0012

CHANGE HISTORY:

Date	Old/New Rev.	Description of Change
2004-08-26	A / B	Pp, Ppk for short-term and Cp, Cpk for long-term capability. Section 5: Table 1 with extended occurrence and severity rankings. Section 6: Documentation of the FMEA process. Section 7: Table 2 split up into 2A and 2B. Reference for process capability changed from GS-0002 to GS-0007. App A: Last section of CIT table. Link to special symbols for critical and key characteristics.
2004-11-07	B / C	App. A: CIT table changed to Customer Importance Table Critical and Key added below the symbols.
2005-05-13	C / D	CIT on <u>first</u> sheet of documentation. Option to include Criticals Location Table.
2009-06-30	D / E	Critical Characteristics changed to Special Characteristics in title. The standard has been totally rewritten.
2009-09-07	E / F	“Zero Defects” changed to “Error Proof” in the CIT table on page 10.

APPENDIX A

Guidelines for Completing The Customer Importance Table (CIT)

CIT TERMS AND DEFINITIONS




Pentagon – with identification for Safety, Key, or Process characteristics, referring to the CIT.

Cp – Process capability index. Reference GS-0007

Cpk – Process capability index adjusted for process off center. Reference GS-0007


Customer Importance Table (CIT)

Table is included in drawing or specification

Customer Importance Table		
Symbol	Description	Requirement
	Safety	Error Proof
	Key	$Cpk \geq 1.33$
	Process	Tolerance required for process not function
None	Standard	$Cpk \geq 1$
CIT is referring to Sauer-Danfoss Global Standard GS-0004		

Special Characteristics Location Table (optional)

Table is included in drawing or specification

ZONE	SHEET
 LOCATION	

The "Zone" column will indicate quantity of "△S's" or , "△K's" or "△P's" with a "(number)X" prefix to the zone (Example: 2X 12H).

It is not necessary to indicate quantity when there is only one critical in a zone.

APPENDIX B

Special Characteristics for Material & Heat Treatment

Special Characteristics may be applied to material and heat treatment specifications

The same rules for determining if a characteristic is a special characteristic should be followed (i.e. DFMEA severity ≥ 5 and occurrence ≥ 4).

It is not appropriate to put “K” on a material specification because the design margin would be low if the producer uses the wrong material or a required heat treatment is omitted.

The special characteristics must be assigned to something that is measurable (hardness, case depth, tensile strength, etc.) and not to the entire specification.

Material/heat treatment special characteristics with DFMEA occurrence rankings 4-7

The production control objective should be to eliminate or detect process problems which could produce characteristics out of specification.

Production Part Approval Process activities should focus activities on the material/heat treatment Process FMEA and the Production Control plan.

The control plan should define samples representing both the “Within” variation due to position in Basket/Oven or order (First, Middle, Last) as well as the “Between” variation due to different batches or runs.

Capability and Gage R&R studies should be replaced by studies to understand and implement the best sampling methodologies.

Material/heat treatment special characteristics with DFMEA occurrence rankings 8-10

The production control objective should be to maintain the process on target with minimum variation.

In addition to the recommendations above the Capability and GR&R activities should be completed.

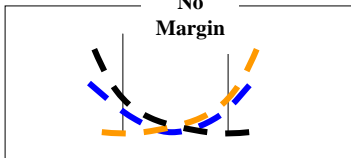
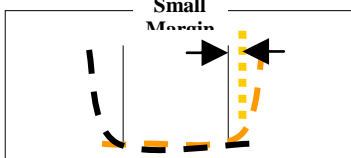
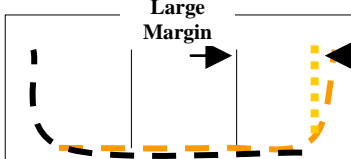
APPENDIX C

Determining Key Characteristics Using a Quality Loss Function

Quality Loss Functions may also be used for determining “Key” Characteristics. It is not appropriate for “Safety” characteristics which must come from DFMEA Severity ratings.

Use of the Quality Loss Function **does not** replace/negate the requirement for completing a DFMEA! It is only a different method for determining “Key” characteristics. Reference GS-0002 for DFMEA requirements.

If Quality Loss Function methodology is used, it should be completed by a panel of Product Engineering experts representing the body of knowledge of the entire engineering department and be facilitated by someone with expert knowledge of loss functions. The figures below summarize determining Key characteristics through loss functions.

<ul style="list-style-type: none"> • Continuous Loss Function Key <ul style="list-style-type: none"> – Losses When “Inside Specification” 	
<ul style="list-style-type: none"> • Low Margin Loss Function May be Key <ul style="list-style-type: none"> – Losses When “Just Outside of Specification” – Small Margin 	
<ul style="list-style-type: none"> • High Margin Loss Function Not Key <ul style="list-style-type: none"> – Losses When “Far Outside Specification” – Large Margin 	

LOSS FUNCTION

