

ISO 13849-1:2023-04 (E)

Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design

| Contents | Page |
|--|------|
| Foreword | vi |
| Introduction | viii |
| 1 Scope | 1 |
| 2 Normative references | 1 |
| 3 Terms, definitions, symbols and abbreviated terms | 2 |
| 3.1 Terms and definitions | 2 |
| 3.2 Symbols and abbreviated terms | 10 |
| 4 Overview | 12 |
| 4.1 Risk assessment and risk reduction process at the machine | 12 |
| 4.2 Contribution to the risk reduction | 14 |
| 4.3 Design process of an SRP/CS | 14 |
| 4.4 Methodology | 15 |
| 4.5 Required information | 16 |
| 4.6 Safety function realization by using subsystems | 17 |
| 5 Specification of safety functions | 17 |
| 5.1 Identification and general description of the safety function | 17 |
| 5.2 Safety requirements specification | 18 |
| 5.2.1 General requirements | 18 |
| 5.2.2 Requirements for specific safety functions | 21 |
| 5.2.3 Minimizing motivation to defeat safety functions | 24 |
| 5.2.4 Remote access | 25 |
| 5.3 Determination of required performance level (PL _r) for each safety function | 25 |
| 5.4 Review of the safety requirements specification (SRS) | 26 |
| 5.5 Decomposition of SRP/CS into subsystems | 26 |
| 6 Design considerations | 27 |
| 6.1 Evaluation of the achieved performance level | 27 |
| 6.1.1 General overview of performance level | 27 |
| 6.1.2 Correlation between performance level (PL) and safety integrity level (SIL) | 29 |
| 6.1.3 Architecture -- Categories and their relation to MTTFD of each channel, average diagnostic coverage and common cause failure (CCF) | 29 |
| 6.1.4 Mean time to dangerous failure (MTTFD) | 36 |
| 6.1.5 Diagnostic coverage (DC) | 37 |
| 6.1.6 Common cause failures (CCFs) | 38 |
| 6.1.7 Systematic failures | 38 |
| 6.1.8 Simplified procedure for estimating the performance level for subsystems | 39 |
| 6.1.9 Alternative procedure to determine the performance level and PFH without MTTFD | 40 |
| 6.1.10 Fault consideration and fault exclusion | 42 |
| 6.1.11 Well-tried component | 43 |
| 6.2 Combination of subsystems to achieve an overall performance level of the safety function | 43 |
| 6.2.1 General | 43 |
| 6.2.2 Known PFH values | 43 |
| 6.2.3 Unknown PFH values | 44 |
| 6.3 Software based manual parameterization | 44 |

| | | |
|---|---|----|
| 6.3.1 | General | 44 |
| 6.3.2 | Influences on safety-related parameters | 45 |
| 6.3.3 | Requirements for software based manual parameterization | 46 |
| 6.3.4 | Verification of the parameterization tool | 47 |
| 6.3.5 | Documentation of software based manual parameterization | 47 |
| 7 | Software safety requirements | 47 |
| 7.1 | General | 47 |
| 7.2 | Limited variability language (LVL) and full variability language (FVL) | 49 |
| 7.2.1 | Limited variability language (LVL) | 49 |
| 7.2.2 | Full variability language (FVL) | 49 |
| 7.2.3 | Decision for limited variability language (LVL) or full variability language (FVL) | 49 |
| 7.3 | Safety-related embedded software (SRESW) | 51 |
| 7.3.1 | Design of safety-related embedded software (SRESW) | 51 |
| 7.3.2 | Alternative procedures for non-accessible embedded software | 52 |
| 7.4 | Safety-related application software (SRASW) | 52 |
| 8 | Verification of the achieved performance level | 55 |
| 9 | Ergonomic aspects of design | 55 |
| 10 | Validation | 55 |
| 10.1 | Validation principles | 55 |
| 10.1.1 | General | 55 |
| 10.1.2 | Validation plan | 57 |
| 10.1.3 | Generic fault lists | 58 |
| 10.1.4 | Specific fault lists | 58 |
| 10.1.5 | Information for validation | 58 |
| 10.2 | Validation of the safety requirements specification (SRS) | 59 |
| 10.3 | Validation by analysis | 60 |
| 10.3.1 | General | 60 |
| 10.3.2 | Analysis techniques | 60 |
| 10.4 | Validation by testing | 60 |
| 10.4.1 | General | 60 |
| 10.4.2 | Measurement accuracy | 61 |
| 10.4.3 | Additional requirements for testing | 62 |
| 10.4.4 | Number of test samples | 62 |
| 10.4.5 | Testing methods | 62 |
| 10.5 | Validation of the safety functions | 63 |
| 10.6 | Validation of the safety integrity of the SRP/CS | 63 |
| 10.6.1 | Validation of subsystem(s) | 63 |
| 10.6.2 | Validation of measures against systematic failures | 64 |
| 10.6.3 | Validation of safety-related software | 65 |
| 10.6.4 | Validation of combination of subsystems | 66 |
| 10.6.5 | Overall validation of safety integrity | 66 |
| 10.7 | Validation of environmental requirements | 66 |
| 10.8 | Validation record | 67 |
| 10.9 | Validation maintenance requirements | 67 |
| 11 | Maintainability of SRP/CS | 67 |
| 12 | Technical documentation | 68 |
| 13 | Information for use | 68 |
| 13.1 | General | 68 |
| 13.2 | Information for SRP/CS integration | 68 |
| 13.3 | Information for user | 69 |
| Annex A (informative) Guidance for the determination of required performance level (PLr) | | 71 |
| Annex B (informative) Block method and safety-related block diagram | | 76 |

| | |
|---|-----|
| Annex C (informative) Calculating or evaluating MTTFD values for single components | 78 |
| Annex D (informative) Simplified method for estimating MTTFD for each channel | 86 |
| Annex E (informative) Estimates for diagnostic coverage (DC) for functions and subsystems | 88 |
| Annex F (informative) Method for quantification of measures against common cause failures (CCF) | 92 |
| Annex G (informative) Systematic failure | 96 |
| Annex H (informative) Example of a combination of several subsystems | 100 |
| Annex I (informative) Examples for the simplified procedure to estimate the PL of subsystems | 103 |
| Annex J (informative) Example of SRESW realisation | 111 |
| Annex K (informative) Numerical representation of Figure 12 | 115 |
| Annex L (informative) Electromagnetic interference (EMI) immunity | 120 |
| Annex M (informative) Additional information for safety requirements specification (SRS) | 124 |
| Annex N (informative) Avoiding systematic failure in software design | 126 |
| Annex O (informative) Safety-related values of components or parts of control systems | 146 |
| Bibliography | 149 |