

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 (PLr) 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