Manufacturer	Shandong HOACO Automation Technology Co., Ltd.
Test subject	Product: **Rotary Die Cutting Machine** Type: HW2500C16 (Ser. No. missing)
Test specification	EN ISO 13849-1:2015 EN ISO 13849-2:2012
Software	SISTEMA Version 2.0.8 build 4
Purpose of examination	Test according to the test specification
Test result	Passed: The test subject was found to be in compliance with the mentioned test specification

Contents

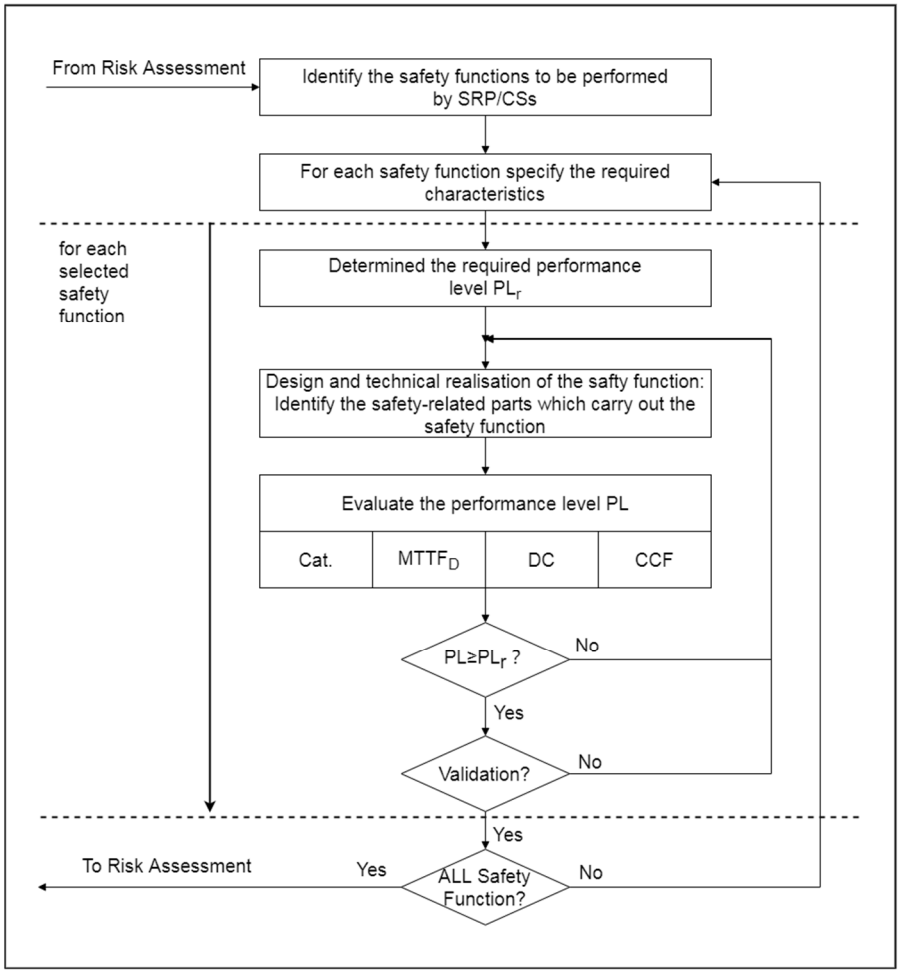
1、Basic information

This report evaluates the performance level of the SRP/CS (Safety-related part of a control system) of the Rotary Die Cutting Machine according to the test specification. The detailed information and procedure should be followed Section 1.2.

1.1 Acronyms, terms & definitions

Acronyms	Terms	Definitions
SF	safety function	function of the machine whose failure can result in an immediate increase of the risk(s)
PL	performance level	discrete level used to specify the ability of safety-related parts of control systems to perform a safety function under foreseeable conditions
PL_r	required performance level	performance level (PL) applied in order to achieve the required risk reduction for each safety function
SRP/CS	safety-related part of a control system	part of a control system that responds to safety-related input signals and generates safety-related output signals
Cat.	category	classification of the safety-related parts of a control system in respect of their resistance to faults and their subsequent behaviour in the fault condition
$MTTF_D$	mean time to dangerous failure	expectation of the mean time to dangerous failure
DC	diagnostic coverage	measure of the effectiveness of diagnostics, which may be determined as the ratio between the failure rate of detected dangerous failures and the failure rate of total dangerous failures
CCF	common cause failure	failures of different items, resulting from a single event, where these failures are not consequences of each other

1.2 Assessment procedure



1.3 Related documents

File 2 SISTEMA Calculation Report

The following documents are provided by the manufacturer as input documents for this report:

Annex 1 Rotary Die Cutting Machine Risk Assessment Report

Annex 2 Electrical schematic

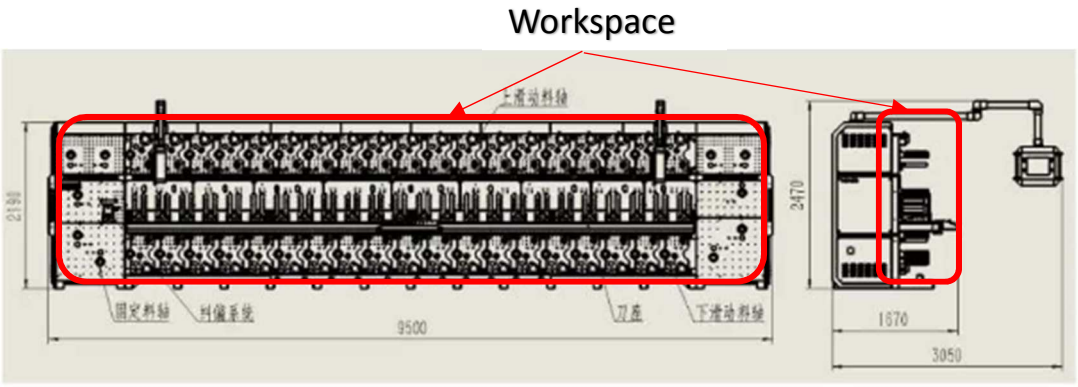
Annex 3 Safety logic diagram

Annex 4 Safety related parts list

Annex 5 Parameter selection specification

2、Risk assessment

According to the Risk Assessment Report of the Rotary Die Cutting Machine, the high-risk positions are described as follows:



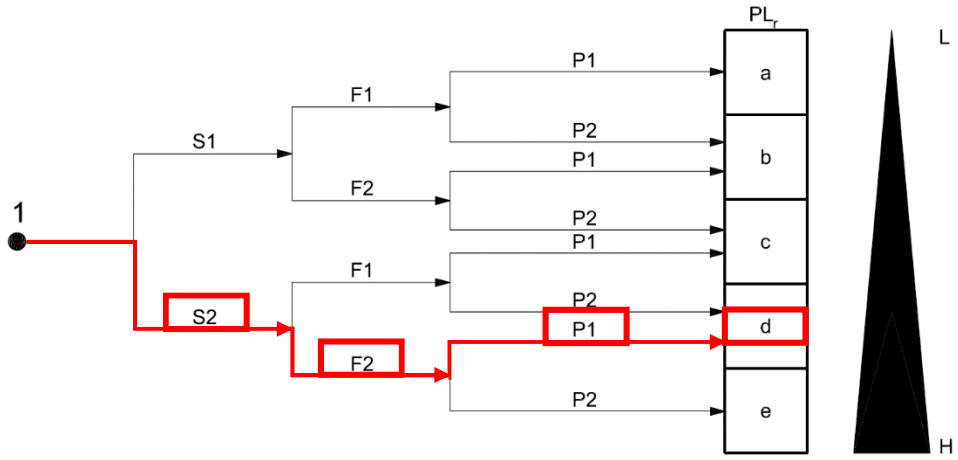
The protective measures relying on a control system listed in the risk assessment report are shown in the following table:

Risk No.	Zones	Harzard Position	Harzard Type	Risk Evaluation	No.	Protective Measure Depend on a Control System
1.1	Workspace	Tension device of material shafts	Crushing	PLd	A	Risk avoidance of workspace with Safety Light Curtain
1.2		Transmission shaft	Drawing-in / trapping	PLd	B	Risk avoidance of workspace with Safety Contact Sensor 1
1.3		Knife shaft	Drawing-in / trapping Cutting / severing	PLd	C	Risk avoidance of workspace with Safety Contact Sensor 2/3
	Machine	Entire machine	Emergency situations	PLd	D	Risk avoidance of entire machine with Emergency Stop

For the performance level assessment of each protective measure SRP/CS, see Parts 3 to 6 of this report.

3、 A Risk avoidance of workspace with Safety Light Curtain

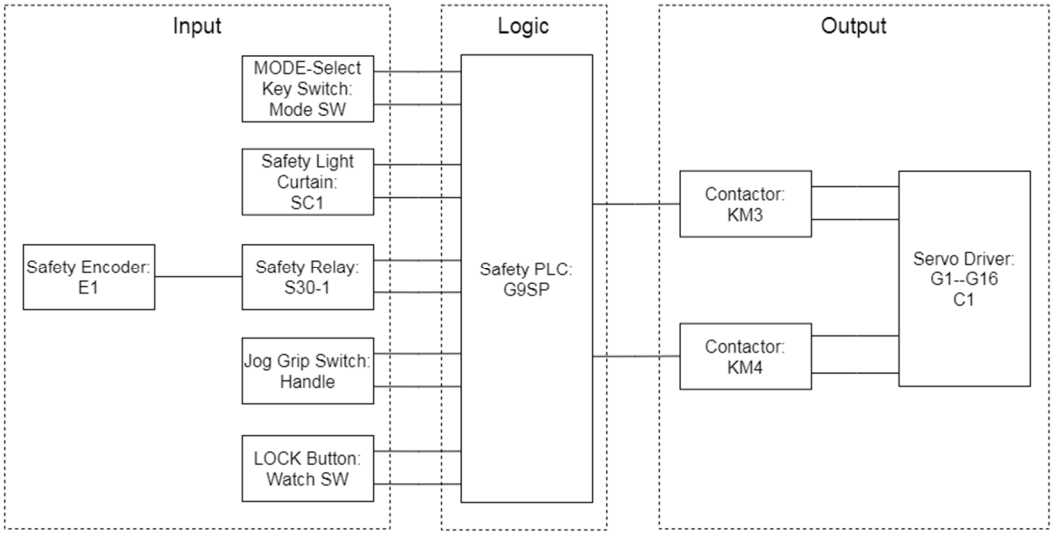
3.1 Performance level required



According to risk assessment, PL_r=d (High risk).

3.2 Design of safety function

The safety circuit design refer to " Annex 2 Electrical Schematic Diagram".
The safety block diagram is shown below:



Safety function logic refer to “Annex 3 Safety logic diagram”.
Considering that the types (or product series) and safety technical parameters of some components are completely the same, they can be evaluated only once. The safety functions performed by SRP / CS can be identified as follows:
SF A.1: MODE-Select Key Switch safety function
SF A.2: Safety Light Curtain safety function

SF A.3: Safety Encoder safety function

SF A.4: Jog Grip Switch safety function

SF A.5: LOCK Button safety function

3.3 Evaluation of performance level

SF A.1：MODE-Select Key Switch safety function

■ Identification of SPR / CS

The SPR / CS list of this safety function is as follows:

No.	ID	Components	Part Number	Manufacturer
1	Mode SW	Key Switch	XB2BG21C	Schneider
2	G9SP	Safety PLC	G9SP-N20S	Omron

Components' safety technical parameters as follows:

① Key Switch XB2BG21C

机械寿命	200000 次
电气寿命	1000000 次, AC-15 在...上 230 V, 工作额定值 <3600 次/小时, 负载系数: 0.5 符合 EN/IEC 60947-5-1 附录 C 1000000 次, DC-13 在...上 230 V, 工作额定值 <3600 次/小时, 负载系数: 0.5 符合 EN/IEC 60947-5-1 附录 C

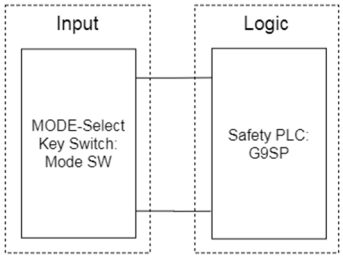
②Safety PLC G9SP-N20S

Using a G9SP-series Controller enables building a safety control system that satisfy the following:

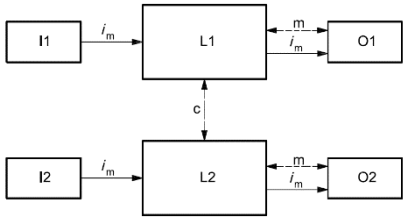
- Requirements for SIL 3 (Safety Integrity Level 3) in IEC 61508, IEC/EN 62061, Safety Standard for Safety Instrumented Systems (Functional Safety of Electrical/ Electronic/Programmable Electronic Safety-related Systems)
- Requirements for PLe (Performance Level e) and for safety category 4 in EN ISO13849-1

■ Category (Cat.)

After identifying the SPR/CS, the control circuit should be simplified as the following block diagram with selecting typical parts:



The safety PLC (G9SP) satisfies the requirements for Category 4. Judging from the above block diagram, the control circuit satisfies the requirements for Category 3.



■ Mean Time to Dangerous Failure ($MTTF_D$)

No.	Components	d_{op}	h_{op}	t_{cycle}	n_{op}	B_{10D}	$MTTF_D$	PFH_D	PL	Data reference
1	Key Switch	300	8	900	9,600	**400,000**	-	-	-	Manufacturer
2	Safety PLC	-	-	-	-	-	-	-	**e**	Manufacturer

■ Diagnostic Coverage (DC)

No.	Components	DC	Characteristic	Reason
1	Key Switch	99%	Input	Cross monitoring of input signals and intermediate results within the logic (L), and temporal and logical software monitor of the program flow and detection of static faults and short circuits (for multiple I/O)
2	Safety PLC	99%	Logic	PL=e

■ Common Cause Failure (CCF)

No.	Measure against CCF	Score	Actual
1	Separation/ Segregation		
	Physical separation between signal paths.	15	15
2	Diversity		
	Different technologies/design or physical principles are used.	0	20
3	Design/application/experience		
3.1	Protection against over-voltage, over-pressure, over-current, etc.	15	15
3.2	Components used are well-tried.	5	5
4	Assessment/analysis		
	Are the results of a failure mode and effect analysis taken into account to avoid common-cause-failures in design.	5	5
5	Competence/training		
	Have designers/ maintainers been trained to understand the causes and consequences of common cause failures?	5	5
6	Environmental		
6.1	Prevention of contamination and electromagnetic compatibility (EMC) against CCF in accordance with appropriate standards.	25	25
6.2	Other influences Have the requirements for immunity to all relevant environmental influences such as, temperature, shock, vibration, humidity (e.g. as specified in relevant standards) be considered?	10	10
	Total	80	Max. 100

Calculated by SISTEMA software using the above parameters, SRP/CS of this safety function satisfies **PLe**. (See File 2　SISTEMA Calculation Report)

SF A.2：Safety Light Curtain safety function

■ Identification of SPR / CS

The SPR / CS list of this safety function is as follows:

No.	ID	Components	Part Number	Manufacturer
1	SC1	Safety light curtain	SND7220-PNP	LNTECH
2	G9SP	Safety PLC	G9SP-N20S	Omron
3	KM3、KM4	Contactor	3RT60 16-1AB02	Siemens
4	G1	Driver	R88D-1SN-10H-ECT	Omron

Components' safety technical parameters as follows:

①Safety light curtain　SND7220-PNP

诊断覆盖率 /DC	>99%
平均无危险故障时间 /MTTFd	200a
安全等级 /Safety level	PL e (EN ISO 13849)

②Safety PLC　G9SP-N20S

Using a G9SP-series Controller enables building a safety control system that satisfy the following:

- Requirements for SIL 3 (Safety Integrity Level 3) in IEC 61508, IEC/EN 62061, Safety Standard for Safety Instrumented Systems (Functional Safety of Electrical/ Electronic/Programmable Electronic Safety-related Systems)
- Requirements for PLe (Performance Level e) and for safety category 4 in EN ISO13849-1

③Contactor　3RT60 16-1AB02

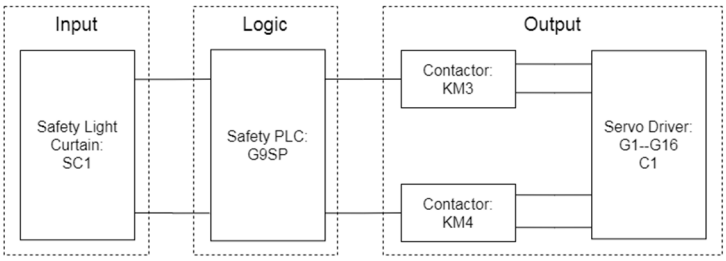
Contactors with small load	Tables D.1 and D.2	IEC 60947	B_{10D} = 20 000 000

④Driver STO　R88D-1SN-10H-ECT

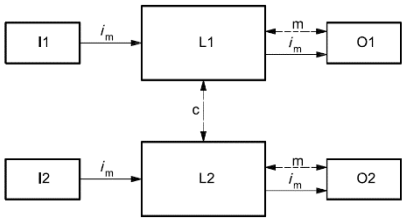
机械指令详情如下。
安全输入信号控制的 STO 功能：EN ISO13849-1 (Cat3 PLe)、EN61508 (SIL3)、EN62061 (SIL3)、EN61800-5-2 (STO)
EtherCAT 通信控制的 STO 功能：EN ISO 13849-1 (Cat.3 PLd)、EN61508 (SIL2)、EN62061 (SIL2)、EN61800-5-2 (STO)

■ Category (Cat.)

After identifying the SPR/CS, the control circuit should be simplified as the following block diagram with selecting typical parts:



The safety light curtain (SC1) satisfies the requirements for Category 4, the safety PLC (G9SP) satisfies the requirements for Category 4, the STO function of servo driver satisfies the requirements for Category 3. Judging from the above block diagram, the control circuit satisfies the requirements for Category 3.



■ Mean Time to Dangerous Failure ($MTTF_D$)

No.	Components	d_{op}	h_{op}	t_{cycle}	n_{op}	B_{10D}	$MTTF_D$	PFH_D	PL	Data reference
1	Safety light curtain	-	-	-	-	-	**200**	-	-	Manufacturer
2	Safety PLC	-	-	-	-	-	-	-	**e**	Manufacturer
3	Contactor	300	8	300	28,800	**20,000,000**	-	-	-	ISO 13849-1
4	Driver STO	-	-	-	-	-	-	-	**e**	Manufacturer

■ Diagnostic Coverage (DC)

No.	Components	DC	Characteristic	Reason
1	Safety light curtain	99%	Input	Manufacturer
2	Safety PLC	99%	Logic	PL=e
3	Contactor	90%	Output	Cross monitoring of output signals with dynamic test without detection of short circuits (for multiple I/O)
4	Driver STO	99%	Output	PL=e

■ Common Cause Failure (CCF)

No.	Measure against CCF	Score	Actual
1	Separation/ Segregation		
	Physical separation between signal paths.	15	15
2	Diversity		
	Different technologies/design or physical principles are used.	0	20
3	Design/application/experience		
3.1	Protection against over-voltage, over-pressure, over-current, etc.	15	15
3.2	Components used are well-tried.	5	5
4	Assessment/analysis		
	Are the results of a failure mode and effect analysis taken into account to avoid common-cause-failures in design.	5	5
5	Competence/training		
	Have designers/ maintainers been trained to understand the causes and consequences of common cause failures?	5	5
6	Environmental		
6.1	Prevention of contamination and electromagnetic compatibility (EMC) against CCF in accordance with	25	25

	appropriate standards.		
6.2	Other influences Have the requirements for immunity to all relevant environmental influences such as, temperature, shock, vibration, humidity (e.g. as specified in relevant standards) be considered?	10	10
	Total	80	Max. 100

Calculated by SISTEMA software using the above parameters, SRP/CS of this safety function satisfies **PLd**. (See File 2 SISTEMA Calculation Report)

SF A.3：Safety Encoder safety function

■ Identification of SPR / CS

The SPR / CS list of this safety function is as follows:

No.	ID	Components	Part Number	Manufacturer
1	E1	Safety Encoder	DFS60S-TDOC01024	SICK
2	S30-1	Safety Relay	PNOZ s30	PILZ
3	G9SP	Safety PLC	G9SP-N20S	Omron
4	KM3、KM4	Contactor	3RT60 16-1AB02	Siemens
5	G1	Driver	R88D-1SN-10H-ECT	Omron

Components' safety technical parameters as follows:

①Safety Encoder DFS60S-TDOC01024

安全完整性等级	SIL2 (IEC 61508) 和SILCL2 (IEC 62061) [1)]
类别	3 (EN ISO 13849)
测试速率	不要求
最大要求速率	连续（模拟信号）
性能等级	PL d (EN ISO 13849) [1)]
PFHd：每小时危险失效概率	1.7 x 10^{-8} [2)]

②Safety Relay PNOZ s30

Operating mode	EN ISO 13849-1: 2015 PL	EN ISO 13849-1: 2015 Category	EN 62061 SIL CL	EN 62061 PFH_D [1/h]	IEC 61511 SIL	IEC 61511 PFD	EN ISO 13849-1: 2015 T_M [year]
Monitoring 1 encoder	PL d	Cat. 2	SIL CL 2	2,88E-08	SIL 2	2,53E-03	20
Monitoring 2 encoder	PL e	Cat. 4	SIL CL 3	1,74E-09	SIL 3	1,46E-04	20
Monitoring safe en-coder	PL e	Cat. 4	SIL CL 3	3,08E-09	SIL 3	2,66E-04	20

③Safety PLC G9SP-N20S

Using a G9SP-series Controller enables building a safety control system that satisfy the following:

- Requirements for SIL 3 (Safety Integrity Level 3) in IEC 61508, IEC/EN 62061, Safety Standard for Safety Instrumented Systems (Functional Safety of Electrical/ Electronic/Programmable Electronic Safety-related Systems)
- Requirements for PLe (Performance Level e) and for safety category 4 in EN ISO13849-1

④ Contactor 3RT60 16-1AB02

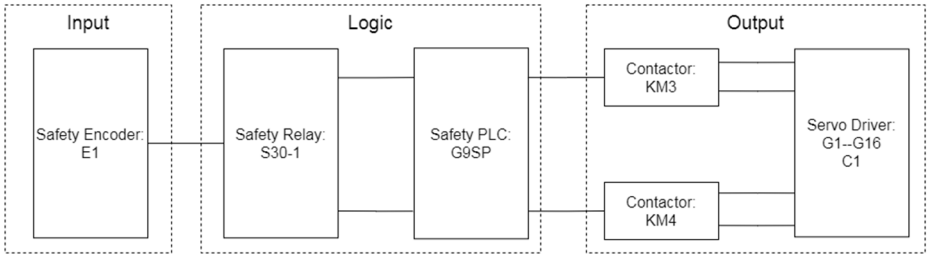
Contactors with small load	Tables D.1 and D.2	IEC 60947	B_{10D} = 20 000 000

⑤ Driver STO R88D-1SN-10H-ECT

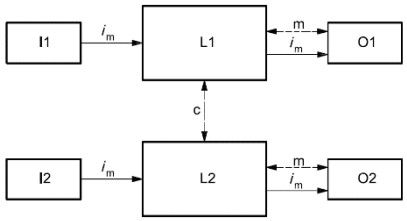
机械指令详情如下。
安全输入信号控制的 STO 功能：EN ISO13849-1 (Cat3 PLe)、EN61508 (SIL3)、EN62061 (SIL3)、EN61800-5-2 (STO)
EtherCAT 通信控制的 STO 功能：EN ISO 13849-1 (Cat.3 PLd)、EN61508 (SIL2)、EN62061 (SIL2)、EN61800-5-2 (STO)

■ Category (Cat.)

After identifying the SPR/CS, the control circuit should be simplified as the following block diagram with selecting typical parts:



The safety encoder (E1) satisfies the requirements for Category 3, the safety relay (S30-1) satisfies the requirements for Category 4, the safety PLC (G9SP) satisfies the requirements for Category 4, the STO function of servo driver satisfies the requirements for Category 3. Judging from the above block diagram, the control circuit satisfies the requirements for Category 3.



■ Mean Time to Dangerous Failure ($MTTF_D$)

No.	Components	d_{op}	h_{op}	t_{cycle}	n_{op}	B_{10D}	$MTTF_D$	PFH_D	PL	Data reference
1	Safety Encoder	-	-	-	-	-	-	**1.7E-8**	-	Manufacturer
2	Safety Relay	-	-	-	-	-	-	**3.1E-9**	-	Manufacturer
3	Safety PLC	-	-	-	-	-	-	-	**e**	Manufacturer
4	Contactor	300	8	300	28,800	**20,000,000**	-	-	-	ISO 13849-1
5	Driver STO	-	-	-	-	-	-	-	**e**	Manufacturer

■ Diagnostic Coverage (DC)

No.	Components	DC	Characteristic	Reason
1	Safety Encoder	99%	Input	PL=e
2	Safety Relay	99%	Logic	PL=e
3	Safety PLC	99%	Logic	PL=e
4	Contactor	90%	Output	Cross monitoring of output signals with dynamic test without detection of short circuits (for multiple I/O)
5	Driver STO	99%	Output	PL=e

■ Common Cause Failure (CCF)

No.	Measure against CCF	Score	Actual
1	Separation/ Segregation		
	Physical separation between signal paths.	15	15
2	Diversity		
	Different technologies/design or physical principles are used.	0	20
3	Design/application/experience		
3.1	Protection against over-voltage, over-pressure, over-current, etc.	15	15
3.2	Components used are well-tried.	5	5
4	Assessment/analysis		
	Are the results of a failure mode and effect analysis taken into account to avoid common-cause-failures in design.	5	5
5	Competence/training		
	Have designers/ maintainers been trained to understand the causes and consequences of common cause failures?	5	5
6	Environmental		
6.1	Prevention of contamination and electromagnetic compatibility (EMC) against CCF in accordance with appropriate standards.	25	25
6.2	Other influences Have the requirements for immunity to all relevant environmental influences such as, temperature, shock, vibration, humidity (e.g. as specified in relevant standards) be considered?	10	10
	Total	80	Max. 100

Calculated by SISTEMA software using the above parameters, SRP/CS of this safety function satisfies **PLd**. (See File 2　SISTEMA Calculation Report)

SF A.4：Jog Grip Switch safety function

■ Identification of SPR / CS

The SPR / CS list of this safety function is as follows:

No.	ID	Components	Part Number	Manufacturer
1	Handle	Jog Grip Switch	A4EG-BM2B041	Omron
2	G9SP	Safety PLC	G9SP-N20S	Omron
3	KM3、KM4	Contactor	3RT60 16-1AB02	Siemens
4	G1	Driver	R88D-1SN-10H-ECT	Omron

Components' safety technical parameters as follows:

① Jog Grip Switch　A4EG-BM2B041

類別 項目	啟動開關	緊急停止開關 (只適用A4EG-BE2R041)	按鈕 (只適用A4EG-BM2B041)
電氣耐久性曲線	10萬次(分鐘) (額定負載)	(設定/重設為1次) (額定負載)	10萬次(分鐘) (額定負載)
機械耐久性	OFF-ON-OFF (直接開啟)： 10萬次(分鐘) OFF-ON：1百萬次(分鐘)	10萬次(分鐘) (設定/重設為1次)	2百萬次(分鐘)

② Safety PLC　G9SP-N20S

Using a G9SP-series Controller enables building a safety control system that satisfy the following:

- Requirements for SIL 3 (Safety Integrity Level 3) in IEC 61508, IEC/EN 62061, Safety Standard for Safety Instrumented Systems (Functional Safety of Electrical/ Electronic/Programmable Electronic Safety-related Systems)
- Requirements for PLe (Performance Level e) and for safety category 4 in EN ISO13849-1

③ Contactor　3RT60 16-1AB02

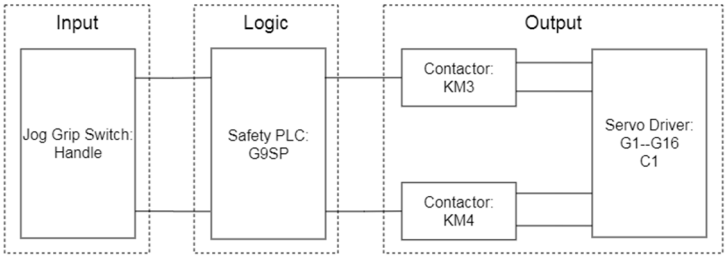
Contactors with small load	Tables D.1 and D.2	IEC 60947	B_{10D} = 20 000 000

④ Driver STO　R88D-1SN-10H-ECT

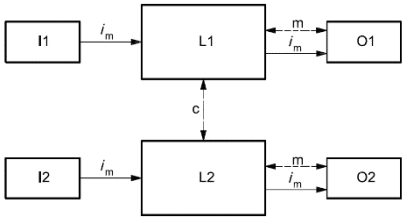
机械指令详情如下。
安全输入信号控制的 STO 功能：EN ISO13849-1 (Cat3 PLe)、EN61508 (SIL3)、EN62061 (SIL3)、EN61800-5-2 (STO)
EtherCAT 通信控制的 STO 功能：EN ISO 13849-1 (Cat.3 PLd)、 EN61508 (SIL2)、 EN62061 (SIL2)、 EN61800-5-2 (STO)

■ Category (Cat.)

After identifying the SPR/CS, the control circuit should be simplified as the following block diagram with selecting typical parts:



The safety PLC (G9SP) satisfies the requirements for Category 4, the STO function of servo driver satisfies the requirements for Category 3. Judging from the above block diagram, the control circuit satisfies the requirements for Category 3.



■ Mean Time to Dangerous Failure ($MTTF_D$)

No.	Components	d_{op}	h_{op}	t_{cycle}	n_{op}	B_{10D}	$MTTF_D$	PFH_D	PL	Data reference
1	Jog Grip Switch	300	8	900	9,600	**500,000**	-	-	-	Manufacturer
2	Safety PLC	-	-	-	-	-	-	-	**e**	Manufacturer
3	Contactor	300	8	300	28,800	**20,000,000**	-	-	-	ISO 13849-1
4	Driver STO	-	-	-	-	-	-	-	**e**	Manufacturer

■ Diagnostic Coverage (DC)

No.	Components	DC	Characteristic	Reason
1	Jog Grip Switch	99%	Input	Cross monitoring of input signals and intermediate results within the logic (L), and temporal and logical software monitor of the program flow and detection of static faults and short circuits (for multiple I/O)
2	Safety PLC	99%	Logic	PL=e
3	Contactor	90%	Output	Cross monitoring of output signals with dynamic test without detection of short circuits (for multiple I/O)
4	Driver STO	99%	Output	PL=e

■ Common Cause Failure (CCF)

No.	Measure against CCF	Score	Actual
1	Separation/ Segregation		
	Physical separation between signal paths.	15	15
2	Diversity		
	Different technologies/design or physical principles are used.	0	20
3	Design/application/experience		
3.1	Protection against over-voltage, over-pressure, over-current, etc.	15	15
3.2	Components used are well-tried.	5	5
4	Assessment/analysis		
	Are the results of a failure mode and effect analysis taken into account to avoid common-cause-failures in design.	5	5
5	Competence/training		
	Have designers/ maintainers been trained to understand the causes and consequences of common cause failures?	5	5
6	Environmental		
6.1	Prevention of contamination and electromagnetic compatibility (EMC) against CCF in accordance with appropriate standards.	25	25
6.2	Other influences	10	10

	Have the requirements for immunity to all relevant environmental influences such as, temperature, shock, vibration, humidity (e.g. as specified in relevant standards) be considered?		
	Total	80	Max. 100

Calculated by SISTEMA software using the above parameters, SRP/CS of this safety function satisfies **PLe**. (See File 2　SISTEMA Calculation Report)

SF A.5：LOCK Button safety function

■ Identification of SPR / CS

The SPR / CS list of this safety function is as follows:

No.	ID	Components	Part Number	Manufacturer
1	Watch SW	Button	AVLW32220DR	APT
2	G9SP	Safety PLC	G9SP-N20S	Omron
3	KM3、KM4	Contactor	3RT60 16-1AB02	Siemens
4	G1	Driver	R88D-1SN-10H-ECT	Omron

Components' safety technical parameters as follows:

①Button　AVLW32220DR

机械性使用寿命	按钮开关	瞬时型	500 万次以上
		交替型	50 万次以上（3 触点以上为 25 万次以上）
		按压锁定旋转复位型	50 万次以上
		其他动作型	50 万次以上
	照明按钮开关	瞬时型	500 万次以上
		交替型	50 万次以上（3 触点以上为 25 万次以上）
		按压锁定旋转复位型	50 万次以上
	选择开关		50 万次以上
	钥匙选择开关		50 万次以上
	照明选择开关		50 万次以上
电气性使用寿命（注 2）	按钮开关	瞬时型	50 万次以上（切换频率 1,800 次 / 小时、动作比 40%）
		交替型	50 万次以上（3 触点以上为 25 万次以上） 切换频率 900 次 / 小时、动作比 40%）
		按压锁定旋转复位型	50 万次以上（切换频率 900 次 / 小时、动作比 40%）
		其他动作型	50 万次以上
	照明按钮开关	瞬时型	50 万次以上（切换频率 1,800 次 / 小时、动作比 40%）
		交替型	50 万次以上（3 触点以上为 25 万次以上） 切换频率 900 次 / 小时、动作比 40%）
		按压锁定旋转复位型	50 万次以上（切换频率 900 次 / 小时、动作比 40%）
	选择开关		50 万次以上（切换频率 1,200 次 / 小时、动作比 40%）
	钥匙选择开关		50 万次以上（切换频率 1,200 次 / 小时、动作比 40%）
	照明选择开关		25 万次以上（切换频率 1,200 次 / 小时、动作比 40%）

②Safety PLC　G9SP-N20S

Using a G9SP-series Controller enables building a safety control system that satisfy the following:

- Requirements for SIL 3 (Safety Integrity Level 3) in IEC 61508, IEC/EN 62061, Safety Standard for Safety Instrumented Systems (Functional Safety of Electrical/ Electronic/Programmable Electronic Safety-related Systems)
- Requirements for PLe (Performance Level e) and for safety category 4 in EN ISO13849-1

③Contactor　3RT60 16-1AB02

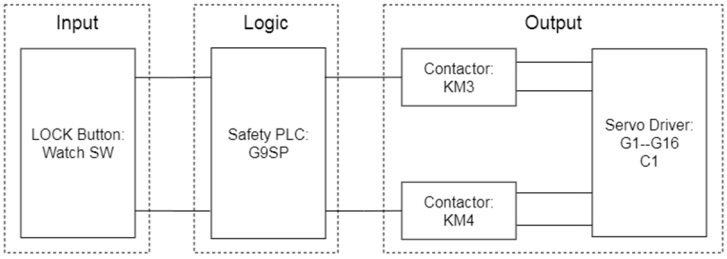
	Contactors with small load	Tables D.1 and D.2	IEC 60947	B_{10D} = 20 000 000

④ Driver STO　R88D-1SN-10H-ECT

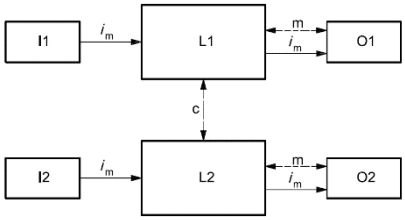
机械指令详情如下。
安全输入信号控制的 STO 功能：EN ISO13849-1 (Cat3 PLe)、EN61508 (SIL3)、EN62061 (SIL3)、EN61800-5-2 (STO)
EtherCAT 通信控制的 STO 功能：EN ISO 13849-1 (Cat.3 PLd)、EN61508 (SIL2)、EN62061 (SIL2)、EN61800-5-2 (STO)

■ Category (Cat.)

After identifying the SPR/CS, the control circuit should be simplified as the following block diagram with selecting typical parts:



The safety PLC (G9SP) satisfies the requirements for Category 4, the STO function of servo driver satisfies the requirements for Category 3. Judging from the above block diagram, the control circuit satisfies the requirements for Category 3.



■ Mean Time to Dangerous Failure ($MTTF_D$)

No.	Components	d_{op}	h_{op}	t_{cycle}	n_{op}	B_{10D}	$MTTF_D$	PFH_D	PL	Data reference
1	Button	300	8	900	9,600	**1,000,000**	-	-	-	Manufacturer
2	Safety PLC	-	-	-	-	-	-	-	**e**	Manufacturer
3	Contactor	300	8	300	28,800	**20,000,000**	-	-	-	ISO 13849-1
4	Driver STO	-	-	-	-	-	-	-	**e**	Manufacturer

■ Diagnostic Coverage (DC)

No.	Components	DC	Characteristic	Reason
1	Button	99%	Input	Cross monitoring of input signals and intermediate results within the logic (L), and temporal and logical software monitor of the program flow and detection of static faults and short circuits (for multiple I/O)
2	Safety PLC	99%	Logic	PL=e
3	Contactor	90%	Output	Cross monitoring of output signals with dynamic test without detection of short circuits (for multiple I/O)
4	Driver STO	99%	Output	PL=e

■ Common Cause Failure (CCF)

No.	Measure against CCF	Score	Actual
1	Separation/ Segregation		
	Physical separation between signal paths.	15	15
2	Diversity		
	Different technologies/design or physical principles are used.	0	20
3	Design/application/experience		
3.1	Protection against over-voltage, over-pressure, over-current, etc.	15	15
3.2	Components used are well-tried.	5	5
4	Assessment/analysis		
	Are the results of a failure mode and effect analysis taken into account to avoid common-cause-failures in design.	5	5
5	Competence/training		
	Have designers/ maintainers been trained to understand the causes and consequences of common cause failures?	5	5
6	Environmental		
6.1	Prevention of contamination and electromagnetic compatibility (EMC) against CCF in accordance with appropriate standards.	25	25
6.2	Other influences Have the requirements for immunity to all relevant environmental influences such as, temperature, shock, vibration, humidity (e.g. as specified in relevant standards) be considered?	10	10
	Total	80	Max. 100

Calculated by SISTEMA software using the above parameters, SRP/CS of this safety function satisfies **PLe**. (See File 2 SISTEMA Calculation Report)

3.4 Verification of performance level

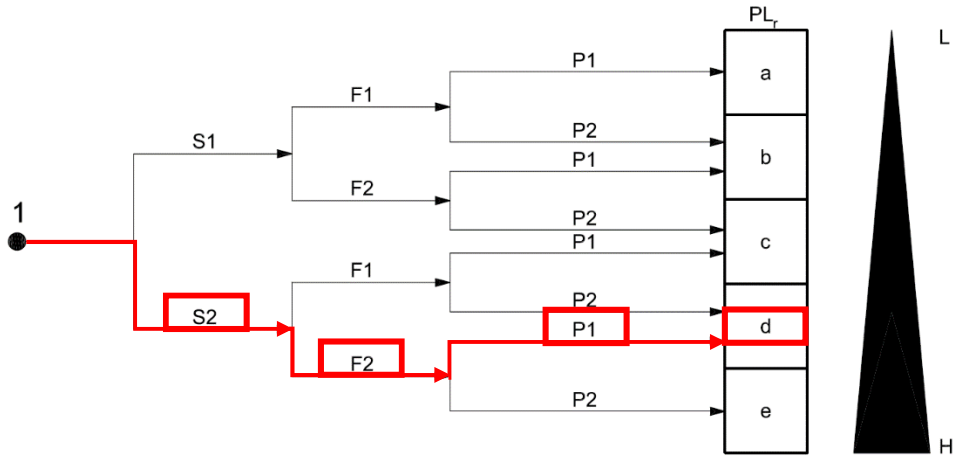
All evaluation results are as follows:

Safety Function	Name	PL	$PL_{overall}$	PL_r	Result
SF A.1	MODE-Select Key Switch safety function	e	d	d	$PL=PL_r$
SF A.2	Safety Light Curtain safety function	d			
SF A.3	Safety Encoder safety function	d			
SF A.4	Jog Grip Switch safety function	e			
SF A.5	LOCK Button safety function	e			

Result: The SRP / CS performance level of all safety functions could match the PL_r.

4、B Risk avoidance of workspace with Safety Contact Sensor 1

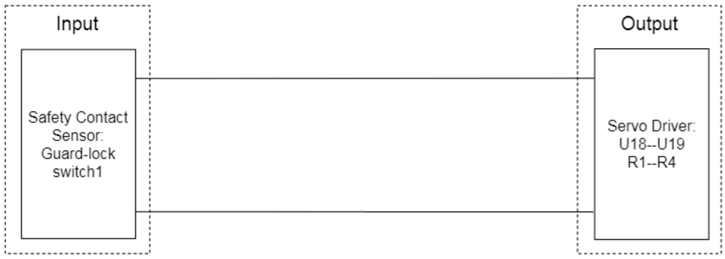
4.1 Performance level required



According to risk assessment, PL_r=d (High risk).

4.2 Design of safety function

The safety circuit design refer to " Annex 2 Electrical Schematic Diagram".
The safety block diagram is shown below:



Safety function logic:
Equipped with 1 safety contact sensor Guard-lock switch1, when it is triggered, directly cut off the STO signal input of the servo drive U18--U19, R1--R4 to stop the operation of the motor it controls.
Considering that the types (or product series) and safety technical parameters of some components are completely the same, they can be evaluated only once. The safety functions performed by SRP / CS can be identified as follows:
SF B.1：Safety Contact Sensor 1 safety function

4.3 Evaluation of performance level

SF B.1：Safety Contact Sensor 1 safety function

■ Identification of SPR / CS

The SPR / CS list of this safety function is as follows:

No.	ID	Components	Part Number	Manufacturer
1	Guard-lock switch1	Safety Contact Sensor	D4NS-4CF	Omron
2	U18--U19、R1--R4	Driver	R88D-1SN-10H-ECT	Omron

Components' safety technical parameters as follows:

① Safety Contact Sensor D4NS-4CF

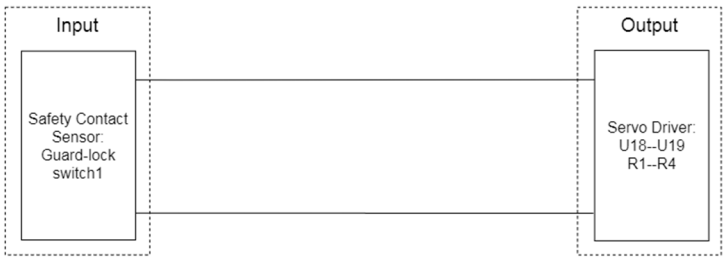
寿命 ※2	机械	<标准型> 100万次以上 <强拉力型> 10万次以上
	电气	<标准型> 50万次以上（AC250V 3A、电阻负载）※3 30万次以上（AC250V 10A、电阻负载） <强拉力型> 10万次以上（AC250V 10A、电阻负载）

② Driver STO R88D-1SN-10H-ECT

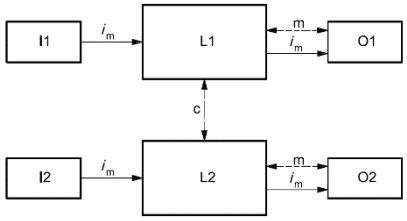
机械指令详情如下。
安全输入信号控制的 STO 功能：EN ISO13849-1 (Cat3 PLe)、EN61508 (SIL3)、EN62061 (SIL3)、EN61800-5-2 (STO)
EtherCAT 通信控制的 STO 功能：EN ISO 13849-1 (Cat.3 PLd)、EN61508 (SIL2)、EN62061 (SIL2)、EN61800-5-2 (STO)

■ Category (Cat.)

After identifying the SPR/CS, the control circuit should be simplified as the following block diagram with selecting typical parts:



The STO function of servo driver satisfies the requirements for Category 3. Judging from the above block diagram, the control circuit satisfies the requirements for Category 3.



■ Mean Time to Dangerous Failure ($MTTF_D$)

No.	Components	d_{op}	h_{op}	t_{cycle}	n_{op}	B_{10D}	$MTTF_D$	PFH_D	PL	Data reference
1	Safety Contact Sensor	300	8	3,600	2,400	**1,000,000**	-	-	-	ISO 13849-1
2	Driver STO	-	-	-	-	-	-	-	**e**	Manufacturer

■ Diagnostic Coverage (DC)

No.	Components	DC	Characteristic	Reason
1	Safety Contact Sensor	60%	Input	Cross monitoring of inputs without dynamic test
2	Driver STO	99%	Output	PL=e

■ Common Cause Failure (CCF)

No.	Measure against CCF	Score	Actual
1	Separation/ Segregation		
	Physical separation between signal paths.	15	15
2	Diversity		
	Different technologies/design or physical principles are used.	0	20
3	Design/application/experience		
3.1	Protection against over-voltage, over-pressure, over-current, etc.	15	15
3.2	Components used are well-tried.	5	5
4	Assessment/analysis		
	Are the results of a failure mode and effect analysis taken into account to avoid common-cause-failures in design.	5	5
5	Competence/training		
	Have designers/ maintainers been trained to understand the causes and consequences of common cause failures?	5	5
6	Environmental		
6.1	Prevention of contamination and electromagnetic compatibility (EMC) against CCF in accordance with appropriate standards.	25	25
6.2	Other influences Have the requirements for immunity to all relevant environmental influences such as, temperature, shock, vibration, humidity (e.g. as specified in relevant standards) be considered?	10	10
	Total	80	Max. 100

Calculated by SISTEMA software using the above parameters, SRP/CS of this safety function satisfies **PLd**. (See File 2 SISTEMA Calculation Report)

4.4 Verification of performance level

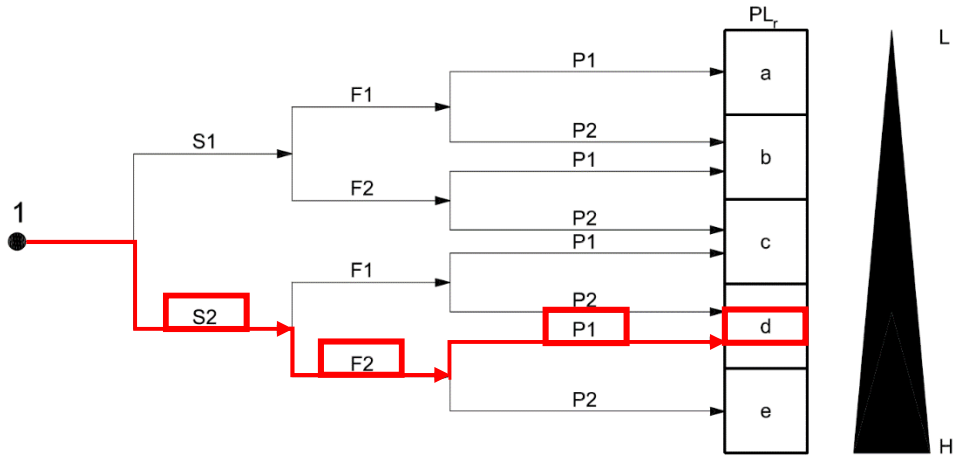
All evaluation results are as follows:

Safety Function	Name	PL	$PL_{overall}$	PL_r	Result
SF B.1	Safety Contact Sensor 1 safety function	d	d	d	$PL=PL_r$

Result: The SRP / CS performance level of all safety functions could match the PL_r.

5、C Risk avoidance of workspace with Safety Contact Sensor 2/3

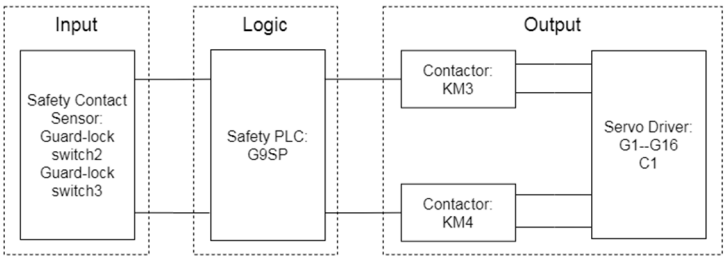
5.1 Performance level required



According to risk assessment, PL_r=d (High risk).

5.2 Design of safety function

The safety circuit design refer to " Annex 2 Electrical Schematic Diagram".
The safety block diagram is shown below:



Safety function logic:
Equipped with 2 safety contact sensor Guard-lock switch2, Guard-lock switch3, connected to the safety PLC G9SP, when any one is triggered, by releasing the contactors KM3, KM4, cut off the STO signal input of the servo drive G1--G16、C1 to stop the operation of the motor it controls.
Considering that the types (or product series) and safety technical parameters of some components are completely the same, they can be evaluated only once. The safety functions performed by SRP / CS can be identified as follows:
SF C.1：Safety Contact Sensor 2/3 safety function

5.3 Evaluation of performance level

SF C.1：Safety Contact Sensor 2/3 safety function

■ Identification of SPR / CS

The SPR / CS list of this safety function is as follows:

No.	ID	Components	Part Number	Manufacturer
1	Guard-lock switch2、Guard-lock switch3	Safety Contact Sensor	D4NS-4CF	Omron
2	G9SP	Safety PLC	G9SP-N20S	Omron
3	KM1、KM2	Contactor	3RT60 16-1AB02	Siemens
4	G1--G16、C1	Driver	R88D-1SN-10H-ECT	Omron

Components' safety technical parameters as follows:

① Safety Contact Sensor　D4NS-4CF

寿命 ※2	机械	<标准型> 100万次以上 <强拉力型> 10万次以上
	电气	<标准型> 50万次以上（AC250V 3A、电阻负载）※3 30万次以上（AC250V 10A、电阻负载） <强拉力型> 10万次以上（AC250V 10A、电阻负载）

② Safety PLC　G9SP-N20S

Using a G9SP-series Controller enables building a safety control system that satisfy the following:

- Requirements for SIL 3 (Safety Integrity Level 3) in IEC 61508, IEC/EN 62061, Safety Standard for Safety Instrumented Systems (Functional Safety of Electrical/ Electronic/Programmable Electronic Safety-related Systems)
- Requirements for PLe (Performance Level e) and for safety category 4 in EN ISO13849-1

③ Contactor　3RT60 16-1AB02

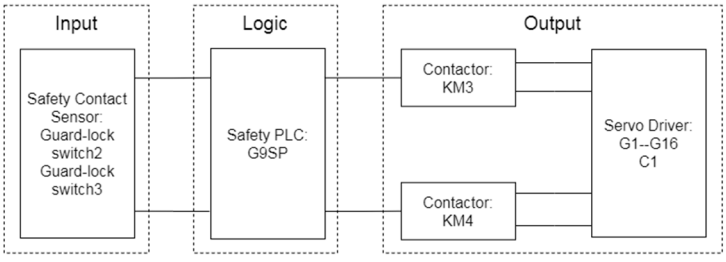
Contactors with small load	Tables D.1 and D.2	IEC 60947	B_{10D} = 20 000 000

④ Driver STO　R88D-1SN-10H-ECT

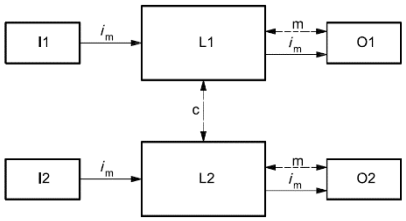
机械指令详情如下。
安全输入信号控制的 STO 功能：EN ISO13849-1 (Cat3 PLe)、EN61508 (SIL3)、EN62061 (SIL3)、EN61800-5-2 (STO)
EtherCAT 通信控制的 STO 功能：EN ISO 13849-1 (Cat.3 PLd)、EN61508 (SIL2)、EN62061 (SIL2)、EN61800-5-2 (STO)

■ Category (Cat.)

After identifying the SPR/CS, the control circuit should be simplified as the following block diagram with selecting typical parts:



The safety PLC (G9SP) satisfies the requirements for Category 4, the STO function of servo driver satisfies the requirements for Category 3. Judging from the above block diagram, the control circuit satisfies the requirements for Category 3.



■ Mean Time to Dangerous Failure ($MTTF_D$)

No.	Components	d_{op}	h_{op}	t_{cycle}	n_{op}	B_{10D}	$MTTF_D$	PFH_D	PL	Data reference
1	Safety Contact Sensor	300	8	3,600	2,400	**1,000,000**	-	-	-	ISO 13849-1
2	Safety PLC	-	-	-	-	-	-	-	**e**	Manufacturer
3	Contactor	300	8	300	28,800	**20,000,000**	-	-	-	ISO 13849-1
4	Driver STO	-	-	-	-	-	-	-	**e**	Manufacturer

■ Diagnostic Coverage (DC)

No.	Components	DC	Characteristic	Reason
1	Safety Contact Sensor	99%	Input	Cross monitoring of input signals and intermediate results within the logic (L), and temporal and logical software monitor of the program flow and detection of static faults and short circuits (for multiple I/O)
2	Safety PLC	99%	Logic	PL=e
3	Contactor	90%	Output	Cross monitoring of output signals with dynamic test without detection of short circuits (for multiple I/O)
4	Driver STO	99%	Output	PL=e

■ Common Cause Failure (CCF)

No.	Measure against CCF	Score	Actual
1	Separation/ Segregation		
	Physical separation between signal paths.	15	15
2	Diversity		
	Different technologies/design or physical principles are used.	0	20
3	Design/application/experience		
3.1	Protection against over-voltage, over-pressure, over-current, etc.	15	15
3.2	Components used are well-tried.	5	5
4	Assessment/analysis		
	Are the results of a failure mode and effect analysis taken into account to avoid common-cause-failures in design.	5	5
5	Competence/training		
	Have designers/ maintainers been trained to understand the causes and consequences of common cause failures?	5	5
6	Environmental		

6.1	Prevention of contamination and electromagnetic compatibility (EMC) against CCF in accordance with appropriate standards.	25	25
6.2	Other influences Have the requirements for immunity to all relevant environmental influences such as, temperature, shock, vibration, humidity (e.g. as specified in relevant standards) be considered?	10	10
	Total	80	Max. 100

Calculated by SISTEMA software using the above parameters, SRP/CS of this safety function satisfies **PLe**. (See File 2 SISTEMA Calculation Report)

5.4 Verification of performance level

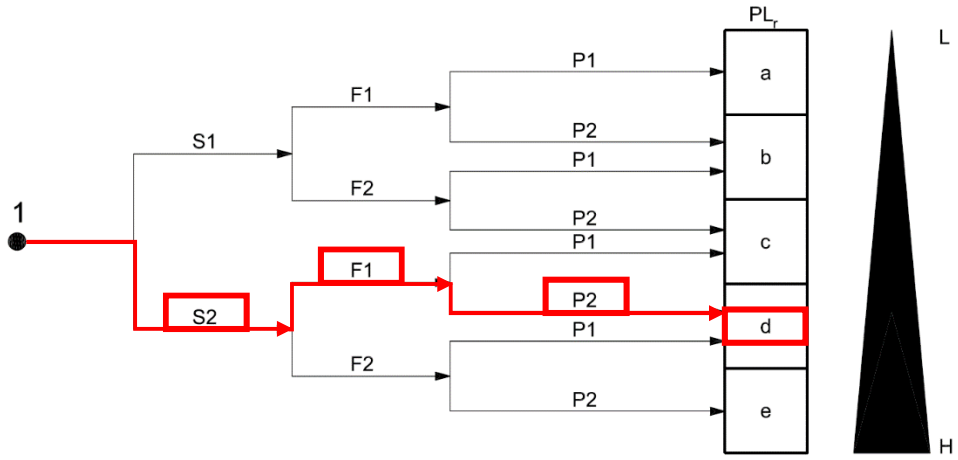
All evaluation results are as follows:

Safety Function	**Name**	**PL**	**$PL_{overall}$**	**PL_r**	**Result**
SF C.1	Safety Contact Sensor 2/3 safety function	e	e	d	$PL>PL_r$

Result: The SRP / CS performance level of all safety functions could match the PL_r.

6、D Risk avoidance of entire machine with Emergency Stop

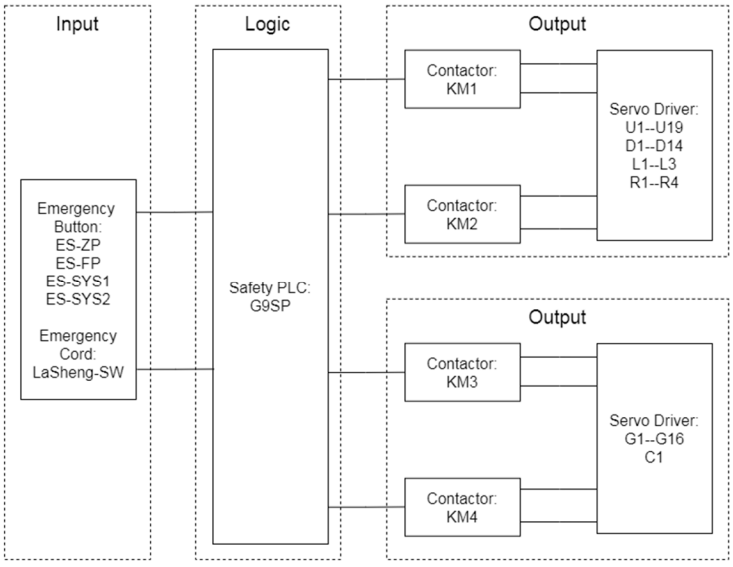
6.1 Performance level required



According to risk assessment, PL_r=d (High risk).

6.2 Design of safety function

The safety circuit design refer to " Annex 2 Electrical Schematic Diagram".
The safety block diagram is shown below:



Safety function logic:
Equipped with 4 emergency buttons ES-ZP, ES-FP, ES-SYS1, ES-SYS2 and 1 emergency cord LaSheng-SW, connected to the safety PLC G9SP, when any one is triggered, by releasing the contactors KM1, KM2, cut off the STO signal input of the servo drive U1--U19, D1--D14, L--L3, R1--R4 to stop the operation of the motor it controls; and by releasing the contactors KM3, KM4 , cut off the STO signal input of servo drive G1--G16, C1 to stop the operation of the motor it controls.

Considering that the types (or product series) and safety technical parameters of some components are completely the same, they can be evaluated only once. The safety functions performed by SRP / CS can be identified as follows:

SF D.1：Emergency Button safety function

SF D.2：Emergency Cord safety function

6.3 Evaluation of performance level

SF D.1：Emergency Button safety function

■ Identification of SPR / CS

The SPR / CS list of this safety function is as follows:

No.	ID	Components	Part Number	Manufacturer
1	ES-ZP、EZ-FP、ES-SYS1、ES-SYS2	Emergency Button	XB2BS542C	Schneider
2	G9SP	Safety PLC	G9SP-N20S	Omron
3	KM1、KM2、KM3、KM4	Contactor	3RT60 16-1AB02	Siemens
4	U1--U19、D1--D14、L1--L3 R1--R4、G1--G16、C1	Driver	R88D-1SN-10H-ECT	Omron

Components' safety technical parameters as follows:

① Emergency Button XB2BS542C

机械寿命	100000 次
电气寿命	500000 次, AC-15, 3 A 在…上 230 V, 工作额定值 <60 次/分钟, 负载系数: 0.5 符合 IEC 60947-5-4 500000 次, DC-13, 0.2 A 在…上 110 V, 工作额定值 <60 次/分钟, 负载系数: 0.5 符合 IEC 60947-5-4

② Safety PLC G9SP-N20S

Using a G9SP-series Controller enables building a safety control system that satisfy the following:

- Requirements for SIL 3 (Safety Integrity Level 3) in IEC 61508, IEC/EN 62061, Safety Standard for Safety Instrumented Systems (Functional Safety of Electrical/ Electronic/Programmable Electronic Safety-related Systems)
- Requirements for PLe (Performance Level e) and for safety category 4 in EN ISO13849-1

③ Contactor 3RT60 16-1AB02

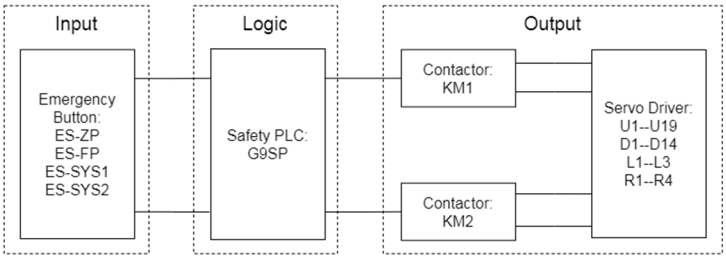
Contactors with small load	Tables D.1 and D.2	IEC 60947	B_{10D} = 20 000 000

④ Driver STO R88D-1SN-10H-ECT

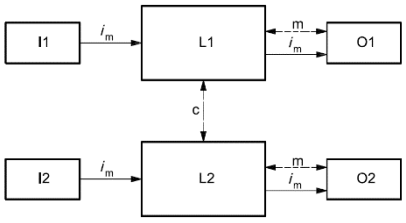
机械指令详情如下。
安全输入信号控制的 STO 功能：EN ISO13849-1 (Cat3 PLe)、EN61508 (SIL3)、EN62061 (SIL3)、EN61800-5-2 (STO)
EtherCAT 通信控制的 STO 功能：EN ISO 13849-1 (Cat.3 PLd)、EN61508 (SIL2)、EN62061 (SIL2)、EN61800-5-2 (STO)

■ Category (Cat.)

After identifying the SPR/CS, the control circuit should be simplified as the following block diagram with selecting typical parts:



The safety PLC (G9SP) satisfies the requirements for Category 4, the STO function of servo driver satisfies the requirements for Category 3. Judging from the above block diagram, the control circuit satisfies the requirements for Category 3.



■ Mean Time to Dangerous Failure ($MTTF_D$)

No.	Components	d_{op}	h_{op}	t_{cycle}	n_{op}	B_{10D}	$MTTF_D$	PFH_D	PL	Data reference
1	Emergency Button	300	8	3,600	2,400	**100,000**	-	-	-	ISO 13849-1
2	Safety PLC	-	-	-		-	-	-	**e**	Manufacturer
3	Contactor	300	8	300	28,800	**20,000,000**	-	-	-	ISO 13849-1
4	Driver STO	-	-	-	-	-	-	-	**e**	Manufacturer

■ Diagnostic Coverage (DC)

No.	Components	DC	Characteristic	Reason
1	Emergency Button	99%	Input	Plausibility check, e.g. use of normally open and normally closed mechanicall linked contacts
2	Safety PLC	99%	Logic	PL=e
3	Contactor	90%	Output	Cross monitoring of output signals with dynamic test without detection of short circuits (for multiple I/O)
4	Driver STO	99%	Output	PL=e

■ Common Cause Failure (CCF)

No.	Measure against CCF	Score	Actual
1	Separation/ Segregation		
	Physical separation between signal paths.	15	15
2	Diversity		
	Different technologies/design or physical principles are used.	0	20
3	Design/application/experience		

3.1	Protection against over-voltage, over-pressure, over-current, etc.	15	15
3.2	Components used are well-tried.	5	5
4	Assessment/analysis		
	Are the results of a failure mode and effect analysis taken into account to avoid common-cause-failures in design.	5	5
5	Competence/training		
	Have designers/ maintainers been trained to understand the causes and consequences of common cause failures?	5	5
6	Environmental		
6.1	Prevention of contamination and electromagnetic compatibility (EMC) against CCF in accordance with appropriate standards.	25	25
6.2	Other influences Have the requirements for immunity to all relevant environmental influences such as, temperature, shock, vibration, humidity (e.g. as specified in relevant standards) be considered?	10	10
	Total	80	Max. 100

Calculated by SISTEMA software using the above parameters, SRP/CS of this safety function satisfies **PLe**. (See File 2　SISTEMA Calculation Report)

SF D.2：Emergency Cord safety function

■ Identification of SPR / CS

The SPR / CS list of this safety function is as follows:

No.	ID	Components	Part Number	Manufacturer
1	LaSheng-SW	Emergency Cord	XY2CH13290	Schneider
2	G9SP	Safety PLC	G9SP-N20S	Omron
3	KM1、KM2	Contactor	3RT60 16-1AB02	Siemens
4	U1	Driver	R88D-1SN-10H-ECT	Omron

Components' safety technical parameters as follows:

① Emergency Cord　XY2CH13290

安全可靠的数据	B10d = 4000000 价值由20年生命时间确定，受机械或接触磨损限制 符合 IEC 60947-5-5

②Safety PLC　G9SP-N20S

Using a G9SP-series Controller enables building a safety control system that satisfy the following:

- Requirements for SIL 3 (Safety Integrity Level 3) in IEC 61508, IEC/EN 62061, Safety Standard for Safety Instrumented Systems (Functional Safety of Electrical/ Electronic/Programmable Electronic Safety-related Systems)
- Requirements for PLe (Performance Level e) and for safety category 4 in EN ISO13849-1

③ Contactor 3RT60 16-1AB02

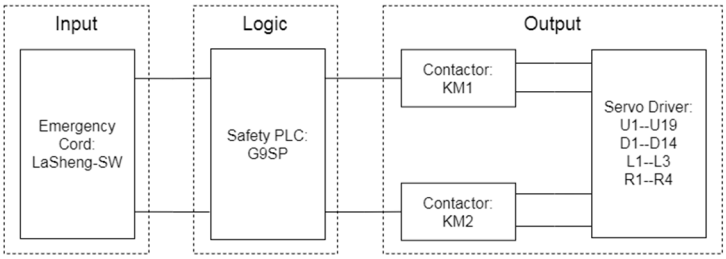
Contactors with small load	Tables D.1 and D.2	IEC 60947	B_{10D} = 20 000 000

④ Driver STO R88D-1SN-10H-ECT

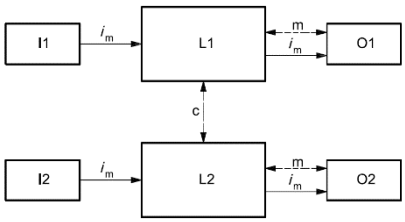
机械指令详情如下。
安全输入信号控制的 STO 功能：EN ISO13849-1 (Cat3 PLe)、EN61508 (SIL3)、EN62061 (SIL3)、EN61800-5-2 (STO)
EtherCAT 通信控制的 STO 功能：EN ISO 13849-1 (Cat.3 PLd)、EN61508 (SIL2)、EN62061 (SIL2)、EN61800-5-2 (STO)

■ Category (Cat.)

After identifying the SPR/CS, the control circuit should be simplified as the following block diagram with selecting typical parts:



The safety PLC (G9SP) satisfies the requirements for Category 4, the STO function of servo driver satisfies the requirements for Category 3. Judging from the above block diagram, the control circuit satisfies the requirements for Category 3.



■ Mean Time to Dangerous Failure ($MTTF_D$)

No.	Components	d_{op}	h_{op}	t_{cycle}	n_{op}	B_{10D}	$MTTF_D$	PFH_D	PL	Data reference
1	Emergency Cord	300	8	3,600	2,400	**4,000,000**	-	-	-	Manufacturer
2	Safety PLC	-	-	-		-	-	-	**e**	Manufacturer
3	Contactor	300	8	300	28,800	**20,000,000**	-	-	-	ISO 13849-1
4	Driver STO	-	-	-	-	-	-	-	**e**	Manufacturer

■ Diagnostic Coverage (DC)

No.	Components	DC	Characteristic	Reason
1	Emergency Cord	99%	Input	Plausibility check, e.g. use of normally open and normally closed mechanicall linked contacts

2	Safety PLC	99%	Logic	PL=e
3	Contactor	90%	Output	Cross monitoring of output signals with dynamic test without detection of short circuits (for multiple I/O)
4	Driver STO	99%	Output	PL=e

■ Common Cause Failure (CCF)

No.	Measure against CCF	Score	Actual
1	Separation/ Segregation		
	Physical separation between signal paths.	15	15
2	Diversity		
	Different technologies/design or physical principles are used.	0	20
3	Design/application/experience		
3.1	Protection against over-voltage, over-pressure, over-current, etc.	15	15
3.2	Components used are well-tried.	5	5
4	Assessment/analysis		
	Are the results of a failure mode and effect analysis taken into account to avoid common-cause-failures in design.	5	5
5	Competence/training		
	Have designers/ maintainers been trained to understand the causes and consequences of common cause failures?	5	5
6	Environmental		
6.1	Prevention of contamination and electromagnetic compatibility (EMC) against CCF in accordance with appropriate standards.	25	25
6.2	Other influences Have the requirements for immunity to all relevant environmental influences such as, temperature, shock, vibration, humidity (e.g. as specified in relevant standards) be considered?	10	10
	Total	80	Max. 100

Calculated by SISTEMA software using the above parameters, SRP/CS of this safety function satisfies **PLd**. (See File 2 SISTEMA Calculation Report)

6.4 Verification of performance level

All evaluation results are as follows:

Safety Function	Name	PL	$PL_{overall}$	PL_r	Result
SF D.1	Emergency Button safety function	e	d	d	$PL=PL_r$
SF D.2	Emergency Cord safety function	d			

Result: The SRP / CS performance level of all safety functions could match the PL_r.