EUROPEAN
SPALLATION
SOURCE

TBL Motion Safety System
(as part of the Common MCA Project)

Instrument Safety Readiness Review TBL

PRESENTED BY THOMAS GAHL

2025-10-10

Agenda

1 Instrument Hazard Analysis (IHA)

2 Risk Analysis & Treatment

3 Safety Requirements Specification (SRS)

4 E-Stop Design

5 Design Verification

6 E-Stop Design Implementation & Installation at TBL

7 Validation

8 Operation

9 Summary

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Instrument Hazard Analysis (IHA)

TBL Reference Documents:

ESS-3078238 - TBL Instrument Hazard Analysis (IHA)

Instrument Hazard Analysis

Handover of hazard treatment to Motion Safety

- Two risks in the IHA identified; classified as CX3 (in maintenance)
- Transferred to Motion Safety WU of CMCA;
- Both are in the Bunker area with no access of user personnel

List conventional hazards related to the various parts and areas of the instrument. See blue heading's comments for more information on each column.				Neutron Instruments Hazards Analysis						
				Component			Maintenance			
Hazard number	Building	Instrument Area	Instrument Sub-area	Instrument System Designation	Sub-System Designation	Component name	Level of Risk		Controls to mitigate risk	Action Owner
ConHaz7	D03	In-Bunker	Heavy stand	Beam Transport and Conditioning System	Beam geometry conditioning	Adjustable Collimator	CX3	Tolerable	Risk mitigation is transferred to the Motion Safty Work Unit of the common MCA Project (CMCA)	CMCA
ConHaz20	D03	In-Bunker	Light Stand	Beam Transport and Conditioning System	Beam filtering System	Filter Station	CX3	Tolerable	Risk mitigation is transferred to the Motion Safty Work Unit of the common MCA Project (CMCA)	CMCA

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Risk Analysis & Treatment

TBL Reference Documents:

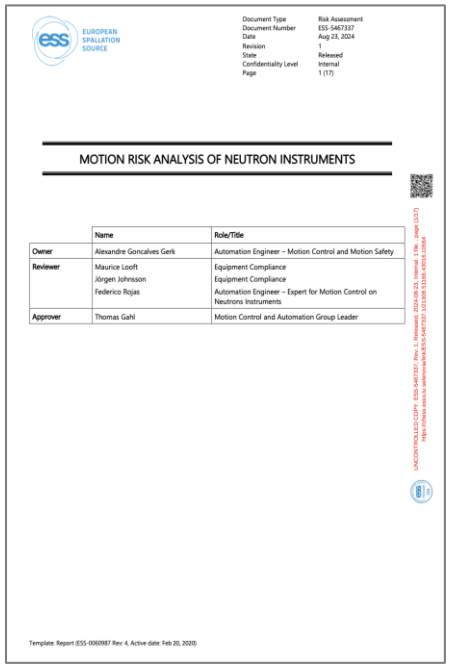
ESS-5467337 - Motion Risk Analysis of Neutron Instruments

Risk Analysis & Treatment

ESS-5467337 - Motion Risk Analysis of Neutron Instruments

- Limits of System
  1. Area: Motion Safety focusses on areas accessible to instrument users (typically in the cave).
  2. Life phases: Experiment Setup & Local Maintenance considered.

Life phases	Cave (User Access, controlled by PSS)	Cave (Service & Maintenance Access, controlled by PSS)	Beam Line, Bunker (Service & Maintenance Access, controlled by procedures)
TBL Areas	TBL Cave	TBL Cave	TBL In-bunker area
Installation, commissioning and testing	excluded	excluded	excluded
Experiment Run	no risks	no risks	no risks
Experiment Setup	included	N/A (no access)	N/A (no access)
Local maintenance	included	included	excluded
External maintenance (in workshop)	excluded	excluded	excluded


MOTION RISK ANALYSIS OF NEUTRON INSTRUMENTS

ESS-5467337

Risk Analysis & Treatment

ESS-5467337 - Motion Risk Analysis of Neutron Instruments

- Simplified approach for hazard analysis and mitigation.
  1. Motion Safety focusses on areas accessible to instrument users (typically in the cave).
  2. Only two levels defined following the severity path; required Performance Levels a/b and c/d.

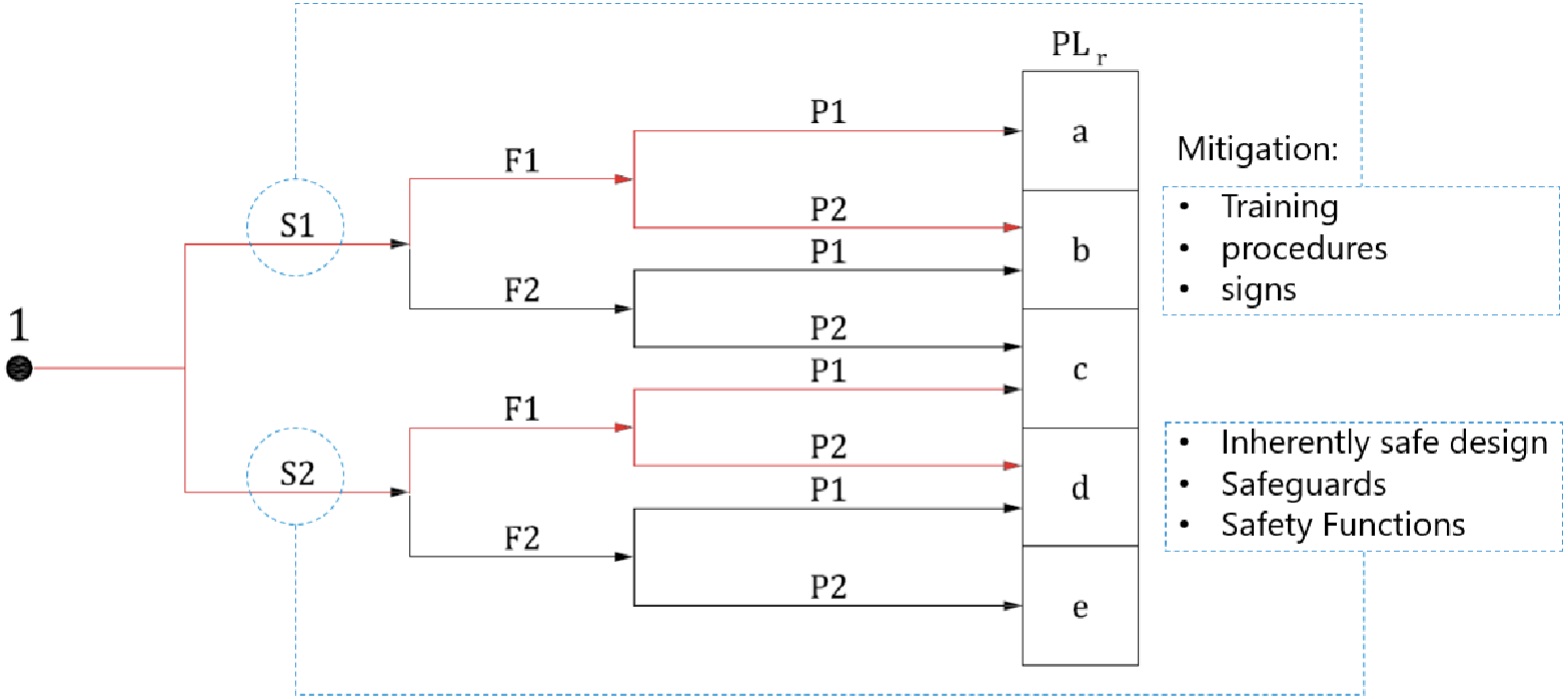
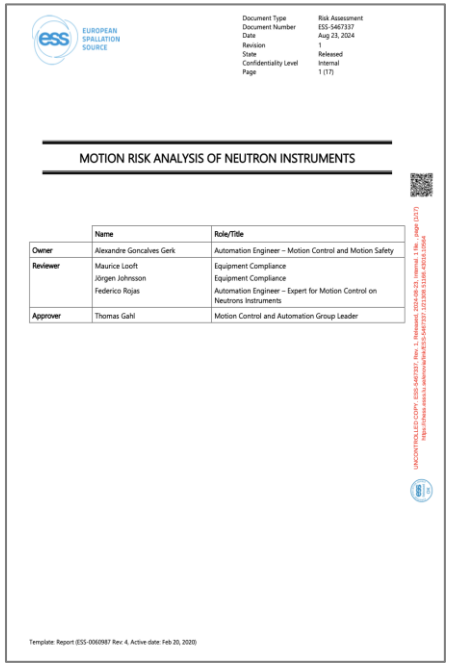


Figure 8 - Risk evaluation


MOTION RISK ANALYSIS OF NEUTRON INSTRUMENTS

ESS-5467337

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Safety Requirements Specification (SRS)

TBL Reference Documents:

ESS-1315508 - TBL Table-of-Motion, sheet 3

Safety Requirements Specification

Table-of-Motion, Sheet 3

Axis description

ConHaz ID

Risk assessment & Treatment for Operation

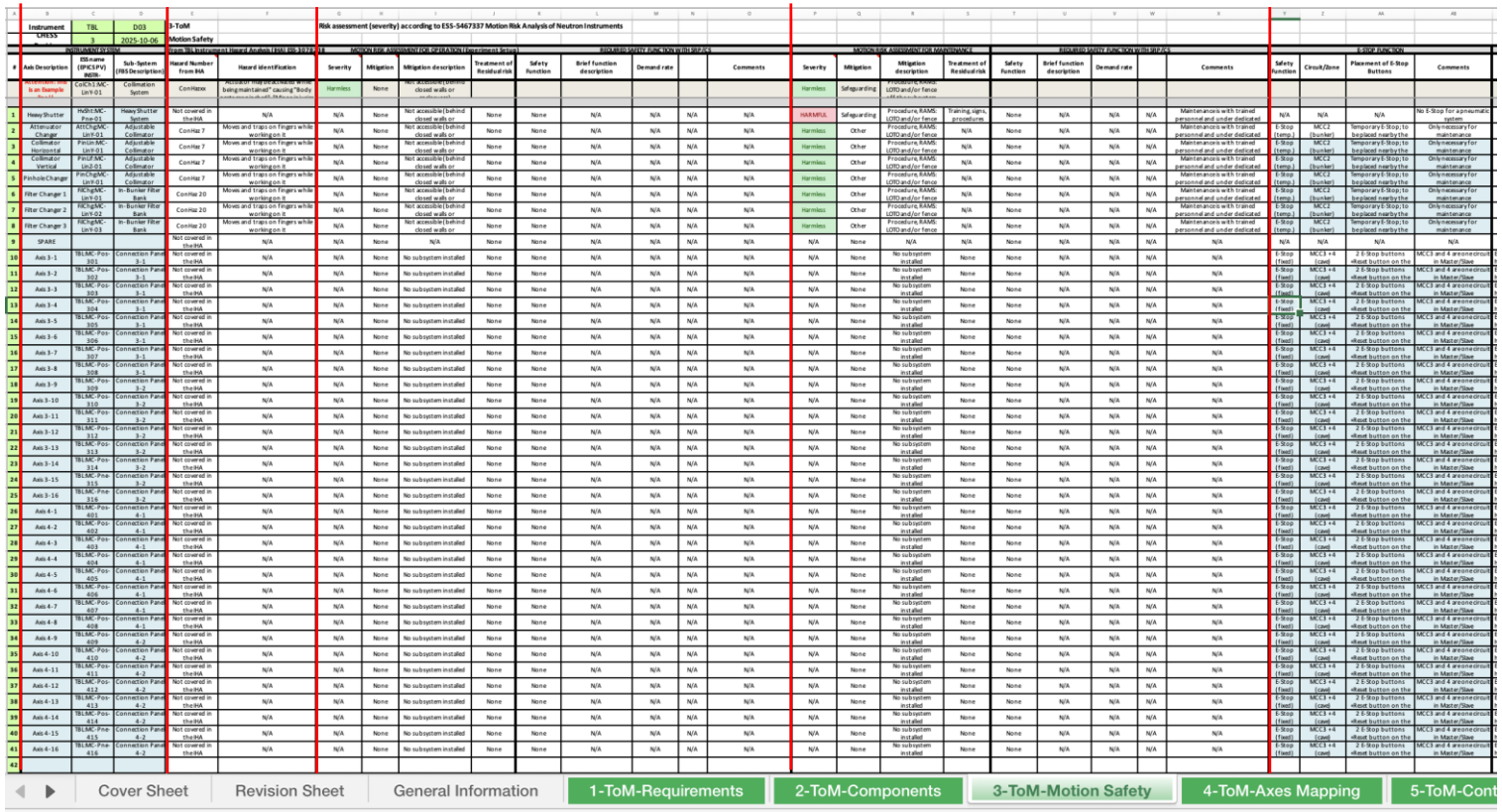
Risk assessment & Treatment for Maintenance

E-Stop

Bunker Area

Axes listing

Cave Area



Instrument	TBL	D03	3-ToM
DRESS	3	2025-10-06	Motion Safety

Risk assessment (severity) according to ESS-5467337 Motion Risk Analysis of Neutron Instruments

#	Axis Description	ESS-name (IPICSV) INSTR-	Sub-System (YBS Description)	Hazard Number from RA	Hazard identification	Severity	Mitigation	Mitigation description	Treatment of Residual risk	Safety Function	Brief function description	Demand rate			Severity	Mitigation	Mitigation description	Treatment of Residual risk	Safety Function	Brief function description	Demand rate		Safety Function	Circuit/Zone	Placement of E-Stop Buttons	
1	HeavyShutter	HvShtrMC-Pne01	HeavyShutter System	Not covered in the HA		N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	HARMFUL	Safeguarding	Procedure; RAMS; LOTO and/or fence	Training, signs, procedures	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	N/A	N/A	N/A	No E-Stop for apneumatic system
2	Attenuator Changer	AttChgMC-Lin01	Adjustable Collimator	ConHaz 7	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure; RAMS; LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
3	Collimator Horizontal	PosInMC-Lin01	Adjustable Collimator	ConHaz 7	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure; RAMS; LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
4	Collimator Vertical	PosZnMC-Lin02-01	Adjustable Collimator	ConHaz 7	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure; RAMS; LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
5	PinholeChanger	PinChgMC-Lin01	Adjustable Collimator	ConHaz 7	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure; RAMS; LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
6	Filter Changer 1	FilChgMC-Lin01	In-Bunker Filter Bank	ConHaz 20	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure; RAMS; LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
7	Filter Changer 2	FilChgMC-Lin02	In-Bunker Filter Bank	ConHaz 20	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure; RAMS; LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
8	Filter Changer 3	FilChgMC-Lin03	In-Bunker Filter Bank	ConHaz 20	Moves and traps on Fingers while working on it	N/A	None	Not accessible (behind closed walls or	None	None	N/A	N/A	N/A	N/A	Harmless	Other	Procedure; RAMS; LOTO and/or fence	N/A	None	N/A	N/A	N/A	Maintenance is with trained personnel and under dedicated	E-Stop (temp.)	MCC2 (bunker)	Temporary E-Stop; to be placed nearby the	Only necessary for maintenance
9	SPARE			Not covered in the HA	N/A	N/A	None	N/A	None	None	N/A	N/A	N/A	N/A	N/A	None	N/A	N/A	None	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	Axis 3-1	TBLMC-Pos301	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
11	Axis 3-2	TBLMC-Pos302	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
12	Axis 3-3	TBLMC-Pos303	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
13	Axis 3-4	TBLMC-Pos304	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
14	Axis 3-5	TBLMC-Pos305	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
15	Axis 3-6	TBLMC-Pos306	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
16	Axis 3-7	TBLMC-Pos307	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
17	Axis 3-8	TBLMC-Pos308	Connection Panel 3-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
18	Axis 3-9	TBLMC-Pos309	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
19	Axis 3-10	TBLMC-Pos310	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
20	Axis 3-11	TBLMC-Pos311	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
21	Axis 3-12	TBLMC-Pos312	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
22	Axis 3-13	TBLMC-Pos313	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
23	Axis 3-14	TBLMC-Pos314	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
24	Axis 3-15	TBLMC-Pne315	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
25	Axis 3-16	TBLMC-Pne316	Connection Panel 3-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
26	Axis 4-1	TBLMC-Pos401	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
27	Axis 4-2	TBLMC-Pos402	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
28	Axis 4-3	TBLMC-Pos403	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
29	Axis 4-4	TBLMC-Pos404	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
30	Axis 4-5	TBLMC-Pos405	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
31	Axis 4-6	TBLMC-Pos406	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
32	Axis 4-7	TBLMC-Pos407	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
33	Axis 4-8	TBLMC-Pos408	Connection Panel 4-1	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
34	Axis 4-9	TBLMC-Pos409	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
35	Axis 4-10	TBLMC-Pos410	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
36	Axis 4-11	TBLMC-Pos411	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
37	Axis 4-12	TBLMC-Pos412	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
38	Axis 4-13	TBLMC-Pos413	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
39	Axis 4-14	TBLMC-Pos414	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
40	Axis 4-15	TBLMC-Pne415	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
41	Axis 4-16	TBLMC-Pne416	Connection Panel 4-2	Not covered in the HA	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	N/A	None	No subsystem installed	None	None	N/A	N/A	N/A	N/A	E-Stop (fast)	MCC3 +4 (cave)	2 E-Stop buttons +Reset button on the	MCC3 and 4 are encircuit in Master/Slave
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Cover Sheet | Revision Sheet | General Information | 1-ToM-Requirements | 2-ToM-Components | 3-ToM-Motion Safety | 4-ToM-Axes Mapping | 5-ToM-Cont

Safety Requirements Specification

Evaluation for TBL

Mitigation	Mitigation description
None	Not accessible (behind closed walls or enclosures)

Severity	Mitigation	Mitigation description	Treatment of Residual risk
HARMFUL	Safeguarding	Procedure, RAMS: LOTO and/or fence off	Training, signs, procedures
Harmless	Other	Procedure, RAMS: LOTO and/or fence off	N/A

ConHaz 7 + 20

Operation

Maintenance

Bunker Area

Cave Area

Mitigation	Mitigation description
None	No subsystem installed

Circuit/Zone	Placement of E-Stop Buttons
MCC2 (bunker)	Temporary E-Stop; to be placed nearby the motion

Circuit/Zone	Placement of E-Stop Buttons
MCC3 + 4 (cave)	2 E-Stop buttons +Reset button on the cave table

4

E-Stop Design

Reference Documents:

ESS-5846469 - Motion Safety Test Bench (ePlan)

E-Stop Design

Design Principle

- Modularity: Define different areas; match the area with the respective control cabinets; this includes standardised circuits in the cabinet and and a Master/Slave hierarchy between (if applicable).
- Scalability: A scalable number of fixed installed E-Stop buttons + one Reset button in the areas accessible to normal users (i.e. the cave).
- Performance Level d as a matter of principle.

- Currently Stop Category 0 (STO); design work is ongoing for Stop Category 1 (SS1).

EN 60204-1	**EN 61800-5-2**
Stop category 0	Safe torque off (STO)
Stop category 1	Safe stop 1 (SS1)
Stop category 2	Safe stop 2 (SS2)

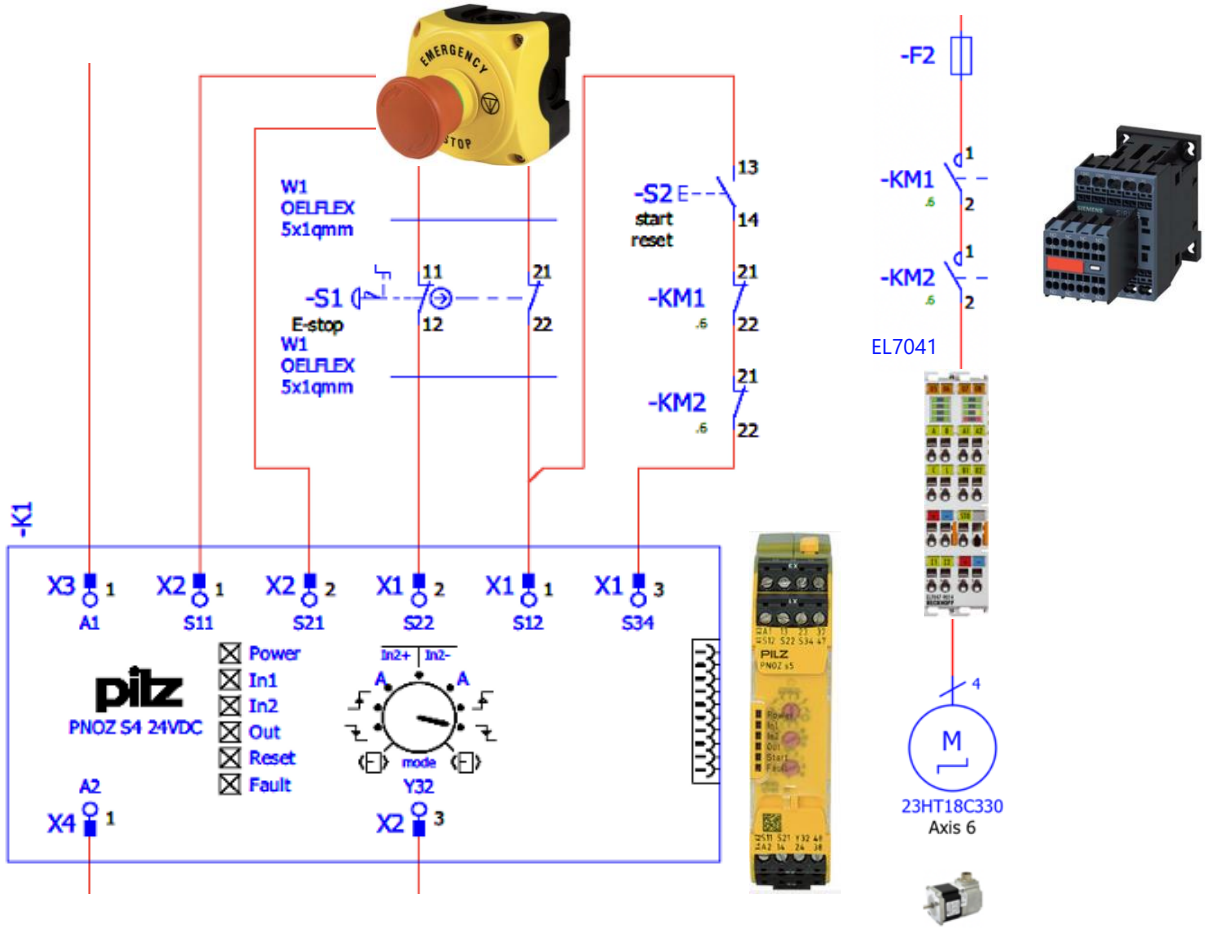
E-Stop Design

Design of E-Stop Circuit

Principle: Contactors are cutting power to the stepper motor drives

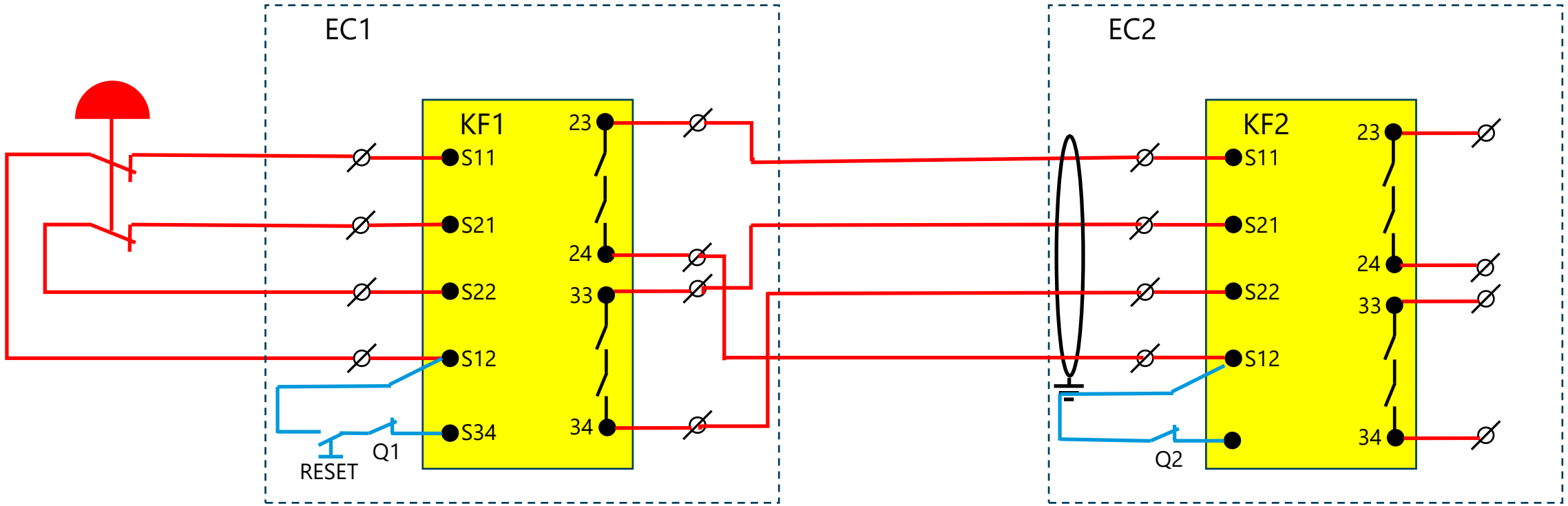
Performance Level d: How to achieve?

- Safety Relay
  - 2 channels
  - With detection of shorts across contacts
  - With detection of shorts to Earth
- Safety contactors
  - Siemens safety contactor type 3RH2262-2BB40
  - 2 in series
  - NC contact in feedback loop



E-Stop Design

Master / Slave



E-stop input

- Dual-channel operation with detection of shorts across contacts.
- Earth fault detection in circuit.
- Reset with falling edge

Slave input

- Dual-channel operation with detection of shorts across contacts.
- Earth fault detection in circuit.
- No special cable necessary (just shielded)
- Auto-Reset

5

Design Verification

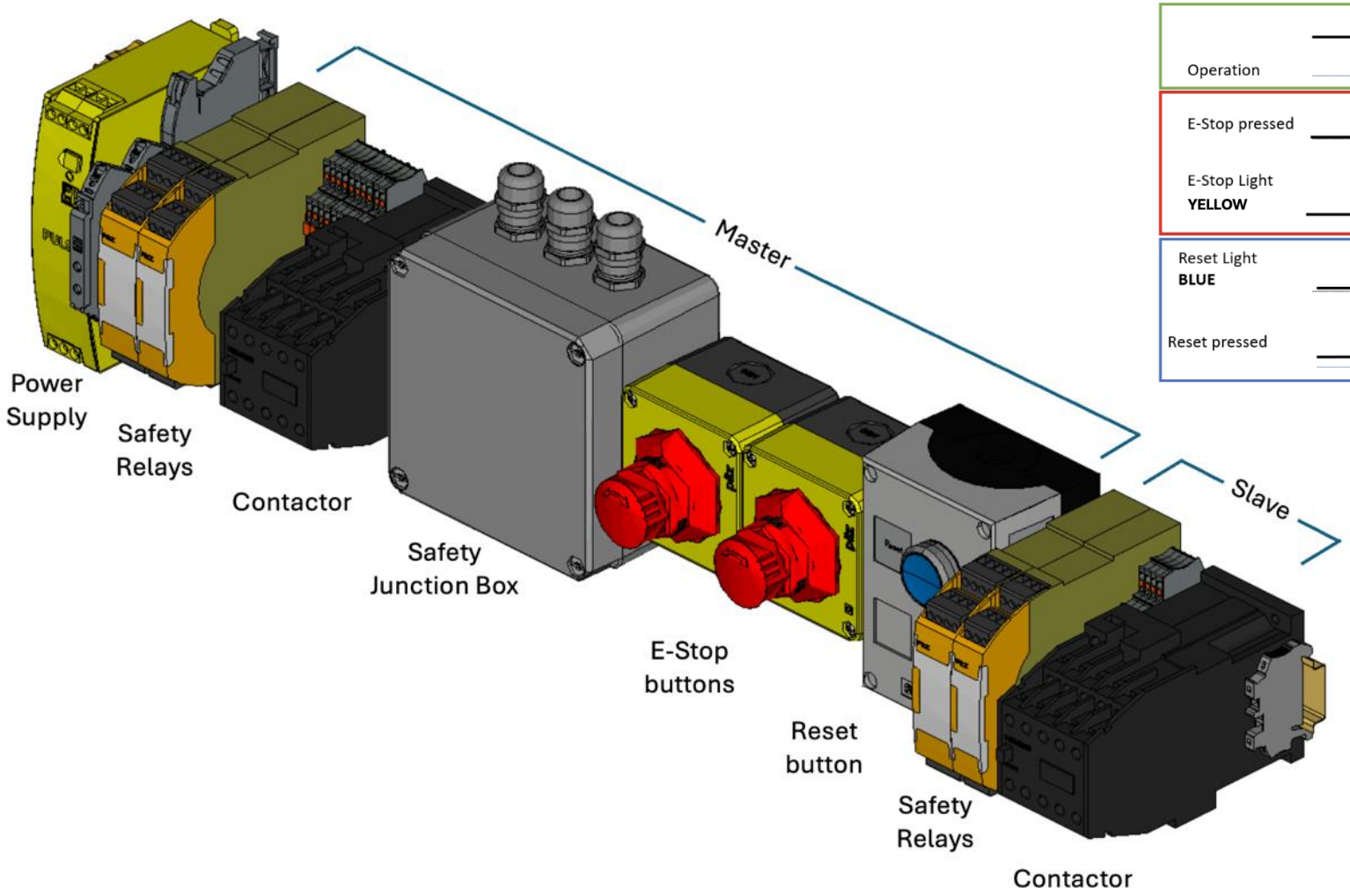
Reference Documents:

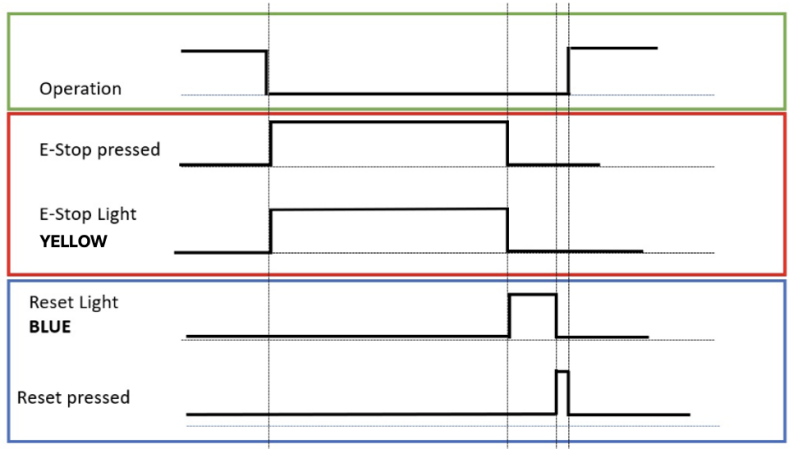
ESS-5830036 - Design Verification & Test Report for Motion Safety E-Stop Circuit

ESS-5846488 - Design Verification Calculation (SISTEMA) for Motion Safety E-Stop Circuit

Design Verification

Functional Verification – Test Bench



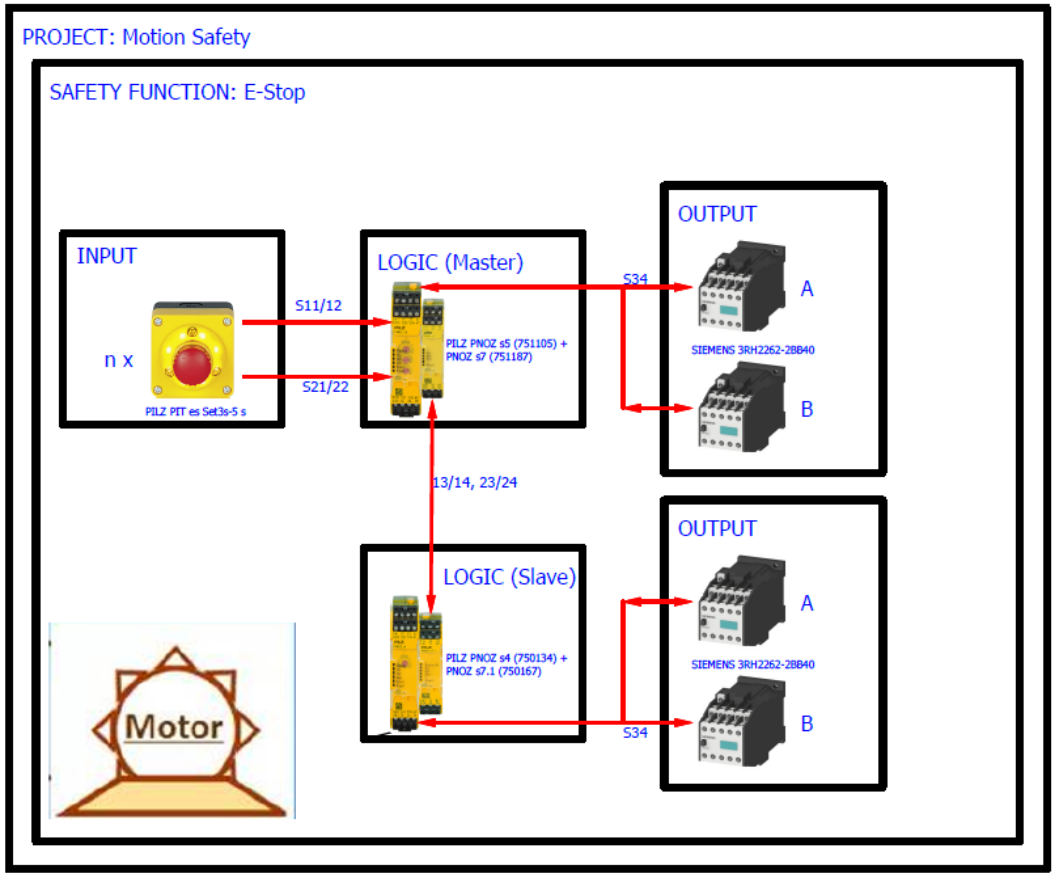


Design Verification

SISTEMA calculation

The SISTEMA analysis for the Motion Safety – E-Stop Circuit has been successfully completed according to EN ISO 13849-1:2023 and ISO 13850:2015.

- The required Performance Level determined by the risk graph was PLd, with a calculated PFH = 1.45E-7 [1/h]; PLd was achieved.
- All subsystems (Pilz E-Stop Boxes, Pilz PNOZ relay, and Siemens SIRIUS contactor relays) demonstrated compliance with relevant requirements for Category 3 or 4 architectures, with high MTTFD values, diagnostic coverage ≥ 90%, and fulfilled Common Cause Failure (CCF) measures.
- No warnings or non-conformities were reported in SISTEMA's evaluation.
- Design of the Motion Safety E-Stop function meets the required safety integrity level.



6

E-Stop Design Implementation & Installation at TBL

Reference Documents:

ESS-5513699 - System Block Diagram for TBL Motion Control

ESS-5346225 - TBL Motion Control 2 (In-Bunker) ePlan

ESS-5346226 - TBL Motion Control 3 (Cave I) ePlan

ESS-5346227 - TBL Motion Control 4 (Cave II) ePlan

ESS-5516374 - System Design Description - TBL Motion Control System

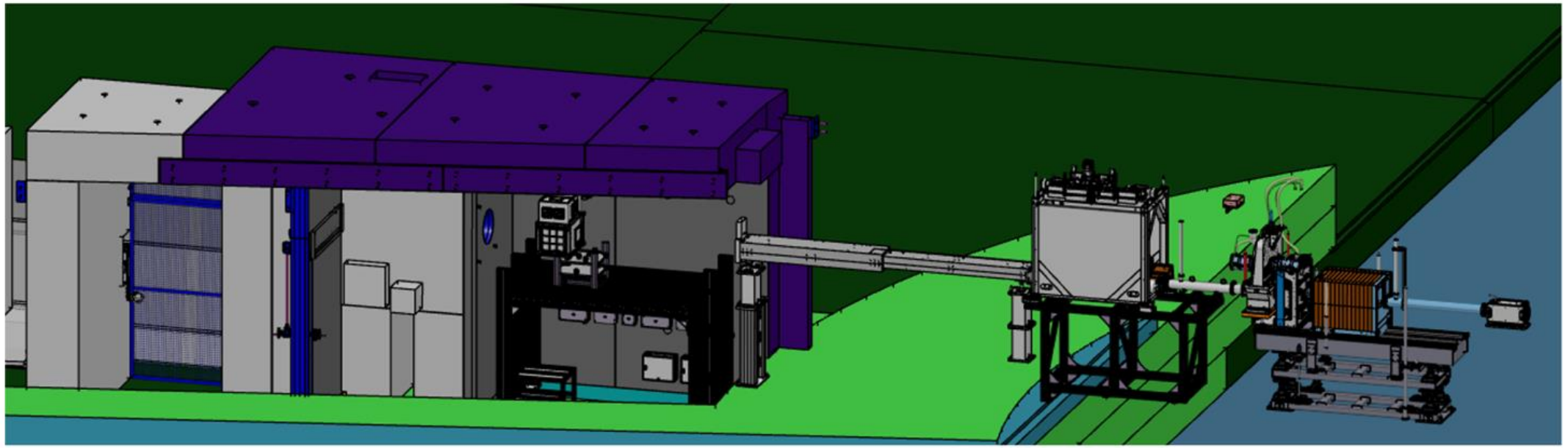
ESS-5595113 - TBL Quality Inspection Report

ESS-5846444 - MCA Self-Inspection Report for TBL Motion Control

ESS-5513746 - TBL Inspection & Test Plan/Report

Table of Motion

Area



Cave

Bunker Area

Table of Motion

Implementation of E-Stop Systems

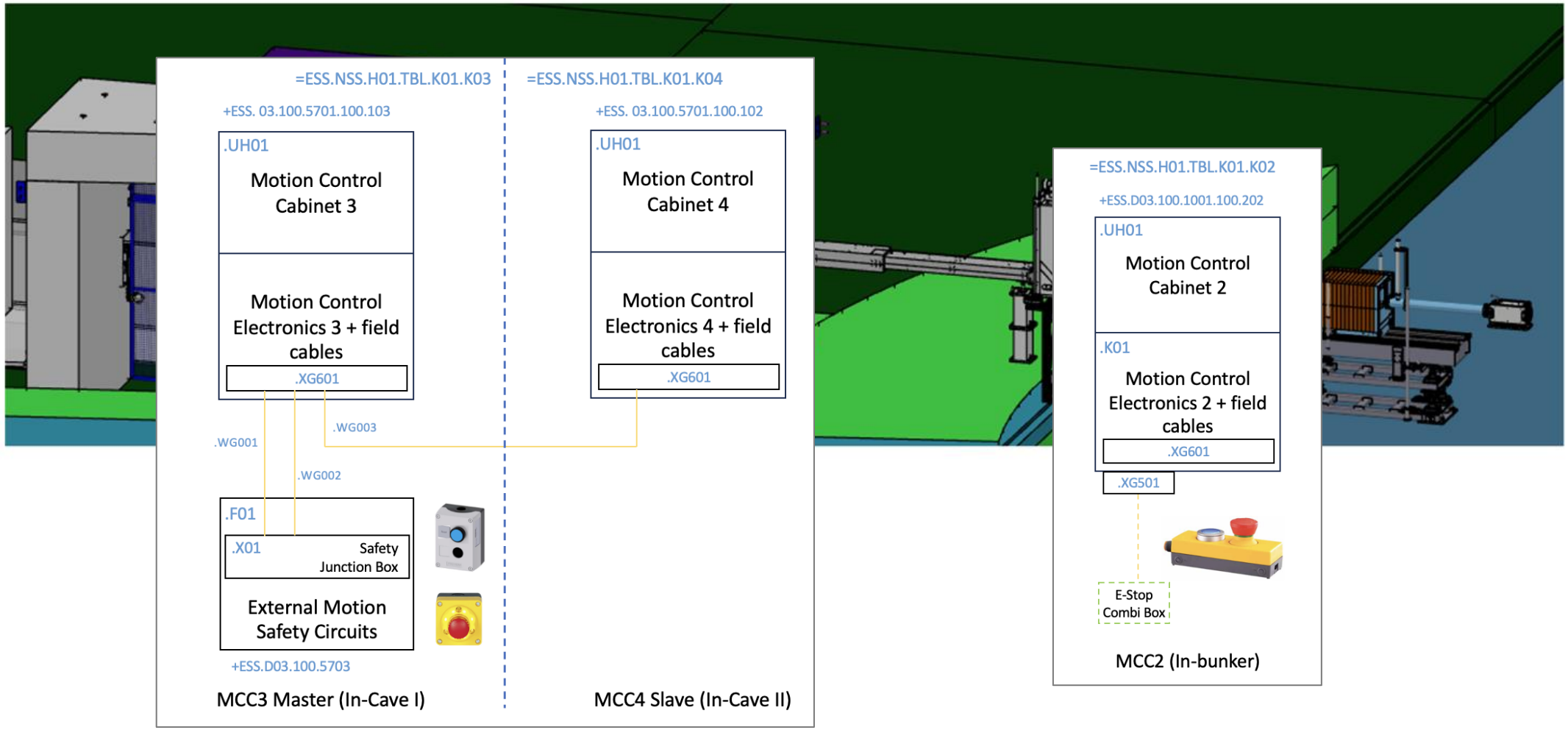
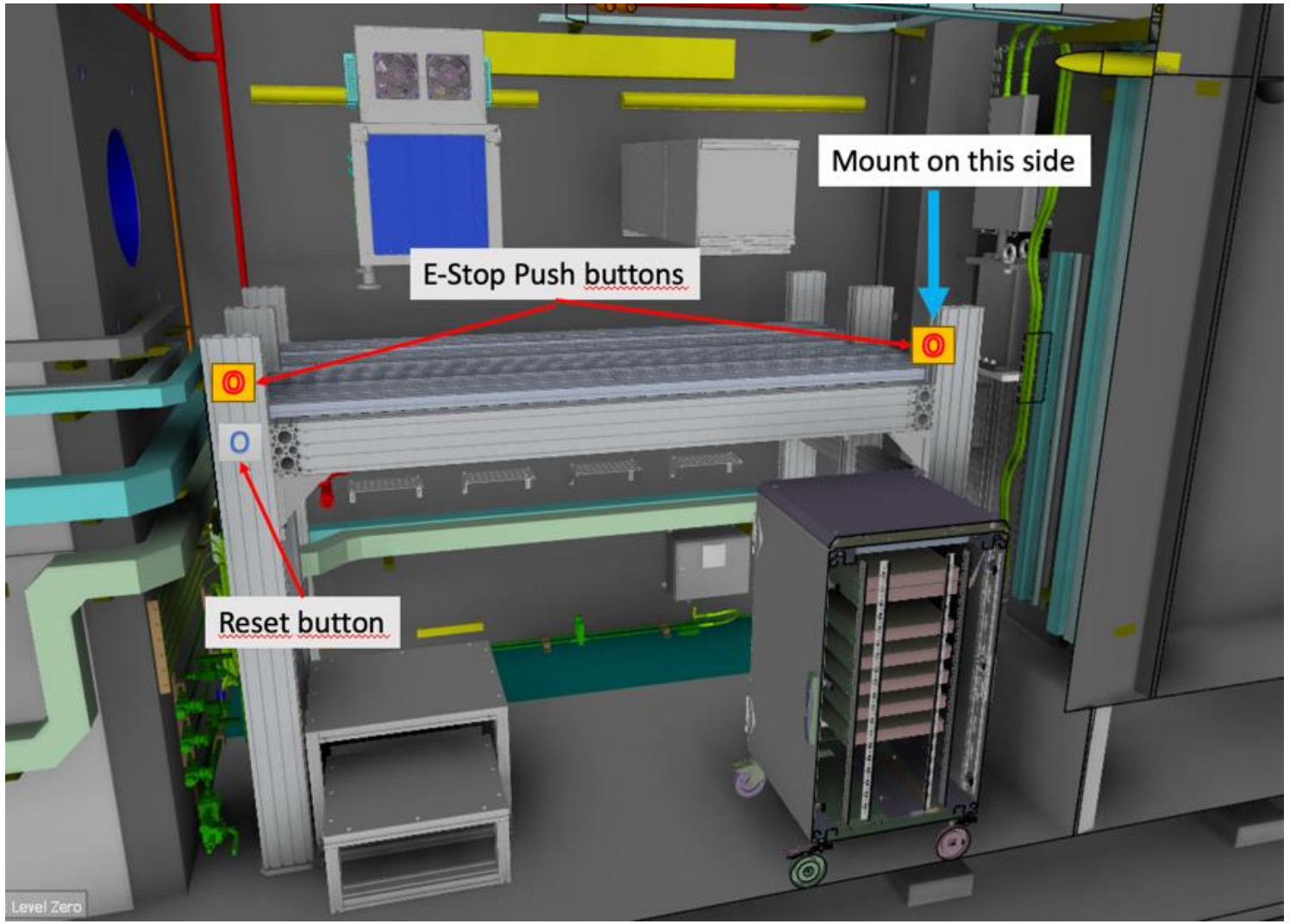


Table of Motion

Location of E-Stop and Reset Buttons



7

Validation

Reference Documents:

ESS-5846551 – Validation Plan/Report for Motion Safety on TBL MCC2

ESS-5846552 - Validation Plan/Report for Motion Safety on TBL MCC3 + MCC4

Validation

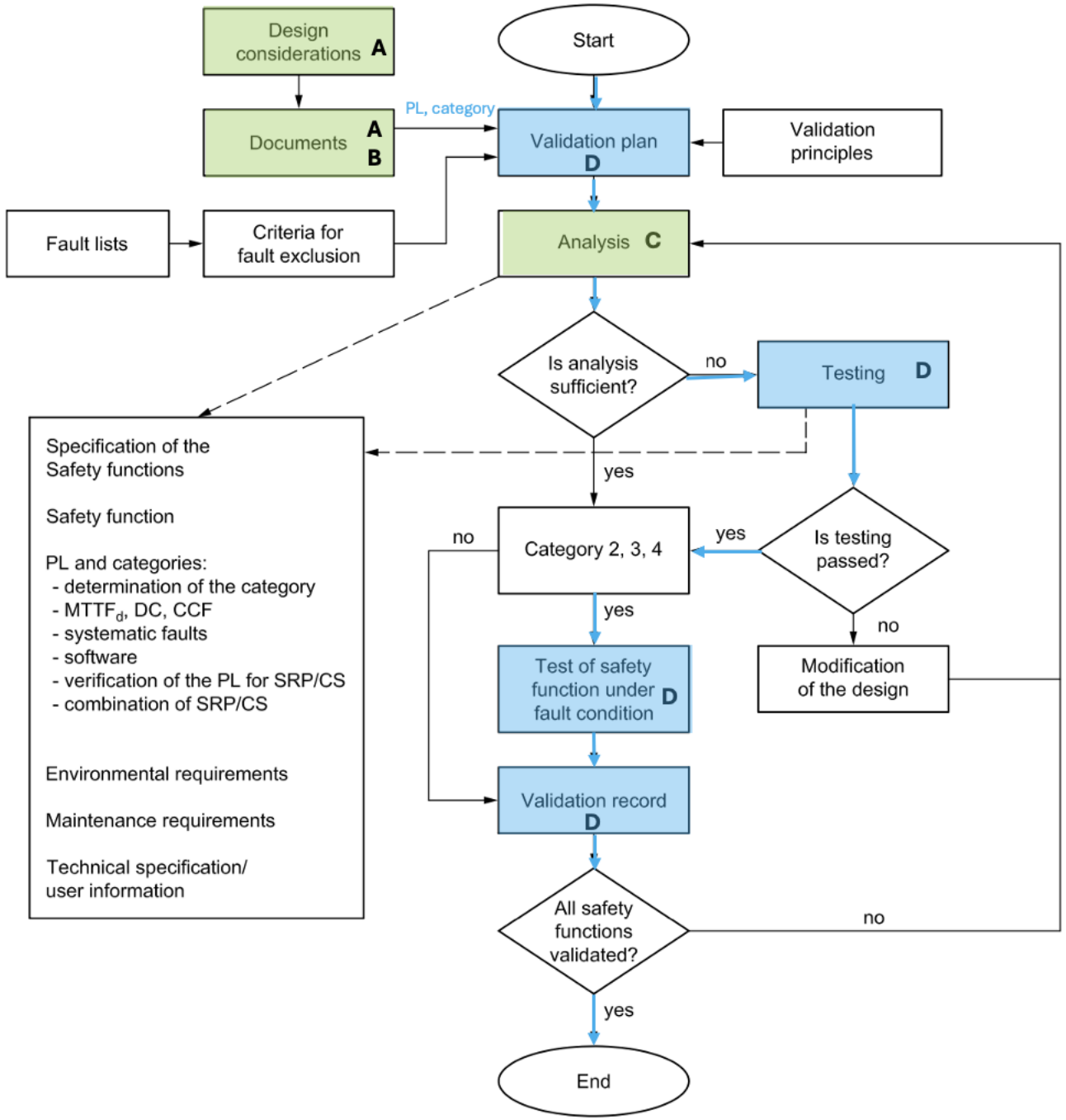
SS-EN ISO 13849-2

A. ESS-5467337 - Motion Risk Analysis of Neutron Instruments.

B. ESS-1315508 - TBL Table-of-Motion (sheet 3).

C. ESS-5830036 - Design Verification & Test Report for Motion Safety E-Stop Circuit.

D. ESS-5846551 – Validation Plan/Report for Motion Safety on TBL MCC2.
ESS-5846552 – Validation Plan/Report for Motion Safety on TBL MCC3 + MCC4.



Validation

Validation Test Plans / Reports (MCC2-Bunker & MCC3/4-Cave)

2.3. Test Readiness

#	Reference Documentation	CHESS ID
[1]	TBL Instrument Hazard Analysis (IHA)	ESS-3078238
[2]	TBL Table-of-Motion (ToM), sheet 3	ESS-1315508
[3]	TBL Motion Control 3 (Cave I) ePlan TBL Motion Control 4 (Cave II) ePlan	ESS-5346226
[4]	System Design Description - TBL Motion Control Syste	
[5]	Design Verification & Test Report for Motion Safety E-	
[6]	Quality Inspection Documents 1. TBL Inspection & Test Plan/Report (new revision) 2. MCA Self-Inspection Plan for TBL Motion Control 3. TBL QC Electrical Inspection Report (new revision)	

Test under Fault Conditions:
We used the test on the test bench as "test on a hardware model" as defined in clause 9.1 of SS EN ISO 13849-2.

TEST CASES (TO BE) PERFORMED	SUMMARY FINDINGS				
	Pass	Fail	N/A	Signature of Tester	Date
1. Document Check & Visual Inspection Comments:	X			Safaa Zaki	2025-09-08
2. Behaviour after Shutdown Comments:	X			Safaa Zaki, Ruben Martinez	2025-09-08
3.1 Function of Master E-Stop circuit (MCC3) Comments:	X			Safaa Zaki, Ruben Martinez	2025-09-08
3.2. Function of Slave E-Stop circuit (MCC4) Comments:	X			Safaa Zaki, Ruben Martinez	2025-09-08
4. Test under Fault Conditions Comments:			X	Safaa Zaki	N/A

Both Validation tests have been passed and approved.

8

Operation

Reference Documents:

ESS-5669198 - Operation Manual - MCU5001: 16Ax. Motion Control Cabinet

Operation

ESS-5669198 - Operation Manual - MCU5001: 16Ax. Motion Control Cabinet

- All three motion control cabinets on TBL (MCC2, MCC3, MCC4) are of the standardised type MCU 5001.
- Checks and LED indicator status tables during setup and E-Stop sequences are part of the Generic MCU 5001 Operation Manual.
- For the maintenance part this document is referring to ESS-5483415 - Service & Maintenance Plan for MCA Cabinets and Boxes.

Document Type	Manual	Date	Oct 2, 2025
Document Number	ESS-5669198	State	Released
Revision	2	Confidentiality Level	Internal

6. MAINTENANCE

Detailed information about the maintenance plan for all MCA cabinets and boxes is provided in ESS-5483415, [7].

10. Check other status indicator LEDs on the safety relay for normal operation.

Status indicators

- ● **FAULT**
- ☼ **IN1** Input circuit at S12 is closed.
- ☼ **IN2** Input circuit at S22 is closed.
- ☼ **OUT** Safety contacts are closed and semiconductor output Y32 carries a high signal.

Sequence	E-Stop LED in door	LED on E-Stop 1	LED on E-Stop 2	LED on Reset button	LEDs on Safety Relay (In 1)	LEDs on Safety Relay (In 2)	LEDs on Safety Relay (out)	LEDs on Safety Relay (Reset)
Initial state	○	○	○	○	●	●	●	○
Push E-Stop button 1	●	●	○	○	○	○	○	○
Push E-Stop button 2	●	●	●	○	○	○	○	○
Pull E-Stop button 1	●	○	●	○	○	○	○	○
Pull E-Stop button 2	●	○	○	●	●	●	○	○
Push Reset button	○	○	○	○	●	●	●	Reset LED on safety relay is ON for the time the button is pressed

Table 3: E-Stop indicator sequence

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Summary

Motion Safety at TBL

Summary

- TBL Hazards on Moving Machinery has been transferred to Motion Safety (ConHaz 7 + 20).
- For experiment operation no hazards could be identified:
  - Bunker Area: Area is covered by shielding walls and blocks and is only accessible for service and maintenance.
  - Cave Area: No subsystems have been installed yet; evaluation needs to be done with each new installed subsystem and additional safety functions defined and designed if necessary.
- For maintenance Motion Safety is achieved by special training, procedures and dedicated Risk Assessments (RAMS) based on tasks or area including LOTO and/or fence off.
- An E-Stop system for Cave and Bunker area has been designed, verified, installed and validated.
- The whole process is documented with the documents submitted to this review.
- The system is ready for trial operation of the instrument.

Motion Safety at TBL

Applicable Standards

- SS-EN ISO 12100 Safety of Machinery – General Principles for design – Risk Assessment and Risk Reduction
- SS-EN ISO 13849 Safety of Machinery – Safety Related Parts of the Control System (Parts 1 and 2)
- SS-EN ISO 13850 Safety of Machinery - Emergency stop function - Principles for design

- SS-EN EN 60204-1 Safety of Machinery – Electrical Equipment of Machines

- SS EN 61800-5-2 Adjustable Speed Electrical Power Drive Systems Part 5-2: Safety Requirements - Functional


Thank You!
2025-10-10

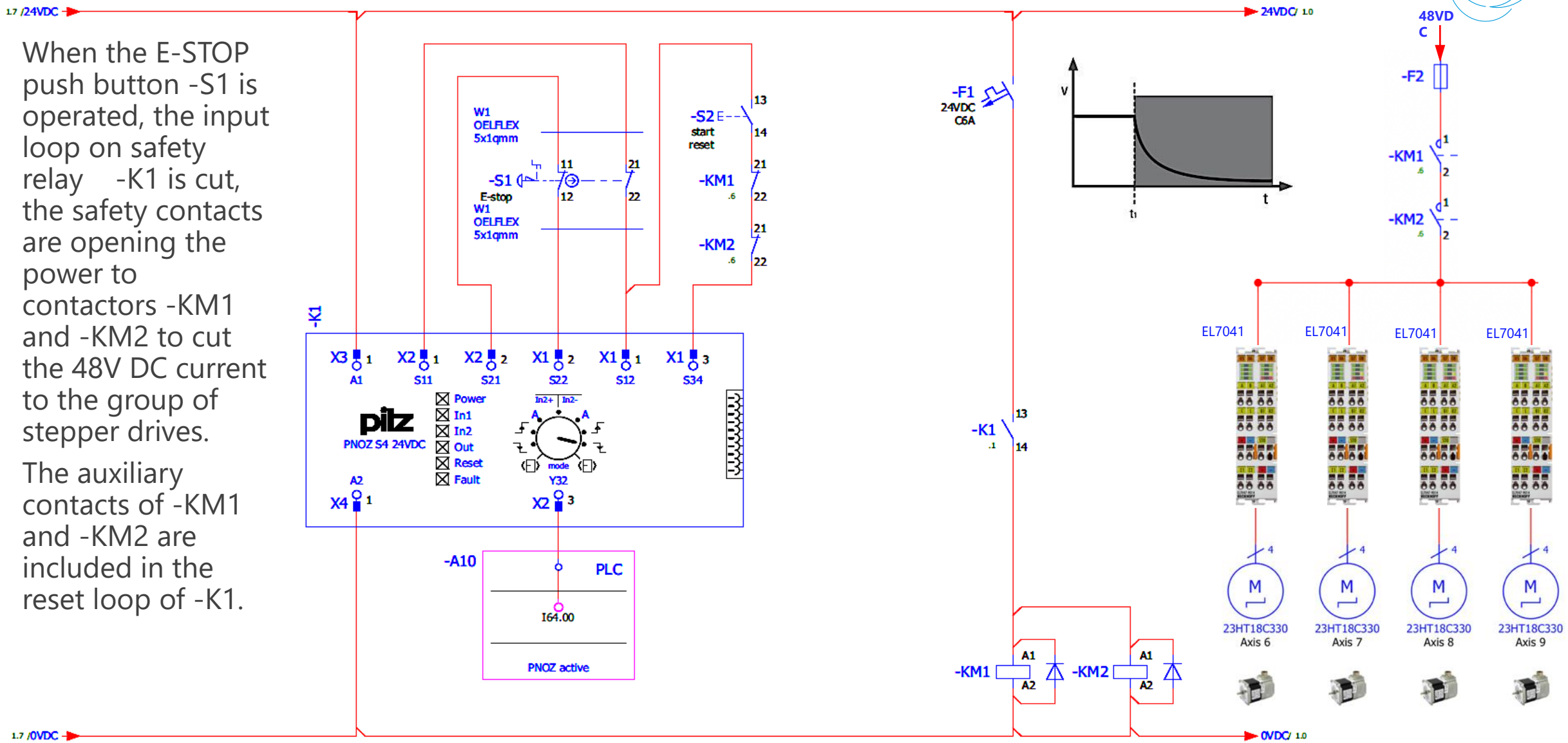
10

Additional Information

E-Stop circuit STO: Switch drive power off – Small stepper motors

When the E-STOP push button -S1 is operated, the input loop on safety relay -K1 is cut, the safety contacts are opening the power to contactors -KM1 and -KM2 to cut the 48V DC current to the group of stepper drives.

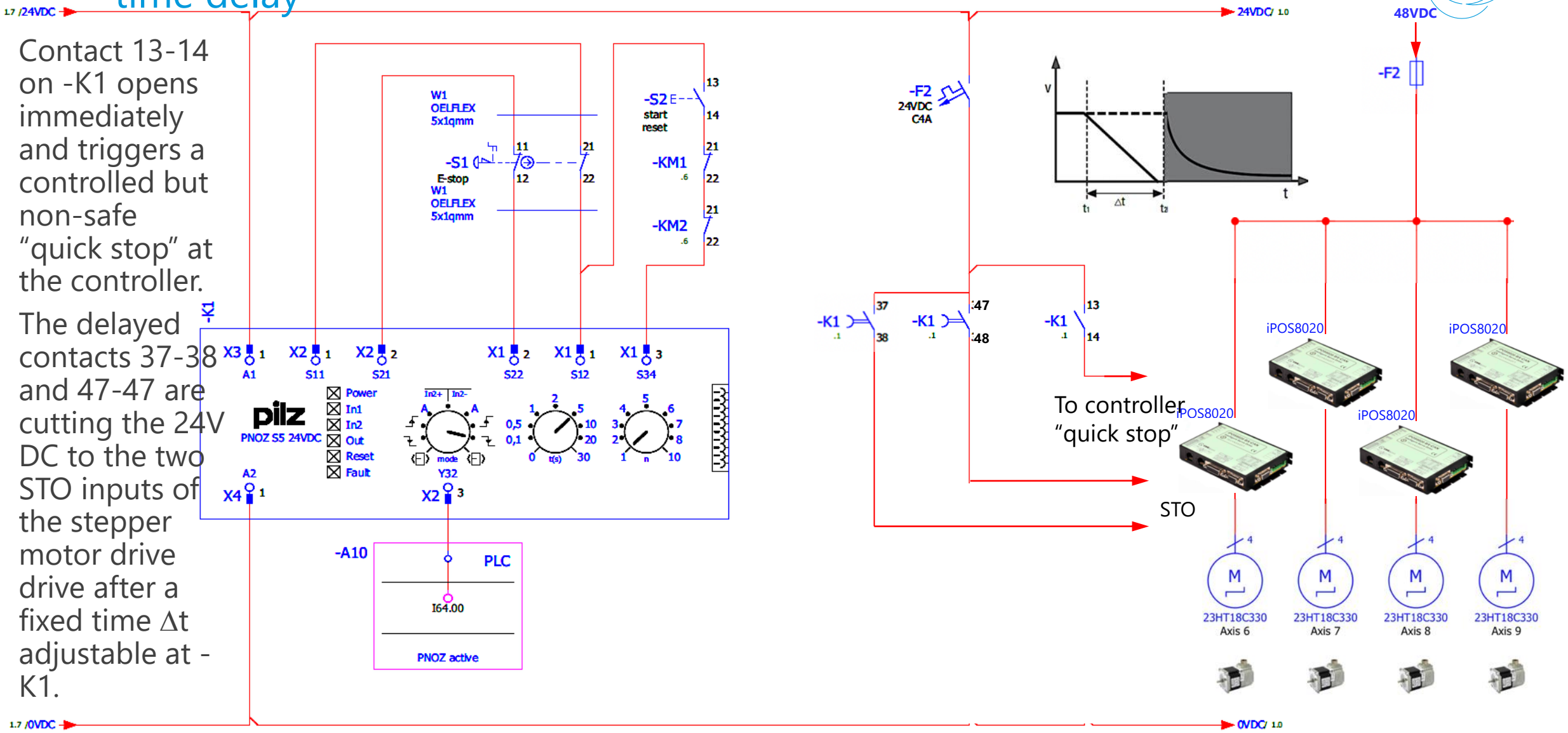
The auxiliary contacts of -KM1 and -KM2 are included in the reset loop of -K1.



E-Stop circuit SS1: Controller with Quick Stop input – Monitoring of time delay

Contact 13-14 on -K1 opens immediately and triggers a controlled but non-safe “quick stop” at the controller.

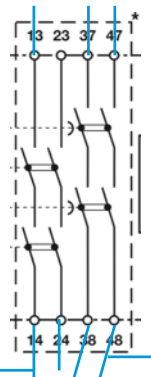
The delayed contacts 37-38 and 47-47 are cutting the 24V DC to the two STO inputs of the stepper motor drive drive after a fixed time Δt adjustable at -K1.



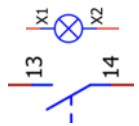
Bifrost Motion Safety

Cabinet 3: MCU 5001a – 2 Safety Circuits (STO) for 12 Beckhoff + 2 Technosoft

24V

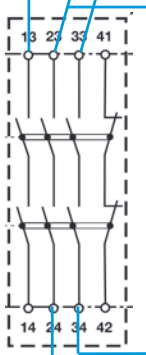


Pilz S5



Reset

PSS contacts for cave access status



Pilz S4

Auto-Reset

48V

48V

2x STO

2x STO

To Beckhoff 7 to 12

To Beckhoff 1 to 6

Technosoft 2

Technosoft 1

S4 is controlling Technosoft 2 in a separate safety function:
Stop when cave is accessible

Table of Motion

Structure

Sheet 1: Sub-System Requirements

Sheet 2: Components Selection

Sheet 3: Motion Safety Requirements

Sheet 4: Axes Distribution and Motion Control Cabinets Requirements

Sheet 5: Higher Control Requirements