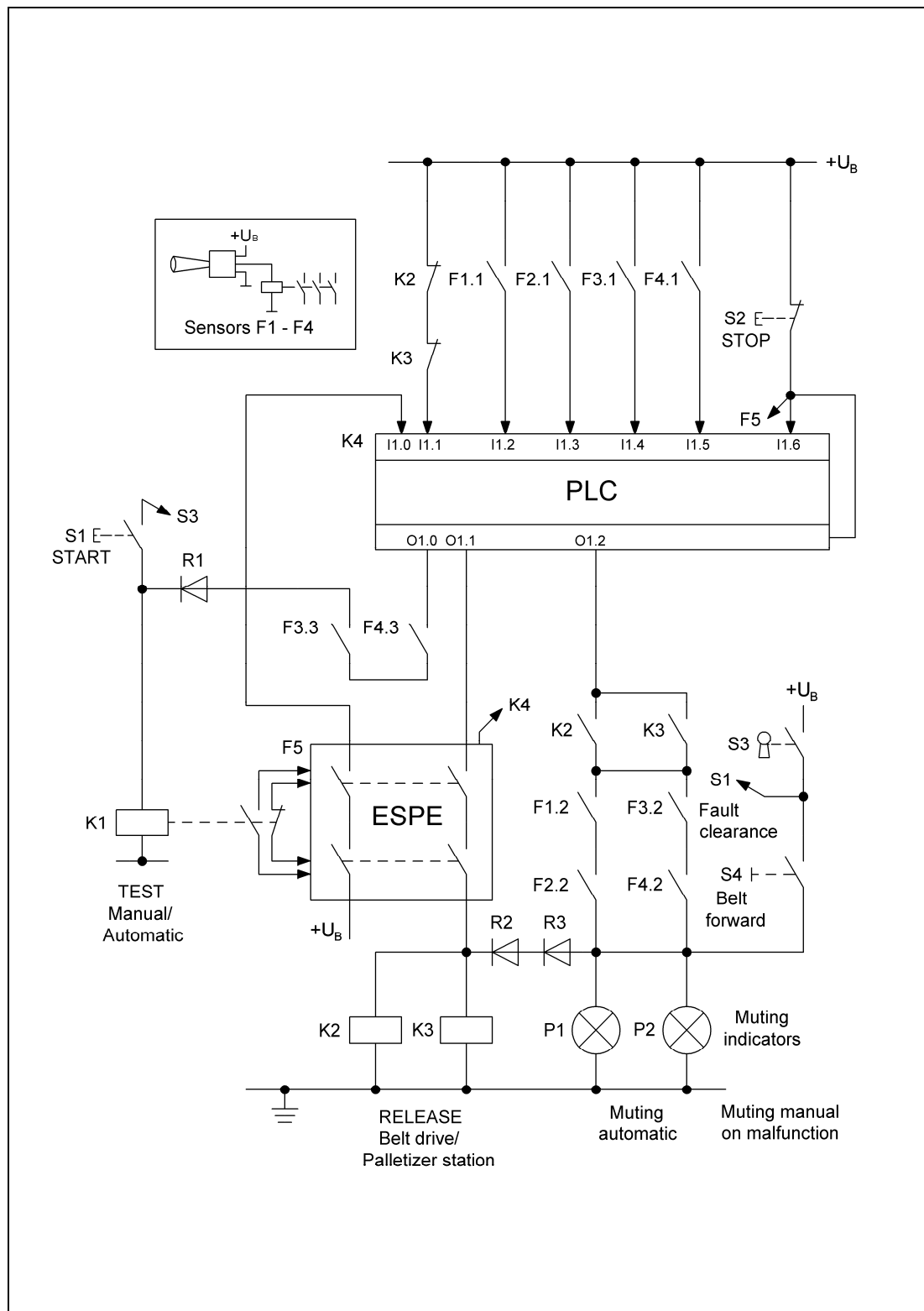
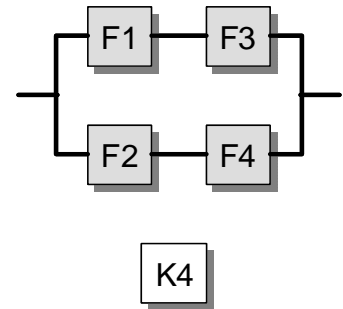


8.2.22 Muting of a protective device – Category 3 – PL d (Example 22)

Figure 8.38:

Muting of a protective device at the discharge point from a palletizing installation controlled by a PLC





Safety function

- Muting function: temporary muting of a protective device as a function of the process. Further safety functions, such as safeguarding of access to the palletizing installation or the start/restart interlock, are not dealt with in detail below.

Functional description

- Access to the discharge point from the palletizing installation is safeguarded by a triple-beam light barrier (ESPE) F5 of Type 4 to EN 61496. The light barrier embodies the additional functions of start interlock and restart interlock which are implemented by means of two antivalent inputs. Disabling of the start interlock of the light barrier is coupled to the start command for the belt drive, i.e. energization of the palletizing station, and is initiated by picking-up and subsequent dropping-out of contactor relay K1 in response to actuation and release of the start button S1. A condition for a valid start command is that contactor relays K2 and K3 have dropped out (queried via input I1.1) and that the start interlock has been cancelled (queried via input I1.0). Output O1.1 is set as a result.
- Four infrared light sensors F1 to F4 (for arrangement, refer also to Figure 8.38) are incorporated for control of the muting process. On inputs I1.2 to I1.5, the PLC monitors the actuation sequence of the four infrared light sensors via the sensors' contacts F1.1 to F4.1, in consideration of two programmed time settings. The muting function is implemented only in the output circuit of the PLC (output O1.2) independently of the output circuit of the light barrier F5. The muting contacts F1.2 and F2.2/F3.2 and F4.2, connected in series, are connected, via the diodes R2 and R3 respectively, by OR logic with the “enabling” function implemented by the contactor relays K2 and K3.
- R2 and R3 cause the muting function to be displayed correctly, and isolate the activated enabling output from the muting displays P1/P2 should the muting function not be active. Faults in R2 or R3 cannot lead to undesired muting (i.e. dangerous failure of the muting function).
- In the event of breakdown and subsequent restoration of the voltage, or with light barrier F5 interrupted and the muting function not active, the contactor relays K2 and K3 are de-energized. The absence under these conditions of latching-in prevents them from picking up again should the muting circuits be closed again. The installation can be restarted only by disabling of the restart interlock, i.e. by deliberate actuation and release of the start button S1.

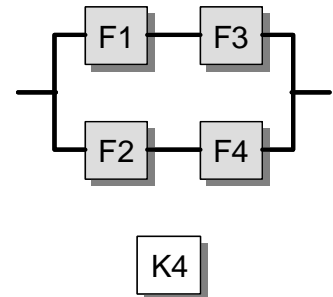
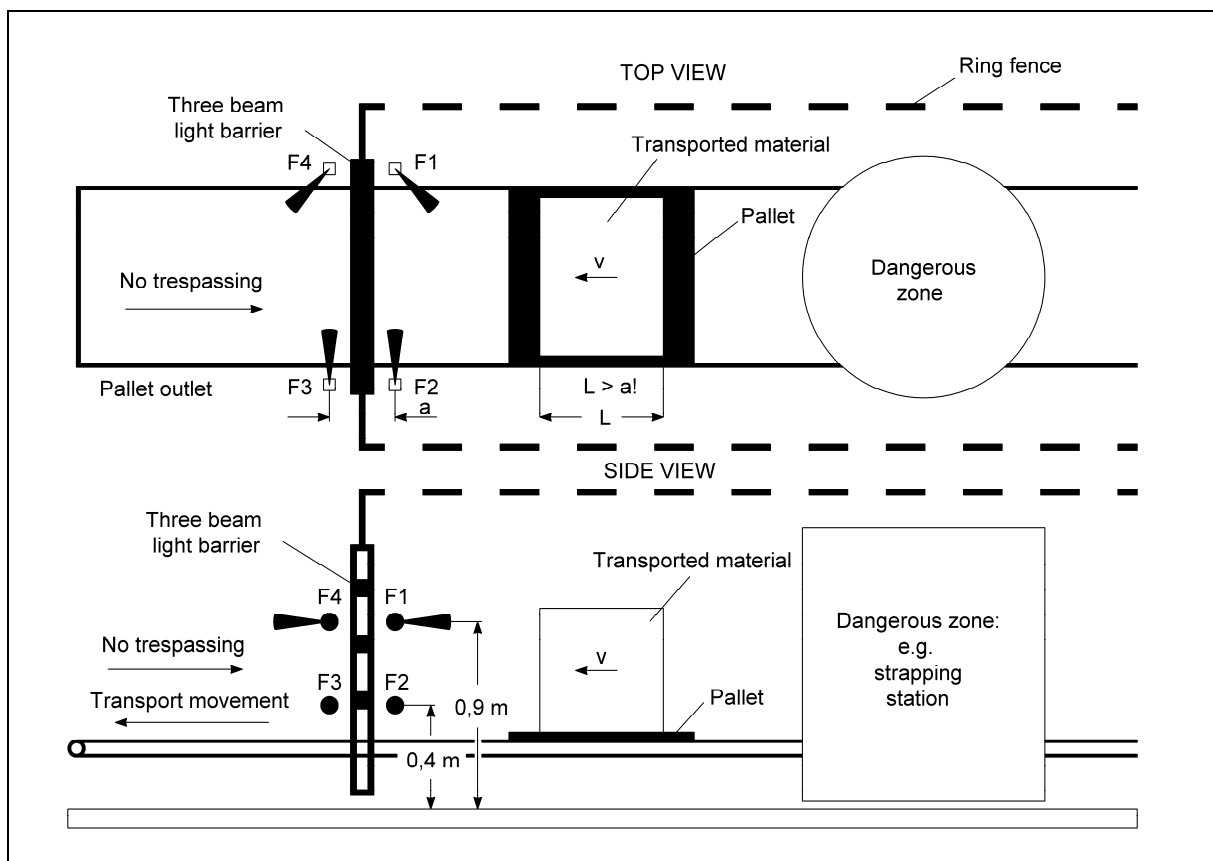
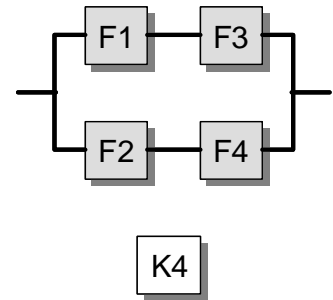


Figure 8.39:
Palletizing station with automatic control – principle of safeguarding of the pallet discharge point by means of a light barrier and arrangement of the muting sensors F1 to F4



- For intended starting/restarting, for example following a fault on the installation, the key switch S3 must be actuated. In the event of a fault condition, the operator can eject a pallet from the detection area of the light barrier and the muting sensors by means of the dead-man's button S4.

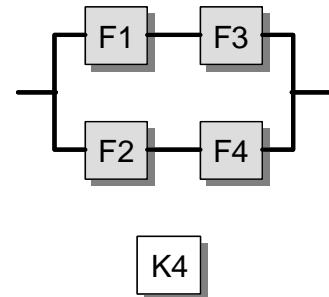
For smooth progress of the pallets through the discharge opening, two time settings in the PLC program must be matched to the velocity of the transport movement:



- The time setting T1 determines the maximum period within which – following activation of the sensor F1 – the sensor F2 must be activated and the muting function thus initiated by the transported product.
- Time setting T2 begins with renewed clearing of sensor F2. T2 must be selected such that when the detection zone of the light barriers becomes clear again, K1 is energized and de-energized again before sensor F3 is deactivated by the transported product and the muting function thereby terminated.
- Failure of the contactors K2 and K3 to drop out is detected at the latest before the belt drive/the palletizing installation start up again, owing to the feedback of the mechanically linked break contacts to the PLC input I1.1. Failure of K1 is detected at the next discharge of a pallet.
- Unintended start-up of the belt drive/palletizing installation in the event of the loss and subsequent restoration of power or a failure of the standard PLC is prevented by the function of the start-up and restart interlocks. The PLC can disable the restart interlock only immediately after the pallet has passed the light barrier, i.e. whilst sensors F3 and F4 are still activated.
- The failure of individual muting sensors is either detected directly by the PLC program (owing to monitoring for proper completion of activation and deactivation), or becomes evident by operating inhibition during transport of the pallet.
- Failure of the dead-man's button S4, which is used only for the clearing of faults (manual muting), is detected directly by the user.

Design features

- Basic and well-tried safety principles are observed and the requirements of Category B are met. Protective circuits (e.g. contact protection) as described in the initial paragraphs of Chapter 8 are implemented.
- Contactor relays K1 to K3 possess mechanically linked contact elements in accordance with IEC 60947-5-1, Annex L.
- The supply conductors to light barrier F5 and to the dead man's button S4 are laid such that short-circuits between individual conductors (including to the supply voltage) can be excluded.
- The control components S1 to S4 are located at a point outside the hazardous area and with a view of it.



- The muting state is displayed by two lights clearly visible to the operator at the access point to the hazardous area.
- The standard components F1 to F4 are employed, where applicable, in accordance with the instructions in Section 6.3.10.

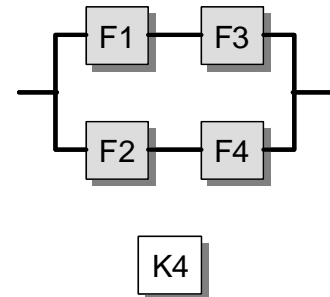
Remarks

- Example implementation of automated material discharge with safeguarding of access points to palletization and depalletization processes, transfer stations, strapping or wrapping machines. The same principle can be used for access points for material infeed.
- In accordance with EN 415-4, it can be assumed that the undetected access of persons through feed or discharge openings is prevented sufficiently reliably when requirements including the following are met:
 - use of a two or three-beam light barrier in consideration of the necessary fitting height (with the access point open or an empty pallet present in it), or
 - with the protective function of the light barrier muted by the loaded pallet with clearances to the side of less than 0.2 m and with muting being activated by the pallet load only immediately prior to interruption of the light beams (without greater timing intervals and geometrical gaps).

Calculation of the probability of failure

In the calculation below, a *DC* of 0% is assumed for the output relays of the muting sensors F1 to F4, since the contacts employed for muting are not subject to automatic fault detection. For this reason, periodic manual inspection which can be achieved by simple means is specified.

- *MTTF_d*: an *MTTF_d* of 100 years [E] is assumed for the sensor part of each of the muting sensors F1 to F4. A *B_{10d}* value of 2,000,000 cycles [S] applies for the output relays F1 to F4. At 300 working days, 16 working hours and a cycle time of 200 seconds, *n_{op}* is 86,400 cycles per year and the *MTTF_d* is 231 years for these elements. The *MTTF_d* of the channel is 35 years ("high").
- *DC_{avg}*: a *DC* of 90% for the sensor part of the muting sensors F1 to F4 is attained by the PLC monitoring. The *DC* for the output relays is estimated erring on the safe side at 0%. The resulting *DC_{avg}* value is 63% ("low").
- Adequate measures against common cause failure (65 points): separation (15), overvoltage protection etc. (15) and environmental conditions (25 + 10)



- The combination of the control elements corresponds to Category 3 with a high $MTTF_d$ per channel (35 years) and low DC_{avg} (63%). This results in an average probability of dangerous failure of 5.16×10^{-7} per hour. This corresponds to PL d.

More detailed references

- *Grigulewitsch, W.*: Speicherprogrammierbare Steuerung (SPS) zum zeitlich begrenzten, prozessabhängigen Aufheben einer Sicherheitsfunktion – Schaltungsbeispiel. In: BGIA-Handbuch Sicherheit und Gesundheitsschutz am Arbeitsplatz. Kennzahl 330 231. 36th suppl. XII/99. Ed.: BGIA – Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung, Sankt Augustin. Erich Schmidt, Berlin 1985 – loose-leaf ed.
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- *Kreutzkamp, F.; Hertel, W.*: Zeitbegrenztes Aufheben von Sicherheitsfunktionen. In: BGIA-Handbuch Sicherheit und Gesundheitsschutz am Arbeitsplatz. Kennzahl 330 214. 19th suppl. X/92. Ed.: BGIA – Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung, Sankt Augustin. Erich Schmidt, Berlin 1985 – loose-leaf ed.
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- EN 415-4: Safety of packaging machines – Part 4: Palletisers and depalletisers (03.97) and amendment AC (12.02)
- EN 61496-1: Safety of machinery – Electro-sensitive protective equipment – Part 1: General requirements and tests (05.04)
- IEC 61496-2: Safety of machinery – Electro-sensitive protective equipment – Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs) (04.06)
- IEC 62046: Safety of machinery – Application of protective equipment to detect the presence of persons (draft standard IEC 44/501/CD:2005)
- EN 999: Safety of machinery – The positioning of protective equipment in respect of approach speeds of parts of the human body (10.98)