

doi:10.22306/am.v4i4.49

CONTACTLESS PROTECTIVE DEVICES FOR DEPLOYMENT IN AUTOMATED WORKPLACES

Marek Vagaš

Technical University of Kosice, Faculty of Mechanical Engineering, Letna 9, Kosice, Slovak Republic,
marek.vagas@tuke.sk (corresponding author)

Alena Galajdová

Technical University of Kosice, Faculty of Mechanical Engineering, Letna 9, Kosice, Slovak Republic,
alena.galajdova@tuke.sk

Dušan Šimšík

Technical University of Kosice, Faculty of Mechanical Engineering, Letna 9, Kosice, Slovak Republic,
dusan.simsik@tuke.sk

Keywords: light curtains, automation, human protection

Abstract: Safety in automated workplaces is the most important feature of any machine, equipment and system as a whole in a modern and advanced society, where some part of it performs mechanical movement. The task is a set of comprehensive measures to prevent contact / collision of the device (robot, conveyor etc.) during this movement with any part of human operator. In addition, behaviour of modern automated workplaces is not always predictable, since movement (performed inside the automated cell) are usually controlled by a control program whose structure is only known to the manufacturer's programmer. These reasons pointed to the advanced functions use that is available in such equipment as light curtains.

1 Introduction

Light curtains as an element for implementation in automated workplaces usually serves as command at workplace to stop before operator is at risk position. This type of device can protect large areas. The advantage over mechanical covers lays in free access to the automated workplace, shorter setup time, material loading and so on. Protective devices must detect persons, parts of the body or objects reaching into the danger zone. Entry between protected zone and danger zone shall not be permitted. If necessary, additional protective devices must be installed. Light curtains must be installed at a distance such that hazard ends before the person enters into the danger zone [1].

The light curtains are made in a version for scanning body parts or even of a whole person. Many versions are capable to identifying whether an operator is intruding into danger zone with its body or is entering supplying material for processing. We can say that it is a kind of "mechanical" equivalent to safety of electrical equipment, where it is necessary to protect human operators from danger before electric current. While requirements for providing of electrical safety are generally understood and considered to be very important, safety against mechanical movements of machines, robotic arms or other types of equipment has been neglected quite often for quite some time, although it can cause as serious accidents as e.g. electric shock [2].

In general, light curtains belong to the basic surface-mounted optical security sensors to ensure automatic protection of inputs and outputs to / from danger area that cannot be fitted with any other type of mechanical barrier (e.g. mechanical barrier, other type of barriers, etc.). This is especially in cases, when operator necessarily moves into the hazardous area and needs free entry and exit for reasons such as automatic supply or removal of finished parts, products and materials see figure 1.

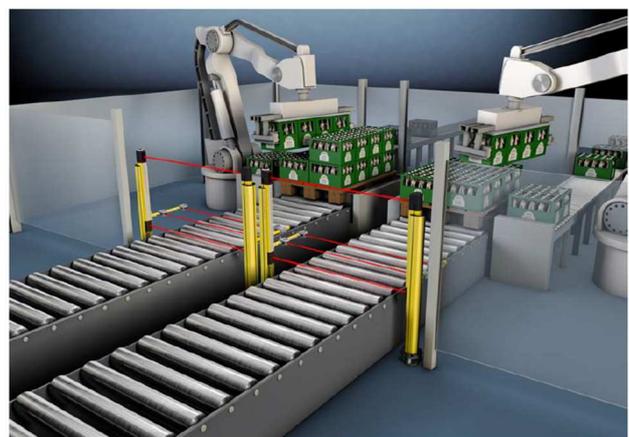


Figure 1 Example of light curtains installation into the automated workplace

As a typical good example is a mechanical safety fence or plexus-glass fences around a robotic loading station, where on the one hand it is necessary to ensure the entry

(arrival) of packaged products as well as the entry (delivery) of packaging material (e.g. pallets, boxes, etc.) and on the other hand, provide the exit (output) of filled packages on conveyor outside from the danger zone, e.g. for purpose of carrying or transporting by hand pallet truck or forklift truck [3]. In these cases, it is usually not possible to ensure mechanical securing of inputs and outputs by means of a classical mechanical door, even if the opening would be solved by its automatic opening. Not only because of high transport capacity for products on conveyors, or because of unwanted frequent shutdown of machine (in this case an industrial robot) to a safe state that significantly reduces machine life, but also because required by a human operator to check security from entire protected area [4]. It must be ensured that after closing of the door, there is no longer any person in danger zone.

2 Suitable position for assembly

Safety light curtains are installed in one of the following modes, see figure 2.

- Vertical (perpendicular to ground or at an angle greater than 30° up to 90°).
- Horizontal (horizontally to ground or at an angle approaching to 30°) to detect presence of a person in a hazardous area.
- Slant (assembly at an angle around 30°) for special functions simultaneously detecting vertical and horizontal entry under certain conditions.

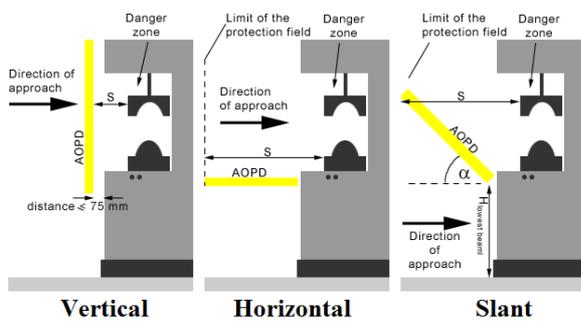


Figure 2 Positions for assembly of light curtain

2.1 Principle of light curtain

Light curtain design must be constructed in such a way that it does not cause injuries to the operator and prevents speculative starting of the automatic mode of workplace [5]. Usually, light curtain consists of receiver and transmitter units and protecting field is between them, see figure 3.

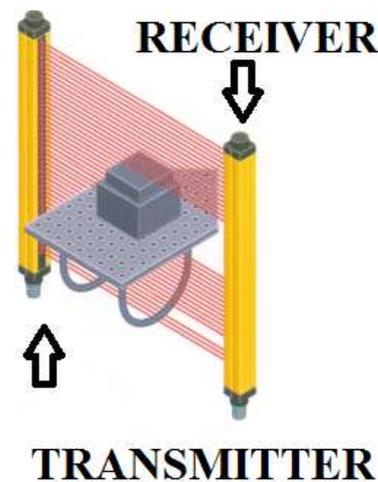


Figure 3 Principle of light curtain

Transmitting unit is equipped by source of infrared light that is transmitted in certain cycles to photo sensors in opposite part of barrier. In case of some object enter into the field and at least one line is missing, opposite receiver doesn't get information and generate signal about this situation, eventually it stop connected equipment resp. move equipment outside from this field (zone) [6]. Width of protected field is depended on maximum distance between transmit and receive unit for safe operation. Obviously starts from zero to several meters. High of protected field is depended only at unit's construction aspect, basically is limited to the two meters. Spacing of two neighbour lines determines resolution of equipment and its effectiveness. If the spacing is too small, it is very good for protection, because smaller object is matched. Resolution of equipment also determines a required IP.

2.2 Advanced function of light curtain

The most appropriate option for deployment of light curtain is using of so-called safety light curtains, equipped with function "muting". This function ensures guarding of free entrance space into the fence by detecting of unwanted entry by person, but at the same time allows completely automatic, i.e. without operator intervention, product entry or its exit [7].

This light curtain with flat surfaces allows detection by interruption (screening) of its rays with aim to control entry of a person into the danger zone, while temporary "muting function" that are implemented as in form of additional sensors allows correct detection / evaluation of the object arrival and automatic momentary deflection for (unlocking) equipment only during entry or exit of desired item [8]. At the same time, correct setting of "muting" function ensures that this unlocking does not cause a person to enter, but only by required products and required objects of automated workplace.

3 Trends – LEUZE MLD light curtain

Light curtains type MLD belongs to the basic curtains with flat surfaces detection by two or four safety sensors (according to the standard EN IEC 61496) at LEUZE electronic GmbH company, that regarding to the safety category 2, 3 or 4 and performance level PL (d, e – standard EN ISO 13849) realise variants with two or three ray system for sensing of input / output for area considered as dangerous. Obviously it is realised by separate active transmitter on one side and an active receiver (we note that active means electrically powered), or only with an active transceiver on the one hand and only a passive light reflecting the "pillar" on the other [9].

The passive reflector is not made up of a simple mirror type that reflects light ray from transmitter back to the receiver, but as a special set of two prisms that receive transmitted ray at one horizontal height level and send ray at the second horizontal height level to the receiver. In this way, required dual-ray horizontal – "optical network" is effectively created with help of single transmitter and receiver, see figure 4.

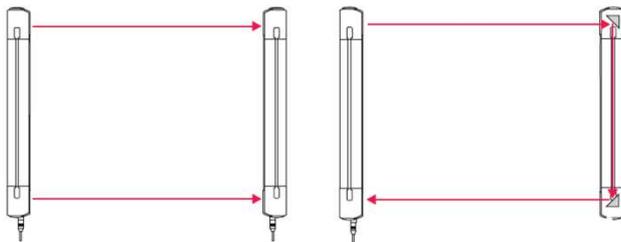


Figure 4 Separated receiver with transmitter (left) versus compound receiver with transmission solution (right)

"Muting" function requires presence of built-in control logic directly in the curtains MLD type (it is not necessary to use advanced safety relay or PLC) together with connection at MLD curtains, which attach in the opposite direction to the direction of movement of rays, in perpendicular to the rays of MLDs themselves. Their signal for sequential or simultaneous occultation by connecting to the related input of main MLD curtain provides information to control logic whether it will deny safety function of vertical rays (if it is desired object and safety outputs will not be activated or not).

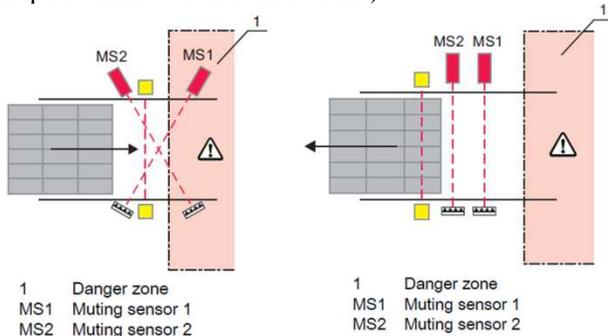


Figure 5 Principle of "muting" function

In particular, MLD 330 or MLD 530 design provides above-mentioned "muting" function, in addition to the vertical curtains themselves, by a set of two or four "muting" sensors (depending on the particular safety situation or selected function mode) that is supplied. Basic two modes of light curtains "muting" function can be seen at figure 5.

3.1 Example of MLD530-RT2M light curtain use

Example of MLD530-RT2M light curtain, their functionality and "muting" function is introduced at figure 6. This example consists of kit: MLDSET-M002-UDC-1600-S2, which contains 2 pieces of "muting" sensors with reflectors on four parts and also 2 pieces of fixing columns to the floor with its sophisticated attachment. This solution greatly simplifies correct installation and commissioning (easy adjustment of perpendicular position and relative rotation of columns by means of locking screws and integrated level) [10].

Kit MLD530-RT2M can also be ordered separately without columns and attached to our own vertical frame or column construction. The designation RT2M means that it is a version with active transceiver on one side and a passive reflective part on the opposite side of guarded vertical space. Their big advantage lay in complete wiring of electrical cables to only one side of guarded area and thus serves as a great simplification of electrical installation [11].

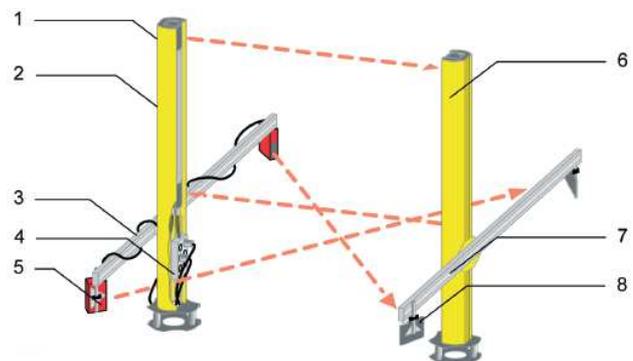


Figure 6 MLD530-RT2M light curtain kit

Where

- 1 = transceiver (associated transmitter/receiver),
- 2 = supporting column,
- 3 = locking "muting" arms with sensors,
- 4 = local interconnection terminal,
- 5 = "muting" sensor,
- 6 = passive reflection column,
- 7 = arms of "muting" reflectors,
- 8 = reflectors.

CONTACTLESS PROTECTIVE DEVICES FOR DEPLOYMENT IN AUTOMATED WORKPLACES

Marek Vagaš; Alena Galajdová; Dušan Šimšík;

4 Conclusion

We can state that advanced safety light curtains are reliably and cost-effectively protection against access into hazardous points and areas of automated workplaces. Suitable choice of the proposed variant together with different equipment functions that can be integrated or can be selected via safe control solutions is considered for replacing of traditional methods such is mechanical barriers, sliding gates and pull-back restraints. The range from small and compact types to extremely robust and resistant variants that withstand special ambient conditions up to the highest safety level makes them suitable for intuitive and cost-effective safely solution.

Acknowledgement

This work has been supported by the Slovak Grant VEGA 1/0330/19 - Research and design of algorithms and systems for the fusion of heterogeneous data in multisensor architectures and H2020: Manufacturing Industry Digital Innovation Hubs (MIDIH), reference no. 767498.

References

- [1] VAGAŠ, M.: Increasing of operational safety robotized workplaces by sensor equipment, *Global management and economics*, Vol. 2015, No. 1, pp. 158-162.
- [2] VAGAŠ, M., ŠIMŠÍK, D., ONOFREJOVÁ, D.: *Factors for successfully implementation of automated solutions based on industry 4.0*, ARTEP 2019 Automatizácia a riadenie v teórii a praxi, 13. ročník konferencie odborníkov z univerzít, vysokých škôl a praxe. Košice, Slovensko, Technická univerzita v Košiciach, pp. 1-8, 2019.
- [3] Details about light curtains, Online, Available: <https://www.schmachtl.cz/>, 2019.
- [4] FLEISCHAUER, H.: *Machine safety, Prevention of mechanical hazards*, Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST) et Commission de la santé et de la sécurité du travail du Québec (CSST), GUIDE RG-597, 2009.
- [5] PAWAR, V. M., LAW, J., MAPLE, C.: *Manufacturing Robotics, the next robotic industrial revolution*, UK-RAS White papers, UK-RAS Network, Robotics & Autonomous systems, 2016.
- [6] VAGAŠ, M., ŠIMŠÍK, D., GALAJDOVÁ, A., ONOFREJOVÁ, D.: *Safety as necessary aspect of automated systems*, ICETA 2018, Proceedings, 16th IEEE International Conference on Emerging eLearning Technologies and Applications, New Jersey (USA), Institute of Electrical and Electronics Engineers, pp. 617-622, 2018.
- [7] VRÁBEL, R., ABAS, M., TANUŠKA, P., VAŽAN, P., KEBÍSEK, M., ELIÁŠ, M., ŠUTOVÁ, Z., PAVLIAK, D.: *Mathematical approach to security risk assessment. Mathematical Problems in Engineering*, Vol. 2015, pp. 1-11, 2015. doi:10.1155/2015/417597
- [8] INABA, Y., SAKAKIBARA, S.: *Industrial intelligent robots in Springer handbook of automation 2009*, Part C, pp. 349-363, 2009.
- [9] BICCHI, A., PESHKIN, M. A., EDWARD COLGATE, J.: *Safety for Physical Human-Robot Interaction*, Springer Handbook of Robotics (Siciliano, B., Khatib, O.), Springer, Berlin, 2008.
- [10] CONSIGLIO, S., SELIGER, G., WEINERT, N.: *Development of Hybrid Assembly Workplaces, CIRP Annals*, Vol. 56, No. 1, pp. 37-40, 2007.
- [11] Daily Automation, *Vedecko-odborný recenzovaný internetový časopis. EN ISO 10218 – Priemyselné roboty a ich integrácia do priemyslu*, ISSN 2453-8175. (Original in Slovak)

Review process

Single-blind peer review process.