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WHITEPAPER

HIGH-PERFORMANCE LIGHT BARRIERS

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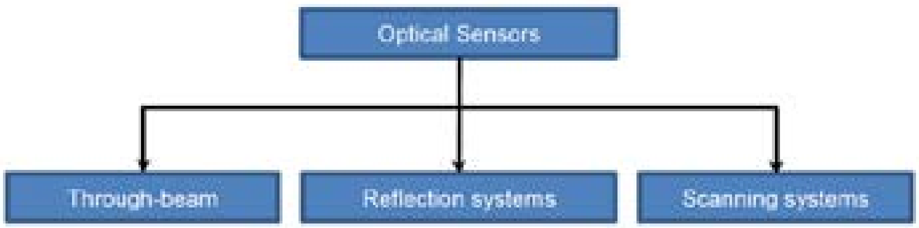
1 INTRODUCTION

In the field of sensor technology, high-performance light barriers belong, in a sense, to the „tried and tested“ technologies. Nevertheless, compared to many other possible solutions, they are still often without alternative, especially when it comes to operating conditions with special requirements and also challenges, such as extremely high dust and dirt loads, high humidity, but also adverse weather conditions such as fog, icing or snow.

This white paper describes the basic functionality as well as individual components of high performance light barriers, deals with the different operating modes as well as service functions of such devices and presents solutions from ipf electronic. In this context, some concrete fields of application illustrate the potential of high performance light barriers. Finally, selected application examples give an impression of the special properties of these systems.

2 BASIC COMPONENTS AND OPERATING PRINCIPLE

High performance light barriers are optical sensors that operate without contact and detect objects regardless of their nature (e.g. shape, color, surface structure, material). The basic mode of operation of optical sensors is based on the transmission and reception of light, whereby they are classified as through-beam sensors, retro-reflective sensors and diffuse-reflection sensors.



High-performance light barriers belong to the class of through-beam sensors and consist as three-part systems of transmitter, receiver and an amplifier. This combination, in conjunction with infrared light as the transmitting signal, gives high-performance light barriers a special position among optical sensors, whereby the solutions are particularly suitable for use in extremely harsh and thus demanding ambient conditions.

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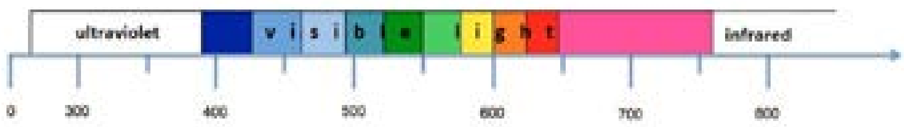
2.1 POWER RESERVES FOR CONTAMINATION COMPENSATION

Depending on the combination of the individual components comprising transmitter, receiver and amplifier, high-performance light barriers can achieve total ranges of up to 70 meters. However, these ranges are not usually exploited, but instead the systems are used with working distances similar to those known from classic light barriers. The power reserves available due to the high transmitting power of the photoelectric sensors are primarily used for highly efficient contamination compensation at shorter distances.

One of the key advantages is that the systems use infrared light as the transmit signal. Due to its wavelength of around 880nm, infrared light has particularly good penetration properties.



It is true that infrared light is not visible to the human eye. However, since the transmitters and receivers of high-performance light barriers have relatively large aperture angles (beam angles), the systems can be aligned with each other without any problems, even at greater distances. Most amplifiers for the light barriers also integrate an alignment function.

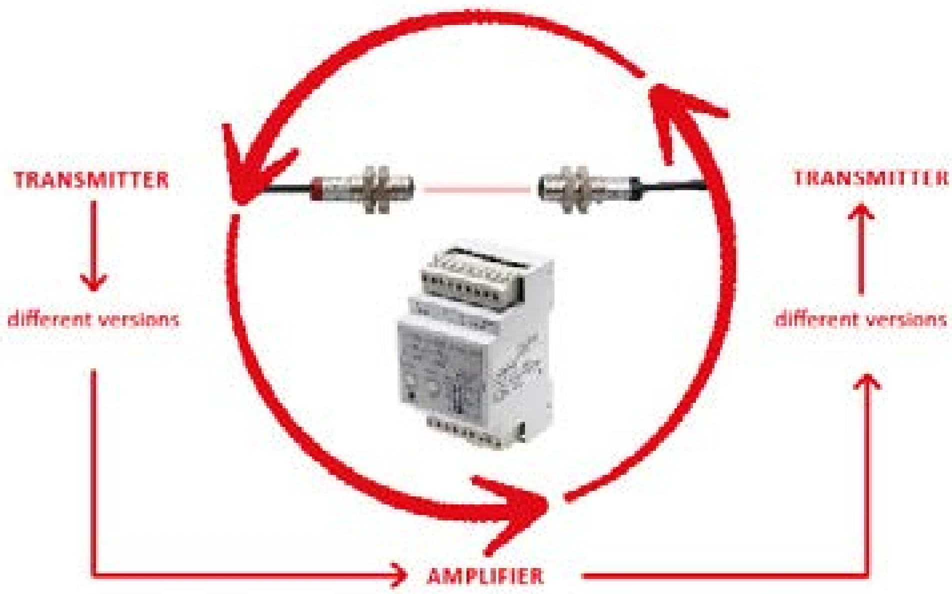
In general, the more precisely the transmitter and receiver of high-performance light barriers are aligned with each other, the greater the possible contamination compensation of the overall system, depending on the performance. However, the range of the light barrier decreases with the size of the transmitter's beam angle (6°, 12° or 25°).

2.2 AMPLIFIERS AS CENTRAL SYSTEM COMPONENTS

The amplifiers are central components of high-performance light barriers, as they allow the signal strength of the transmitters to be adapted to the specific application and, moreover, various operating modes to be selected. ipf electronic's portfolio consists of both single-channel and multi-channel amplifiers (multiplex amplifiers). More about this in chapter 4.

OV620800 one-channel amplifier (right) and **OV650840** multiplex amplifier with 8 channels.

While one light barrier can be connected to single-channel amplifiers, multiplex amplifiers allow the connection of two, four or eight light barriers with little wiring effort. Compared to single-channel amplifiers, multiplex amplifiers are slower in signal processing and also have lower power. Therefore, light barriers connected to a multiplex amplifier also have a shorter range than devices operating through a single-channel amplifier.



However, light barriers connected to multiplex amplifiers do not influence each other during operation. Therefore, complete light barriers can also be realized via a special amplifier function (see chapter 3.4). In such a case, all light barriers are connected to one signal output, which always generates an output signal when one of the light barriers in the light grid is interrupted. Alternatively, the light barriers connected to a multiplex amplifier can also be evaluated via separate signal outputs. Further detailed information on ipf electronic's amplifier portfolio and their properties in chapter 4.

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3 OPERATING MODES AND SERVICE FUNCTIONS

The extremely wide range of applications for high-performance light barriers results, among other things, from the wide variety of basic functions that single-channel and multiplex amplifiers provide in conjunction with various service functions. These include manual or automatic power control, a measuring operating mode, light grid operation and various service functions such as teach-in, alignment control and fault diagnosis.

3.1 MANUAL MODE

In the manual operating mode, a fixed and thus always constant power is specified for the transmitter of the light barrier. The manual operating mode is suitable, for example, for fill level checks in which residual media adhesion to the sensors is to be reliably suppressed or in order not to trigger a switching function during refilling by a material flow..

By manually setting a constant power, the overall system can be optimally adjusted to the respective application in this operating mode (see also the application example for „turbidity monitoring" in a cathodic dip coating at the end of this white paper).

Light barrier with single-channel amplifier (manual operating mode) for overfill protection on a rock crusher. The material flow does not trigger a switching function during refilling.

Light barrier with single-channel amplifier (manual operating mode) for level control in a silo.

3.2 AUTOMATIC OPERATING MODE

In the automatic operating mode, the amplifier automatically readjusts an initially once specified transmit power. This readjustment takes place depending on the prevailing ambient conditions. For this purpose, the amplifier keeps the light barrier at a minimum, but continuously monitored transmitting power, depending on the application. If the specified signal strength on the receiver side decreases, e.g. due to increasing contamination of the sensor optics, the amplifier automatically readjusts the transmit power until the received signal returns to the previous output value. The signal drift is thus compensated for by a corresponding increase in the transmitted signal. Failure of the high-performance light barrier due to excessive contamination of the optics can be ruled out here, since a signal output is set as an indication to clean the optics even before the overall system reaches its control limits.

With regard to the automatic operating mode, a distinction must be made between first-generation single-channel amplifiers and corresponding solutions of more recent design (see chapter 4). Various single-channel amplifiers allow the basic transmit power to be preset in 4 steps. Which setting is best for an application must be determined by practical tests. The aim here is always to achieve a setting that does not lead to any undesirable switching behavior.

Potential fields of application for amplifiers with automatic mode are applications which require a high response sensitivity due to the application (e.g. scanning of small or semi-transparent objects), but where contamination is to be expected which has to be compensated. However, the two aforementioned requirements are actually in conflict with each other, since a high response sensitivity is also associated with a high sensitivity to contamination. Pollution compensation is therefore implemented here by means of the automatic operating mode in order, on the one hand, to ensure a high response sensitivity of the light barrier (reduction of the transmitting power to a minimum level) and, on the other hand, to automatically readjust the transmitting power as pollution increases (pollution compensation).

Possible areas of application for such system solutions include car washes (see also the corresponding application example at the end of this white paper), sawmills, cement plants or, in general, outdoor applications such as the control of gates and barriers, whereby in the latter cases the light barriers not only compensate for soiling of the optics, but also for other weather-related disturbing influences such as fog, icing or snow.

Light barrier with multiplex amplifier (2-channel) at a gate entrance. The system works perfectly even if the snow on the ground protrudes into the lower infrared beam, as the specified transmission power is automatically readjusted.

3.3 MEASURING OPERATING MODE

Some amplifiers have an analog output that proportionally maps the received signal of the light barrier and thus provides measured values for evaluation on a plant control system (PLC). This output therefore offers a wide variety of possibilities for evaluating the attenuation behavior of materials, for example, to check the turbidity of liquids in transparent lines, or to query the current degree of contamination of the transmitter/receiver system. In addition, the measuring mode could also be used, for example, for double layer control of superimposed flat, non-metallic materials to determine whether, for example, one, two or three layers are present at an interrogation point. Another interesting field of application for high-performance light barriers in measuring mode is the interrogation of several component inserts arranged one above the other in an enclosure and thus the „view“ into a closed, opaque enclosure. Similar to the double layer inspection, the exact number of component inserts in an enclosure can be determined via the 0-10V signal of the analog output. However, both the inserts to be checked and the housing itself must not be made of metal or have a completely metallic coating.

As an alternative to the measuring mode, a single-channel amplifier in manual mode with a switching output can also be used for part-in-part detection. For more information, see chapter 3.5. Using the teach function described in this chapter, it is also possible to use such a system to check several different products and thus monitor different limit values, e.g. if the size or material thickness of the test specimens change or their housing materials change.

High-performance light barrier with single-channel amplifier in measuring mode for double layer control. The number of material layers can be precisely determined via the analog output.

3.4 LIGHT GRID FUNCTION

A light grid function can be activated on the multiplex amplifiers for the connection of 4- or 8-transmitter/receiver systems. If this function is selected, a single switching output is activated when any light beam is interrupted. For a flexible light grid height, several amplifiers can be coupled together to integrate additional light barriers into the light grid. Such light grids are used, among other things, in sawmills to reliably detect the beginning of tree trunks on conveyor systems, for example, in front of band saws. The light grid operation thus allows application-specific solutions with flexible light grid heights to be realized, whereby the individual high-performance light barriers do not influence each other during operation.

Light grid on a conveyor belt for logs in front of a band saw. By coupling several multiplex amplifiers, solutions with flexible light grid height can be realized.

3.5 SERVICE FUNCTIONS

The most important service functions provided by the amplifiers include a teach function, an alignment check and an error diagnosis.

With the teach function, the switching point of a switching output can be parameterized. The object to be detected is placed between the sensors and the teach function is activated directly on the amplifier by pressing a button. The optimum setting of the switching threshold is determined automatically, so that the switching output always provides a reliable signal as soon as a corresponding object passes the light beam.

In some applications, however, the described procedure for detecting a reference object can be problematic, especially if the high-performance light barrier is located at a greater distance from the installation location of the amplifier. Therefore, ipf electronic introduces a new amplifier with an integrated connection for a remote teach-in button. An electrical pushbutton connected to the amplifier can then be used to set the switching threshold of the amplifier directly on site at the light barrier. If the solution is implemented, for example, in the form of a permanently installed key switch, this can be actuated by an authorized person when a new reference object is taught-in.

DIP switches on the amplifier also provide the option of setting the system to respond either to additional attenuation or to a decrease in attenuation. This essentially defines what the specific teach situation must be. An example will illustrate this. If the target is defined as detecting an insert in a closed housing (part-in-part), the following options arise: If the amplifier is set to detect additional attenuation, the system must be taught without the insert to be detected (part not present). In the case of monitoring for decrease of attenuation, on the other hand, the amplifier must be taught with the insert installed (part present).

With the alignment control, a flashing LED signals how well the transmitter and receiver are aligned with each other. If the alignment is optimal, the LED flashes 10 times. For amplifiers with analog output, the alignment check of transmitter and receiver could also be performed using a multimeter. If a system error occurs during operation of a high-performance light barrier, this is indicated on the amplifier by LEDs and, on some devices, is also signaled via a separate switching output. In addition, the source of the error can be narrowed down on some amplifiers by means of a diagnostics button and therefore it can be determined specifically whether a line problem or the failure of a transmitter or receiver is the cause of an error.

4 HIGH APPLICATION FLEXIBILITY DUE TO AMPLIFIER

As already described in chapter 2.2, the single-channel and multiplex amplifiers are central system components, since they open up a wide range of potentials for the flexible use of high-performance light barriers in very different applications, among other things due to their different operating modes. For this reason, the device series currently available from ipf electronic are described in more detail here (as of March 2021).

In general, the amplifiers are available either with a switching output or, in addition to this, with an additional analog output. In this case, the devices allow, for example, the automatic operating mode, in which the transmission power, once specified, is automatically readjusted depending on the application (e.g., increasing contamination or other disturbing influences acting on the transmitter and receiver) (see chapter 3.2- Automatic operating mode).

Devices with an additional analog output offer far more possibilities for the flexible use of high-performance light barriers, since measured values can be transmitted, for example, to a PLC for application-specific evaluation. Amplifiers with an analog output also enable alignment checks to be carried out directly at the point of use of a light barrier using a conventional multimeter, which can be used to determine the signal strength on the receiver side more accurately.

With regard to the portfolio of amplifiers for high-performance light barriers from ipf electronic, one could basically speak of two „variant series“ that are currently offered: „tried and tested“ solutions that are still in demand on the market, and a younger generation of devices with more functions as well as more flexible application options.

4.1 FIRST GENERATION AMPLIFIER

The **OV58** series is representative of the first generation amplifiers. The devices have an 11-pin plug-in connection and require a separate plug-in socket, e.g. for DIN rail mounting. Since the amplifiers are still in demand both as spare parts for existing applications and as solutions for new applications, the **OV58** series continues to be an integral part of ipf electronic‘s product portfolio in the field of high-performance light barriers.

Front and side view with plug-in socket (right) of an amplifier of the **OV58** series.

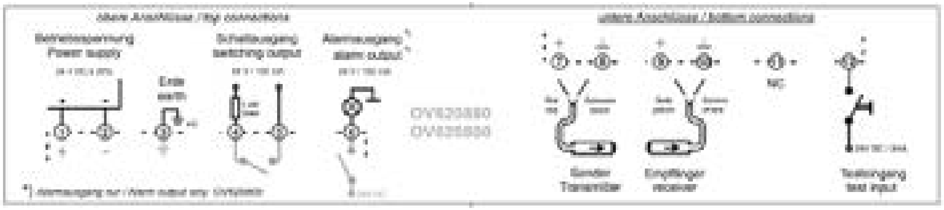
DIP switches are located on the rear of the amplifiers, with which, for example, the switching function, basic power, modulation frequency and multiplex speed can be set. High-performance light barriers use clocked light as the transmit signal. The „Modulation frequency“ function is used to determine the respective frequency of this signal. This option is always helpful when the light grid function of a multiplex amplifier reaches its limits in an application due to its slower signal processing or shorter range compared to single-channel amplifiers, and therefore two or more single-channel amplifiers must be operated in parallel. Different frequencies for the light barriers can be set for each amplifier via the modulation frequency so that the systems do not interfere with each other.

The first generation solutions also include the **OV590920**, a multiplex amplifier for connecting up to 8 light barriers. The device with additional light grid function is designed for manual operation mode only.

Multiplex amplifier **OV590920**

4.2 MORE FUNCTIONS THROUGH FURTHER DEVELOPMENTS

The **OV62** series (single-channel amplifiers) and **OV63** to **OV65** (multiplex amplifiers), on the other hand, are designed for direct DIN rail mounting and have terminal connections. Therefore, these devices offer more connection options compared to the **OV58** and the **OV590920**. For example, the **OV62** series provides a total of 12 terminals.



The **OV620800** and **OV620880** single-channel amplifiers have a total of 12 terminal connections: Operating voltage, ground, switching output, alarm output, transmitter and receiver as well as a test input, (terminal 11, without using).

As already mentioned above, the devices of the **OV63** to **OV65** series are multiplex amplifiers (2x, 4x or 8x). The only exception is the single-channel device **OV634915**, where the operating mode can be switched between manual and automatic. In addition, the amplifier integrates a changeover contact (NO/NC- normally open/ normally closed) as a signal output as well as different time functions acting on it. Thus, the user has the possibility, for example, to choose between manual and automatic mode without having to replace the amplifier for this purpose. Currently, ipf electronic‘s multiplex amplifiers can be realized with a maximum of 54 terminal connections and the single-channel amplifiers with a maximum of 18 terminal connections.

The original intention for the development of the **OV62** to **OV65** series was to reduce the type diversity of amplifiers for high-performance light barriers. As already emphasized, however, the devices of the **OV58** series are still in such high demand on the market that they continue to be offered.

5 APPLICATION EXAMPLES

The following pages present some application examples that give an impression of the versatility and special properties of high-performance light barriers in practice.

5.1 HIGH RESPONSE SENSITIVITY AND CONTAMINATION COMPENSATION

A classic example for the use of high-performance light barriers are car washes or so-called portal car washes. In particular, the main cleaning brushes and dryer fans of such systems, which travel over the car body during cleaning and drying, require a sensitive light barrier that is also capable of detecting vehicle glass (e.g. front and rear windows) in order to control the corresponding pressure of the brushes or the distance of the dryer fan according to the vehicle contours. In addition, the brushes for the wheel rims can also be controlled via a light barrier.

In such systems, the optics of the high-performance light barriers are primarily exposed to contamination from the wash water and the impurities detached from the vehicle. Depending on the regions in which the car wash is operated, the water may also contain lime, so that lime residues can also be deposited on the optics. Other environmental conditions typical of such washing systems include cleaning agents and foam.

As already mentioned, a solution with high response sensitivity is required here, which can simultaneously compensate for the contamination to which the optics of the transmitter and receiver are exposed. Since a light barrier with a fixed setting of the transmitting power is not able to cope with these basically opposite requirements, solutions such as the single-channel amplifiers with automatic mode of operation had to be developed. Due to the reduction of the transmitting power to an operationally safe minimum level, they enable a high response sensitivity of the light barrier, but are also capable of automatically readjusting the transmitting power in case of increasing contamination of the optics. Another advantage is that such a system solution outputs a signal before the connection amplifiers reach their control limits due to contamination of the optics of the high-power photoelectric sensor, and thus the transmitter and receiver can be cleaned in good time or as scheduled.

5.2 PRESENCE CONTROL OF PLASTIC PARTS

However, high-performance light barriers can do much more than just compensate for contamination, as the following application shows.

After a furnace run, the presence of flat, large-format plastic parts on a conveyor belt for transfer to a subsequent transport process is to be checked. The ambient temperatures in the inspection area are higher because the plastic parts are still warm, and the process generates a lot of dust. Due to the application, it is necessary to look through the conveyor belt, which consists of a rod mesh, without false signals if possible.

In order to reliably penetrate the conveyor belt to check the presence of the plastic parts, the solution consists of a transmitter with a beam angle of 6 degrees for maximum transmission power with a long range, a receiver (beam angle 25 degrees) and a single-channel amplifier with an additional analog output for precise adjustment of the transmitter and receiver, with the degree of alignment being displayed via a 0-10V signal. Since the light barrier can achieve long ranges, the transmitter and receiver could be mounted in an outer, thermally uncritical area of the conveyor belt. In contrast to initially unsuccessful attempts with other solutions, this system enables reliable and continuous presence monitoring of the plastic parts.

Due to its long operating range, the photoelectric sensor could be mounted be mounted in a thermally uncritical area of the conveyor belt.

However, there are occasional applications in which the supposedly correct solution for a high-performance light barrier leads to problems and the special environmental conditions therefore require an alternative, as shown in the following example.

5.3 LEVEL MONITORING IN WOOL PROCESSING

A company for yarns and knitwear processes, among other things, wool into fleece. At the start of a plant that prepares the raw wool for this purpose, there is a bunker that is filled with the raw material, which is then fed to the preparation process via conveyor belts.

The filling is done by a compressed air system which blows the raw wool into the bunker. Once the required filling quantity has been reached, the system is stopped until the bunker is almost empty. Only then is it refilled. Conventional light barriers were initially used to monitor the filling level of the bunker and control the compressed air system. However, since wool residues kept getting caught on the optics of the light barriers during emptying, malfunctions frequently occurred because the system control then received a false signal from the sensor system that the material bunker was still sufficiently filled. As a result, the compressed air system was also not activated and therefore no raw wool was refilled.

As a solution to the problem, ipf electronic preferred two high-performance light barriers, each with a single-channel amplifier. The transmitters and receivers were mounted at the level of the previous light barriers at the minimum and maximum filling level of the material bunker, and the systems were to operate in automatic mode. In automatic mode, the devices specified a minimum, continuously monitored transmit power. The idea was to use the control function integrated in the amplifiers to virtually eliminate any wool residues that might adhere to the transmitters or receivers. For this purpose, the amplifiers were to increase the transmitting power until the light beam penetrated the adhering residues without any problems.

However, this solution also resulted in malfunctions. The cause: At the beginning of filling the three-meter-wide hopper, a kind of wool mound is formed in the center of the hopper, with the raw wool initially lying relatively loosely on top of one another. As the filling quantity increases, however, this wool mound becomes visibly denser. Due to the hopper dimensions and the relatively small amount of wool fed via the compressed air system, this process progresses only slowly. The amplifier of the high-performance light barrier evaluated this creeping compaction of the wool as contamination of the optics and reacted to this with a permanent readjustment of the transmission power. This ultimately meant that the switching threshold for the „container full“ status was not reached and the system did not output a signal to stop the refilling process.

But this problem could also be solved. The previous amplifiers of the high-performance light barriers were replaced by devices that allow the systems to be operated manually. Here, a potentiometer in the respective device was used to adjust the transmitting power of the light barrier in such a way that the amplifier no longer switched at the maximum possible adhesion of wool residues to the transmitter and receiver, or that these residues penetrated. In this way, it was possible to specify a constant transmitting power for the high-performance light barriers for level control of the material hopper and, at the same time, to reliably blank out any wool residues on the sensors.

High-performance light barriers are used to detect contamination instead of compensating for it at a leading automobile manufacturer, as the following application example shows.

5.4 TURBIDITY MONITORING IN THE CATHODIC DIP COATING PROCESS

Round cells supplied with DC voltage and cooled via a supply and return system are installed in the tanks of a cathodic dip painting (CDP) system for vehicle components. The round cells consist of a membrane and a titanium anode with a natural aging process.

The high-performance photoelectric sensors, each of which operates autonomously, are installed at a total of 156 measuring points for turbidity monitoring in the cathodic dip coating line.

As a result of this and other external influences, individual cells and their membranes can be damaged, causing the paint to penetrate and contaminate the cooling medium passed through the round cells. Other cells in the dip tank may also be contaminated as a result.

If even a very slight clouding of the cooling medium interrupts a light barrier, the corresponding evaluation channel on the multiplex amplifier generates a switching signal.

A glass tube is therefore located at the return of each round cell for so-called turbidity monitoring. A self-sufficient high-performance light barrier (transmitter and receiver with fiber optic light guide) with separate evaluation via a multiplex amplifier is installed at each of the 156 measuring points.

Since the application requires high sensitivity, the transmitting power is manually set to a specific limit value. If even a very slight clouding of the cooling medium interrupts a light barrier, the corresponding evaluation channel on the multiplex amplifier generates a switching signal which is transmitted to a PLC to generate a message in the control station of the cathodic dip coating system. A defective round cell is thus clearly identified and can be screened off and replaced after the cooling system has been switched off. The remaining coolant and other round cells in the dip tank are also protected from contamination in this way.

The high-performance light barriers have already reliably detected several cell failures, which has made it possible to avoid major plant shutdowns and more costly repair measures and to sustainably increase the availability of the cathodic dip coating line.

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