Introduction

The following details refer to the provisions of EN 60947-5-2, Sept. 95
The technical terms of the paragraph headings reflect those used in the wording of this standard, whilst those in italics are synonyms.
The specifications listed relate to the nominal performance envisaged by said standard and apply to products whose technical specifications do not include a specific figure.

Operating principle

A photoelectric system is made up of an element emitting luminous radiation which directly or indirectly reach a receiver. The luminous signal level is converted to an electric signal, amplified and processed in order to drive sensor output elements. The luminous radiation is generated by a solid-state source made up of high-performance long-life semiconductor elements. The radiation used can be from outside the visible band and is usually modulated (pulse emission and reception) in order to obtain increased instantaneous power, and thus increased range and high ambient-light immunity.

Diffuse reflection proximity switch (D)

The emitter and receiver form part of the same unit. The optical beams are either parallel or slightly converging. The presence of an object inside the range of the optical field causes diffused reflection of the luminous beam onto the receiver and thus detects the object itself. The reflective properties of the object are important, however it is generally possible to detect the presence of any object with a high degree of reliability unless it is perfectly reflective or better still black. Clear objects with a reflective power of 90%, are detected close to the rated operating distance Sn, whilst dark objects with 18% reflectivity are detected at about 1/2 Sn.

Retro-reflective photoswitch (R)

The emitter and receiver form part of the same unit. The optical beams are parallel (non-coaxial optics). The emitter's luminous beam is reflected by a reflector and redirected towards the sensor where it makes contact with the receiver. Detection occurs when the path of the beam is interrupted by the presence of an opaque object. Operating distance mainly depends on the quality of the reflector utilized and on the optical-beam angle.

Through-beam photoswitch (T)

Emitter and receiver are housed in two separate units and are installed one in front of the other. Detection occurs when the path of the beam is interrupted by the presence of an opaque object.

Focused diffused proximity switch
Fixed-focus

The emitter and receiver form part of the same unit. The optical beams are focused and converging at the point of maximum sensitivity; away from this point the sensitivity is drastically reduced. Depth of range is determined by the inclination of the beams and by excess gain. To sum up, background and foreground suppression occurs which is only moderately effective.

Background-suppression proximity switch

This is a photoelectric system based on the principle of triangulation. It is sensitive to the angle of reflection that decreases in proportion to the distance of the object. The emitter and receiver form part of the same unit. The emitter has a small angle of emission and therefore the luminous area that hits the target is also small. Receiver optics focus a light spot on a pair of sensors; one receives the light reflected by nearby objects and the other by distant objects. The signal from the two sensors is processed in order to enable distinction between near and distant objects. In this case the colour of the target has little effect on system efficiency.

Polarized retro-reflective photoswitch

This is a variant of the retroreflective system which eliminates its main defect, i.e. non recognition of standard specular reflective surfaces facing the optical axis in that they cannot be distinguished from the reflector. A polarizing filter is placed in the emitter's optical system along an axis that we will call "horizontal", whilst a vertical polarizer is placed in the receiver.
This results in the elimination of reflections from surfaces which are not optically active. On the other hand, the light reflected from the reflector possesses a component that is strongly polarized in a perpendicular direction to the incident light, and therefore becomes the only recognizable reflected-light source. It is however necessary to take care when detecting objects in thin transparent film or covered in this material, in that they can distort polarization to a certain degree.

Independent action

Switching of output status does not depend on the approach speed of the target and there are no transition stages between ON and OFF.
Photoelectric proximity switches are of this type unless otherwise indicated.

Standard target

This is the target used for photoswitch settings. It differs according to type of photoswitch under consideration. The targets listed are those meeting EEC standards or the most commonly used. Product specification sheets may differ slightly according to type and size.
For models R and T, the standard target does not correspond to the target that will in practice be detected, but consists of one of the two active elements that make up the photoelectric switch.

- **Diffuse reflection proximity switch:**
A sheet of opaque white paper is used with a reflective power of 90%,. Dimensions are 100x100 mm for operating distances up to 400 mm, and 200x200 mm for greater distances. On occasions figures are quoted for black paper with reflectivity of 18% and 8%. The same targets can be used for focused and background-suppression models.
- **Retroreflective and polarized retroreflective photoswitch:**
Use reflector model RL110.
- **Through-beam photoswitch:**
Use emitter of the same type.

Excess gain (Eg)

Indicates the ratio between the signal obtained at a specific distance and that necessary to trigger the device (see also "Excess-gain graph"). Although switching of sensor ON/OFF state always occurs at Eg levels close to 1, technical specifications of a particular model relating to **S** parameter could refer to Eg>1.
In this case **S** is intended as the distance at which the signal operating margin is guaranteed greater than 1.

Operating distance (S)

If expressed for Eg=1, indicates distance at which standard target will trigger output circuit. This form is usually quoted for type D photocells.
If expressed for EG>1, indicates the recommended operating distance at which performance should be regular and virtually unaffected by environmental conditions. This form is usually quoted for type R and T photoswitches.

Blind zone

Photoelectric proximity switches have blind zones near to the optics. In these zones Eg is less than 1.
Reducing sensitivity can lead to a blind zone which did not previously exist, or if there is already a blind zone, it can increase in size. A previously non existent blind zone can appear if a target is used with a lower reflective power than that of the standard target. Full details on blind zones can be obtained by referring to the Eg diagrams. As a rule, the data for blind zones are only given for adjustment at maximum sensitivity or refer to actuators other than the standard target.

Rated operating distance (Sn)
Nominal sensing distance

Conventional value of operating distance **S** for photoelectric switches without sensitivity adjustment. This conventional value does not consider manufacturing tolerance (±10%) and variations that can be produced by differently rated supply voltages and temperature outside the range 23±5°C.

Sensing range (Sd)

Range within which the operating distance can be regulated if the sensor is fitted with a sensitivity adjuster. The maximum value of Sd has the same definition as Sn. If minimum value of Sd is not quoted it should be taken as being equal to 0. If it is given however, tolerance is not guaranteed that of Sn.

Effective operating distance (Sr)

Is the sensor operating range with nominal conditions of power supply voltage and ambient temperature (23±5°C). It is expressed as a percentage of Sn.
This is effectively the manufacturing tolerance.
Type D series sensors without sensitivity adjustment and some series with adjustment have guarantee of **Sr** within range 90% -133% of **Sn** with Eg=1.
Other type D series sensors with sensitivity adjustment can have guarantee of **Sr** within range 90% -133% of **Sn** with Eg=1.5.
Type R series sensors with or without sensitivity adjustment have guarantee of **Sr** within range 90% -150% of **Sn** with Eg=1.5.
Type T series sensors have guarantee of **Sr** within range 90% -200% of **Sn** with Eg=1.5.

Usable operating distance (Su)

Is the sensor operating range calculated with power supply voltage at between 85 and 110% of nominal value and a specified ambient temperature. The manufacturer guarantees that it is between 90 and 110% of Sr. Minimum **Su** is however guaranteed as being >81% of Sn.

Assured operating distance (Sa)

This is the true sensor operating range when all environmental factors have been considered.
The manufacturer guarantees that the sensor can operate within the entire zone ranging between 0 and 0.81 of Sn only in the case of photoswitch without blind zones and referring to specific targets.
The user should consider this as the working range which is at all times guaranteed in the whole range of environmental working conditions specified.

Repeat accuracy (R)

This guarantees that the % variation of Sr in an 8 hour period, at ambient temperature 23±5°C, specified humidity, specified supply voltage value and variable within ±5%, can never exceed the declared value R. If not declared the value of R is intended as <0.1 Sr.
N.B. In type T and R sensors the target crosses the optical beams perpendicularly and therefore the repeat accuracy and hysteresis quoted as above bear no direct relation to what actually happens in practice. Only in the case of type D sensors is there correspondence.

Differential travel (H)

This is given as a percentage of Sr and expresses as an absolute value the maximum difference between the switching points during the target's approach and departure from the operating face.
The difference between the two switching distances is purposely introduced to guarantee the constant state of the output should the object come to be found inside the switching points. Unless otherwise indicated, 0.02Sr≤H≤0.2Sr. H can be influenced by the thermal drift, but the value specified remains

inside that declared in the ambient temperature range.

Rated operational voltage (Ue)
Expresses the supply voltage range. The manufacturer guarantees that the sensor will function correctly in a voltage range between 0.85 Ue min. and 1.1 Ue max. (see Ub).

Voltage rating (UB)
Operating voltage
Expresses the power supply voltage range between minimum and absolute maximum values.

Ripple
Amplitude of maximum acceptable ripple in the DC power supply voltage expressed as a percentage of the average value of the latter.
Correct operation is guaranteed with ripple < 10% Ue.
In actual fact many sensors operate perfectly well even when the ripple is much higher.

Voltage drop (Ud)
Indicates maximum value of drop across the active output, with rated load current (Ie), power supply voltage within UB range and temperature 23±5°C.
Unless otherwise stated the manufacturer guarantees the following:
For 2-wire DC models ≤8V
For 3-wire DC models ≤3.5V
For 2-wire AC models ≤10V

Rated insulation voltage (Ui)
Unless otherwise stated, sensors up to 50 Vac and 75 Vdc are tested to 500V AC.
Class 1 sensors (with earth lead) up to 250 Vac are tested to 1500 Vac, whilst those in class 2 (double insulation, no earth lead) are tested to 3000 Vac.

Impulse voltage withstandability (Uimp)
Unless otherwise indicated, the supply terminals and output leads are tested with a pulse amplitude of 1KV in the case of dc units and 5KV for ac ones (1.2/50µs, 0.5J, generator impedance 500Ω).

No-load supply current (Io)
The current drawn by a three or four-terminal proximity switch from its supply when not connected to a load. Specifications include **Iomax** which indicates the maximum current drawn within the voltage range Ue.

Rated operational current (Ie)
Load current
Is the current drawn by the load. The tables quote the Iemin indicating that guaranteed in worst possible operating conditions.

Minimum operational current (Im)
The current which is necessary to maintain ON-state conduction of the switching element within the supply voltage range Ue.
In ac sensors it assumes higher values because it is the holding current of the output triac. In 2-wire sensors (ac & dc) it assumes even higher value as it also includes the supply current.

OFF-state current (Ir)
Leakage current
The current which flows through the load circuit of the proximity switch in the OFF-state at the maximum supply voltage (UBmax).
The load value is specified in such a way that at UBmax the load itself can be bridged by a current equal to Ie. The user must ensure that the Ir current is below that required to hold load in ON-state or this could result in the load remaining connected even if in OFF-state. With parallel connection of sensors the Irs need to be added together. In 2-wire sensors (ac and dc) it assumes even higher values than 3-wire models as it includes the supply current.

Repetitive peak current
Unless otherwise stated, the ac switching element has a make capacitance under normal conditions of 6 Ie with a duration of 20ms and a period of 10s (category AC-140)

Non-repetitive peak current
Indicates maximum amplitude and duration of a single current pulse which can flow through the ac switching element without failure.

Utilisation categories
Unless otherwise indicated, dc sensors are the **DC-13** category whilst the ac sensors are the **AC-140** category.

Switching element function
The functions can be expressed as follows:
a) by indicating the state of the receiver with reference to ON/OFF state; or
b) indicating ON/OFF state with reference to the presence of the target
1a) Dark operate. Function that allows current to flow when the path of the luminous beams is interrupted and will prevent flow when the path of the luminous beams is not interrupted.
2a) Light operate. Function that allows current to flow when the path of the luminous beams is not interrupted and will prevent flow when the path of the luminous beams is interrupted.
1b) Make (NO normally open). A make function causes load current to flow when a target is detected and not to flow when a target is not detected.
2b) Break (NC normally closed). A break function causes load current to flow when a target is detected and not to flow when a target is not detected.
Make-break or complementary function
A switching element combination which contains one make function and one break function.
In order to establish a relationship between the two different modes, it is necessary to distinguish between type D sensors (light diffusion) and types R and T (light reflection or transmission):

Type	Dark operate	Light operate
D	NC	NO
R	NO	NC
T	NO	NC

Type of output and load connection
3-wire NPN: two power supply wires and one output wire. The switching element is connected between output and negative terminal. When in ON-state the current is drawn from load across the output terminal. The other load terminal is connected to the positive terminal of the power supply.
3-wire PNP: two power supply wires and one output wire. The switching element is connected between output and positive terminal. When in ON-state the current is drawn from positive pole and supplied to the load across the output terminal. The other load terminal is connected to the negative terminal of the power supply.
Programmable 4-wire NPN or PNP: two power supply wires, one NO/NC selection input and one output. The selection wire sets NO or NC function depending on which power supply terminal it is connected to.
4-wire NPN or PNP (complementary outputs): two power supply wires and two complementary outputs, one NO and the other NC.
4-wire NPN or PNP: two power supply wires and two output wires. The type of output can be programmed. NPN output is obtained by connecting the PNP terminal to the negative terminal. PNP output is available connecting the NPN terminal to the positive terminal.
Open collector: The output transistor is not internally connected to a pull-up or pull-down load. Therefore it is possible to connect an external load supplied by an external voltage.
If the output is not the open-collector type, it is possible for the load to be supplied by an external voltage using a blocking diode in series to the output.
This solution increments the output voltage drop.
DECOUT®: Two power supply wires and two optically decoupled output terminals make up this unique design created by D.M..
Thanks to its decoupled static relay, it is capable of offering both NPN, PNP, parallel and series configurations as well as interfacing with any input desired. The changeover (make-break) function allows switching from NO to NC and vice versa by simply reversing the polarity of the power supply leads in turn permitting complex logical functions.
3-wire ac: Two power supply wires and one output. The switching element is connected between output terminal and phase line. In the ON-state current is drawn from the phase line and supplied to the load across the output terminal. The other load terminal is connected to the neutral line.
4-wire ac: Three power supply wires and one output. Two of the supply wires control the changeover function and NO or NC can be selected as desired by connecting to the phase whilst the unused lead must not be connected.
2-wire ac: The two leads make up the switching element itself. In the ON-state, with one terminal connected to the phase and the other to the load, current is drawn from the phase line and supplied to the load across the output terminal. The other load terminal is connected to the neutral line.

Check input
Some T models have a test circuit in the emitter which enables a user-friendly test to be effected in order to verify that the sensor is operating correctly. The test input consists of two wires which are decoupled from those of the power supply. In light state, connecting the check input, the emission of luminous pulses is interrupted. This condition simulates the presence of a target within the detection range and forces the receiver output to switch. If switching does not occur, it indicates a fault in the system.

Short circuit protection
All dc sensors are usually supplied with integrated short-circuit protection, whilst ac sensors do not and the fitting of external devices such as fuses will not protect them from internal damage.
Output protection of dc sensors in the case of short circuit or overcurrent is effected by establishing a maximum current threshold (limiting current). When this threshold is exceeded (usually between 1.5 and 3 times **Ie**), the proximity switch opens the output circuit.
Normal operation is resumed by following certain procedures which vary according to type of protection.
a) autoreset: reset occurs automatically straight after the cause of the short circuit has been removed
b) with hold: to restore normal operation it is necessary to effect a switching exercise or switch off power supply and remove cause of short circuit
In both cases, during the short circuit a] one or b] a burst of current pulses (whose amplitude can reach 5A) will flow across the output.

Polarity-reversal protection
No damage will occur to proximity switches if the supply wires are reversed.

Overvoltage protection
When the UB voltage is exceed for a few moments,
ac and dc proximity switches will not generally be damaged provided dissipated energy does not exceed 0.5J (see also Uimp).
The ac sensors are not protected when power

supply voltage permanently exceeds Ub.
For sensors with both ac and dc voltage, the Ub value in direct current can be exceeded in continuation without provoking damage until such time as the equivalent peak value in alternating current is reached. In this particular range, the sensor will not function and the output remains disconnected.

Inductive-load protection
Unless otherwise stated, dc sensors are fitted with an inductive-load (surge) protection which consists of a diode or Zener diode. See section on electrical wiring for maximum L value.

Time delay before availability (tv)
This is the time between the switching on of the supply voltage and the instant at which the proximity switch becomes ready to operate correctly.
During this phase the output circuit remains in OFF-state; false signals may be present for a maximum of 2ms. This time is necessary for preventing that when switching on the sensor output find itself in an undefined state and that there may be false operating cycles present capable of exciting the load. Unless otherwise stated the delay is ≤300ms.

Switching frequency (f)
This is the maximum output switching frequency performed by the output circuit and is stated as:

$$f = \frac{1}{t_{on} + t_{off}}$$

For ac sensors, the minimum output pulse width must not fall below half sine period.
Alternatively, **ton** and **toff** may be supplied instead of **f**.

Turn on time (ton)
This information is not usually quoted. It is used along with toff to calculate f. The time indicated represents that required to switch output to light-pulse state with respect to the instant in which the receiver element has effectively switched to this same state.

Turn off time (toff)
This information is not usually quoted. It is used along with ton to calculate f. The time indicated represents that required to switch output to dark state with respect to the instant in which the receiver element has effectively switched to this same state.

Status indicators (LED)
The LED indicators can be classified according to colour:
CONTINUOUS GREEN: Power on
CONTINUOUS YELLOW: Output on
CONTINUOUS RED: Fault
When there is only one LED it is usually red and indicates output state.

Alarms
• Low signal alarm
Some models are fitted with a dedicated output which is used to warn that the signal is not at the required level.
The alarm can be triggered as follows:
a) The condition of signal received between Eg=1 and Eg=5 remains for a time greater than T [alarm Tall]
b) For a number N of consecutive changes from dark to light state, the condition of signal received does not exceed Eg=1.5.
The alarm is automatically de-energized once correct margins are restored.

Autocheck
Self-monitoring
Some models have an autocheck circuit which generates a continuous pulse train obtained as a complement of the actual output state. The pulses have a duration of 150-300µs and a period of 4-8ms. They are present in both ON and OFF output states and are generated by a test cycle of the sensor itself. These pulses only decrease the mean value of the output current by about 10%, therefore a standard load continues to operate correctly. Even a normal PLC input is not capable of detecting these pulses. An external watchdog circuit, a fast PLC input or dedicated logic can be used to detect the presence of the autocheck pulses: their presence means that the sensor works properly and their absence that a failure has occurred.

Degree of protection
Protection degree
The minimum required degree of protection for photoelectric sensors is IP54 (partial protection against dust and water jets). In general, the minimum degree of protection offered is IP65 (complete protection against dust and water jets).

Pollution degree
The degree of environmental pollution for intended use is that relating to industrial environments (3), which allows non conductive dry pollution that could become conductive due to condensation. These devices do not usually have exposed electrical components. When connectors or terminal clips are fitted they will be enclosed in a protected microenvironment.
The operating distance of photoelectric sensors can be affected by a dirt being deposited on the optical components.

Ambient temperature range
Temperature range
The EEC standard guarantees a minimum temperature swing from -5 to 55°C. In general a larger range from -25 to +70°C is guaranteed.
The figures quoted are valid within the declared ambient temperature range. Generally speaking the sensors can be used within a 10°C greater range with only a slight loss of performance.
Details regarding thermal drift of currently available sensors for wider temperature ranges are available on request.

Temperature drift
Maximum change in the operating distance within the temperature range expressed as a percentage of the effective value Sr. The manufacturer guarantees that photoelectric sensors have a thermal-drift range of ±10% of Sr.

Relative humidity (RH)
The relative-humidity range within which normal performance is guaranteed. Photoelectric sensors can be affected by a high RH in the form of condensation which could be deposited on the optical surfaces
Some plastic materials can deteriorate if left for long periods in a dry environment (RH<10%), but even if used, these materials do not form part of the sensors functional components.

Shock
In accordance with IEC 68-2-27:
Pulse shape: half-sine
Peak acceleration: 30 g
Duration of the pulse: 11 ms

Vibration
In accordance with IEC 68-2-6:
Frequency range:10 Hz to 55 Hz
Amplitude: 1 mm
Sweep cycle duration: 5 min
Duration of endurance
at 55 Hz: 30 min in each of the three axes (90 min in all).

Interference to ambient light
Interference to external light
Unless otherwise indicated, it is intended that the sensing range Sd remain unaffected when the receiver is illuminated by artificial ambient light from lamps and light bulbs, etc. (3000°K) varying from 0 to 5000 Lux.. This immunity level is not sufficient to exclude the possibility that part of the sensor may be affected by the presence of a strong natural or artificial illumination. It is advisable to keep the sensors away from direct sunlight and positions close to lamps and they should not be placed facing lighting systems. Immunity to high-frequency fluorescent lights is less than that provided against incandescent lighting.

Excess gain graph
This is prepared for all models. It expresses the signal margin with respect to the distance of the standard target. The points at which Eg>1 indicate the distances at which the switch is in light state. Where Eg<1 it is in dark state.
The vertex of the curve shows the distance of maximum sensitivity or the focal point. For sensors of types D and R, curves may be given for targets of a different type to the standard one (black paper, reflectors of different types and sizes, etc.)

Object size graph
Distance/target size graph
This is prepared for model D. Indicates minimum dimensions required for side of actuator in order to have Eg=1 in relation to distance. Different curves may be supplied for actuators of other colours.

Parallel displacement graph
It is supplied for all models using the standard target and indicates the maximum linear displacement in relation to distance.
For models D and R it expresses the distance between edge of actuator and sensor axis.
For model T it expresses the distance between the two parallel axes of the emitter and the receiver.

Detection range graph
This is prepared for model D when details regarding particular types of targets are required (e.g. metal wires). Indicates the area in which the target is detected.

Angular displacement graph
This is prepared for model T. Expresses maximum angle of displacement for Eg=1 in relation to distance. It can be supplied for both elements. If only one curve is supplied, it is the more critical.

Mutual interference graph
This is prepared for model T. It indicates minimum linear displacement required between the emitter and a receiver of another through-beam pair in order to have a interference signal lower than hysteresis in relation to distance.

Background suppression graph
This is prepared for the type-D background-suppression models. It demonstrates the ability of the photoswitch to discriminate between a closely positioned black-paper actuator with 6 and/or 18% reflectivity and the 90% reflective white-paper background. It also illustrates the relationship between movement of the adjuster screw and Sn.

Choosing a sensor
• Choose a sensor suited to the working environment: check chemical compatibility between the sensor build materials and any substances present, temperature range, degree of protection against dust and liquids, presence of dust or steam, presence of condensation or ice, vibration, shock, presence of strong natural or artificial light, electromagnetic compatibility, suitability of power supply voltage and type of load. **If necessary consider the possibility of fitting specially-designed accessories.**
• Select an operating distance suited to the dimensions, colour and opaqueness of the material to be detected. Consider the possible effects of shiny surfaces.
• Verify that minimum distances have been respected between sensor and materials which are more shiny or reflective than the background material. Check for possible interference from other nearby sensors.
Preference should always be for type T

photoswitch in that they offer greater reliability and repeat accuracy with opaque objects. If it is not possible to use two powered elements, or semitransparent objects are to be detected, use type R photoswitches.
Use type D sensors when a single element is indispensable.
• Ensure that the number of operations required does not exceed the frequency of operating cycles. Should signal phase also be important, give careful consideration to **ton** and **toff**.

Positioning of unit

All photoswitches must be positioned so as ensure that dust and or liquids do not come into contact with the optical surfaces and thus adversely effect the path of the luminous beams. Mount in a position that protects both optics and body from coming into contact with the target material and ensure than power cables are suitably placed where wear-and-tear and the possibility of breakage are reduced to a minimum. The receiver should not be directly pointed towards sources of artificial or natural light. Always keep sensor away from sources of heat, in particular columns of hot air and radiation emanating from incandescent material.

Installation

The instructions listed below refer to particular conditions of Eg which are as follows:
Eg=1; The signal received is very close to the ON/OFF threshold and the sensor output switches at around this level. The output LED or the load itself will indicate this state.
Eg=2; The signal received is very nearly double the ON/OFF threshold and the sensor output is in light state. If present, it is the signal margin LED that indicates this state. In some models the safety margin is Eg=1.5 but this fact does not alter the significance of this description.
Refer to product specification sheets for a full explanation regarding LED indicators.
Type D with sensitivity adjustment.
For type D sensors it is necessary to choose an operating distance compatible with size and colour of target object and background. With dark coloured objects choose operating distance ≤Sa/2 and if the background is clear maintain at distance ≥1.5 Sn. Only in the case of clear objects is it possible to choose an operating distance close to Sa.
1) Fix the sensor securely but not definitively at a distance not greater than Sa from the target object. Keep the optical axis perpendicular to the object's direction of movement.
2) Check that power supply voltage and load are within the prescribed limits and power on sensor.
3) Position the target object and verify that the optical axis is perpendicular to the surface (in the case of very reflective objects, tilt the photoswitch a few degrees in order to avoid specular reflection). **Adopt the least favourable of working conditions** (smaller object or part of object, darker colour, shinier surface, greater operating distance, greater inclination)
4) Set trimmer to maximum by turning clockwise. Try to obtain condition Eg >2 (refer to the indications of Eg LED) by improving orientation or reducing distance between object and photoswitch.
5) Next turn trimmer counterclockwise so as to obtain condition Eg=1 (refer to the indications of output LED). Turn the trimmer clockwise until obtaining condition Eg=2. Identify this position of the trimmer as A.
The position found is that which offers optimum working conditions for detecting presence/absence with equal precision and discreet safety margins.
If there is no background or the spaces are sufficiently wide, the trimmer can be turned beyond position A to obtain even greater signal margins.
6) If there is a background, remove object. One should obtain the condition Eg<1. If this does not occur, it indicates that with object and Eg=2, background reflection is too strong. In such case the sensor must be placed nearer to the object or tilt the sensor and **restart setting from point 5** (in this manner sensitivity is reduced or the reflection is eliminated).
7) Now turn trimmer clockwise until condition Eg=1 is obtained for background. If this does not occur it means the background cannot interfere. Therefore turn trimmer clockwise to maximum and mark as position B.
Turn counterclockwise until obtaining condition Eg<1 (background not visible) and assume this point as position B.
8) Position trimmer at an intermediate point between A and B.
9) Definitively fix sensor and recheck whole system.
Type D without sensitivity adjustment.
1), 2), 3) As above.
4) Try to obtain condition Eg=1 (indicated by output LED) by improving orientation or reducing distance between object and photoswitch. If this condition is already present, move the photoswitch away and then bring back. **Identify the position obtained as A.**
5) If there is no background it is sufficient to reduce distance to 0.7A in order to have a regular operating distance (Eg >2), then fix photoswitch.
If there is a background, it is necessary to verify that the signal level is not close to the threshold. Remove target object and move progressively closer to the background. If the background is not detected or is detected at a distance of < 0.5A with respect to object position, it is possible to fix the photocell at 0.7A.
The position found is that which offers optimum working conditions for detecting presence/absence with equal precision and discreet safety margins.
6) If the conditions of point 5 cannot be obtained it indicates that background reflection is too strong. In such case the sensor must be tilted and **setting should restart from point 4.**
7) If the background is visible for a distance from object of <0.7A, then it will not be possible to obtain suitable working conditions with the model of photoswitch chosen. If the background is visible for a distance from object of between 0.7 and 0.5A, mark as position B and place photoswitch at an intermediate point between A and B. Carefully check correct operation under actual working conditions since this position is critical. In conclusion definitively fix photoswitch.
Type R with sensitivity adjustment.
It is first of all necessary to choose correctly the type of reflector and operating distance in accordance with type of target (small or large objects, opaque or semitransparent) and degree of dirt present in the working environment (see table; reflectors and Eg curves). If the relative distance between reflector and photoswitch can vary and become close to 0, consider also utilising a blind zone.
a) With large and completely opaque objects, it is advisable to maximise the signal margin (Eg>>2) by keeping the set sensitivity at maximum.
If working environment is dusty it is necessary to operate with ample margins of Eg (3-10) by using distances below Sa or very efficient reflectors. At distances close to Sa it is also possible to fit rows of reflectors.
b) If it is necessary to intercept small objects, it is recommended to maintain Eg=2. In this case, the minimum diameter of a detectable object varies along the optical axis. The minimum diameter that the reflector is capable of intercepting will be equal to half the diameter of its active surface, whilst the minimum diameter that the sensor is capable of intercepting will always be equal to half the diameter of the optics.
c) If it is necessary to intercept semitransparent objects, choose low-efficiency or small-size reflector in order to have Eg=2 at desired operating distance. This will guarantee the largest possible range of movement when rotating the trimmer in order to effect adjustments. When operating with small signal margins, the working environment should obviously have a degree of cleanliness that will not compromise the stability of the setting.
d) If the target objects have shiny surfaces, are covered in shiny transparent film or are metallized, the use of polarized models is recommended which do however have inferior ranges and margins of gain than the non-polarized type. The choice of a polarized model is essential when the reflective surface of the object is irregular, has recesses or is curled in such a way that the reflective beams are denied a regular path.
1) Mount reflector so that its surface is perpendicular to the optical axis. Fix the sensor securely but not definitively, if possible using the brackets supplied and keeping the optical axis perpendicular to the object's direction of movement. Position the sensor so that the optical axis is directed towards the reflector.
If the target material has a shiny highly-reflective surface and a non-polarized model has been selected, it is necessary that when effecting installation the optical axis be inclined with respect to the surface of the material.
2) Check that power supply voltage and load are within the prescribed limits and switch on sensor.
3) Set trimmer to maximum by turning clockwise. Next position the photoswitch so as to firstly obtain minimum operating conditions (output switching) and then maximum condition Eg. If the light emitted is visible it is possible to see the reflected light by looking at the reflector from a position directly alongside the optical axis.
Where orientation is critical and the light emitted is not visible, the switching point (Eg=1) can be found by pointing an edge of the photoswitch housing towards the reflector. Then effect a regular scan with a continuous movement from left to right and oscillating vertically.
4) Improve orientation until the highest Eg possible is obtained. To pinpoint optimum orientation the reflector should be gradually obscured and the orientation repeated. If the distance between photoswitch and reflector is small, the light spot that hits the reflector can be smaller than the dimensions of the same. In this case, it may be necessary to verify that it hits a central point where there are no marks, flaws or fixing screws. If the minimum Eg=2 cannot be obtained, check that the suitability of the chosen combination of photoswitch/reflector with regards to operating distance.
If the target objects are opaque and of large dimensions, verify that the trimmer is at maximum and definitively fix photoswitch. If on the other hand the objects are small and not completely opaque, continue as follows.
5) Having obtained optimum orientation with Eg>2, turn the trimmer counterclockwise until obtaining Eg<2, and then turn clockwise until obtaining Eg>2. Mark this point as position A.
The position found is that which offers optimum working conditions for detecting presence/absence of small objects or semitransparent materials with equal precision and discreet safety margins.
6) Place the target object along the optical axis and by moving check that the sensor switches (Eg<1). If this does not occur it means that the target object is too transparent or too small and it will be necessary to operate (environment permitting) with signal margins below 2. In this case, with the object still in position, turn the trimmer counterclockwise until obtaining Eg<1.
Memorise this point as position B and position trimmer at an intermediate point between A and B.
Carefully check correct operation under actual working conditions since this position is critical.
In conclusion definitively fix photoswitch.
Type R without sensitivity adjustment.
1), 2), 3) As above.
4) To improve orientation until the highest Eg possible is obtained, the reflector should be gradually obscured and the orientation repeated. The condition Eg=2 is obtained when output switches by obscuring _ the active surface of

the reflector. If the distance between photoswitch and reflector is small, the light spot that hits the reflector can be smaller than the dimensions of the same. In this case, it may be necessary to verify that it hits a central point where there are no marks, flaws or fixing screws. If the minimum Eg=2 cannot be obtained, check that the suitability of the chosen combination of photoswitch/reflector with regards to operating distance.
If the target objects are opaque and of large dimensions, verify that Eg>>2 has been obtained and definitively fix photoswitch. If on the other hand the objects are small and not completely opaque, continue as follows.
5) Having obtained optimum orientation with Eg>>2, try to obtain Eg=2 by partially obscuring the reflector or replacing it with a smaller one. Identify the reflector area as A.
The position found is that which offers optimum working conditions for detecting presence/absence of small objects or semitransparent materials with equal precision and discreet safety margins.
6) Place the target object along the optical axis and by moving check that the sensor switches regularly (Eg<1). If this occurs the sensor can be definitively fixed. If this does not occur it means that the target object is too transparent or too small and it will be necessary to operate (environment permitting) in very critical conditions with signal margins below 2. In this case, with the object still in position, continue to obscure the reflector until obtaining Eg<1. Memorise this condition (extent that reflector is obscured) as B then reset an intermediate reflector area between A and B. Check that sensor switches regularly and definitively fix.
Type T with sensitivity adjustment.
It is first of all necessary to choose correctly the type of emitter/receiver combination in accordance with type of target material (small or large objects, opaque or semitransparent) and degree of dirt present in the working environment (see Eg curves).
a) With large and completely opaque objects or for detecting holes, it is advisable to maximise signal margin (EG>>2) by keeping the set sensitivity at maximum.
If working environment is dusty it is necessary to operate with ample margins of Eg (3-10) by using distances below Sa.
b) For detecting small objects it is recommended to maintain Eg=2. In this case, the minimum diameter of the target object corresponds to 1/2 the active diameter of the optics. If smaller diameters need to be detected, consider using shutters which can be supplied as accessories.
When operating with small signal margins, the working environment should obviously have a degree of cleanliness that will not compromise the stability of the setting.
c) If the target objects are close to shiny surfaces parallel to the optical axis, it is necessary to consider the possibility that the object may be not detected by the reflection on the shiny surface of the peripheral beams. In this case use models with a narrow beam.
1) Fix the sensor securely but not definitively, if possible using the brackets supplied. Position the sensor so that the optical axes coincide.
2) Check that power supply voltage and load are within the prescribed limits and switch on sensor. If the check function is fitted, ensure that it is disconnected.
3) Set the receiver trimmer to the maximum by turning clockwise. Select maximum emission power.
If the light emitted is visible, place the receiver on a reflective sheet of paper and observe reflected light from behind the emitter as close as possible to the optical axis. The emitter should now be orientated to obtain maximum reflected luminosity.
If the light emitted is visible, the emitter can be orientated by pointing an edge of the housing towards the receiver.
4) Next go to receiver and orientate towards emitter with the maximum precision. Then effect a regular scan with a continuous movement from left to right and oscillating vertically until output switches (Eg>1).
5) Improve orientation until the highest Eg possible is obtained. To pinpoint optimum orientation the receiver optics should be gradually obscured. If the minimum Eg=2 cannot be obtained, check that the suitability of the chosen combination with regards to operating distance.
If the target objects are opaque and of large dimensions, verify that the trimmer is at maximum and definitively fix photoswitch. If on the other hand the objects are small and not completely opaque, continue as follows.
6) Having obtained optimum orientation with Eg>2, turn the trimmer counterclockwise until obtaining Eg<2, and then turn clockwise until obtaining Eg>2. Mark this point as position A.
The position found is that which offers optimum working conditions for detecting presence/absence of small objects or semitransparent materials with equal precision and discreet safety margins.
7) Place the target object along the optical axis and by moving check that the sensor switches (Eg<1). If this does not occur it means that the target object is too transparent or too small and it will be necessary to operate (environment permitting) with signal margins below 2. In this case, with the object still in position, turn the trimmer counterclockwise until obtaining Eg<1. Memorise this point as position B and position trimmer at an intermediate point between A and B.
Carefully check correct operation under actual working conditions since this position is critical. In conclusion definitively fix photoswitch.
Type T without sensitivity adjustment.
1), 2), 3) 4), 5) As above.
6) Having obtained optimum orientation, the only way to reduce Eg is to fit a specially-made diaphragm to the optics or make use of the accessories supplied with each particular model. In any event, use a diaphragm that allows Eg=2 to be obtained. This is indicated by the fact that obscuring 1/2 the aperture causes output to switch. **The position found is that which offers optimum working conditions for detecting presence/absence of small objects or semitransparent materials with equal precision and discreet safety margins.**
Carefully check correct operation under actual working conditions and in conclusion definitively fix sensors.
Type D with background suppression.
For type-D background-suppression sensors, it is necessary that the operating distance be compatible with the ability to distinguish between close-up and background. At maximum operating distance the ability to distinguish is at its worst.
1) Fix the sensor securely but not definitively at a distance not greater than Sa from the target object. Keep the optical axis perpendicular to the object's direction of movement.
2) Check that power supply voltage and load are within the prescribed limits and switch on sensor.
3) Position the target object and verify that the optical axis is perpendicular to the surface (in the case of very reflective objects, tilt the photoswitch a few degrees in order to avoid specular reflection). **Adopt the least favourable of working conditions** (smaller object or part of object, darker colour, shinier surface, greater operating distance, greater inclination).
4) Turn adjuster screw until target is detected and fine-tune until the condition Eg=2 is obtained (refer to the indications of Eg LED). Mark this point as position A.
5) Remove object to render background visible. The sensor should be in condition Eg<1. If not then the background is too close or too reflective and the current operating distance cannot be maintained. If possible, reduce operating distance and reset from the beginning. Having reached condition Eg<1 without object, background not detected, it is necessary to verify that the background is not visible with a good safety margin. Turn the adjuster screw clockwise until obtaining condition Eg=1 (the background becomes visible). Mark this point as position B.
6) Position trimmer at an intermediate point between A and B.
7) Definitively fix components and recheck whole system.

Electrical connections

• Sensor connection leads should not run close to other power cables.
• Ensure power supply voltage does not exceed the limits specified by Ub.
If a non-stabilized supply voltage is used for dc sensors, check power supply peak-voltage value with minimum absorption. Also check minimum value and amplitude of ripple at maximum absorption. If the same voltage is also used to switch inductive loads, a suitably-sized suppressor should be installed. Suppressors also offer protection against incorrect connection of the power supply that could prove potentially disastrous for all sensors.
Ac sensors can be subject to high voltage surge pulses which could cause damage to the sensor if exceeding the rated value. Fitting a suitably-sized suppressor increases machine reliability.
A safety fuse should always be fitted to the power supply line even if using a stabilized power supply.
• Verify compatibility of load with type of sensor output.
The current drawn by the load must not exceed the value Ie but should not be less than Im. Load excitation voltage must not be less than the minimum supply voltage minus Ud. Load deenergize current must be greater than Ir. When interfacing with logical inputs check compatibility VIL /Ud. Driving a filament lamp could result in the intervention of the short circuit protection. If necessary arrange to limit the lamp's switch-on current.
When driving dc inductive loads, check that load inductance L (Henry) does not exceed the value indicated in the following formula and that the number of operations with this L value is no more than 6/min (A13 category).

$$L = 2U_e^2 \times 10^{-3}$$

When driving an ac power relay, the power factor should not be less than 0.3 and the peak current should not exceed 6 x Ie with a maximum duration of 20ms and a maximum of 6 operations per minute (A140 category).
A dc capacitive load must not exceed the rated value if the intervention of the current-limiting circuit is to be avoided. It should be noted that some logic or timer inputs may have an R-C coupling. If the peak current triggers the current-limiting circuit, the problem can be resolved by fitting a 100-300Ω resistor in series at the input.
When using very long connection leads, consider the cable capacitance (150pF/m).

Series/parallel connections

Parallel connection of two or more sensors is achieved by connecting their output terminals to a common load. In this way it is possible to realise OR logic with NO outputs (load is excited even if just one of the sensors is activated) and NAND logic with NC outputs (load is deenergized only if all sensors are activated).
With parallel connection it should be noted that the OFF-state current through the load (the sum of the OFF-state currents of every single sensor) must be less than the deenergize current.
With models that are not the open-collector type, it is recommended that a diode be inserted in series at the output to maintain the independence of the sensor's internal LED.
Series connection is achieved by supplying power to the second sensor through the output of the first one and continuing in the same manner. In this case it should be noted that voltage available for exciting the load minus the sum of the single voltage drops should exceed minimum voltage.

Series connection is not recommended because the sensor in cascade only switches after the time delay before availability has expired; the maximum frequency of operating cycles is therefore notably reduced. It is however always possible to create equivalent parallel series connections using a complementary output.
If just two sensors are to be series connected, it is worth using two sensors having different types of output (PNP/NPN) with load connected between them. The same connection can be set up for 3-wire ac sensors by inverting the power supply wires.
To effect multiple series/parallel connections with complex logic functions, the use of sensors with DECOUT® output circuit (DECoupled OUTput) is advised. These enable series and parallel connections without limitation since they are fitted with static contacts which do not have programmable NO or NC potentials.

Electromagnetic compatibility

Fast transient burst immunity

Our dc and ac sensors all conform to standard EN61000-4-4, 1995. Unless otherwise stated, test level is 2KV with capacitive coupling. Criterion A is adopted for performance analysis during the test.
The device should continue to operate correctly even in the presence of interference by maintaining a minimum performance level. Unless otherwise indicated, minimum performance level is intended as meaning that the device must not be subject to false output signals or that in any event these false signals should have a duration of no more than 1 ms in the case of dc devices and a half wave for ac devices.
All devices are tested in both ON and OFF-state.
Photoelectric devices are tested so that the signal received is at least two times greater than the trigger threshold and at least half the trigger threshold.

Electrostatic discharge immunity

Our dc and ac sensors all conform to standard EN61000-4-2, 1995. Test levels are as follows: 4KV with contact discharge for devices with metal housing, 8KV air gap discharge for plastic housing. Criterion B is adopted for performance analysis during the test
After the disturbance has finished, the device should function normally without the need for resetting.

Radiated electromagnetic field immunity

All our devices conform to standard ENV50140, 1994. Unless otherwise stated, test levels are as follows:
80MHz - 1GHz 3V/m 80% AM modulation 1KHz sine wave. Criterion A is adopted for performance analysis during the test.
The device should continue to operate correctly even in the presence of interference by maintaining a minimum performance level. Unless otherwise indicated, minimum performance level is intended as meaning that the device must not be subject to false output signals or that in any event these false signals should have a duration of no more than 1 ms in the case of dc devices and a half wave for ac devices. All devices are tested in both ON and OFF-state.
Photoelectric devices are tested so that the signal received is at least two times greater than the trigger threshold and at least half the trigger threshold.

Radiated emission

All our devices conform to standard EN55022 Class B, 1986.

Conducted emission

All our devices conform to standard EN55022 Class B, 1986.