Radioelectric wave detection of persons on non-metallic material conveyors

In the current state of the art, radioelectric wave detection of persons emerges as the only technical method of making material conveyors safe, if the conveyed materials are non-metallic.
This practical datasheet concerns conveyor installers and their clients, provides basic principles ensuring proper application of the prevention means and recalls the relevant technical requirements and regulations.

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ED 959

1. Introduction

Detection of the presence of a person finding himself accidentally or intentionally in the final section of a conveyor, upstream of a baling press or crusher, is imperative at operating centres in the waste sorting and recycling industry.

This person can be mixed up with waste products of various types (paper, cardboard, plastic, etc.) and can be exposed to mortal danger.

This imperative is also present in other production sectors (cardboard transformation, material crushing, etc.).

In the current state of the art, prevention players consider radioelectric wave detection to be the technical solution most capable of responding to this problem. This detection has therefore become the main form of personal protection for such work equipment, yet, under no circumstances, must it be substituted for organisational measures to be adopted by the user for controlling accident risks.

2. Operating principle

The person to be protected is required wear an electromagnetic badge comprising an electronic circuit enabling him to be distinguished from his work environment. The badge only emits a radio wave, when it is prompted by a signal from an emitting beacon. The badge therefore operates in the same way as a transponder *(cf. figure 2)*.

The beacon, which receives the characteristic electromagnetic radiation emit-

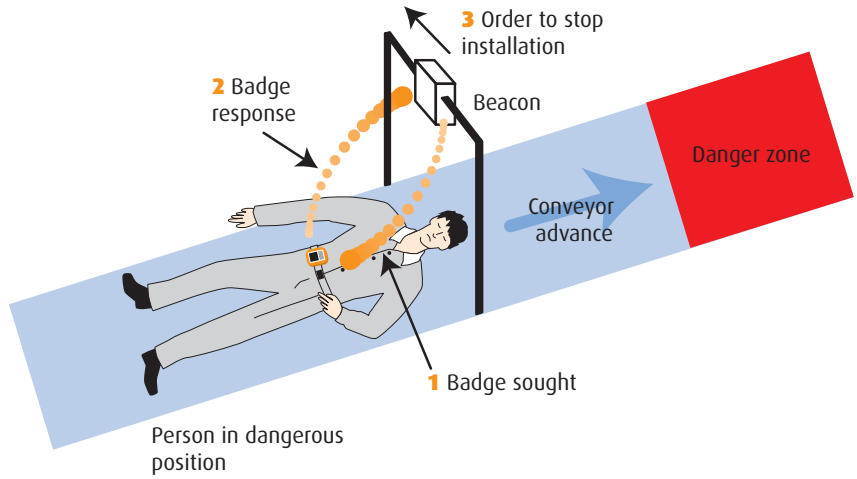

Fig. 2. Transponder operating principle of a detector installed on a conveyor.

Fig. 1. Baling press and conveyor at a recyclable waste sorting centre.

ted by the badge, is judiciously positioned to cover the zone in which presence of any person wearing a badge must be imperatively detected (detection zone). This zone precedes the danger zone located immediately in front of the baling press or crusher (cf. figure 2).

Detection occurs when the person is sufficiently near the beacon and this event effectively triggers work equipment stoppage.

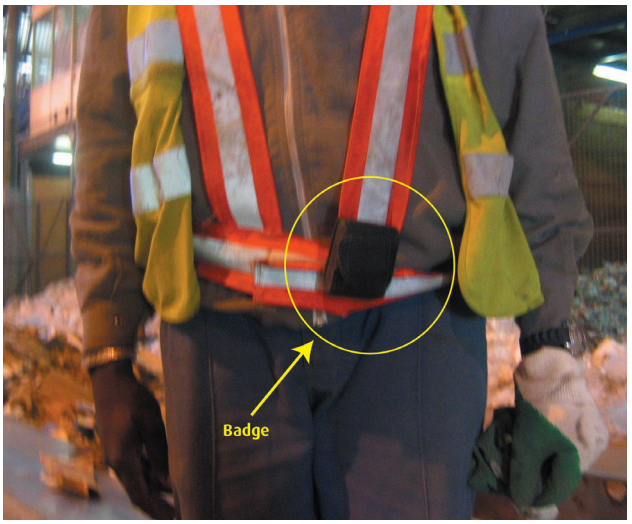

Fig. 3. Example of badge worn by person to be protected.

3. Expected qualities

Permeability to obstructions

Detection can be rendered ineffective if obstructions reflecting or absorbing radio waves are interposed on the direct path between the badge and the beacon. This can be the case of metallic objects, water-saturated materials or the body of the person to be protected.

Detection operates effectively if radioelectric frequencies below 500 MHz are used to ensure that radio waves pass through non-metallic obstructions normally found on the conveyor. It should be recalled that radio waves, even below 500 MHz, do not pass through metallic materials.

Note.
During conveyor start-up, detection system operation should be checked by conducting tests representative of real operating situations (especially for so-called "sensitive" materials such as those saturated with water and drinks packs).

Detection directivity

Detection causing untimely machine stoppage can occur, for example if beacon emission is insufficiently directive and when the detection zone *(cf. figure 4)* extends beyond the conveyor.

To prevent untimely stoppages, whilst ensuring detection of a person present on the conveyor, the detection zone must be variable so that it can be adjusted as closely as possible to the work environment *(cf. figure 4)*.

The detection zone must sometimes be limited by installing deflecting metal screens. This can be the case if the beacon is relatively near to areas in which operators may find themselves.

On the other hand, the badge must be fitted with a multidirectional antenna to ensure that beacon detection is independent of the position of the person in a dangerous situation.

Insensitivity to electromagnetic disturbances

The system comprises radioelectric signal reception circuits, which are naturally sensitive. As a result, reception of the signal carried by the radio wave may be subject to the effect of electromagnetic disturbances due to various sources (radio messenger service, mobile telephone, Herzian communication, etc.) specific to the site. Radioelectric links must be protected against electromagnetic disturbances by having them convey digital information, which can be basic (e.g. a succession of 0's and 1's corresponding to a square signal waveform).

Resistance to environmental constraints

Detectors should be designed for use in an environment sustaining climatic (extreme temperatures, humidity, etc.),

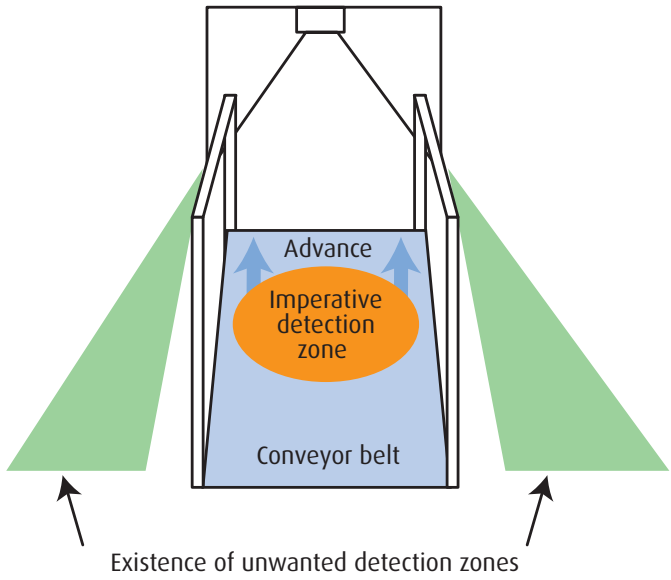

Fig. 4. Existence of unwanted detection zones.

mechanical (badge impacts, beacon vibration) and electromagnetic (radio communication equipment, radiation emitted by work equipment) influences. An IP 65 minimum protection rating, according to standard NF EN 60529, ensuring imperviousness to dust and water lance projections, must be guaranteed for each component constituting the detector.

4. Implementation on conveyors

Figure 5 illustrates typical implementation of a system for detecting persons on a recyclable waste (paper and cardboard) conveyor.

Given the maximum speed (approximately 20 m/min) of the conveyor, the beacon should be placed at least 3 m from the press or crusher inlet. To prevent untimely actuation, the beacon must be installed such that it does not detect the operator during his normal movements. The beacon support should be designed not to obstruct passing of the bulkiest waste items such as cardboard boxes *(figure 6)*.

When possible intrusion can take place between the beacon and the press, protectors should be installed to prevent access, based on the requirements of standard NF EN 294.

Additionally, an emergency stop cable must be maintained throughout the conveyor length. This can be arranged longitudinally or transversely across the conveyor.

5. Raising the safety level

A detector is liable to break down, just like any system. Undetected failure of this type of detector can cause a dangerous situation and personnel are then unaware that protection is no longer ensured. Technical measures permitting separate or overall checking of different detection system components should be implemented to raise the safety level.

Badge periodic manual checking module

A testing module identical to the beacon must allow the badge wearer to

Fig. 5. Typical implementation of radio wave detection system on conveyor.

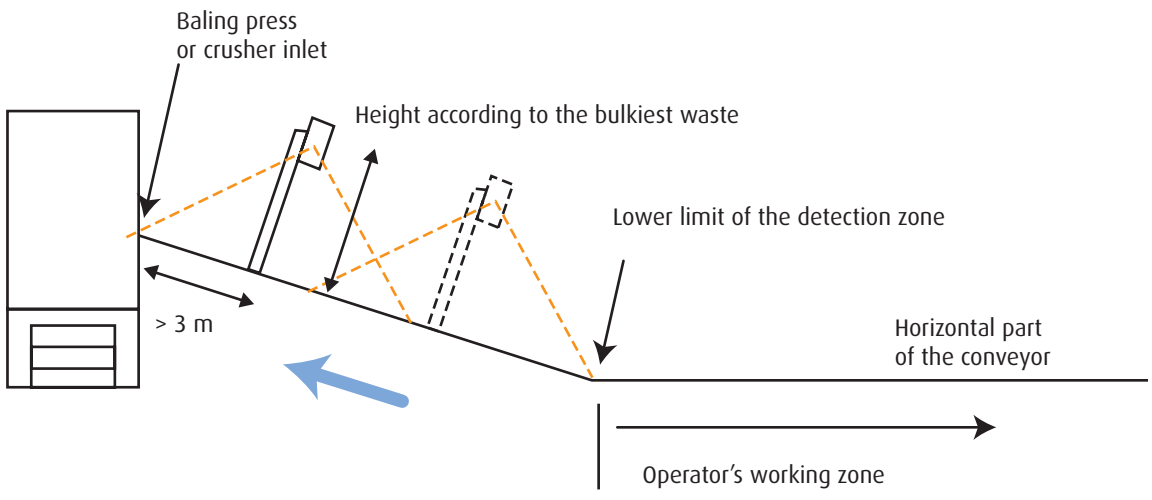

Fig. 6. Limits for the beacon implementation.

check manually proper badge operation at the entrance to the badge operating zone.

The badge is placed in front of the module, which indicates immediately its operating condition. There must be a requirement for the person to be protected to give warning of an observed fault. A faulty badge wearer must then be prohibited from the working area until he has been issued a new badge in good condition. Prohibition may be verbal, if access is monitored, or physical through a security gate, for example.

Beacon permanent checking module

A self-monitoring module placed on the conveyor at the protection zone boundary *(figure 7)* detects detection zone modification resulting from beacon failure or improper adjustment. Self-monitoring should not be limited to presence or absence of the radioelectric signal emitted by the beacon, but must be capable of detecting any modification of digital or analogical information possibly contained in this signal.

This self-monitoring must also provide assurance that the beacon is capable of receiving and processing information contained in the signal emitted by the badge.

System combined checking

System combined checking may be envisaged instead of separate badge and beacon checking. For detectors currently available, combined checking can only result from intentional action stemming from organisation-related measures. For this, a real danger situation should be reproduced by placing each badge in front of each site beacon and ensuring that the installations effectively stop.

Figure 8 illustrates diagrammatically the first two measures.

Fig. 7. Example of beacon self-monitoring module location (Source U-Tech).

6. Safety level-related statutory requirements

These systems are considered safety components if they are declared to be so by their manufacturer and if they are separately placed on the market. They must fulfil on their own a specified safety function, when mounted on machinery. These combined properties result in their inclusion in the area of application of so-called "Machinery" directive 98/37/EC.

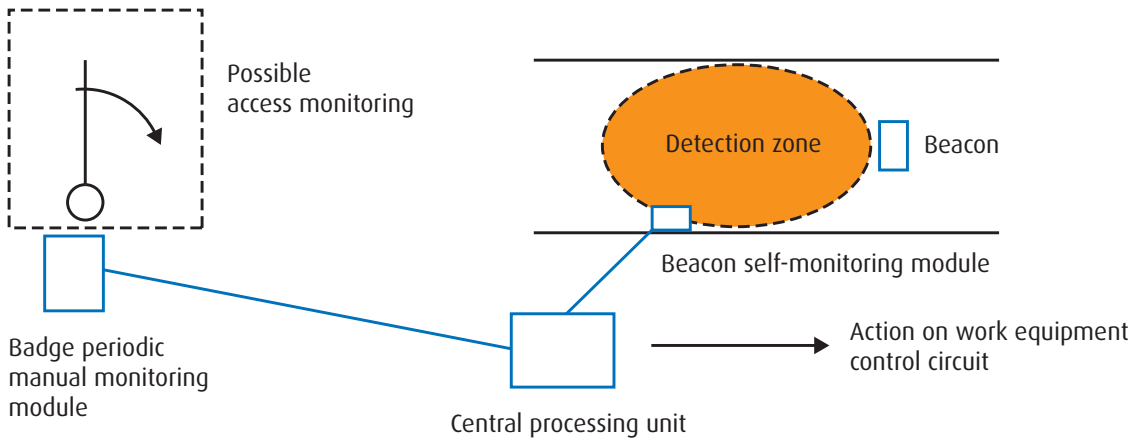

Fig. 8. Diagrammatic representation of measures for raising safety level.

Moreover, as electrosensitive systems, they are included in annex IV of the above directive. An installer, wishing to equip a conveyor with such a system, will be required to ensure, through the manufacturer, that the system has been the subject of 3rd party certification (EC "type" examination) [1] prior to its placement on the market.

The user is responsible for modifying the machine on site, even when the modifiying operation is performed by an external contractor. The user must therefore ensure that the system installed by himself or an intervening contractor has been designed to fulfil a safety function ensuring a sufficient, guaranteed safety level.

The certification approach allows a safety level predefined and claimed by the system manufacturer to be guaranteed. A certified system must adopt a determined behaviour in the event of failure of a component or its circuit, or in the presence of external influences.

Finally, installation of such systems must not create new risks for users.

Note.
The "type" examination procedure applies to protection systems placed separately on the market (in view of their installation on a machine in service or on a second-hand machine). A manufacturer can therefore equip his conveyor with a detection system, which has not been subjected to this procedure (e.g. by manufacturing the system himself). In this case, he incurs responsibility for the essential requirements of the directive in relation to his entire machine.

7. Organisational measures

The following measures condition the efficiency of a radioelectric wave detection system.

7.1 Wearing the badge

Personal protection through the use of such detectors necessarily implies wearing the badge. The first measure therefore comprises ensuring that **each person** to be protected is fitted with a badge, which must be worn in the same way as personal protective equipment (PPE) and must be securely fixed to work clothing or incorporated in it.

It is feasible to provide the badge with the DATI [2] function or to integrate it into PPE regularly and visibly worn by all intervening personnel (fluorescent jacket, helmet, etc.). A daily badge allocation and removal procedure should be laid down.

To prevent oversights and entry of "unauthorised", insufficiently informed persons into the operating zone, installation of access controls complemented by suitable fences is strongly recommended so that only persons wearing a badge can access danger zones.

These access controls can either be automatic or ensured by a supervisor.

Persons unauthorised to enter the site must pass through a control point, at which they will be issued a badge before gaining access to the area around the danger zone.

Zones, in which a badge must imperatively be worn, should be provided with access control. If this measure is not feasible, it is essential that zones, in which a badge must be worn, be clearly delimited and **indicated.**

Zones, in which the presence of persons wearing badges could cause untimely triggering of the detection system (if these zones have not been eliminated), must be marked.

The beacon detection zone must be marked to prohibit any operator from penetrating it, e.g. to remedy an operating incident (see section 7.3).

7.2 Periodic checking

Periodic checking must be undertaken at least at every shift takeover.

This frequency may be increased according to the risks and the activity.

Overall checking described in section 5 often turns out to be excessively onerous for complex installations, resulting in a preference for installations comprising badge and beacon manual checking modules.

7.3 Training

Detection system efficiency depends on both effective wearing of the badge and organisational measures, whence the importance of operator training and information.

Production operators concerned (especially new recruits, temporary personnel, etc.) must receive suitable training specific to this detection system, prior to first using these detectors, and must be aware of their end-purpose.

Operator training must be periodically renewed.

Persons in charge of maintaining these detectors must be trained for all preventive and remedial maintenance operations required to ensure safety system efficiency.

Moreover, it is helpful to associate production and maintenance operators in implementing organisational measures to ensure closer compliance with these measures because they can be considered a hindrance. ■

(1) Previous discussions between prevention specialists and users have revealed that, for waste conveyor-related application and according to the current state of the art, reduction in risk can be ensured by a system at least meeting the type-2 requirements of standard NF EN 61496-1.
(2) DATI: Dispositif d'alarme pour travailleur isolé [alarm device for isolated worker].

MORE INFORMATIONS

[1] ■ **Conception des centres de tri des déchets de collecte sélective.** *INRS, ED 914, 2005, 64p.*

[2] ■ **KLEIN R. – « La détection de personnes par ondes radioélectriques sur les convoyeurs de déchets », projet de publication dans la revue INRS HST/CND n° 200, 3e trimestre 2005**.

[3] ■ **Directive 98/37/CE du 22 juin 1998. Rapprochement des législations des états membres relatives aux machines,** *JO-CE N° L207 du 23/7/1998, 46p.*

[4] ■ **Directive 89/655/CEE du 30 novembre 1989. Prescriptions minimales de sécurité et de santé pour l'utilisation par les travailleurs au travail d'équipements de travail.** *JO N° L 393 du 30/12/1989 pp. 0013-0017*

[5] ■ **NF EN 61496-1 : 2004. – Sécurité des machines. Equipements de protection électrosensibles – Partie 1 : Prescriptions générales et essais –** *AFNOR, Paris, 58p.*

[6] ■ **Conception des centres de tri des déchets industriels banals et des déchets de chantiers.** *INRS (à paraître fin 2005).*

[7] ■ **NF EN 294 : 2004. – Sécurité des machines - Distances de sécurité pour empêcher l'atteinte des zones dangereuses par les membres supérieurs –** *AFNOR, Paris, 24p.*

[8] ■ **Conception des usines d'incinération des ordures ménagères.** *INRS (à paraître fin 2005).*