PREVENTION OF OSTFA (OCCUPATIONAL SLIPS TRIPS AND FALLS ACCIDENTS): THE ACTIVITIES AND PERSPECTIVES OF THE INRS

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The prevention of occupational accidents (OA) is one of the missions of the INRS (French National Research and Safety Institute). The importance of the challenge of preventing OSTFA is first emphasised by the statistical data of OAs occurring in French companies. The INRS targets different groups of OSTFA in its activities in view to taking into account both the real diversity of OSTFA and the need to set up priority and/or specific prevention actions in certain cases of accident. The specific characteristics of each group of OSTFA are presented first, followed by a description of the INRS's different activities and medium term perspectives dedicated to preventing them.

Introduction

The INRS's mission is to prevent occupational accidents and occupational diseases from occurring in French companies. This article presents the stakes for these companies in terms of preventing occupational accidents commonly known as OSTFA, the different groups of accidents targeted and all the works and perspectives associated with them.

The stakes in terms of statistical occupational accident (OA) data

In 2010, occupational accidents designated by the acronym OSTFA represented about 37% of the 658,847 OAs with time off work, 32% of the 41,176 OAs with permanent disability, 43% of the 37,194,643 days lost by temporary incapacity and 13% of the 529 fatal OAs (CNAMTS, 2011). These accidents are most often caused by a disturbance of walking or more generally by a disturbance of movement while working. This disturbance can upset bodily balance and lead to a fall from height if the employee is exposed to such a fall. In the latter case, the accident is particularly serious and often fatal.

Groups of OAs targeted by INRS's activities and falling within the framework of OSTFA

Work situations can be affected by a diversity of movement disturbances: slipping and tripping, but also collisions (a wrench which slips, an employee that knocks themselves, etc.), jamming (of hand when opening a door or window, etc.), stepping on an uneven surface, etc. Furthermore, priority or specific measures must be taken for certain types of accidents. For

example, when an employee is exposed to the risk of falling from height, the regulations demand that protection against such falls in particular be implemented. Moreover, the installation of an anti-slip floor coating is necessary in certain workshops where the floor is almost always greasy. To take into account both the diversity of movement disturbances and the priority and/or specific actions to be implemented, the works performed by the INRS target the prevention of four generic types of event encountered recurrently for all OSTFA. Extracts of accounts of accidents grouped as a function of type are presented in table 1. Four subgroups of OSTFA are thus considered:

- Falls from heights;
- Balance disturbed by a sudden external force;
- Slipping on wet and/or greasy floors;
- Movement disturbances that are neither generated by a sudden external force, nor by slipping on a wet and/or greasy floor, and which do not lead to a fall from height.

It should be specified that these recurrent types of event are close to the injury in the genesis of the accident. The contributing factors and root causes upstream in the accident genesis are not mentioned but are obviously taken into account in the framework of prevention. What is more, the subgroups defined in this way are not absolutely exclusive, meaning that the prevention of accidents at the intersection of two subsets benefits from works performed on each of these two subsets.

Table 1. Different sets of OSTFA targeted by the INRS's activities

Generic event	Extracts of accounts of accidents
Fall from height	… not having seen that the safety rail had been removed, the apprentice stepped back and fell 5 m onto the lawn of the house … … a roofer climbed up a ladder to a height of 6 metres and held the console (of the scaffolding). He fell … … the employee was working on the gangway at a height of 8 metres. … The victim took hold of a plate that had not been fastened well enough …. The plate detached, causing the victim to fall from a height of 7.50 m ….
balance disturbance due to a sudden, external force	… the employee, who was moving in a train, was thrown off-balance when the train went over the switchgear … … the victim was standing on a travelling crane that collided with another travelling crane. Surprised, the victim was thrown off-balance. … … The wedge was ejected, … the fitter was thrown backwards and his head hit the floor …
Slipping on a wet and/or greasy floor	… During this displacement, the employee slipped then fell to the floor in the kitchen. … … The operator (of the automatic press) wanted to straighten it (the metal strip) and, simultaneously, slipped on an oily metal plate placed on the floor …
movement disturbance not due to a sudden, external force, or to slipping on a wet and/or greasy floor, and not occurring in a working situation at height	… the employee tripped over the forks of the forklift truck and fell to the floor … … when climbing down from the truck, the employee hit his head against the low point of the hatch … … when the truck was leaving, the two handlers climbed onto the running board. One of them slipped and fell … … The wrench slipped when the victim was unscrewing a bolt and he fell to the floor …

The INRS' Activities and Perspectives relating to preventing OSTFA

Preventing falls from heights

These accidents occur when the person is going to, or during, work at height. They are particularly serious and subject to many regulations. They occur in all sectors of activity, though the highest proportion occurs in the construction sector - 26% in 2010 - with the severest consequences: 57% of deaths.

The INRS's activities in these issues essentially include **consulting assistance**, providing information, training and standardisation. Regarding the first point, the INRS responds to a large number of direct requests from companies seeking advice on prevention in the framework of specific work situations, or clarifications regarding regulatory provisions. This activity is provided by its Technical Expertise and Consulting Department (ECT). The same experts also work with the manufacturers of materials and equipment used to gain access to, and work at, heights, that want to obtain the recommendations of INRS's experts on innovative equipment, and integrate the principles of ergonomic design and prevention. Collaboration from the INRS is also sought by professional organisations. Mention can be made of its regular collaboration with companies specialised in scaffolding engineering (design and installation of structures) in the framework of the Technical Commission which has led to making progress with safety in professional rules.

Regarding **information**, the INRS publishes specific documents and brochures with information on risks and the means of preventing them, organisational resources and equipment. The INRS issues publications (INRS, 2007; 2010 and 2012) on the subject of falls from height of which the last bore the title *Prevention of risks of falls from height*. It is a synthesis intended for actors in companies and which provides them with elements for organising an approach to prevention based on applying the principles of prevention, good understanding of regulations, and knowledge of the types of equipment used for reaching and working at heights, their characteristics and their limitations.

The INRS also relies on **French, European and international standards** in view to making progress in ensuring conformity with prevention by drafting texts on certain items of equipment. Regarding this, mention can be made:

- in the scope of French standardisation, a standard on steel shoring towers (pr NF 93-551) focused on the materials assessment and a standard on overhanging work platforms (pr NF 93-351). These two standards are scheduled for publication in the next few months.
- in the scope of European standardisation, a standard on Structural Protection Systems based on elements of scaffolding systems (pr EN 16508) and the revision of the standard on rolling scaffolds (EN 1004).
- in the scope of international standardisation, the revision of standards relating to permanent access to machines (EN ISO 14122, parts 1 to 4).

Lastly, regarding **training**, it is noteworthy that the CNAMTS (French National Health Insurance Fund for Salaried Workers) has given the INRS the task of establishing the reference framework for training dedicated to the assembly, dismantling, and utilisation of scaffolding, as part of its National Training Plan for 2013. This approach is aimed at standardising the certification procedures of training organisations and improving the quality of their services.

Prevention of loss of balance in situations where balance disturbance is caused by a sudden, external force or a movement of the floor

The INRS carries out **research** in this area in cooperation with the "*laboratoire d'intégration des systèmes et des technologies (CEA/LIST)*". A **human balance control model** has been developed (Collette et al., 2007a; 2007b; 2008) that is capable of predicting the dynamics of a humanoid model subjected to external disturbances such as a thrust at torso level, a floor movement, etc. Its originality stems from an approach using forward mechanics and the management of multiple non-coplanar contacts. This model has been modified to predict and simulate situations of changes of foothold, such as taking a step in the case of push recovery

(Mansour et al., 2011a; 2011b). A stability criterion has been established that allows predicting the need to change foothold as a function of the magnitude of the disturbance. The digital "Virtual Human" model, capable of simulating the behaviour of operators subjected to sudden, strong disturbances, could be enhanced by simulating more complex situations. In the long term, this approach will **improve tools for computer-aided design,** taking account of Man-Machine interactions (for example to design elevator platforms or to secure hold-to-run controls). The content of the training to prevent risks linked to physical activity could also benefit from the results obtained from these works.

Prevention of slips occurring on wet and/or greasy industrial floors

The INRS has **developed a measurement method** for evaluating the slip resistance of floor coatings in the laboratory. This method uses the LabINRS device developed previously to evaluate the slip resistance of safety shoes (Tisserand, 1985) and it provides a dynamic friction index for characterising the anti-slip performance of floor coatings (Leclercq et al., 1991). To measure this performance in companies, the INRS is equipped with a Portable Friction Tester (PFT) that measures friction indexes correlated with laboratory measurements (Leclercq et al., 1994). This portable device is used by 5 regional prevention departments (French Regional Health Insurance Fund) in different parts of France. In addition, the methods developed have allowed the CNAMTS (French National Health Insurance Fund for Salaried Workers) to first issue a recommendation on floor coatings intended for food production premises: the dynamic friction coefficient required to ensure good safety for pedestrians must be equal to or higher than 0.30 and, second, to manage a list of floor coatings for such premises corresponding in particular to this criterion.

A technical specification (CEN/TS 16165, 2012) established by the European Standards Organisation (CEN) proposes two methods for evaluating floor slip resistance that use the Inclinable Plane Friction Tester and the Pendulum Skid Resistance Tester (SRT). The INRS has **compared its own methods with those proposed by the CEN**. To this end, it has developed a method for the psychophysical evaluation of the perceived slipperiness of floor coatings (Marchal & Jacques, 2013) that has led to the reference classification of a panel of 15 floor coatings, ranging from the least to the most slippery. This panel was then measured using the different methods studied. The inclinable plane friction tester gave results that are well-correlated with the reference classification, but it requires test samples and does not permit measurements on site. Conversely, the pendulum SRT is adapted for measurements on site, but correlation with the psychophysical method is poor. As for the PFT, the results were well-correlated with the reference classification and it can be used for measurements in the laboratory and on site.

Furthermore, the deterioration of floor coatings due to mechanical, chemical and heat damage can cause changes in their slip resistance. A study by the INRS (Saulnier & Jacques, 2010) led to the development of a **method to accelerate the aging of floor coatings** when they are subjected to mechanical aggression by rolling and skidding, inherent to company activities. The classification according to the friction coefficient measured of five floor coatings commonly used in the agro-foodstuff industry was the same for both coatings subjected to aggressions in the laboratory and those subject to real wear in companies.

It is important to continue the promotion of anti-slip floor coatings. The outlook for the future includes **increasing the number of slip resistance measurements on site** performed by regional prevention departments, and **improving their selection criteria,** especially by taking into account their sustained performance through time.

Slipping is very frequent in agro-foodstuff production premises, and this sector is specifically targeted by the INRS's current works. It will be necessary to set up actions in other sectors in which there is also a high risk of slipping.

The prevention of collisions, tripping, slipping and other disturbances of movement that are neither caused by a sudden, external force, nor by a wet and/or greasy floor, and which do not lead to a fall from height.

These accidents occur in every sector of activity and every trade is affected. The INRS's activities in this area mainly include two modes of action: training/providing information and research. **Making actors of prevention aware** is a vital prerequisite for ensuring progress. Video DV 0331 (INRS, 2005), documents ED 140 (INRS, 2011) and ED 840 (INRS, 2013) that use the results of the research carried out contribute to this awareness in work groups, training activities, seminaries and conferences. The aim is to get **perceptions** to change towards a group of situations that conforms to the real diversity of accidents due to movement disturbance (Leclercq et al, 2010) and to the seriousness of many of them. It is also to include their genesis in the functioning of a **socio-technical system** and demonstrate that prevention cannot be limited to neutralising accident factors present visibly and permanently in the working environment. Along with other European organisations, the INRS has also contributed to the production of a video film DV 0399 (AUVA, DGUV, HSE, INAIL, SUVA & the European Agency for Safety and Health at Work, 2013) intended to promote good practices in the prevention of slips and trips.

Recent research works carried out in companies and in the laboratory, including some in the framework of cooperations with university laboratories ("*Université de la Méditerrannée, Laboratoire Mouvement et Perception - UMR 6152*" and "*Université de Paris 8, Laboratoire Paragraphe*") have led to the identification of accident factors of different nature (linked in particular to the physical environment, the task done, work organisation, the operator, etc.) and the recurrent combinations they form (**recurrent scenarios**) in work situations and which cause movement disturbance (Leclercq et al., 2007 ; Derosier et al, 2008; Sicre et al., 2008; Abdat et al., 2013). These works, whose starting point is accidental situations, will be completed by analyses focused on the activities performed and which take greater account of the context of companies.

With the aid of X. Cuny (honorary professor of Health and Safety) the INRS has proposed a **model** representing the final sequence of any accident caused by movement disturbance (Monteau et al., 2009; Leclercq et al., 2013). This model highlights similarities and differences between this type of accident and an OA in which injury is caused directly by an element with which any contact will cause an injury (high voltage source, corrosive chemical product, moving parts of a machine, etc.). This has led to underlining the difficulties/impossibilities of implementing certain prevention actions in the case of accidents with movement disturbance. Developing a method dedicated to the analysis of this type of accident would contribute to taking better account of them in current approaches applied within companies.

In parallel, **research** has highlighted **characteristics shared by all the risks manifesting themselves in movements at work** (musculoskeletal disorders (MSDs) and accidents with movement disturbance). These are diffuse and emerging risks, affecting every sector of activity for which the injury is not directly caused by an element with which any contact leads to an injury. The consequences of these proximities in the field of prevention were described by Leclercq et al. (2013) who showed that the prevention of accidents with movement disturbance, which deserves more attention given the magnitude of the risk involved, should benefit from progress made in the field of MSD prevention. In particular, the interest of studying the application of controls in occupational situations to perform an activity while preserving safety is emphasised. These controls are applied at different levels: movement in the work activity, the activity as a whole, the work situation, and the company.

Conclusion

OSTFA make up a third of occupational accidents with time-off and form a heterogeneous group of accidents that require numerous actions to ensure prevention. The INRS dedicates

much of its actions (training, providing information, assistance, standardisation, studies and research) to this end.

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