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# Systemic analysis of so-called “accidents on the level” in a multi trade company

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## Abstract

Slips, trips and falls on the level are considered commonplace and are rarely subjected to in-depth analysis. They occur in highly varied circumstances in an occupational situation. In-depth analysis of these accidents was conducted within a company with the aim of better understanding them, to be able to discuss prevention field possibilities and priorities for the company concerned. Firstly, available data on “accidents on the level” occurring over the last four years were analyzed and a typology for these accidents was derived, based on individual activity at the time of the accident and accident location. The three most serious accident-causing situations were analyzed in depth from interviews with injured persons, as well as from activity observation and activity-related verbal information obtained from operatives. These most serious situations involved accidents occurring when climbing down from trucks or when walking either in surroundings outside company premises or from (to) a vehicle to (from) a work location. In-depth accident analysis and characterization of accident-causing

situations as a whole enhance our understanding of the accident process and allow us to envisage priorities for action in the prevention field, in operational terms. Each accident-causing situation reveals environmental factors that in fact constitute accident factors (obstacle, stone, etc.), when the individual walks or climbs down from a truck. Analysis shows that other events are necessary for accident occurrence. For example, the individual may be subjected to a time constraint or he may be preoccupied. Results obtained here, in a company integrating different trades, are discussed and compared with those referred to in the literature. Generalization of some of these results is also considered.

## 1. Introduction

INRS (French National Research and Safety Institute ) has integrated into its study program a topic on the prevention of cases of balance disturbances in occupational situations. Research conducted within the scope of this topic concerns accidents during which balance of the injured person has been disturbed (not necessarily threatened), whilst performing work that cannot be considered as undertaken at height. Victims subsequently recover their balance or fall, suffering injuries in either case. Will be considered surfaces featuring either no abrupt change of level or abrupt changes of level such as sidewalk, curbs and steps, or a gradual change of level, such as a slope. Research and studies will hinge around two main lines (Leclercq, 2003), the first one being systemic analysis of contexts involving injuries in occupational situations. Study presented here is part of this project.

For all companies belonging to the French national health insurance scheme, “accidents on the level” is a category of occupational accidents, the majority of which comprise balance disturbances. In 2001, this “accident on the level” category represented (Bastide, 2003) 21% of occupational accidents leading to work stoppage, 20% of occupational accidents leading to permanent disablement and 23% of days lost due to temporary disablement. These accidents

are therefore not only frequent but their consequences are as serious as those of occupational accidents considered as a whole. They take place in all sectors of activity. They are fatal in some cases. Figures published in the literature show that these accidents are equally of concern in other countries. Nearly 20% of occupational accidents declared to the United Kingdom HSE (Health and Safety Executive) result from a slip, a trip or a fall on the level (HSE, 1985). An American private company insuring 6 million workers counted 10% of falls on the level among 1,699,298 reports filed in 1989 and 1990. The cost of these accidents represents 13% of the total cost of occupational accidents (Leamon and Murphy, 1995). 12% of the 83,255 occupational accidents, which occurred in Sweden during the first 6 months of 1979, followed a slip. In Sweden, injuries suffered at work in 1975 led to 3 million work stoppage days, of which 26% were due to falls (Strandberg and Lanshammar, 1981). Slips cause 3 to 5% of serious occupational accidents in Finland (Gronqvist and Roine, 1993).

In the multi-trade company involved in the study, balance disturbances on stairs or when climbing down from trucks are classified as “accidents on the level”. The “fall from a higher level” category being considered for falls from a great height (e.g. cherry picker or pylon). “Accident on the level” terminology has been used in this article, even if the activity performed at the moment of injury cannot always be considered as “on the level”. We mean by accident, a sequence of events (which are not unforeseeable) leading to injury. Occupational situations involving “accidents on the level” occur in highly varied circumstances (activity at the time of the accident, accident location, etc.). The phenomenon most frequently encountered during these accidents is unexpected disturbance of balance. Literature-based review reveals many factors influencing balance disturbance. These factors are linked to the individual, to the task he is performing at the time of the accident, to the equipment he is using or, again, to his working environment (Davies, 1983, Fothergill et al.,

1985, Gauchard et al., 2001, Leclercq, 2002). These four components characterize the occupational situation, considered as a system. The adopted approach is systemic because accident factors linked to the different components will be taken into account (Monteau, 1974a). Buck and Coleman (1985) have calculated coefficients of exposure to slips, trips and falls, that vary depending on sector of activity and the age of the injured person. Kemmlert and Lundholm (1998) have shown that factors contributing to falls on the level in an occupational situation differ according to the sector of activity involved.

An individual's balance can be disturbed when the foot slips. Slips can occur in every sector of activity. They are especially common in certain food industry processing shops and in mechanical engineering shops, where personnel has to move across greasy and sometimes smooth flooring. Wearing of anti-slip shoes and installation of anti-slip flooring are ways of preventing accidents triggered by a slip within these premises. Such recommendations imply measuring floor and shoe slip resistance. The October 2001 Special Issue of *Ergonomics* indicates that research into slip resistance measurement has been extensive and reports the proceedings of a symposium recently dedicated to this subject (Courtney et al., 2001). However, anti-slip shoes and floorings do not provide an answer to the prevention of all falls on the level. Research reported here concerns unexpected loss of balance and focuses on the sequence of events as a whole, i.e. all phenomena leading up to injury and not only those that immediately precede injury (a slip, for example).

“Accidents on the level” are only rarely considered as "trade"-related accidents. They occur in highly varied contexts that are only exceptionally examined in depth. This leads to general recommendations in the prevention field such as "avoid hurrying" and these are difficult to implement in practice. Determining priorities preventing “accidents on the level” in companies requires in-depth systemic analysis of the circumstances in which these accidents take place. Following such an analysis, Bentley and Haslam (1998) discussed prevention

measures against falls of which postmen are victim when distributing mail. The purpose of our study was to analyze “accidents on the level” that occur in a company integrating several trades, to understand the circumstances surrounding these accidents, especially if they are serious, and to be able to derive priorities in the prevention field. Analysis was conducted within a company and was therefore based on a limited number of “accidents on the level”. A systemic approach to these accidents was adopted (Monteau, 1974a) because accident factors are linked to all work situation components (Leclercq, 2002). Moreover, when isolated, an accident factor contributes only very little to accident occurrence, whilst it has a high probability of being observed. It is a combination of factors that generates an accident-causing situation (Monteau, 1997a) and this is why we sought to characterize these situations as a whole or by accident factor combinations. For example, walking in the presence of an obstacle can be characteristic of “accidents on the level”. Yet, these two events (walking and presence of an obstacle) are very often both present in a work situation, yet do not cause an accident. They are not sufficient for accident occurrence; other accident events must be present. For example, “individual attention focused on the task in hand” may be an accident factor because, in a work situation, attention is not solely dedicated to maintaining balance. Capitalization of accident analyses can lead to review and generalize knowledge resulting from accident case studies. Several cases can effectively present similarities in their process and lead to similar preventive measures (Leclercq, 2003).

## 2. method

### 2.1. *Brief description of company*

The study was conducted at a regional center for a major industrial company. This center distributes power over approximately 6000 square kilometers to 3 customer categories : private and professional consumers, local authorities and companies. The center is organized

into "trade"-based agencies located on 9 geographical sites. These agencies perform the following services :

- customer reception and account management ;
- network operation : power distribution and network maintenance;
- customer technical services : technical interventions and advice to customers;
- specialized maintenance : specialized power supply maintenance, operation agency-related work (specialized maintenance of distribution substations upstream of the customer in conjunction with network operating personnel);
- site supervision : new installations, designs, plans (engineering);
- commercial development;
- logistics;

The center employs a workforce of approximately 500, three-quarters of which are men.

## 2.2. *Analysis of "accident on the level" information available at the company*

2.2.1. *Data* : Whether it causes a work stoppage or not, each occupational accident is recorded by the company. Certain data are associated with it : some are systematically entered, others more infrequently :

- accident date and time;
- identity and age of injured person;
- geographical site and location of accident ;
- accident class ("accident on the level", "handling accident", etc.);
- nature of work performed by the injured person at the time of the accident;
- tools, personal protection equipment (PPE) used;
- climatic, environmental conditions;
- chronology of phenomena leading up to the accident;



- consequences of the accident (type of injury and number of work stoppage days).

Initially, we analyzed data available on the 51 “accidents on the level”, with and without work stoppage, that had occurred over the 4 years preceding our study (between 1998 and 2001). Although it would have allowed us to possess a larger data volume, information earlier than 1998 was not used, for fear of moving away from current reality (constantly evolving work situations) and also to be able to collect from injured persons the maximum amount of data concerning their previous accident.

2.2.2 *Quantitative analysis* : The 51 “accidents on the level” and the work stoppage days caused by these accidents were compared with those of other accident categories in the same company. An “accident on the level” frequency indicator was then calculated according to casualty sex, age and trade. Unlike many occupational accident categories, all operatives are effectively exposed to the risk of an “accident on the level”. Age or, again, trade are factors that can influence this exposure (Buck and Coleman, 1985, Kemmlert and Lundholm, 1998, Gauchard et al., 2001). This is why a frequency indicator was calculated using equation (1) to see if some populations were more affected than others by in-company “accidents on the level”.

$$\text{Frequency coefficient} = \frac{\text{(number of “accidents on the level” in the population concerned, during the 4 years studied} \times 10^3)}{\text{(size of population concerned} \times 4 \text{ years)}} \quad (1)$$

In view of the fact that there was little personnel movement during the 4 years considered, operative characteristics (age, sex, trade) considered for calculating these coefficients correspond to the company workforce in the year 2001.

2.2.3. *“Accident on the level” typology* : “Accidents on the level” take place in varied circumstances and their typology was established based on the activity performed at the time of injury and location of the accident. This information is frequently recorded and forms two components essential to the work situation (Monteau, 1974a). Available data on accident circumstances and number of work stoppage days were consolidated for each accident-causing situation leading to the highest number of work stoppage days. This summary led to drawing up of an accident occurrence hypothesis. Only 41 “accidents on the level”, with and without work stoppage, out of the 51 that occurred between 1998 and 2001 could be used to establish this typology. For the remaining 10, we knew neither the activity of the injured person at the time of the accident nor the accident location.

### 2.3. *In-depth analysis of the most serious “accident on the level” circumstances*

Company analysis of “accidents on the level” is often limited to phenomena immediately preceding injury and companies therefore focus on factors involving the surroundings or environment that have contributed to balance disturbance (e.g. an obstacle, etc.). Injured persons were interviewed to build the logical sequence of events that led to injury, so as to extend these circumstance-based analyses. Building of the events sequence was performed using the causal tree method (Monteau, 1974b et 1997b). This method allows phenomena generated by the work situation and contributing to the accident to be sought. This search starts from the injury itself (the first known event) and works its way back systematically, step by step, asking the following questions for each known event : what event was required for it to appear(?) - was another event required(?), until the answer "no" is given. Questioning enables events to be interlinked, broken lines representing hypothetical links. The advantage of using this method for analyzing occupational “accidents on the level” occurring is that

analysis is not based on an a priori accident model. At present, knowledge of the real circumstances surrounding these accidents is in fact limited and use of an accident model could therefore inhibit emergence of phenomena contributing to occurrence. The causal tree method will thus allow the greatest number of accident-related events to be revealed and subsequent seeking of phenomena common to all accidents of the same type, i.e. occurring during the same activity and at the same kind of location. A total of 13 causal trees could be built up for the 3 accident-causing situations leading to the greatest number of work stoppage days.

We then sought to enhance our understanding of the presence and role of certain accident factors and to highlight potential factors influencing “accidents on the level”, but which did not necessarily play a part in the accidents studied. To achieve this, the work activity was observed and work activity-related verbal information was obtained from operatives. Observations and work activity-related verbal information were guided by hypotheses derived from qualitative analysis, enriched with information from causal trees. Seven days were spent with seven teams, each including an operative who had been a person injured in an accident on the level.

### 3. Results

#### 3.1. *Quantitative analysis*

Figures 1 and 2 represent distributions of 163 occupational accidents, with or without work stoppage days, that took place in the company between 1998 and 2001, along with the days lost due to these accidents. Occupational accident categorization shown in these figures is that used in France. These categories do not take into account the multifactorial nature of accident phenomena. Moreover, only categories for which at least one in-company accident has been classified between 1998 and 2001 appear. It can be observed that “accidents on the level”

were most frequent and that, after “vehicle accidents”, it was “accidents on the level” that caused the highest number of work stoppage days.

[Insert figures 1 and 2 about here]

Men were more affected by “accidents on the level” than women, although frequency coefficients were not statistically different. Figures 3 and 4 represent the “accident on the level” frequency coefficient based on age and the "trade" agency to which the injured person belongs, respectively. These figures prompt the following comments : Operatives aged below 26 appear to be more affected by “accidents on the level” than operatives aged over 45, who appear to be less affected by these accidents. Moreover, the latter operatives did not fall victim to a single “accident on the level” leading to work stoppage between 1998 and 2001. Operatives aged over 45 were statistically less affected by “accidents on the level” leading to work stoppage than those aged less than 45, at a confidence level exceeding 94%. On the whole, operatives older than 35 were statistically less affected by “accidents on the level” than those younger than 35, at a confidence level exceeding 98%. Moreover, operatives appear to be affected differently by “accidents on the level”, depending on the "trade" agency to which they belong and depending, therefore, on their activity. The network operation agency is statistically more affected than logistics or site supervision agency, at confidence levels exceeding 96% and 90% respectively.

[Insert figures 3 and 4 about here]

### 3.2. *“Accident on the level” typology*

Table 1 records the typology of “accidents on the level” that took place in the company between 1998 and 2001. This table highlights :

- the diversity of accident-causing situations and their seriousness ;
- the fact that accidents occurring in this company when climbing down from a truck or going down a staircase are recorded as “accidents on the level”. This company reserves the "fall from a higher level" heading for falls from a great height (e.g. from a cherry picker or pylon). No occupational "fall from a higher level" occurred in the company between 1998 and 2001 ;
- The fact that pains occurring during movement excluding walking (e.g. when a person sitting in a vehicle turns round to grab something on the back seat) are recorded as “accidents on the level”. There is therefore no specific heading for these accidents and the term "accident on the level" is sufficiently loose for occupational injuries, during which the injured person did not necessarily lose his balance, to be recorded under it.

[Insert table 1 about here]

Accident-causing situations a, b and c (cf. table 1) are those that led to the highest number of work stoppage days, on average and this is why they were subjected to further in-depth analysis. Table 2 summarizes data available on accident circumstances and seriousness for these 3 situations. This table reveals information common to several accidents of the same type. Based on this information, an accident occurrence hypothesis is suggested for each of the 3 accident-causing situations a, b and c. For accident-causing situation a, the hypothesis is : poor climatic conditions in the morning, ignorance of the site, impetuosity and limited experience of young operatives, combined with the activity of climbing down from a truck

(during which body weight is all on one foot at the moment it touches the ground), cause accidents leading to numerous work stoppage days. For accident-causing situation b, the hypothesis is : especially after a week-end, having to cope with obstacles/dangers when walking in unknown surroundings outside company premises can cause often serious accidents on the level. For accident-causing situation c, the hypothesis is : bad weather and poor state of the surroundings, combined with an activity when walking from (to) a vehicle to (from) a work location, considered secondary and potentially time-saving, cause accidents with or without work stoppage.

[Insert table 2 about here]

### 3.3. *In-depth analysis of circumstances surrounding most serious “accidents on the level”*

The 3 most serious types of “accident on the level” include 22 accidents. These accidents particularly affect field personnel, i.e. mainly “network operation” and “customer technical services” agency men, who are most affected by such accidents (cf. figure 4 ). In the morning, these operatives receive their work schedule for the day, which may involve working on one or more sites. They are also issued with the equipment and materials required for this (these) site(s). They are in more or less direct contact with customers, depending on the work they perform. Among the 22 most serious “accidents on the level”, it was possible to meet 13 casualties, within the scope of this study, to collect further information on their accidents and build the "causal tree" for each accident. Figures 5, 6 and 7 present three of these causal trees, each associated with one accident in situations a, b and c (described in table 1), respectively. Reading these trees and using observations and work activity-related verbal information led to the information developed in the following paragraphs.

[Insert figures 5, 6 and 7 about here]

### *3.3.1 Case of accidents occurring when climbing down from a truck*

Three causal trees were built from the five accidents of this type. These 3 injuries occurred when climbing down from trucks of low height (approximately 50 cm) compared with cherry picker or drilling trucks likely to be used by operatives. Climatic conditions appear in none of these three causal trees and therefore had no impact on injury occurrence through making the ground slippery. However, their role could be situated upstream of the "causal tree" and not appear here because the injured people did not refer to it. Work environment intervenes in every case, despite being neither of unusual nor uncommon character (e.g; sidewalk curb). It was when preparing or checking the equipment and material required for the work that the 3 injuries took place. Observations and work activity-related verbal information allowed us to better understand why these accidents most often take place in the morning, during equipment and material preparation, and during the winter. We were also able to investigate another aspect of the hypothesis : the young age of injured persons Operatives explain that they prefer to, "perform major work in the morning to avoid the rain. It's not the cold we dread, but working in the rain". The fact that accidents all occurred in the morning could be indirectly linked to climatic conditions : when rain is probable, operatives hurry to do the most work before the weather deteriorates over the day. In the morning, the first operation performed by operatives is to load equipment and material required for the day's work into the truck. This equipment and material has been prepared for them and is assumed to form the requirement for the day's work. On arrival at the first site, they climb down from the truck and unload what they need for that site. Throughout the day, they can therefore climb up onto and down from the truck several times to prepare equipment and material and unload what they specifically need at each site. The problem is that they do not always have the required

material, when it is out of stock and delivered only twice a week, for example. When deliveries are incomplete, operatives sometimes have to request the missing parts several times. Moreover, since several operatives share the same vehicle, they do not know the basic material contents of the vehicle they are going to use. Consequently, equipment and material preparation becomes more of a concern. “Accidents on the level”, when climbing down from trucks, occur most frequently in the morning, during the equipment and material preparation phase. It appears that the operative is preoccupied during this phase, which could explain why he is less attentive to commonplace environmental factors (e.g. sidewalk curb) at this time. Moreover, operative observations concerning climbing down from a truck show that the younger men tend to jump. With age, operatives appear to take more care of their health and approach site work with a more detached attitude.

*Summary* : Serious “accidents on the level” occur when climbing down from trucks. During this activity, body weight is all on one foot at the moment it touches the ground, which can cause sprains depending on the state of the surroundings. Accident factors involving the environment outside the company are present (e.g. sidewalk curb), yet these are neither unusual nor uncommon. Furthermore, they constitute factors on which the company employing operatives cannot take action. On many occasions during the day, operatives have to climb onto or down from a truck near sidewalks and gutters, for example. The association of these two events (climbing down from truck, external environmental factor) is more characteristic of accident-free situations than of accident-causing situations. Factors that combine with these to cause an “accident on the level” are linked to preparation of site equipment and material; a subject of concern to operatives, which mobilizes their attention. Factors are also linked to the threat of bad climatic conditions in winter, which induce operatives to work "more quickly" in the morning, and to the young age of operatives.



### 3.3.2 *Case of accidents occurring when moving in surroundings outside company premises*

Four causal trees were built from the 10 accidents of this type. These again show that, in these cases, nothing related to the external environment is of unusual or uncommon character (sidewalk, gate, stone, brambles). In 3 accidents out of 4, operative activity could not be considered as unique : he was walking whilst performing another physical activity such as carrying equipment/material or closing a gate. Moreover, operatives referred to a time constraint in every case. The hypothesis associated with this type of accident states, in particular, that confronting obstacles/dangers in unknown surroundings causes “accidents on the level”. After analyzing these 4 causal trees, it is difficult to validate or invalidate this hypothesis component. Moreover, whilst observations and work activity-related verbal information provide no explanation of the fact that 30% of these accidents took place on Monday, they do allow us to understand the origin of time constraints. Concerning operatives working on "minor interventions", customer appointments are sometimes cancelled and replaced at the last minute. Operatives then waste time returning to the center to pick up the required equipment and material before going to the new work location. Furthermore, transmitted work instructions are not always correct and this causes a waste of time for operatives, who go to the scheduled work location only to find that they have to go elsewhere.

*Summary* : “Accidents on the level” take place when the operative moves on foot whilst performing another physical activity. He has to cope with obstacles/dangers in surroundings outside the company premises that are neither unusual nor uncommon. Potential accident factors that combine with these two factors to cause an accident are linked to time constraint.

### 3.3.3. *Case of accidents when walking from (to) a vehicle to (from) a work location*

Six causal trees were built from the seven accidents of this type. These show that snow could make the ground slippery or conceal dangers in 5 accidents out of 6 and various

environmental factors (large stone, open manhole, eroded or smooth sloping ground) also played a part in 4 accidents. The operative performed an activity in direct contact with the customer in 4 accidents out of 6. A time constraint played a part in 4 accidents.

In these situations, unusual environmental factors, specifically snow concealing a danger (e.g. when it hides a manhole without a cover), are themselves enough to cause a moving person to lose his balance. In such cases, the time constraint could constitute an accident aggravating factor. Observations and work activity-related verbal information attempt to explain why operatives are more affected by this type of accident, when they are in direct contact with customers. They also provided the opportunity to further understand the twin role played in these accidents by climatic conditions. Operatives in direct contact with customers have different successive appointments with different customers during the day. If work at one customer takes longer than expected or if the customer arrives later than expected, operatives are late and try to recover lost time. We have seen that, in these situations, poor climatic conditions constituted an accident factor in themselves. Snow made the ground slippery or concealed danger, for example. By slowing down operatives on the road, its impact on “accident on the level” occurrence is increased because operatives will try to recover "lost" time when they walk. Operatives intervene over a vast territory and vehicle journeys are often very long.

*Summary* : These “accidents on the level” occur when the operative walks from (or to) his vehicle to (or from) his work location. Obstacles/dangers in the external environment are present, especially snow that makes the ground slippery and conceals dangers. The presence of these factors, when walking, is enough to cause an accident. Time constraint, resulting especially from loss of time due to snow during vehicle journeys, and/or the constraint of respecting successive appointments, is an aggravating factor.

## 4. Discussion

First and foremost, it should be noted that the balance of the injured person is not systematically threatened in cases of “accidents on the level” with and without work stoppage. A fall rarely occurred in this company during the 4 years considered. For example, in the case of accidents that occurred when climbing down from trucks, the injured person suffered a sprain when stepping down onto a stone. Balance is slightly disturbed without being threatened, yet the consequences are no less serious. This study reveals the importance of extending “accident on the level” analysis to better understand the reasons for the occurrence of these accidents and be capable of discussing various possibilities open to the company for taking action in the area of their prevention. For example, 4 accidents out of 5 that took place when climbing down from a truck, occurred in winter. Rain made the ground slippery and we assumed initially that operatives slipped when climbing down from the truck. Only in-depth accident analysis enabled us learn that a slip had not occurred and that, when rain threatens, it is operative strategy that enables the role of these climatic conditions to be understood (cf. § 3.3.1). A second example involves the twin role played by climatic conditions during accidents when moving on foot from (to) a vehicle to (from) a work location. Initial analysis indicated that the presence of snow and operative movement on foot are often sufficient to cause the accident. As a result, snow impact on accident occurrence is in fact increased because operatives are slowed down during their vehicle journeys to reach the work location. Operatives will effectively accumulate lost time, which they will try to recover when walking. In both these cases, it would clearly appear that possibilities for action in the prevention field and the relevance of this action depend directly on accident analysis and understanding both the work activity and its constraints. Bentley and Haslam (1998), who studied the circumstances surrounding falls to which postmen are subjected, when distributing mail note

that "snow and ice make it difficult to keep to time as the operative is forced to walk more slowly".

An environmental factor almost always plays a part in the accident. In most cases investigated in this study, these factors were usual, e.g. sidewalk, roots in forest, stone etc.. In all cases, the company concerned is incapable of taking action on such factors. Operatives in fact work in an environment that cannot be completely controlled by the company (site, private home). Possibilities for action will therefore concern accident factors linked to work organization rather than the working environment. Only in-depth accident analyses can result in possibilities for action in relation to operative work organization (e.g. consideration for delays on the road during periods of snow). These actions will have an impact on accident occurrence by permitting the operative to "not hurry".

Accident-causing situations within the scope of this study were characterized as a whole. The literature reports many factors involved in "accidents on the level", e.g. poor lighting, time constraint, etc.. (Fothergill et al., 1995, Leclercq, 1999a). For all that, knowledge of these many factors does not ensure that the prevention specialist is any less at a loss, when confronted by these accidents. In fact, considering just one or even several factors in isolation comes down to characterizing further normal accident-free situations, rather than accident-causing situations. Taking the case of accidents occurring when climbing down from trucks : in this company, associating the two accident events – "climbing down from trucks" and "external environmental factor" (e.g. sidewalk curb) is more characteristic of normal accident-free situations than accident-causing situations. In paragraph 3.3.1, it was observed that 3 other factors combine with the above two to cause the accident. This is why prevention specialist support and prevention action relevance also depend on characterization of accident-causing situations as a whole.

Research involving prevention of falls on the level has highlighted the variety of occupational accident contexts for all sectors of activity combined (Strandberg and Lanshammar, 1981, Kemmlert and Lundholm, 1998, Leclercq, 1999a). This study shows that circumstances surrounding “accidents on the level” are also varied within the same company integrating different trades. Furthermore, if we consider the most serious “accidents on the level” occurring in the company, we observe three types of accident-causing situation involving field operatives, i.e. operatives performing fairly similar trades. Although similar, these trades are not performed under the same constraints, e.g. use of truck, direct contact with customers and this may explain the different accident-causing situations.

“Accidents on the level” occurring when climbing down from trucks are the most serious. Several studies have already described accidents taking place at the moment a person enters or leaves a vehicle or machine (Skiba, 1983, Nicholson and David, 1985, Albin and Adams, 1989, Leamon and Murphy, 1995). Type b and c “accidents on the level” occur when an individual walks. This result mirrors results from other “accident on the level” analyses (e.g. Strandberg and Lanshammar, 1981). For the company considered in this study, either the person was performing another physical activity, whilst walking, or was walking from (to) a vehicle to (from) a work location. Moreover, the casualty was subjected to a time constraint. It would appear that operatives try to "save time" or "recover lost time", when walking. It is effectively difficult to "save time" when performing the trade-specific activity or during conversations with customers. This is why it is when walking, an activity considered secondary to trade-specific activities, that the operative tries to "save time", when the daily work scheduled has been delayed. Moreover, the fact of performing another physical activity when moving on foot can prevent the operative from perceiving danger, either by limiting his

field of view (e.g. carrying a load) or by deviating his sight towards the activity aim (e.g. operative pulling a gate behind him). Furthermore, when the operative walks from (to) his vehicle to (from) a work location, he has to move across different ground surfaces in a short time, e.g. he leaves his car, walks on snow-covered ground, possibly a sidewalk, then a path, arrives at the house entrance, then enters the house. On the one hand, when a person walks several paces across the same surface, he corrects his adopted gait according to tactile and proprioceptive feelings after one or more paces. The fact of moving over different surfaces in a short time probably increases the loss of balance risk (Andres et al., 1992, Leclercq, 1999b). On the other hand, when walking, the operative adapts his gait or avoids surfaces according to what he anticipates visually (Patla, 1991). Presence of snow makes the ground slippery or conceals dangers. In the former case, it should be noted that slip-causing factors (e.g. slippery ground) are less easily recognized through anticipation than trip-causing factors (e.g. an obstacle). In the latter case, it is impossible to anticipate visually the danger. Individual balance will then be disturbed with all the more serious consequences when the operative is moving quickly.

The fact that young operatives in this company are most affected by “accidents on the level” (figure 3 and table 2) is a somewhat unexpected result. Literature dealing with balancing refers particularly to elderly people's susceptibility to falling (Gabell et al., 1985). According to Pyykkö et al. (1990), the hierarchy of receptor systems governing posture control changes during life. Children appear to use more proprioceptive and vestibular information and elderly people appear to use primarily visual information. Within the scope of laboratory experiments, these authors have observed that the proprioceptive sensitivity threshold of calf muscles is greater for people aged over 85, compared with subjects with an average age of 55. They confirm also that the vestibular system deteriorates with age and has a higher detection

threshold. This is what Alexander et al. (1992) assume, when observing highly variable responses, suggesting possible head stabilization difficulty in space, for elderly people (aged 72, on average) in difficult situations, (standing on a beam and subjected to anteroposterior disturbance). Research described by Perrin et Lestienne (1994) corroborate these results : among the most obvious signs of age effect, they refer to proprioception alteration and greater visual dependence. These laboratory studies have shown that elderly people (aged over 70) experience more balance control difficulties than younger people (aged 55, on average). The 3 accident-causing situations considered in our study concern field operatives with an average age of 41. Phenomena referred to in the literature are therefore probably absent or, in general, rarely present in an occupational situation. Bentley and Haslam (1998) observed no clear effect of age on falls occurring among postmen. On the other hand, Buck and Coleman (1985) showed that a frequency coefficient for occupational "slips, trips or falls on the level" increases with employee age (between 16 and 60), based HSE (Health and Safety Executive) national statistics. It is probably accident context, activity constraints or, again, operative experience that will provide an explanation of the fact that young operatives are more affected by "accidents on the level" in certain situations. This study reveals that age is an "accident on the level" factor, when climbing down from trucks, but it did not appear to be so in the other two accident-causing situations. This unexpected result may be explained by the impetuosity of young operatives and their more limited experience, which makes them approach the work program in a different way. This is probably specific to the situation studied (climbing down from trucks, situational constraints).

Similarly, in relation to age, the fact that men were more affected by "accidents on the level" than women in this company is a somewhat unexpected result. Analysis of the 1734 "slip, trip or fall" cases, to which postmen were victim while distributing mail between April 1993 and March 1995, revealed that women had a 50% higher coefficient of exposure for "slip, trip and

fall" than men (Bentley and Haslam, 1998). Unlike the Bentley and Haslam study, frequency coefficients reported here concern different trades. It is probably because of their trade that men are more exposed to "accidents on the level" leading to work stoppage. The most serious "accidents on the level" involve effectively field operatives, who are almost always men.

No explanation has been found for the fact that one third of accidents, that involved walking in surroundings outside company premises, occurred on Monday. On that subject, Davezies (2002) has calculated the number of occupational accidents declared in one French region during 44 weeks, excluding public holidays, for each of the 5 weekly working days. He explains the slight increase in occupational accidents on Monday (28% of accidents) by "particularly costly changes in pace". Individual mobilization cost and accident risks appear to be effectively higher during a start-up period than during stabilized operation.

Finally, one difficulty encountered during this work should be highlighted : collection of information concerning "accident on the level" contexts. This difficulty can be partly explained by the time that had elapsed between the accident and the interview of the injured person. Haslam and Bentley (1999) analyzed 40 "slips, trips and falls" based on interviews of the injured persons, but they limited the average time that had elapsed between accident and interview to just 10 days. It was impossible for us to implement this constraint within the scope of our study. However, its integration should always be sought. Moreover, balance adjustment is more or less automatic and it is sometimes difficult for individuals to describe exactly everything that happened, all the more when accidents are less serious.

## 5. Conclusion

This study concerns "accidents on the level" that took place within a company integrating different trades. Initial analysis suggests that operatives are not similarly affected by "accidents on the level"; these would appear to depend on their age, sex and trade. These



factors are not independent, e.g. men and women do not exercise the same trades within this company. This is why these results can only be discussed following in-depth analysis of the circumstances in which these in-company “accidents on the level” occur. Such an analysis allowed us to identify several accident-causing situations and accident factors linked to all work situation components : the individual, his activity, the equipment and material he uses and the environment in which he moves. Yet, it is a combination of accident factors that creates an accident-causing situation. Understanding “accidents on the level” therefore requires these situations to be characterized as a whole and accident contexts to be analyzed in depth. Different possibilities and priorities derived in the prevention field can then be discussed in operational terms.

Factors derived from this exploratory study cannot be generalized to all occupational situations. However, some of them probably have an impact in many situations. For example, the fact that people try to "save time" or "recover lost time" when walking. The twin role played by climatic conditions in the occurrence of these accidents can probably also be generalized to numerous situations.

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Table 1 : “accident on the level” typology based on activity at the time of the accident and accident location. These situations are referred to in the text by artificially attributed letters "a" to "f". “Moving without “walking” activity is e.g. when a person is sitting in a vehicle and turns round to grab something on the back seat.

Table 2 : information summary of circumstances and seriousness of accidents of the same type for the 3 most serious accident-causing situations.

Figure 1 : distribution of in-company occupational accidents recorded between 1998 and 2001, based on nomenclature used in France (types of accidents in each category are : vehicle (a person collided with a vehicle), manual handling (injury occurred during manual handling), moving object (a person collided with an accidentally moving object), animals (a person bitten by an animal), equipment (injury occurred when using tool)).

Figure 2 : distribution of days lost due to in-company occupational accidents recorded between 1998 and 2001, based on nomenclature used in France (types of accidents in each category are : vehicle (a person collided with a vehicle), manual handling (injury occurred during manual handling), moving object (a person collided with an accidentally moving object), animals (a person bitten by an animal), equipment (injury occurred when using tool)).

Figure 3 : Frequency coefficient for “accidents on the level” according to age.

Figure 4 : Frequency coefficient for “accidents on the level” according to trade.

Figure 5 : "Causal tree" associated with an accident occurring when climbing down from a truck (type a)

Figure 6 : "Causal tree" associated with an accident occurring when walking outside company premises (type b)

Figure 7 : "Causal tree" associated with an accident occurring when walking from (to) a vehicle to (from) a work location (type c)

Table 1

Accident -causing situation	Injured person activity at time of accident	Accident location	Total number of accidents (number of accidents with work stoppage)	Total number of work stoppage days  (sum of n° stoppage days per accident)
a	climbing down from truck	off company premises	5 (3)	81 (44+21+16)
b	walking	off company premises	10 (4)	36 (4+20+6+6)
c	walking	vehicle ↔ work location	7 (2)	16 (10+6)
d	walking	on company premises	4 (0)	0
e	going down staircase	on and off company premises	8 (2)	8 (6+2)
f	movement without "walking"	on and off company premises – inside vehicle	7 (2)	11 (6+5)

Table 2

Accident-causing situation	Number of accidents	Accident circumstances	Number of accidents with work stoppage and average number of work stoppage days
a : climbing down from truck off company premises	5	<ul style="list-style-type: none"> <li>◆ morning between 8h00 and 11h00</li> <li>◆ site (4 cases)</li> <li>◆ in winter (4 cases)</li> <li>◆ average casualty age : 32 (average field operative age = 41)</li> </ul>	◆ 3 accidents with work stoppage (81 days)
b : walking off company premises	10	<ul style="list-style-type: none"> <li>◆ Monday (3 cases)</li> <li>◆ site (4 cases), at a customer (2 cases), in forest (2 cases), sidewalk, yard</li> <li>◆ other physical activity during walking (at least 4 cases out of 6 recorded – carrying equipt./material, closing gate, etc.)</li> </ul>	◆ 4 accidents with work stoppage (36 days)
c : walking vehicle ↔ work location	7	<ul style="list-style-type: none"> <li>◆ at a customer (4 cases), site, yard (2 cases)</li> <li>◆ snow (5 cases), frost (1 case)</li> <li>◆ Thursday (3 cases)</li> </ul>	◆ 2 accidents with work stoppage (16 days)



Figure 1

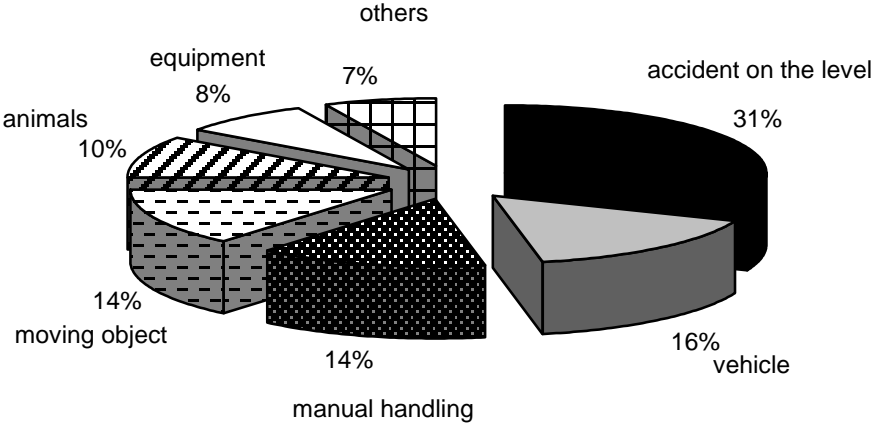


Figure 2

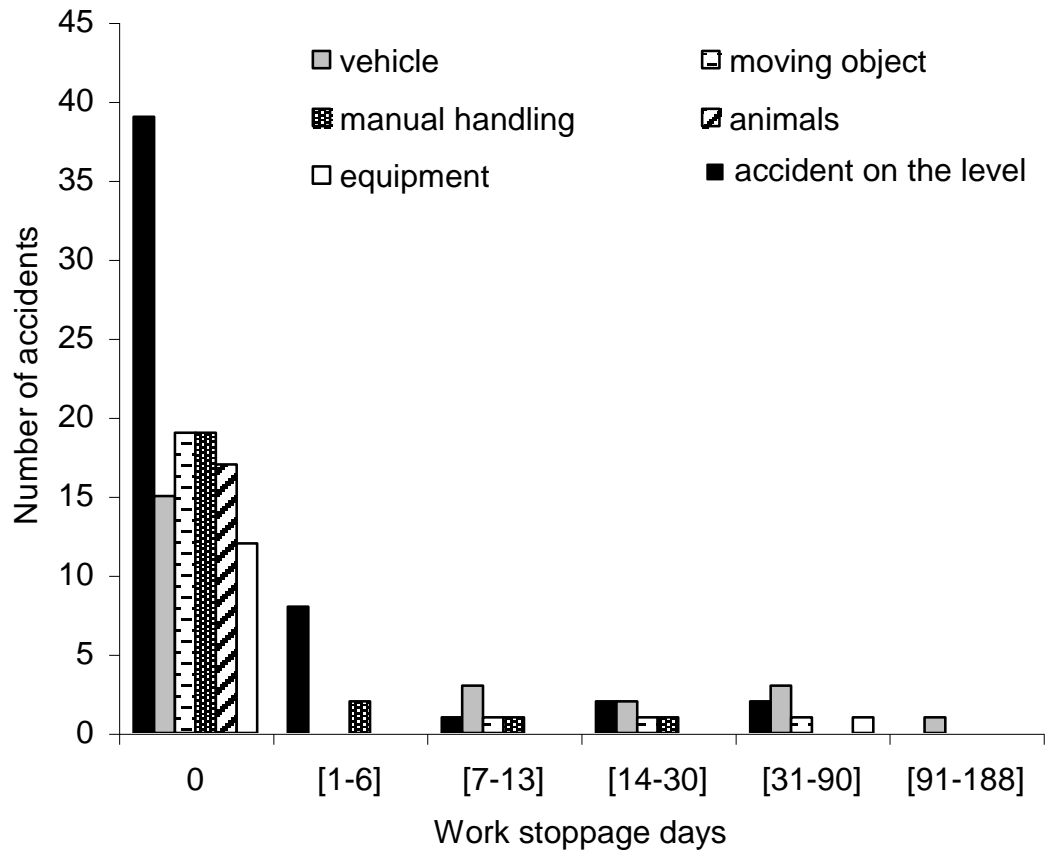


Figure 3

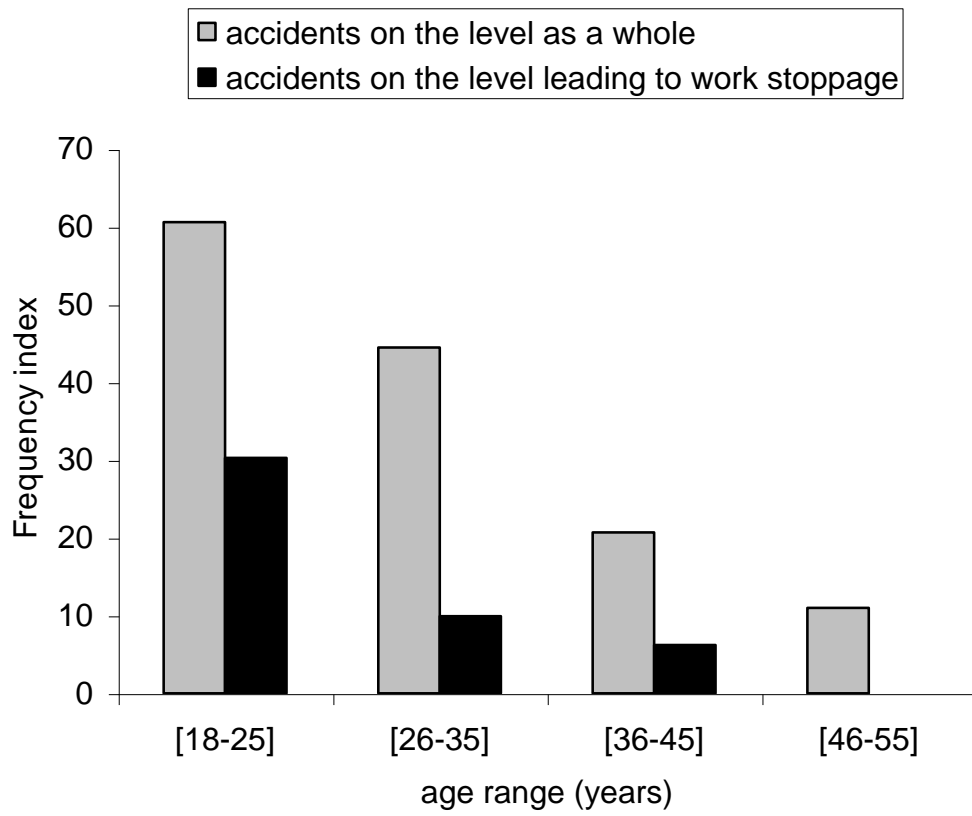


Figure 4

1

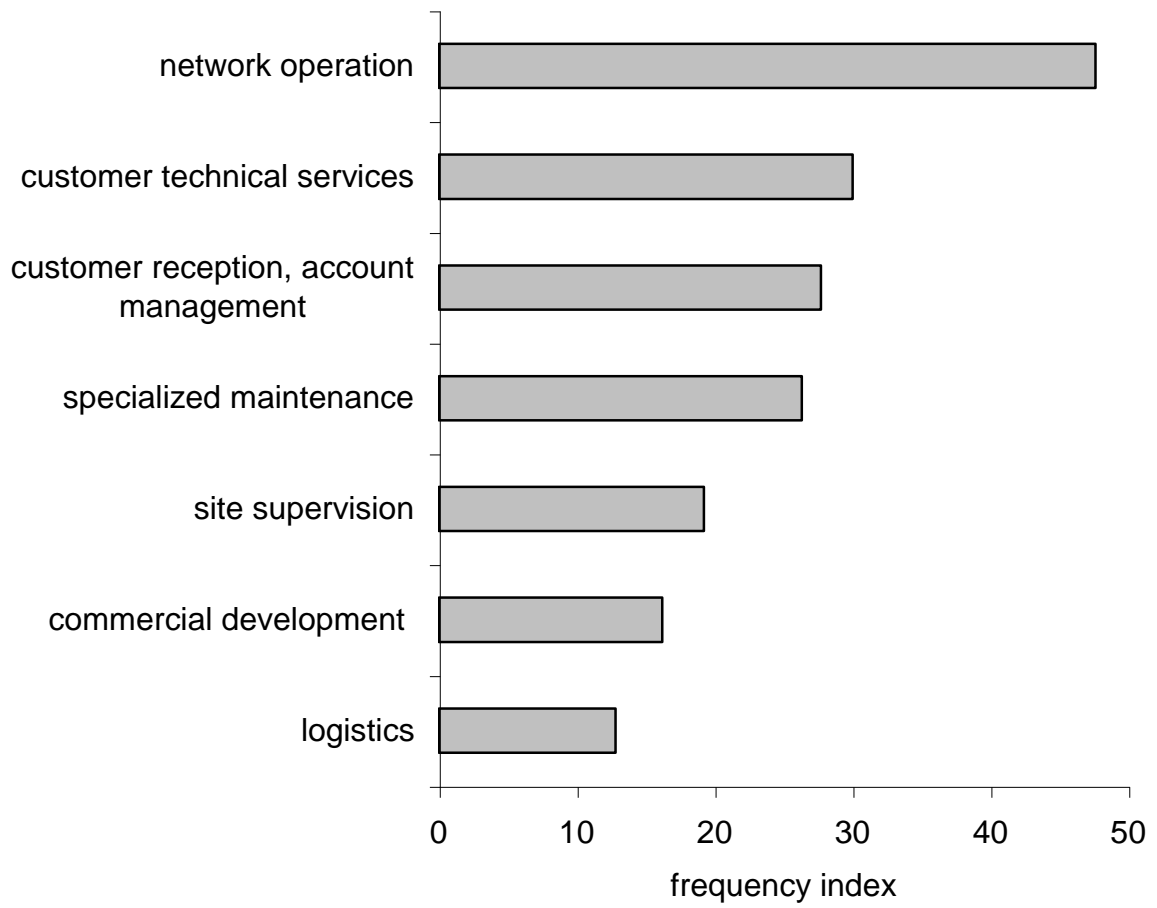


Figure 5

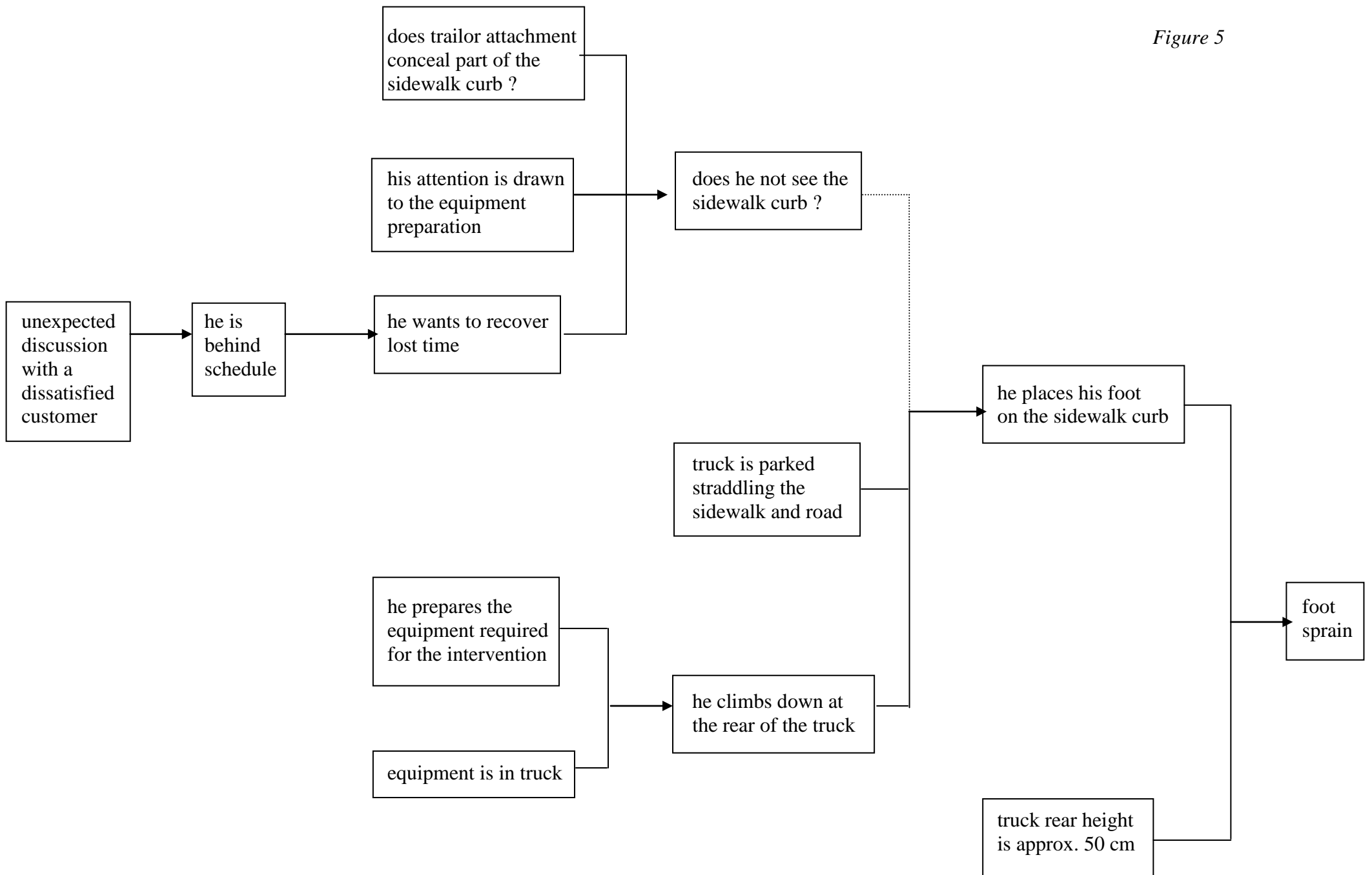


Figure 6

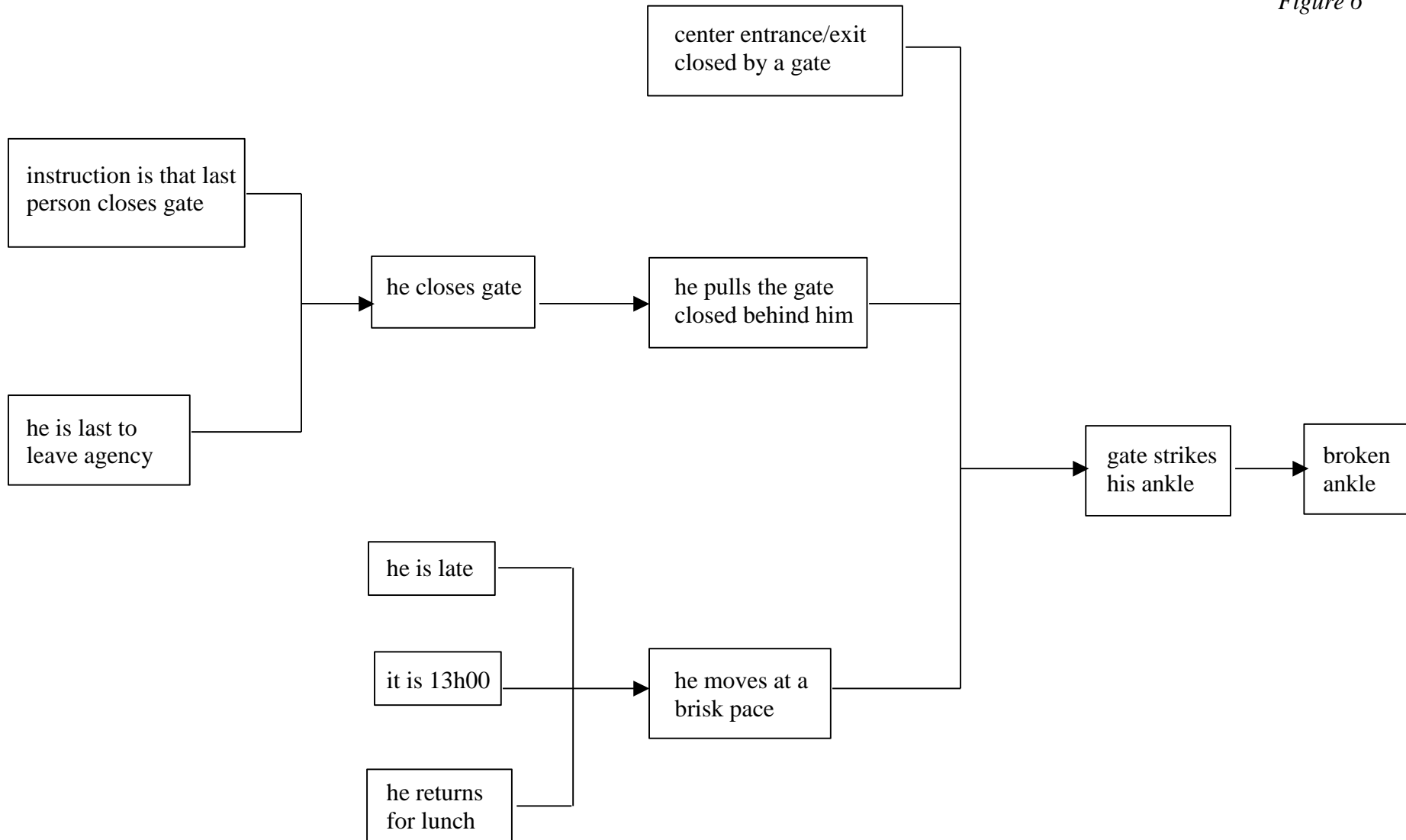


Figure 7

