4 WORKPLACE ACCIDENTS

4.1 THE PHENOMENON OF THE WORKPLACE ACCIDENT

4.1.1 Definition

In a war there is the intent of combatants to kill or injure; in industry there is no such intend, yet accidents do kill people or wound them badly. In war, the wounded no matter how minor, sometimes would be awarded Purple Heart medals.

A shortest definition of an accident at work is that this is a realisation of a workplace hazard. Figure 4.1 contains a somewhat more formal definition of the workplace accident is given by the EUROSTAT (EU statisticians) that are collecting data on this kind adverse events [4.1: 12]. Accidents at workplace can be as diverse as the workplace hazards which realise themselves as the accidents. Table 4.1 is an attempt to present a short classification of workplace accidents which are usually mentioned in the field of OSH. However workplace accidents can also be considered from the standpoint of risk analysis. The following section contains a description of some workplace accidents as they are mentioned in the literature on OSH. Section 4.2 presents short look at workplace accidents from the position of risk analysis.

An accident at work is defined as a discrete occurrence in the course of work which leads to physical or mental harm. This includes cases of acute poisoning and wilful acts of other persons, as well as accidents occurring during work but off the company's premises, even those caused by third parties. It excludes deliberate self-inflicted injuries, accidents on the way to and from work and accidents having only a medical origin and occupational diseases. The phrase “in the course of work” means whilst engaged in an occupational activity or during the time spent at work. This includes cases of road traffic accidents in the course of work.

A fatal accident is defined as an accident which leads to the death of a victim within one year of the accident.

Figure 4.1 Definition of workplace accidents used in EU countries [4.1]

4.1.2 Workplace accidents related to different activities

The road traffic accidents in the course of work are considered workplace accidents. Road accidents concern not only persons whose occupational activity is exerted mainly on public highways, e.g., lorry or coach drivers, but also those occupational activities which frequently or occasionally imply journeys on public roads.

These occupational activities include, e.g., repairing, commercial activities or other service activities carried out at the premises of the customers. This includes also a car accident, say, of a manager who occasionally goes, in the course of work, from his office to an external meeting. Such an accident would still be considered as a work accident, even if the place belongs to his company or a client, another company or institution. Road traffic accidents as described above also include incidences in car parks and the internal carrier-ways at the premises of the enterprise.

The expression “whilst engaged in an occupational activity or during the time spent at work” used in Figure 4.1 should therefore be understood in broader terms. Thus, other types of accidents on public highway or places should also be included. This concerns, for example, slips on the pavement or falls on staircases, or even aggressions from other persons, provided that the victim is still in the course of work. This will also apply to accidents on board any means of transport, e.g., underground train, tramway, train, boat, plane, etc. This includes also accidents in the arrival and starting points of any means of transport, e.g., stations, airports, ports, etc., provided that the victim is still in the course of work.

Accidents that have occurred within the premises of a company other than the one that employs the victim should also be regarded as an accident at work. Such activities include all kind of meetings and services which takes place outside the premises of the company provided that the victim is still in the course of work. This includes also the following examples: Accidents that occur in the course of meetings or visits out of the company; accidents during the delivery of goods on customers’ premises (company or private individual) or while carrying out other services such as repairing, maintenance, errands, etc. on clients’ premises; more permanent secondments in another company, or during activities at home which are in the course of work; accidents caused by other work activities not related to the course of the victims work activities, etc.
In summary, all the accidents corresponding to all risks the employed person is exposed to in the course of his/her should be included in the management of risks at workplace. This applies not only to the specific risks he is exposed to in the premises of the employer, but also the risks outside the premises which he can be exposed to in the course of work, for example on public highways, means of transport or risks caused by third parties. This is irrespective of whether or not his employer can prevent or reduce partially, the level of these risks outside his own premises.

Table 4.1 Classification of workplace accidents

<table>
<thead>
<tr>
<th>Classification by</th>
<th>Type of accident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fatal accidents (accidents at work leading to the death of the victim within some prescribed time limit after the day of the accident (one year in the European statistics [4.1: 14 and 25])</td>
</tr>
<tr>
<td></td>
<td>Non-fatal accidents</td>
</tr>
<tr>
<td>Time of absence from work*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>With less than 3 days’ (at least 4 calendar days) absence at work</td>
</tr>
<tr>
<td></td>
<td>With more than 3 days’ absence at work</td>
</tr>
<tr>
<td>Place of occurrence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accidents occurring within the premises of the company that employs the victim</td>
</tr>
<tr>
<td></td>
<td>Accidents occurring within the premises of the company other than the one that employs the victim (all kind of meetings and services which take place outside the premises of the company provided that the victim is still in the course of work; e.g., accidents that occur in the course of meeting or visits out of the company, accidents during the delivery of goods on customers’ premises (company or private individual) or while carrying out other services such as repairing, maintenance, errands, etc. on clients premises, permanent secondments in another company or during the activities at home which are in the course of work)</td>
</tr>
<tr>
<td></td>
<td>Road traffic accidents in the course of work (public highways, car parks, internal ways inside the premises on the enterprise)</td>
</tr>
<tr>
<td></td>
<td>Accidents (slips, falls, aggressions, etc.) in a public place (pavement, staircases) or in the arrival and starting points (station, port, airport etc.) of any mean of transport, during a journey in the course of work</td>
</tr>
<tr>
<td></td>
<td>Commuting accidents (accidents on the way to and from work)</td>
</tr>
<tr>
<td>Link to occupational activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accidents linked to occupational activity</td>
</tr>
<tr>
<td></td>
<td>Accidents from strictly natural causes (e.g., cardiac or cerebral incidents or any other sudden medical disorders, which have occurred during work, but a priory have no link with the occupational activity of the victim and the injury is only related to the medical disorder)</td>
</tr>
<tr>
<td>Consciousness of involved persons</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unintended accidents</td>
</tr>
<tr>
<td></td>
<td>Accidents due to wilful acts of other persons</td>
</tr>
<tr>
<td></td>
<td>Deliberate self-inflicted injuries</td>
</tr>
</tbody>
</table>

* Accidents at work with more than 3 calendar days’ absence at work are reported in the European occupational statistics [4.1: 12]

4.2 WORKPLACE ACCIDENTS IN VIEW OF QUANTITATIVE RISK ASSESSMENT

4.2.1 Workplace accidents due to failures of engineering systems

The classification of workplace accidents discussed in the previous does not reveal anything about the particular circumstances in which the accidents occur. However, it more or less obvious that the likelihood of an accident in case of abnormal situation is less that the one related to the process of work happening under normal, usual conditions. An abnormal situation at workplace can be dangerous in two respects:

- The abnormal situation can pose a direct hazard to employees as it occurs as a failure of the engineering system in which or in vicinity of which people work. Such failure can occur as a violent release of energy (e.g., accidental explosion, rupture of a pressure vessel, or severe fire) or a release of toxic chemicals.
- The abnormal situation can also be hazardous also in the indirect sense as it can be the cause of an inadequate reaction of the workers to the abnormality and hazards not directly impending on them. The inadequate reaction can be the feelings of fear, panic, disorientation, which, when take place, can be the cause of a workplace accident.

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Thus one can speak about the workplace accidents which can be caused by failures of engineering systems and accidents which occur under normal service conditions of the systems (Figure 4.2). It is natural to expect that the time of personnel exposure to the hazards present under normal conditions at workplace exceeds considerably the time of exposure to the hazards generated by a system failure. Consequently, accident occurring under the normal conditions should be much more frequent that ones under abnormal conditions. On the other hand consequences of accidents due to system failures can exceed by far consequences of accidents under normal system’s service conditions. Extreme examples of the former type of accidents are Bhopal disaster (1984, India) and Chernobyl nuclear power plant catastrophe (1986, Ukraine).

![Diagram of workplace accidents](image)

**Figure 4.2** Definition of workplace accidents used in EU countries [4.1]

The pair of “accident likelihood” and “accident consequences” is the main subject of the probabilistic (quantitative) risk assessment [4.6, 4.10]. It allows to calculate and to compare risks of accidents, no matter what are the conditions under which they occur, in terms of product of frequency (quantitative measure of likelihood) and severity (quantitative measure of consequences). The risk relationship is shown in Figure 4.3. It indicates constant risk as linear contours. Acceptable risk is also shown as a line although due to risk aversion this line of acceptable risk is commonly preset as non-linear curve.

![Graphical representation of the relationship expressing risk](image)

**Figure 4.3** Graphical representation of the relationship expressing risk: constant risk contours, acceptable and unacceptable risk, the limit of acceptability

The vertical axis labelled as “frequency of accident” is commonly expressed as annual exceedance frequency as shown in Figure 4.3. In general the term used to denote any measure predicting a future occurrence of accident is called “likelihood” [4.10: 4]. In the common literary language the term “likelihood” is used as a synonym of “probability” (Figure 4.4). However, in the risk analysis uses this term to denote either frequency or probability or any other quantitative measure forecasting future occurrence of accidents. The terminological tradition of OSH is to characterise accidents by the term “rate” which is a quantitative measure expressing, directly or indirectly, the periodicity of accident occurrence. The field of OSH uses the terminological constructs “frequency rate” (US) and “incidence rate” (EU) to reflect occurrences of accidents in the past and, what can be done at the same time, to predict a future occurrence of the accidents. Although industrial accidents involving harm to personnel are or, at least, should be a common subject of risk analysis and OSH, terms used in both fields seem not to be unified.

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The chance of something happening (synonym of probability).

Frequency
The rate at which something happens or is repeated.

Rate
A measurement of the number of times something happens or exists during a particular period.

Incidence
The number of times something bad happens.

The accidents occurring under normal conditions in the workplace are usually limited by the harm caused to the victim. In addition scenarios of such accidents are not utterly complicated and, in many cases, involve an error to perform safely working operations. Industrial accidents causing harm to personnel occur commonly as a sequence or combination of adverse events which escalate into an accident itself. Such sequences are initiated by a failure of system component, error made by worker or operator, or an external event, say, an extreme natural phenomenon or a deliberate adverse action of humans (Figure 4.5).

Formally an industrial accident is only then of interest to persons concerned with occupational safety when consequences of the accident involve harm to personnel. Unfortunately, many industrial accidents involve such harm. Therefore the field risk analysis developed quantitative measures which are used to express the number of fatalities or injuries which can occur among employees of the plant where the accident occurs and the general public subjected to the hazard of this accident. These measures are evaluated using the data on past accidents and at the same time they serve as predictions of future accidents, that is, measures of the likelihood of the accidents.

4.2.2 Measures of the likelihood of harm to people used in risk analysis

The number of injuries and fatalities which can be encountered in an industrial accident can be expressed by the fatal accident frequency rate (FAFR). It expresses the average number of deaths by accidents in $10^8$ hours of a particular activity:

$$1 \text{ FAFR} = \frac{1 \text{ fatality}}{10^8 \text{ hours}} = \frac{1 \text{ fatality}}{(10^8 \text{ hours})/(24 \times 365 \text{ hours/year})} = \frac{1 \text{ fatality}}{11,415 \text{ years}}$$

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Thus one FAFR corresponds to one fatality in 11,415 years or 87.6 fatalities per one million years. Thus a motor driver according to Figure 4.6 would, on the average, encounter a fatal accident if he/she drove continuously 17 years and 4 months, while a chemical industry worker requires more than 3000 years for his/her fatality. Figure 4.6 illustrates risk exposure during a typical day. One can see that values of FAFR related to occupational activities range between 3.5 and 70. These values were estimated for the daily work in chemical industry and construction, respectively. Table 4.2 shows numbers of FAFRs related to some occupational and non-occupational activities. The can be compared to values shown in Figure 4.6. This table shows that the risk of death from structural failure is very small.

![Figure 4.6](image)

**Figure 4.6** Fatal accident frequency rates (FAFRs) of daily activities [4.3]

<table>
<thead>
<tr>
<th>Activity</th>
<th>FAFRs (or risk of death per hour per 10^8 persons exposed to hazard)</th>
<th>Hours of exposure per person per year</th>
<th>Ratio of wounded to number of deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trawl fishing (deep sea, 1958…1972)</td>
<td>59</td>
<td>2900</td>
<td>Not reported</td>
</tr>
<tr>
<td>Flying (crew)</td>
<td>120</td>
<td>1000</td>
<td>&lt;&lt;1</td>
</tr>
<tr>
<td>Flying (passengers)</td>
<td>120</td>
<td>100</td>
<td>&lt;&lt;1</td>
</tr>
<tr>
<td>Coal mining</td>
<td>21</td>
<td>1600</td>
<td>Not reported</td>
</tr>
<tr>
<td>Automobile travel</td>
<td>56</td>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>Construction</td>
<td>7.7</td>
<td>2200</td>
<td>450</td>
</tr>
<tr>
<td>Home accidents</td>
<td>2.1</td>
<td>5500</td>
<td>Not reported</td>
</tr>
<tr>
<td>Factory work</td>
<td>2</td>
<td>2000</td>
<td>Not reported</td>
</tr>
<tr>
<td>Building fires</td>
<td>0.15</td>
<td>5500</td>
<td>5</td>
</tr>
<tr>
<td>Structural failure</td>
<td>0.002</td>
<td>5500</td>
<td>6</td>
</tr>
</tbody>
</table>

Another measure of the likelihood of fatal industrial accidents is used at drawing the so-called Farmer’s curves [4.6:37, 4.10:5]. They are relations of the annual frequency of \( x \) or more fatalities caused by 100 nuclear power plants. These frequencies are compared with fatal frequencies caused by air crashes, fires, dam failures, explosions, chlorine releases, and air crashes (Figure 4.7). Non-nuclear frequencies are normalised by a size of population affected by 100 nuclear power plants; these are not frequencies observed on a world wide scale. Each curve in Figure 4.7 is called the Farmer curve or the risk profile. The horizontal axis denotes the accident severity and the vertical one the complementary cumulative frequency per unit time.
\[
fr(x) = 1 - \frac{\text{at least } x \text{ fatalities per year}}{N}
\]  

where \(N\) denotes the size of the affected population.

Only fatalities greater than or equal to 10 are displayed in Figure 4.7. This is an exceptional case. Statistics on fatalities usual start with unity. In actual risk problems, a zero fatality has a far larger frequency than positive fatalities. Inclusion of a zero fatality in the Farmer curve requires the display of an unreasonably wide range of likelihoods.

The Farmer’s curves introduce a probabilistic approach in determining acceptable safety limits [4.6: 101]. Frequency and consequence values are calculated for each level of risk, generating a curve that is unique to the hazard of concern. The area to the right (outside) of the curve is generally considered unacceptable, as the frequency and consequence values are higher than the average value delineated by the curve. The area to the left (inside) of the curve is considered acceptable, as frequency and consequence values are less than the estimated value of the curve.

![Figure 4.7 Comparison of annual frequency of \(x\) or more fatalities [4.4]](image)

In principle, the frequencies (4.1) and (4.2) can be applied to both fatalities and injuries. Unfortunately, Farmer’s curves given in Figure 4.7 reflect fatalities among general public exposed to the hazards of activities represented by individual curves. Therefore they can hardly be of direct interest to estimating the likelihood of accidents in specific situations of exposure to workplace hazards. The measure of FAFR is, to the contrary, very simple and very close to measures of likelihood of workplace accidents. It differs from them only in the way how the exposure to workplace hazards is measured.

### 4.3 Likelihood of Workplace Accidents

#### 4.3.1 Accident frequency rate in US occupational statistics

Workplace accidents are measured and indicated by numbers of occurrences, fatalities, or injuries. Likelihood of accidents can be expressed by the frequency rate of accidents and injuries. If \(A\) is the event for which the frequency rate is to be calculated, \(B\) is the numerical base and \(C\) is the exposure, then

\[
\text{Frequency rate} = \frac{A \times B}{C}
\]  

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If 1 000 000 man-hours is used as the base, an accident frequency rate can be computed by

$$\text{Accident frequency rate} = \frac{\text{number of accidents} \times 1 000 000}{\text{man-hours of employee exposure}} \quad (4.4)$$

A plant that had 18 accidents in a year during which employees worked a total of 1 200 000 man-hours, the accident frequency would be

$$\text{Accident frequency rate} = \frac{18 \times 1 000 000}{1 200 000} = 15.0 \text{ per million man-hours}$$

If during the same time there were 6 disabling injuries at that plant, the injury frequency would be

$$\text{Injury frequency rate} = \frac{6 \times 1 000 000}{1 200 000} = 5.0 \text{ per million man-hours}$$

The Bureau of Labour Statistics uses a base of 100 full-time employees as opposed to the 1 million man-hours used by American National Standard Institute (ANSI). It is assumed that 100 full-time employees would work 200 000 hours (40 hours per week per worker, 50 weeks per year). Computed on this basis, the injury frequency rate for the plant mentioned would be

$$\text{Injury frequency rate} = \frac{6 \times 200 000}{1 200 000} = 1.0 \text{ per 200 000 man-hours}$$

It is therefore evident that when rates are cited it is necessary to know the basis \( B \) on which they were calculated.

### 4.3.2 Accident incidence rate in EU occupational statistics

The ESAW (European Statistics on Accidents at Work) methodology considers 2 main types of indicators on accidents at work: the numbers of accidents and the incidence rates [4.1: 21]. The numbers of accidents are related to the reference population of persons in employment (persons exposed to the risk of accident at work). This allows to establish the incidence rates (frequency).

The incidence rate is defined as the number of accidents at work per 100 000 persons in employment:

$$\text{Incidence rate} = \frac{\text{number of accidents (fatal or non-fatal)} \times 100 000}{\text{number of employed persons}} \quad (4.5)$$

The incidence rate can be calculated for Europe, a Member State, or any sub-population breakdown according to one or more of the variables above characterising the victim of the accident (economic activity, age, etc.). It can be established for all accidents or breakdowns according to one or more of the variables above characterising the accident (part of body injured, etc.). Separate incidence rates are calculated for fatal accidents and accidents leading to more than 3 days’ absence.

Furthermore, an additional incidence rate is calculated for fatalities at the European level, which excludes road traffic accidents, in order to provide comparable incidence rates for all Member States. This is due to the fact that road traffic accidents in the course of work are not recorded as accidents at work in a few Member States. Fatalities caused by road traffic accidents represent an important share of the number of fatal accidents. For this reason, comparisons of national incidence rates for fatalities would introduce a serious bias without this adjustment of the rates. This applies also to accidents on board of any means of transport during a journey in the course of work, which are also excluded from this adjusted rate of fatalities.

### 4.3.3 Validity and application of data on accidents

Accident statistics and frequency rates are derived from the after-the-fact (historic) data on accidents which is used to determine the safety level of any plant or industry. This data may be indicative only after there has been a sizable accumulation of past numerical accident information. These data generally provide limited answers about relationships between causes and effects so only broad accident prevention measures can be taken.

Accident statistics do provide valuable information to regulatory agencies and insurance companies. They identify causative factors and whether additional safety measures are needed to lessen future accidents. Insurance company can use accident data to establish costs of future premiums for employers.
Some safety engineers use accident rates for comparative purposes to determine:

- How rates for his/her plant or company compare with the averages for the industry.
- How accidents, injuries, and severity compare from period to period and whether are improving or deteriorating.
- How different types of hazardous operations compare.
- How well different departments are doing regarding safety. An increase in rates may indicate a lack of supervisory emphasis. The data can also be used to determine which department or plant had the best or worst performance if an accident prevention competition is held.

### 4.4 OUTCOMES OF WORKPLACE ACCIDENTS

#### 4.4.1 Consequences and severity of industrial accidents

An industrial accident occurs due to a failure of an engineering system, no matter what scenario has led to this failure. The failure of the system could lead to a need to assess potential failure consequences and severities (Figure 4.8). Failure consequences are the results of the action or process of failure. Failure severity is the quality, condition, strictness, impact, harshness, gravity, or intensity of the failure consequences. The amount of damage that is (or that might be) inflicted by a loss or catastrophe is a measure of the severity.

**Failure consequences**
For an event of failure, consequences can be defined as the degree of damage or loss from some failure. Each failure of an engineering system has one or more consequences. A failure could cause, for example, economic damage, environmental damage, injury, or loss of lives. Consequences must be quantified in terms of failure-consequence severities using relative or absolute measures for various consequence types to facilitate risk analysis. For an event of success, consequences can be defined as the degree or reward or benefits from success. Such an event could have, for example, beneficial economic outcomes or environmental effects. Consequences must be quantified using relative or absolute measures for various types to facilitate risk analysis.

**Failure severity**
Failure severity is an assessment of potential losses related to failure consequences.

![Figure 4.8](image.png)

Event consequences from the standpoint of risk analysis

Each system failure that can arise has consequences and severities. A failure could cause economic damage, such as reduces productivity, temporary or permanent loss of production, loss of capital or bad publicity. It could also result in more serious events, such as environmental damage, injury or loss of human life, of public endangerment. The severity can not be assessed with certainty but it is preferable to try to define it in monetary units. Failure severity is an assessment of potential losses that could include losses of

- Property
- People
- Wildlife
- Environment
- Capability to produce, etc.

Consequence and severity estimators are based on either events in past history or on educated guesses and include analytical predictive tools.

One of the most difficult and debated steps in determining the risk associated with an engineering system can be quantification of the consequences and severities. For instance, the value of property can be easily determined based on the expense required to replace or restore the damage caused by a failure. But placing a numeric value on other losses is not as direct or simple. Two of them most difficult consequences to quantify are the loss of human life and damage to the environment. One way to quantify these consequences is to place different levels of loss in different categories. For example, any event that results in the loss of one or two lives might be labelled as a category 4 loss, an event resulting in three or four lives would be a category 3 loss, five to six lives would be a category 2 loss and seven or more lives lost would be a category 1 loss. The Marine Safety Evaluation Program (MSTEP) of the US Coast Guard has used this type of conse-
Certain consequences can be judged by different groups of people to have different levels of importance. Therefore, in risk analysis, the consequences must somehow be quantified even if they are qualitative, and a number or quantity assigned to a particular consequence must be clearly defined as part of a complete risk study.

### 4.4.2 The cost of occupational accidents

Accidents at workplace are indicated by numbers of occurrences, fatalities, and injuries. Over the years monetary values of losses become established as the principal means by which values of accidents are estimated and based in courts. Table 4.3 indicates many of the economic factors involved because of accidents and attendant safety costs.

#### Table 4.3 Losses due to accidents and other safety costs [4.1]

<table>
<thead>
<tr>
<th>Losses to or because of personnel</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Labour time for persons killed and injured</td>
<td></td>
</tr>
<tr>
<td>2. Degradation of capabilities in activities such as employment, sports, or recreation</td>
<td></td>
</tr>
<tr>
<td>3. Medical costs for intermediate care of victims in an accident, or their extended care and rehabilitation</td>
<td></td>
</tr>
<tr>
<td>4. Consortium of a spouse who had been killed or severely injured; awards to surviving children</td>
<td></td>
</tr>
<tr>
<td>5. Labour time of fellow workers distracted by nearly being injured in a fire, collision or other “near miss”</td>
<td></td>
</tr>
<tr>
<td>6. Time of managers and other supervisory personnel, public relations and other stuff members whose activities were distracted or who were required to participate in corrective action</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Losses or damage can include</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Equipment, product system, facility, plant or material damaged or destroyed</td>
<td></td>
</tr>
<tr>
<td>8. Degraded operations</td>
<td></td>
</tr>
<tr>
<td>9. Overhead costs while damaged or destroyed plans are not operating or productive</td>
<td></td>
</tr>
<tr>
<td>10. Actions to correct deficiencies (redesign or retooling)</td>
<td></td>
</tr>
<tr>
<td>11. Disruption of operating schedules and lessened outputs because of accidents or unsafe conditions</td>
<td></td>
</tr>
<tr>
<td>12. Recalls, including investigations, redesigns corrections, public notifications, legal actions, and attendant problems</td>
<td></td>
</tr>
<tr>
<td>13. Notifications, investigations, and liaisons with internal organisations, insurers, or municipal or state agencies</td>
<td></td>
</tr>
<tr>
<td>14. Accident evaluation and reporting</td>
<td></td>
</tr>
<tr>
<td>15. Obsolescence of a product and accompanying materials</td>
<td></td>
</tr>
<tr>
<td>16. Loss of public confidence</td>
<td></td>
</tr>
<tr>
<td>17. Loss of prestige</td>
<td></td>
</tr>
<tr>
<td>18. Deterioration of morale of company personnel</td>
<td></td>
</tr>
</tbody>
</table>

**Hazards, accidents or their possibilities create losses and costs for**

<table>
<thead>
<tr>
<th>Costs of the government include</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19. Insurance premiums for workers’ compensation</td>
<td></td>
</tr>
<tr>
<td>20. Car liability and physical damage liability and coverage against fires, marine, boiler and machinery, and glass damage</td>
<td></td>
</tr>
<tr>
<td>21. Amounts not covered by deductibles or because limits were exceeded</td>
<td></td>
</tr>
<tr>
<td>22. Legal costs such as review of insurance, litigation initiated because of accidents and their defence</td>
<td></td>
</tr>
<tr>
<td>23. Fines, penalties, or other punitive actions because of violation of public laws</td>
<td></td>
</tr>
</tbody>
</table>

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All the items listed in Table 4.3 can be expressed by the following equation:

\[
\text{Total safety costs} = \text{immediate losses due to accidents} + \text{rehabilitation and restoration costs} + \text{legal costs} + \text{insurance costs} + \text{welfare} + \text{other safety costs} + \text{immeasurables}
\]

The immediate costs are those due to work losses, damages to equipment and facilities that must later be repaired or replaced, medical, fire and police personnel, and similar items. Welfare applies only to those who are put to this need because of accidents. “Other safety costs” would include the indirect effects resulting from other than the immediate direct losses which are results of accidental deaths and injuries that have already taken place. These indirect effects may be increased due to apprehension regarding accident potential and added insurance premiums, added safeguards, or costs of observance of new laws, fines, or penalties imposed because of non-observance. For example, in April 1986, OSHA (US) ordered the Union Carbide Corporation to pay nearly $1,4 million for “conscious, overt and wilful” safety violations at the Industry, West Virginia pesticide plant where a huge toxic gas leak had injured 135 people [4.5: 7].

**Figure 4.9** Definitions of terms used for recording severity of workplace accidents according to the ANSI standard Z 16.1 [4.9]

### 4.4.3 Severity of workplace accidents in US occupational statistics

Certain industries may show high-injury-frequency rates but the injuries may be minor. Other industries may have few injuries and an extremely low-injury-frequency rate but when injuries do occur they are severe. ANSI has therefore established a means of measuring severity through use of times charges [4.9]. With this method fatalities and injuries are assigned times charges to be used in determining the rates. These changes are based on average experience. For example each fatality or total permanent disability is assigned a time charge of 6000 days (Figure 9). This was based on the life expectancy of the average worker times the average working days per year. Time charges are tabulated in ANSI standard Z 16.1 [4.9]:

- Loss of an arm above the elbow, 4500 days.
- Loss of an eye or sight, 1800 days.
- Loss of both eyes or sight in one accident, 6000 days.
- Complete loss of hearing in one ear, 600 hours, or in both ears (one accident) 3000 days.

Injuries resulting in temporary disabilities are charged the number of calendar days lost for computations by ANSI methods.

With the Bureau of Labour Statistics method, only actual workdays lost are charged. The Bureau of Labour Statistics method requires time charges be included even if an employee is assigned another job. Any change in occupation resulting from a work accident or illness is recordable. Therefore, by ANSI Z16.1:
Disabling injury severity rate = \frac{\text{total days charged} \times 1\,000\,000}{\text{man-hours of employee exposure}} \quad (4.6)

If the six disabling injuries indicated above resulted in 240 days lost, the disabling severity rate would be

```
\text{Disabling injury severity rate} = \frac{240 \times 1\,000\,000}{1\,200\,000} = 200 \text{ days per million man-hours}
```

The average severity per injury can also be determined. This can be done in either of two ways:

```
\text{Average days charged} = \frac{\text{total days lost or charged}}{\text{total number of disabling injuries}} = \frac{240}{6} = 40
```

```
\text{Average days charged} = \frac{\text{injury severity rate}}{\text{injury frequency rate}} = \frac{200}{5} = 40
```

### 4.4.4 Severity of workplace accidents in EU occupational statistics

To the best of author’s knowledge the European occupational statistics does not apply any formal measures of severity of accidents. The word “severity” is not even mentioned in the ESAW methodology [4.1]. The report [4.8] measures “severity” mainly as the number of days which the victim is absent from work after the accident (e.g. Table 53 in [4.8: 170]). The distinction between fatal and non-fatal accidents is also understood as two different degrees of severity of occupational accidents. The ESAW methodology does not also contains any information of financial consequences of occupational accidents.

### 4.5 AN OVERVIEW OF STATISTICAL DATA ON WORKPLACE ACCIDENTS

#### 4.5.1 Generic European occupational data

General statistics on workplace accidents in EU do not tell the whole story, but statistics are an essential part of any analysis of safety and health issues. They reveal, for example, the following ugly truths [4.7]:

- Every three and a half minutes, somebody in the European Union dies from work-related causes.
- Every year, 142 400 people in the EU die from occupational diseases and 8 900 from work-related accidents.
- Up to a third of these 150 000 fatalities each year can be attributed to hazardous substances at work in the EU, including 21 000 to asbestos.

The European Agency for Safety and Health at Work collects occupational safety and health statistics and surveys from around the world. The Agency’s statistical reports cover areas such as accidents at work, demographic trends and work-related diseases. The reports produced by the agency analyse data sources at national and EU level and describe the implications of these Figures for occupational safety and health (see, for example, the report “Noise in Figures” report). The Agency maintains close co-operation with the European Foundation for the Improvement of Living and Working Conditions and Eurostat, the EU’s statistical office, in order to build up a clear picture of occupational safety and health in the EU. Another European organisation collecting occupational statistics, among other data of very broad spectrum, is EUROSTAT [4.1, 4.8].

Safety and health policy and practice have to adapt. Working environments are continually changing as a result of the introduction of new technologies, changes in the way work is organised, and shifts in economic, social, and demographic conditions. Europe’s workforce is:

- Ageing.
- Becoming more female.
- Employing an increasing proportion of migrant workers, both legal and undeclared.
- Using more temporary and part-time workers.
- Making increasing use of new technology.

The European Agency for Safety and Health at Work collects and publicises statistics for the major safety and health topics, and the most hazardous sectors. These are some of the most significant [4.7]:

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Agriculture

The fatal accident rate for the old EU 15 Member States is 12.6 per 100,000 workers; for accidents with more than three days’ absence, the rate is more than 6,000 per 100,000 workers. These are some of the highest rates for any industry. In the old Member States just 4% of the working population work in agriculture, but in the new Member States it is 13.4%.

Construction

Around 1,300 workers are killed each year, equivalent to 13 employees out of every 100,000. This is more than twice the average of other sectors.

Education

Some 15% of employees in Europe’s education sector, from teachers and cooks to administrative staff, have suffered physical or verbal abuse at work.

Health care

The accident rate in the health care sector is 34% higher than the EU average.

Muscular disorder diseases

Lower back disorders affect 60…90% of people at some point in their life; at any one time, 15…42% are affected.

Noise

An estimated one third of Europe’s workers - more than 60 million people - are exposed to high levels of noise for more than a quarter of their working time.

Small and medium size enterprises

There are 19 million small and medium-sized enterprises (SMEs) in the EU, employing nearly 75 million people. However, SMEs record an over-proportional 82% of all occupational injuries, rising to about 90% for fatal accidents.

Stress

More than one in four workers are affected by work-related stress in the European Union.

Young workers

Across Europe, 18 to 24-year-olds are at least 50% more likely to be injured in the workplace than more experienced workers.

4.5.2 Specific European data on workplace accidents

4.5.2.1 Reporting procedures

Detailed results of the harmonised collection of statistical occupational data of EU-15 countries can be found in the report [4.8]. The data collection was carried out by Eurostat together with EU-15 States. The data was collected by applying ESAW methodology which was introduced to harmonise and coordinate data collecting and recording in EU [4.1].

In accordance with the Framework Directive [4.12], all cases of accidents at work leading to an absence of more than three calendar days are included in the ESAW data. The Framework Directive (Article 9) speaks about working days. However, it has been decided for ESAW methodology to follow the most common practice in the Member States, which is to use calendar days in calculating the number of days with an absence from work. In practice it means that an accident at work is included in ESAW if the person is unfit for work for more than 3 days even if these days include Saturdays, Sundays or other days where the person is not usually working. It is considered that accidents with more than 3 days’ absence from work have a higher reporting level than accidents with less than 4 days’ absence, allowing to achieve better data quality. A fatal accident at work is defined in ESAW as an accident which leads to the death of a victim within one year of the accident.

Eurostat receives the ESAW data from the Member States’ national registers or other national bodies responsible for the collection of data on accidents at work. The ESAW data are occurrence-related and based

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on administrative sources in the Member States. ESAW data therefore depend on the operative reporting procedures, the possibility of modifying these or adapting their data to ESAW concepts and specifications.

Mainly, two types of reporting procedures can be identified in the various Member States of the European Union. The insurance-based systems, which can be found in 10 Member States, have reporting procedures mainly based on the notification of the accidents to the insurer, public or private according to the case. On the other hand the reporting procedures of the five other Member States (Denmark, Ireland, the Netherlands, Sweden and the United Kingdom) are mainly based on the legal obligation of the employer to notify the accidents to the relevant national authorities, which is often the National Labour Inspection Service.

**Insurance-based systems**

In the insurance-based systems, the supply or the refunding of care benefits and the payment of benefits in cash (daily subsistence allowances, rents where applicable, etc.) resulting from accidents at work, are conditioned in its report to the public or private insurer. Additionally, in a number of these countries, the benefits thus paid under the accidents at work insurance legislation are higher than in the case of non-occupational accidents. Thus, there is an economic incentive for the employer and the employee to notify an accident at work in the insurance-based systems. Due to these various factors, the reporting levels for accidents at work are in general very high in the insurance-based systems and considered being about 100 percent. However, the coverage of the data on accidents at work in these Member States is defined by the actual coverage of the insurance schemes. For example, some groups such as self-employed are often not covered by the insurance system or employees in the public sector or specific economic activities (Fishing, Mining, etc.) are covered by specific scheme which data is not always available.

**Non insurance-based systems**

The five other Member States have in general a system of universal social security “coverage”, i.e. national health systems where treatment is free of charge at the point of delivery. In such systems the benefits provided to the victim of an accident at work are not depending on a preliminary reporting of the accident, except for the specific benefits paid for the most serious accidents (rents for permanent disability, etc.). Consequently, the economic incentive for notifying accidents at work is not very strong in the non-insurance based systems. Nevertheless, there is a legal obligation for the employer to notify an accident at work for all branches of economic activity and all groups of professional status. In practice only a part of work accidents are actually reported and the systems based on the employers liability to notify work accidents to the authorities have only a medium reporting level usually ranging from 30 to 50 percent on average for the main branches of economic activity taken together (see Table 9 in [4.8:52]).

**4.5.2.2 Coverage of economy branches**

All groups or sectors should in principle be covered by national legislation or other statutory arrangements that require cases of accidents at work to be notified to the authorities, or to a private or public insurance body in accordance with the law. However, not all data are compiled for statistical purposes. Either the data are kept in a format that does not allow for statistical analyses or the data files are not for the moment available for the ESAW. For this reason the term coverage in the following should be understood as the coverage of the accidents data that actually have been sent to Eurostat in accordance with the ESAW methodology [4.1].

In general the private sector is covered by all national reporting systems. However, some important sectors are not covered by all Member States. Particularly parts of the Public Sector (in particular Public Administration), Mining and Quarrying and parts of the Transport, Storage and Communication branch (maritime, air or railways transport) are not or only partly covered by the national reporting systems. This includes also Education and Health and Social Work as these branches are partly public in most countries. Some high-risk groups such as off-shore miners or police and fire-brigades are not covered by all countries.

The population included in the ESAW data of the different Member States does not cover the same economic activities or groups of workers. Only 9 branches of activities are covered by the ESAW data of all the 15 Member States:

1. Agriculture, hunting and forestry.
3. Electricity, gas and water supply.
4 Construction.
5 Wholesale and retail trade and repairs.
6 Hotels and restaurants.
7 Transport, storage, and communication.
8 Financial intermediation - real estate.
9 Renting and business activities.

The ESAW incidence rates are then only calculated on these 9 branches where a European frequency can be considered. The total number of persons in employment covered by ESAW in these 9 “common” branches to all Member States and concerned by the calculated incidence rates, was 99.3 million in 1999, about 71% of the total coverage of the ESAW data (Table 8 in [4.8: 52]).

### 4.5.2.3 Examples of occupational data

Table 4.3 shows occupational data extracted from the report [4.8:94] for the 9 “common” branches for the year 1999. The data is related to accidents with more than 3 days absence from work. According to this data the total incidence rate in all 9 “common” branches in EU-15 is

\[
\text{Total incidence rate in EU-15} = \frac{4058272}{99269000} = 4088 \text{ per 100 000 employed persons}
\]

This rate is used to calculate a relative incidence rate related to individual branches. The latter number is a simple percentage of the former:

\[
\text{Relative incidence rate in EU-15} = \frac{\text{Incidence rate in branch}}{\text{Incidence rate in EU-15}} \times 100 \quad (4.7)
\]

Values of this indicator are given in the last column of the Table 4.4. The relative incidence rates are shown also in Figure 4.10 where they can be compared with the ones calculated for the branches “fishing”, “health”, “mining”.

<table>
<thead>
<tr>
<th>Coverage area</th>
<th>Number of employees in 1000s</th>
<th>Number of accidents in 1999</th>
<th>Incidence rate in 1999</th>
<th>Incidence rate in 2000</th>
<th>Relative incidence rate in 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>All 9 branches</td>
<td>99 269</td>
<td>4 058 272</td>
<td>5 124</td>
<td>845 315</td>
<td>1158</td>
</tr>
<tr>
<td>Agriculture, hunting and forestry</td>
<td>30 021</td>
<td>1342 302</td>
<td>1158</td>
<td>16 459</td>
<td>9 412</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>10 826</td>
<td>845 694</td>
<td>1158</td>
<td>16 459</td>
<td>7 570</td>
</tr>
<tr>
<td>Electricity, gas and water supply</td>
<td>21 037</td>
<td>525 071</td>
<td>1158</td>
<td>16 459</td>
<td>44 752</td>
</tr>
<tr>
<td>Construction</td>
<td>5425</td>
<td>201 328</td>
<td>1158</td>
<td>16 459</td>
<td>1851</td>
</tr>
<tr>
<td>Wholesale and retail trade and repairs</td>
<td>7832</td>
<td>196 412</td>
<td>1158</td>
<td>16 459</td>
<td>44 752</td>
</tr>
<tr>
<td>Financial intermediation &amp; real estate</td>
<td>17846</td>
<td>319 412</td>
<td>1158</td>
<td>16 459</td>
<td>44 752</td>
</tr>
</tbody>
</table>

Figure 4.11 shows the relative incidence rates calculated for specific workers groups, namely, older workers, craftspeople, part-time workers, workers doing shits or working at night, young workers, male workers, workers employed by SMEs, and workers with less that 2 year of seniority. It is obvious from Figure 4.11 that the relative incidence rates for these groups of employees exceed the EU-15 average calculated by the formula (4.7).

A further example of a the visualisation of the statistical occupational data presented in the form of tables reported in the document [4.8] are pie charts shown in Figures 4.12 and 4.13. These graphs are also related to the data reflecting the occupational situation in the year 1999.

Figure 4.12 indicates the distribution of accidents according to the number of days the victim is absent from work. It is easy to see that accidents causing permanent disability (incapacity) or absence from work for at least 3 months amount only for 4% of all reported occupational accidents. However, accidents with more
that 3 days of absence from work make up 63% of accidents. It is also clear that the number of accidents causing relatively low harm to victims, which is reflected by the short absence from work (less than 4 days), comprise relatively high percentage of accidents, namely, 37%.

Figure 4.13 represents data on work-related health problems. This data covers all diseases, disabilities and other physical or psychological problems, apart from accidental injuries, suffered by persons during the last 12 months, caused or made worse by the work.

![Figure 4.10](image1.png)

**Figure 4.10** Relative incidence rate of accidents at work by economic activity (EU-15, 1999, all accidents at work, EU mean = 100, source [4.8: 101])

![Figure 4.11](image2.png)

**Figure 4.11** Relative incidence rate of accidents at work by sensitive workers group including accidents that did not lead to an absence from work or resulted in less than four days’ absence from work (EU-15, 1999, all accidents at work, EU mean = 100, source [4.8: 101])

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4.5.3 Lithuanian occupational data

Lithuanian occupational data is collected by the State Labour Inspectorate (URL: http://www.vdi.lt). This organisation has fully implemented the ESAW methodology of data collection and recording. A short extraction of Lithuanian occupational statistics is given in Figures 4.14 to 4.17. These figures were extracted from the report of the Inspectorate on 2006.

In the statistics of the Inspectorate, occupational accidents are classified into

- Fatal accidents.
- Heavy non-fatal accidents (accidents causing serious injuries with possible permanent disabilities).
- Light non-fatal accidents (accidents causing absence from work for at least one day and causing light injuries which do not result in permanent disabilities).

According to the methodology of ESAW, the reports of the Inspectorate present numbers of accidents as well as incidence rates calculated by Formula (4.5). Figure 4.14 shows the general numbers of accidents encountered the years 1997-2006. This figure covers accidents which occurred in the course of work and com-
muttering accidents. In Lithuania, accidents of these two types are reported in the documents known as Form N-1 and Form N-2, respectively.

Figure 4.14 Number of accidents at workplace and road accidents in Lithuania in 1997-2006

Figure 4.15 shows the numbers of accidents of the aforementioned three categories for the years 2002 to 2006. This figure clearly indicates the increase (upward trend) of light and heavy accidents in the last five years. The average number of fatal accidents in these years was 104. Number of fatal accidents fluctuates over the period 2002 to 2006.

Figure 4.15 Number of workplace accidents in Lithuania in 2002-2006

Figures 4.16 and 4.17 indicate numbers and incidence rates of accidents in 2005/2006 by economic activity. A conclusion which can be drawn from these two figures is evident: the most hazardous industry in Lithuania is construction. In 2006, of the 108 of fatal accidents, 29 (27 %) occurred in the industries of construction and transportation, and 13 in manufacturing. In 2005/2006, the construction industry was in the “leading” position causing fatal and non-fatal accidents. This contribution of construction corresponds to the highest rate of this branch in EU-15 statistics shown in Figure 4.10. In Lithuania, construction was “followed” by the branches of manufacturing and transportation in the sad statistics of occupational accidents.
4.5.4 **Controversial issues of collecting data on workplace accidents**

In industry, many injuries, especially the lesser ones, would never even be reported. It has been estimated that the number of industrial accidents and injuries is actually ten times that cited by the National Safety Council (US) [4.1: 6]. Some industrial companies may fail to report properly the occurrences of accidents or will downgrade their severity to lessen insurance costs or indicators of unsafe plants or operations. Non-disabling injuries not always reported. Other data lacking on accident experience can be listed:

- Deaths and injuries resulting from workers assimilating toxic, fine but debilitating solids, or radioactive substances after-long term exposures to injurious working conditions.

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To defend good safety records some companies hide knowledge of injuries either by not reporting them or by transferring workers to less strenuous activities they are physically able to perform. In this way, companies rationalise there have been no lost-time injuries to report.

Only certain industries are required to report injuries, which omits, for example, employments not covered by workers’ compensation, such as some agricultural or domestic service.

Certain losses are rarely or never reported. For example, in US, railroads report damage that occurs to their equipment, track, and roadbed, and little more. Nothing is included for the amounts accidents cost the railroads for injuries or damage occurring off the track or roadbed, freight losses, evacuations because of ruptures of tank cars or toxic fluids.

Legal costs resulting from accidents.

References


Examination questions

1. How are classified workplace accidents according to mortality, time of absence from work, place of occurrence and link to occupational activity?
2. How are workplace accidents categorized by taking into account industrial accidents?
3. What are the indicators for the reporting workplace accidents in European Union? How to calculate incidence rate of workplace accidents?
4. List the five branches of industry in EU-15 countries and Lithuania with the highest rates of workplace accidents.