

Monitoring of Accidents and Risk Events in Industrial Plants

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Abstract: Monitoring of Accidents and Risk Events in Industrial Plants: Krzysztof SWAT. Nofer Institute of Occupational Medicine—The aim of our 3-year study begun in 1994 is to develop an organizationally useful method of recording risk events in plant to help in finding causes of accidents and preventing them. In the first stage, four plants in different industrial branches were selected for the study: foundry, machinery, meat processing and furniture. The four plants employed a total of 2,964 workers. Eighty-three accidents which happened in 1993 were analyzed from the view point of frequency, severity and their direct and indirect causes. Plants had different frequency rates for different types of accidents. At least 45.8% of the accidents studied involved violation of the fundamental principles of housekeeping. An additional study on accidents and minor injuries carried out in 1994 in the meat processing plant revealed that 95% of all incidents are not reported. The conclusions of the study are as follows: 1. Accidents should be recorded according to the circumstances in which they occur and especially to their types whereby information is provided on the type of relevant safety management problem; 2. One should note minor injuries in plant, especially those requiring first aid. There is a surprising repeatability of these events, their sources and effects; 3. Poor housekeeping constitutes a frequent source of accidents and housekeeping control should be incorporated into the safety monitoring system.

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Key words: Occupational accidents, Monitoring of accidents, Incidents, Injuries, Accident prevention, Operation

Conventional methods of documenting accidents in Poland seem to be somewhat infective. Up to now, safety management problems have been solved rather intuitively. No detailed account of the losses resulting from accidents and incidents has been available in Poland. The costs associated with the medical treatment of accident-related

injuries are included in the overall costs of the national health care system operation and the number of accidents does not affect the amount of the insurance premium paid by the plant. Also unplanned events, such as machine stoppages, which point to some disturbances in the production process usually are not monitored.

The aim of the 3-year study begun in 1994 is to develop an organizationally useful method of recording risk events in plant to help in finding causes of accidents and preventing them. The research, sponsored in part by the National Labor Inspectorate (PIP) and State Committee for Scientific Research, is expected to result in a draft project for standardization of accident risk monitoring at industrial plants.

The number of reported injuries constitutes a natural, direct source of information on accident risk. Therefore, first of all, chances for successful monitoring of accidents and slight injuries were investigated. Eighty-three accidents which happened in 1993 in four plants from different industrial branches were analyzed from the viewpoint of frequency, severity and their direct and indirect causes. Additional study on accidents and minor injuries was carried at a meat processing plant in 1994. This paper presents some results of recent investigations and conclusions on possibilities of accident safety monitoring in industrial plants.

Methods

As the first stage, four plants in different industrial branches were selected for the study: foundry, machinery, meat processing and furniture. All these plants are located in Lodz. The foundry manufactures mainly cast iron parts for ovens used in central heating systems. The ovens are also assembled at the foundry. The machinery plant manufactures various types of textile machines. The meat plant processes beef and pork, from slaughter to the final product, such as meat, cured products and preserves. The furniture plant manufactures mainly wooden furniture for living flats, but also some office furniture. All the plants studied are rather old. The bulk of the equipment in the foundry is dozens of years old. The meat processing plant, which had been refurbished ten years ago is relatively the

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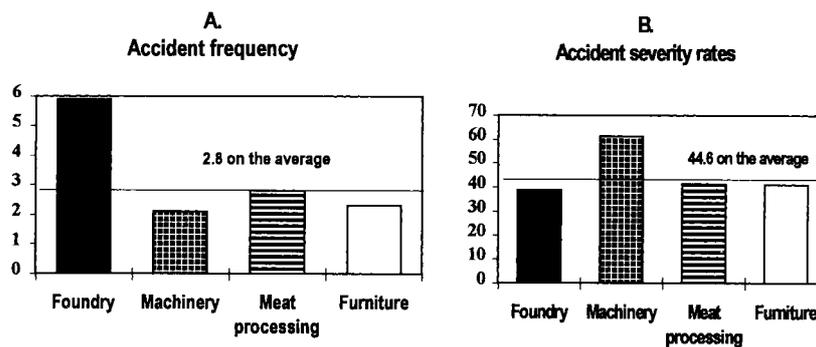


Fig. 1. Accident frequency and severity rates in the individual plants vs. the rate for all plants studied.

most modern. A total number of 2,964 workers were employed in the four plants (334 in the foundry, 1,120 in the machinery, 814 in the meat processing and 664 in the furniture plant) in 1993.

The number of accidents is the most common source of information on the risk involved. In our study, accident means a case formally reported as an accident by the collaborating safety supervisor of each plant. It means a sudden undesired event connected with work, resulting in impairment of health of the worker. Practically only accidents with sick leave days or death cases are reported in Poland. Accident frequency means the number of injury accidents with sick leave days per 100 employees in a year. The accident severity rate is the number of sick leave days per accident. The eighty-three accidents which happened in 1993 were analyzed for frequency, severity and their direct and indirect causes. Our analysis was based on three information sources: collective accident reports provided by safety supervisors, our own investigation of individual accident protocols, and interviews with the safety supervisors and line managers.

The second source of information on the risk of accidents in industrial plant is minor incidents which happen there. Many incidents do not actually result in death, serious injury or serious damage. There incidents as well as accidents constitute a source of valuable information on labor safety in the plant. The analysis performed for the meat processing plant therefore also included minor injuries which had occurred there. Incident means accident or recognized possibility thereof. In our sense, an incident is any sudden event which results in personal injury.

In our work, we attempted to assess the total number of injuries in the meat processing plant. Data on all first-aid cases reported by the plant's outpatient clinic were analyzed. We selected the cases connected with the job performed. In assessing the total number of incidents, results of the interviews with employees were also taken into consideration. We conducted sampling interviews with 96 workers (20% of all blue-collar workers in the plant) asking

them about all, even small, injuries they had in the near past.

Results

1. Accidents

The accident frequency (rates) in plants were: 2.8 for all plants, 5.9 for foundry, 2.1 machinery, 2.8 meat processing, 2.3 furniture, (Fig. 1A). The accident severity rate was 44.6 sick leave days for all plants (38.8 foundry, 61.2 machinery, 41.4 meat processing and 41.2 furniture) (Fig. 1B).

Several types of accidents were distinguished, dependent on the circumstances in which they occurred:

1. falls and slips
2. accidents connected with manual work
3. accidents connected with contact with working parts of machinery
4. accidents connected with contact with sources of energy
5. other.

The accident frequency for selected accident types proved to be distinctly different in the individual plants (Fig. 2).

The frequency rates for the fall and slip accidents (per 100 employees) were 0.7 for all plants but for meat processing they were as high as 1.2 and as low as 0.3 for furniture. The frequency rates for "manual" accidents were 1.1 for all plants but as much as 2.6 for foundry. The frequency rates for the "machinery" accidents were 0.7 for all plants but as much as 1.5 for the foundry. The frequency rates for the "energy source" accidents were only 0.2 for all plants and as high as 0.9 for the foundry. The accidents of other types occurred very seldom (frequency rate 0.1 for all plants). For example, there was only one accident associated with moving vehicles in in-plant transportation, which occurred at the foundry.

We have distinguished 4 essential causes of accidents:

1. Insufficient supervision (inadequate control of whether the worker has followed the correct code of practice),
2. Poor workplace organization (faults in the determination of workplace organization system, e.g. inadequate personal protection, too high a pace of

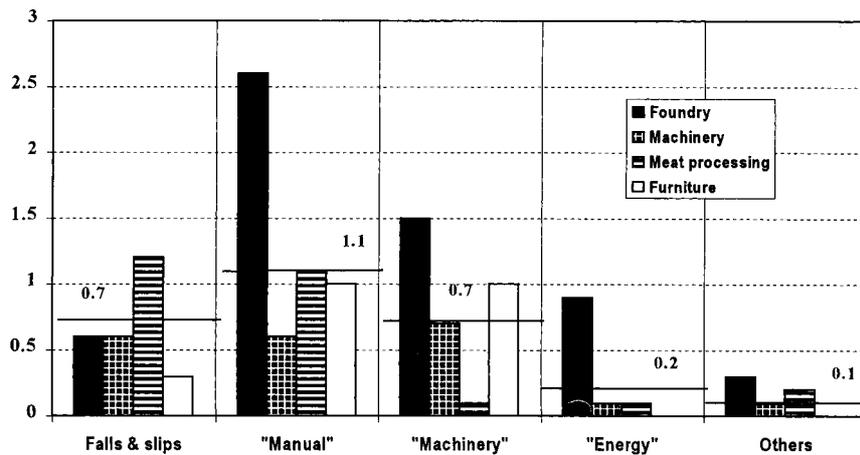


Fig. 2. Accident frequency rates for various accident types in the particular plants vs. mean values for all plants studied.

work, incorrect work procedures, failure to nominate a person responsible for group tasks),

3. Technical factors (defects in technical object, failure to meet the predetermined technical requirements),
4. Worker inadvertence (individual error of the worker difficult to predict by the supervisor, resulting e.g. from an inadvertent action).

At least several abnormalities were found to coexist in almost all the accidents studied. Insufficient supervision was found in as much as 89% of cases studied. Poor workplace organization was involved in 40% of the accidents. Worker inadvertence constituted an essential cause of 14% of accidents. Technical factors were responsible for only 11% of the cases studied. It should be added that the mechanism of 9 (13%) accidents could not be clearly explained.

As the result of frequent coincidence of several sources contributing to a single accident, the above classification cannot be easily employed for accident monitoring.

Poor housekeeping is a frequent source of accidents^{1,2}. This results generally from the faults mentioned above. Where possible, we have isolated the poor housekeeping factor as an accident source independent of the previous classification, as we have concluded that poor housekeeping is an evident symptom of safety management faults and is relatively easy to control.

At least 45.8% of the accidents studied involved violation of the fundamental principles of operation. There were 65% such cases at the foundry; the corresponding numbers for the other plants were: meat processing 47.8%, furniture 37.5% and machinery 33.3%.

The frequency of accidents and their types were found to depend on the housekeeping of a workplace. The recurrent housekeeping-related accidents reported in the study are: slips on slippery floor (12 cases), falls on stairs caused by faulty stair cases (5 cases), stumbles (4 cases), use of improper tools, not suitable for the task involved (4 cases),

Incidence of poor housekeeping-related accidents

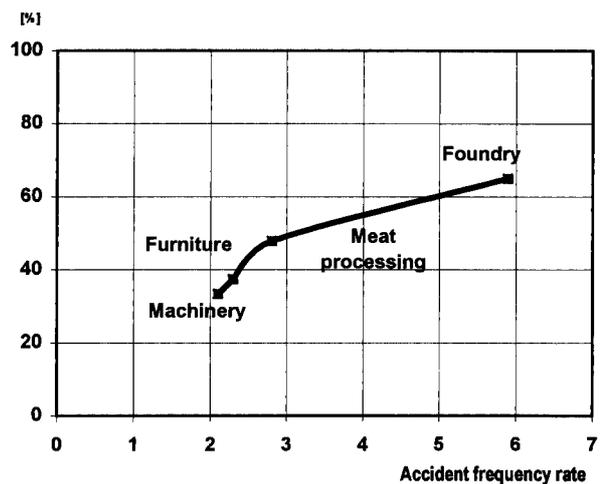


Fig. 3. Relationship between accident frequency rates and the incidence of poor housekeeping related accidents in the plants studied.

scorches caused by hot slag getting into the shoe top as a result of wearing short-legged trousers which shrank when washed (3 cases), and a workpiece falling on the operator's head, hand, foot or leg (7 cases). There were also two other operation-related accidents connected with unsuitable clothes and, among them one serious case in which an unbuttoned apron was caught in rotating machine parts.

The plants in which accident frequency rates were higher, also had a greater share of poor operating factors in the causes of their accidents (Fig. 3). In the foundry, the accident frequency (rate) was 5.9 and the share of operation-related accidents was as high as 65%. In meat processing, the corresponding values were 2.8 and 47.8% in furniture 2.3

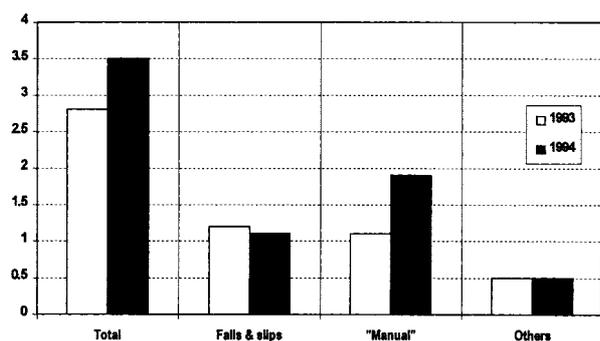


Fig. 4. Accident frequency rates for total and particular-type accidents in the meat processing plant in 1993 and 1994.

and 37.5% and in machinery 2.1 and 33.3%. It seems, therefore, that poor housekeeping should be considered to constitute an integral accident risk factor.

2. Incidents

The accident frequency rate in the meat processing plant increased remarkably from 2.8 (per 100 employees) in 1993 to 3.5 in 1994. The increase in the "manual accidents" frequency rate (from 1.1 to 1.9) was the major contributing factor, (Fig. 4). The "fall and slip" accidents frequency rate was almost unchanged (the respective values being 1.2 and 1.1).

We also attempted to determine the number of all incidents which occurred during 1994, (Fig. 5). We found 254 injuries which required first aid or medical treatment, including twenty-three cases with sick leave days (generally, in Poland only sick leave accidents are reported), of which 5 were serious injuries requiring over 30 sick leave days each. From interviews with the employees, we estimated that the total number of incidents in the meat processing plant was at least 520.

The incidents ratio obtained in our study was as follows: there were 4.6 injuries with sick leave days, 50.8 injuries requiring medical treatment or first aid, and 104 incidents; each serious injury requiring over 30 days sick leave. This means that 95% of all incidents are not reported. Of course the information on risk situations which occurred in the plant might have still been incomplete.

Wounds (cut, chafed or pierced skin) constitute the main category of injuries in the plants studied. Among the 254 reported injuries requiring pre-medical or medical aid, 209 (82%) were wounds and other injuries were remarkably less frequent. There were also 14 scaldings, 11 bruising, 9 sprains, 6 breakages of extremities and 5 other injuries. The majority of cut skin cases were due to the use of knives.

"Manual" injuries (218 cases) constituted the bulk of 254 injuries. There were also 17 "fall and slip" injuries, 14 "energy" injuries, and only one "machine injury." Four "other" injuries did not fall within any of these categories.

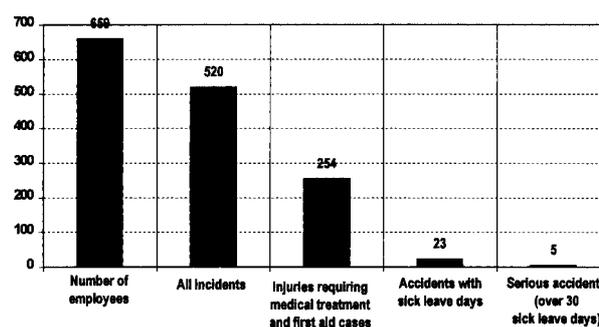


Fig. 5. Incidents and accidents at the meat processing plant recorded in 1994.

Injuries to the upper extremities (219 cases) dominated. The left hand was more frequently injured (148 cases) than the right hand (71 injuries). Fingers were the most frequently injured parts of the upper extremities: there were 114 (77%) left-hand finger injuries and 53 (75%) right-hand ones. Injuries to the palms: 14 (9%) left, 10 (14%) right-hand injuries; to the wrist: 13 (9%) left, 7 (10%) right-hand injuries; and to the forearms: 7 (5%) left, 1 (<1%) right-hand injuries, were less frequent.

Discussion

Monitoring is the final step in the process of accident prevention and it is also the first step: we spot problems for detailed analysis before applying remedies³. Monitoring is a crucial problem in the cycle of prevention activities as it enables suitable control.

The classification of accident types proposed in our study seems to ensure sufficient discrimination between the types of labor safety problems encountered in the plants. This made it possible to isolate the problem of "manual accidents" which contributed to the observed increase in the overall accident frequency rate in the meat processing plant in 1994.

The collection of information on minor injuries in the meat processing plant made it possible to determine how many dangerous events happen in the plant before an accident occurs. Incident studies constitute excellent material for accident prevention in industrial plants. Unfortunately, generally acceptable criteria for collecting information on minor incidents are not available. Information on accidents only is collected in Poland, while e.g. in the U.S.A. the OSH Act⁴ also requires information on injuries without lost workdays on record keeping form OSHA No.200 if the injury resulted in "loss of consciousness," "restriction of work or motion" or "transfer of the employee to another job."

According to Heinrich³, "the ratio 1-29-300 show that in a unit group of 330 similar accidents occurring to the same person, 300 will result in no injury, 29 will produce minor injuries and 1 will cause a serious injury." Heinrich quotes also the Bird accident ratio study where the 1-10-30-600

relationship means that 1 serious or disabling injury occurs per 10 minor injuries and 630 property damage or no loss incidents. In our study, every 20 injury incidents was an accident. The analysis of the total number of injuries which happened in the meat processing plant made it possible to determine the specific character of those events and their most frequent effects and the body parts which are most frequently involved.

A relatively large number of accidents recorded in all studied plants, in which poor housekeeping had a considerable share, encourages us to suggest including the rate of operation-related accidents into the monitoring system. Boylston in his book⁵⁾, *Managing Safety and Health Programs*, states that "No better visible evidence of manager concern for safety and health can be offered than good operation." Saari²⁾ in his *Tuttawa* prevention program has put particular stress to the strict correlation between good housekeeping and safety. Saari¹⁾ states that, following implementation of his method, accidents at a shipyard were reduced by 70–90%. Monitoring of the operation-related accidents share in the overall number of accidents occurring in a specified plant seems to be a valuable tool to use in controlling one of the most common sources of accidents.

Our analysis shows that well-designed monitoring of accidents and incidents may highlight most the important accident risk areas in an industrial plant. Detailed analysis and applying remedies constitute the next step in the accident prevention process.

Industrial analyses are usually conducted at the level of the individual worker only, where the link between the cause and the effect is easy to establish. But safety is not only the sum of safe performance of individual workers; it is rather the technological and human systems which interactively contribute to overall safety in the plant⁶⁾.

"Process safety refers to the protection of people and property from episodic and catastrophic incidents that may result from unplanned or unexpected deviations in process conditions."⁷⁾ We should therefore also attempt to obtain indirect information on safety through monitoring of all unplanned events and production process disturbances, as each unplanned circumstance may serve as a warning symptom. Identifying suitable indirect safety indicators may be an additional promising way to assess work safety particularly in big, technologically advanced industrial plants⁸⁾, where information on unplanned events is automatically collected for the purpose of production process monitoring.

The problem of identifying indirect safety indicators will be the next step in our study on monitoring risk events in industrial plants.

Conclusions

The results of the study should enable development of several general guidelines for monitoring of accident risk in industrial plant.

1. Accidents should be recorded according to the circumstances in which they occurred and especially to their type, eg. falls and slips, "manual," "machine," "energy," vehicle accidents etc., whereby information is obtained on the type of relevant safety management problems in the plant. The comparison of the frequency indicators for particular accident types with the nation-or branch-wide values may possibly supply more information on the extent of safety management faults in the plant studied.

2. One should note also lesser incidents in plant, especially all injuries requiring premedical aid. There is a surprising repeatability of these events and their sources; this provides more abundant data for work safety analysis than the statistically small number of serious accidents which are reported.

3. One should always note whether poor housekeeping affected the occurrence of an injury or its gravity. Poor operation constitutes a frequent source of accidents or contributes to magnifying accident consequences. Poor operation should be regarded as an integral risk factor and operation control should be incorporated into the safety monitoring system.

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