

Safety in materials handling

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HÄKKINEN K. Safety in materials handling. *Scand j work environ health* 7 (1981): suppl 4, 109—114. According to several studies and statistics, approximately 30 % of all occupational accidents occur in materials handling. This paper presents a general description of the work system of materials handling and its elements and safety characteristics and offers some examples of accident prevention possibilities. Also presented is a survey of the methods used to study the safety of materials handling. An analysis of crane accidents revealed that focusing attention on the safety of load fastening and load loosening and improving the tackle itself would reduce crane accidents. Some of the results of a study of the problems of sheet metal handling are also included, as well as the testing of the safety characteristics of plate clamps with a method developed for this particular purpose.

Key terms: accidents, accident prevention, cranes, research methods.

According to various studies (1, 4, 5, 9, 12, 21), about 25—35 % of all occupational accidents occur in materials handling at workplaces. The official Finnish statistics from 1978 show that 28 % of all accidents resulting in at least 3-d absences from work are connected with this activity (18). About half of these accidents occur in manual operations and are due either to overexertion or to slips and falls which occur when materials are being lifted or carried (fig 1). A third of the handling accidents are connected with lifting and transport machinery. Most equipment-related accidents occur when motor vehicles, lifting equipment, forklift trucks, or conveyors are being used. Serious or fatal accidents concentrate in mechanized handling operations.

Materials handling has been a priority area of occupational safety research at the Institute of Occupational Health in Finland from the outset of the safety research program which began about 5 a ago. In addition to preventive studies concerning the focal points of accidents, methods are

being developed for safety and accident analyses applicable in the study of materials handling.

Safety and the work system of materials handling

The work system of materials handling may be studied at different levels. The material flow may be analyzed according to (i) handling at a workplace, eg, a machine; (ii) handling within a department, eg, assembly; (iii) handling at the plant level.

The materials handling system consists of the following elements: the worker, the material to be handled, the equipment

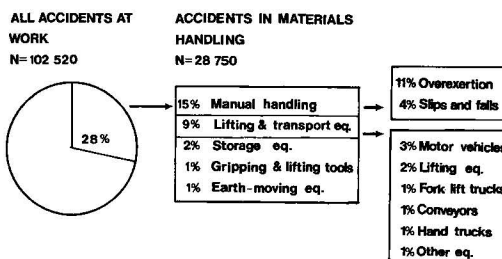


Fig 1. Accidents in materials handling reported in Finland in 1978 (19).

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used, the workplace, and the task. All of these components include characteristics which should be considered in the evaluation of the level of safety. Different methods of accident prevention are possible for each element. Table 1 lists examples of the elements of the work system, some characteristics to be noted, and examples of possible measures to prevent accidents (8, 12).

One must take into account the fact that the operator of different handling tasks is a man, a machine, or a man and a machine working together. The degree of mechanization in transport and handling can be objectively stated according to the proportion of the task carried out mechanically.

The analysis of possible interactions between the elements of the materials handling system is of central importance both to the evaluation of safety characteristics and to the development of measures designed to improve safety. For example, the material itself may damage the lifting equipment, which in turn causes the load to fall and injure the slinger. The design of equipment, such as the placement of controls with respect to visibility, must take into account all the interactions between the elements. A specially tailored system approach is necessary to study manual handling safety in systems in

which complicated interactions are possible between the elements of worker, material, and workplace.

It is essential to determine which elements, which characteristics, and which possible measures are important for improving safety. The objectives of the particular study (eg, machine design or workplace arrangement) and the type of system to be studied, in turn, determine which elements, characteristics, and measures are important. There is, however, a shortage of methods available for the evaluation of safety characteristics and possible measures.

Methods for studying safety in materials handling

A survey of the methods used in safety literature is presented in fig 2. The analysis of accidents is often used as the basis for safety studies and for the development of accident prevention. In an analysis of accidents which occur during materials handling, the study tends to concentrate on certain handling operations, on handling accidents which occur at a particular workplace, or on the equipment used. The reliability of the analysis is highly dependent on the basic information obtained from accident reports. Recently de-

Table 1. Elements of the materials handling system, examples of such elements, their characteristics and examples of accident prevention.

Element	Examples	Characteristics	Examples of accident prevention
Worker	Crane driver, slinger, forklift operator	Education, experience, physical/mental capacity	Training, selection, motivation, use of personal protectors
Material	Sheet metal, timber wastes, machine, fuels	Sharp edges, gripping properties, risks of fire & explosion, weight, size & form	Protective packaging, reducing weights, proper forms & sizes, markings, design of handles & fastenings
Equipment	Forklift truck, overhead crane, hand truck, conveyor	Energy, velocity, mechanical reliability, pinch points, sharp edges, ergonomic properties	Machine guarding, fail-safe components, warning signals, repair & inspection, design of man-machine systems
Workplace	Foundry, warehouse, outdoor roads	Illumination, noise, dust, gases, friction conditions, temperature	Minimizing handling, separation of transport routes, floor material selection, proper illumination conditions
Task	Transport, handling, storage, fastening/unfastening	Time, frequency, monotony	Work organization

veloped accident models and theories offer new ways to collect data about accidents; data collected in these new ways provide more systematic statistics (12, 15, 22).

In many cases, an analysis of the safety problems of both the equipment and the process should take place before any accident has occurred. Various methods of safety and hazard analysis are available for this purpose. For example, fault-tree analysis has been used to evaluate the safety of overhead cranes and magnet lifters (7, 17).

The value of conventional methods of safety analysis in the study of transport and handling is limited, and special methods have been developed for transport operations. These methods are based primarily on the logistic principles presented in the previous section (8, 14).

The study of safety is often carried out using a checklist or other methods of data collection to record observations systematically (3). Photography and video recording have also been used to obtain more objective and versatile information. The so-called photo-optical method has been used, eg, to study the risk of crane collision or risks caused by a freely suspended crane load (18).

The dangerous character of the work in some operations can be revealed in measurements of the physical strain involved. Some accident analyses have shown that the occurrence of accidents, especially in auxiliary tasks accompanying transport (eg, load fastening, entering a cabin, etc) is partially due to the great physical strain the work phases require (6).

Measuring the characteristics of the work environment often provides valuable information on the safety of materials handling. This procedure is especially pertinent with respect to the levels of noise and illumination, both of which are important to communication between men and between men and machines. The analysis of material failures in handling and transport provides another source of information relevant to safety. Data can be collected either about failures in the load transported or about failures of the equipment used (2).

Studies of accidents and safety often involve various types of inquiries. Although

METHODS OF RESEARCH

ACCIDENT ANALYSES

- Case studies
- Statistical surveys

HAZARD ANALYSES

- General
- Transport analyses

PHOTO-OPTICAL ANALYSIS

WORK MEASUREMENTS

- Straining, work loading
- Work conditions: illumination, noise, etc

CHECKLISTS

- Equipment
- Workplace
- Work process

INQUIRIES

MATERIAL FAILURE ANALYSES

- Goods
- Equipment

EXPERIMENTAL PROCEDURES

- Testing of stability
- Testing of visibility
- Strength and reliability

Fig 2. Methods applicable in safety studies of materials handling.

the inquiries alone are insufficient, as the information they provide is subjective, they can be a source of valuable additional information when used jointly with observations and other methods of data collection (16).

The experimental testing of handling equipment is one form of preventive research. Examples of this type of safety research are investigations of the stability and visibility of forklift trucks, the testing of roll-over protective structures, and the testing of lifting tackle and load grippers (10, 20). The development of the methods used for testing is often one result of a research project. These methods may afterwards become part of routine inspections.

Much work is still necessary to develop the methods used in safety research; methods applicable in research on the safety of in-plant transport also require further

Table 2. Distribution of crane accidents (100 accidents occurring in 1976) according to type of accident and part of equipment involved (10).

Object involved in accident	Type of accident					Total
	Falling objects	Blows from objects	Crush between objects	Falls of persons	Over-strain, sprain	
Control equipment	—	2	1	—	—	3
Entrance	—	1	1	1	2	5
Boom, bridge	—	—	4	1	—	5
Entire crane	2	9	5	4	—	20
Lifting gear	2	13	10	2	1	28
Load	9	12	8	1	1	31
Lifters of persons	1	1	1	—	—	3
Objects in environment	—	4	—	—	1	5
Total	14	42	30	9	5	100

Table 3. Distribution of the accidents in table 2 according to the phase of work (10).

Phase of work	Number
Handling of lifting gear	5
Fastening of load	10
Beginning the lift, lifting	20
Steering of load manually	6
Operation and manipulation of crane	9
Descent of load	11
Loosening of load	10
Entering or leaving of cabin	8
Maintenance and repair	5
Erection, dismantling and transport	6
Lifting of persons with a crane	2
Blows from a part of the equipment to an outsider	8
Total	100

development. The issue of measuring safety may now be approached in several ways, depending on the type of work situation concerned. Perhaps one day there will be a universal method, applicable to all handling systems, which is reliable and provides both quantitative and objective safety data even before the occurrence of accidents. Such a method should be simple enough to be suitable for regular use at workplaces. The development of methods for experimental testing to be used in laboratory studies is another important task. Many of the standardized testing methods now available, eg, methods used to test lifting equipment, provide only secondary information about accident risks and the level of safety.

A survey of crane accidents

A study was conducted on accident material from all sizes and types of cranes used in different occupations (10). Although the majority of crane accidents occur during normal lifting operations, other accidents associated with cranes, such as assembling, dismantling, maintenance, repair or transport, are also considered crane accidents.

In Finland, the insurance companies are required by law to report to the labor protection authorities all accidents which result in 3-d absences. I examined 100 of the reports on crane accidents filed in 1976 — this figure represents about 10 % of the total for that year — for the following information: type of accident, part of crane directly responsible for the accident, and work phase in which the accident occurred. The results are shown in tables 2 and 3.

Most of the people injured were workers fastening loads, loosening loads, or steering loads by hand during lifting. The most common types of accidents were hands crushed between the load and the lifting gear, blows from the lifting gear, blows from the load, falling loads, and falling tackle. Only 20 % of the workers injured were crane operators, who were the most susceptible to accidents when entering or leaving the cabin of the crane.

In conclusion, some of the most important measures for the prevention of crane accidents are as follows: (i) mechanizing load-fastening and load-loosening opera-

tions using new types of clamps; (ii) improving the reliability of conventional lifting tackle; (iii) minimizing the possibilities of incorrectly fastening or installing lifting tackle; (iv) improving the communication between crane drivers and slingers — better visibility, good illumination, the development of warning signals, the use of communication devices, etc; and (v) training slingers to fasten loads using different types of lifting tackles.

This sort of accident survey has also been carried out for other types of materials handling machinery. In addition to Finnish data on accidents, the surveys make extensive use of foreign literature on this subject.

Safety in the handling of sheets and plates

The characteristics of work involving the handling of sheets and plates and the safety problems these operations cause were analyzed in seven different firms — one steel works, one shipyard, and five metal-working companies. Process flow studies and accident reports were used when the safety of handling sheets and plates at these firms was evaluated (12, 13).

The study revealed that the most important safety problems in the handling of sheets and plates occur in the following work phases: (i) the binding and packing of sheet stacks in steelworks; (ii) the transport of packed sheet stacks; (iii) the manual handling of sheets at shears and presses with conventional lifting equipment; and (iv) the lifting of heavy plates, in particular, the lifting of heavy plates with clamp-type lifting tackle.

The safety aspects of lifting clamps was thoroughly analyzed (11) and the literature on different types of clamps, and factors of design, use and maintenance which affect the safety of clamps, surveyed. A test method developed for this particular purpose was used to compare clamps used in the vertical lifting of plates (fig 3). The prepressing force of safety locks was not great enough to prevent loads from slipping in the presence of strong lateral forces that occur when the primary clamping force activated by the load is ineffective. The fact that safety locks do not prevent

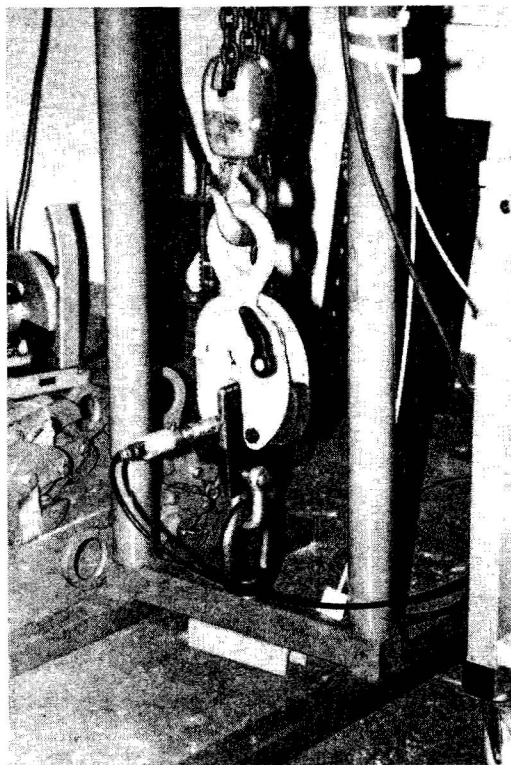


Fig 3. Testing a lifting clamp (11).

accidents which happen when loads slip and plates fall is not generally known. Safe behavior should be emphasized during the use of these clamps. It is important that no one stay in the area where contact with falling plates is possible.

Differences between various types of clamps were found, as well as differences between clamps of the same type manufactured by various manufacturers. In theory, the relation of pressing force to tensile load should be a constant characteristic for each clamp; in practice, however, the tests revealed variations dependent on such features as the thickness of the plate and the magnitude of the load; the relation varied between 1.1 and 2.

The best-designed clamps are those with the greatest relative values of pressing force to tensile load and those with the least variation in their relative values. When the relation of pressing force to tensile is low, even slight wear of the gripping surfaces of the clamp can be critical enough to reduce gripping safety considerably. One disadvantage of clamps with

high relative values is their weight, which makes their handling difficult.

Other clamp characteristics were also evaluated, including the effect of repeated loading on gripping safety and the magnitude of tracks made on plates by the gripping jaws of clamps. Safety regulations based on the results obtained are being prepared.

Further studies of strapping methods and of equipment used to pack sheet metal products are in progress. Gripping tools used in the manual handling of sheets and plates are also being studied and evaluated. Balance type cranes equipped with vacuum grippers have been tested at a guillotine shear, and the effects of mechanization on safety evaluated.

Material has also been collected on various types of handling aids used in sheet metal operations, eg, on hand tools, grippers, conventional crane systems, manipulators, and industrial robots. In addition their safety features have been compared, and ideas for the further development of handling methods have been compiled for operators and manufacturers.

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