

Severe chemical accidents in Finland in 1978–1985

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In Finland about 1 800 occupational accidents occur annually involving injury caused by some chemical. This number accounts for about 2 % of all occupational accidents annually. In some branches of industry the proportion of chemical accidents is much greater. For instance in the pulp industry it is 9 % (1). Chemical accidents seem to be more severe than occupational accidents on the average. About 10 % of all fatal occupational accidents are caused by chemicals (3).

Chemicals also cause many other types of accidents than occupational ones. Chemicals cause injuries in accidents occurring at home and during leisure time, and they cause property and environmental damage without injuries. Finnish fire departments receive about 2 000 alarms per year because of fuel oil leaks, 80 because of explosions, and 220 because of other dangerous properties of chemicals (2).

In Finland severe chemical accidents and pressure vessel accidents must be reported to the Technical Inspection Center even if they have not caused personal injury. During 1978–1985 464 accidents were reported that were investigated by inspectors of the Technical Inspection Center. These investigation reports are stored in a computer data bank, which was formed jointly with the Institute of Occupational Health (2). The Center maintains the register and updates it annually with new cases. The data base includes a complete description of each accident, and each word in the description can be used as a key word in data-base searches. There are also more than 20 classified variables which help to locate the right cases.

The purpose of this paper is to present risk priorities based on chemical accidents in the data base. The personal injuries and costs of different accident types have been used as risk measures. However, the actual consequences of accidents are, for the most part, fortuitous. An accident sequence has seldom resulted in the maximum possible consequences. The subjective estimates of this maximum potential severity of each accident is included in the data base, and in this paper they are used as another measure of risk.

Materials and methods

An accident was defined as a chemical accident when a chemical was involved as a direct or indirect cause

of personal injury, property damage, or environmental damage. In the data base there were 270 such chemical accidents for 1978–1985. They caused 29 fatalities and 105 other personal injuries. The accidents were classified according to 25 variables, and these classifications were included in the data base. Classifications were made, for instance, according to branch of industry, technical device, chemical, process, preceding events, accident type, and actual and potential personal, property and environmental damage. The reliability of the classification was tested beforehand with three estimators, and the classes were corrected when necessary. The reliability of the conclusive variables was determined to be 80–95 %.

The estimates of potential personal injuries, property damage, and environmental damage was based on written accident reports. In particular the amount and the type of chemical involved in the incident and the population in the danger zone were taken into consideration. Potential personal injuries were classified according to the following scale: (i) injuries not possible, (ii) one or two persons in danger but fatal injuries not possible, (iii) 3–10 persons in danger but fatal injuries not possible, (iv) > 10 persons in danger but fatal injuries not possible, (v) death of one or two persons possible, (vi) death of 3–10 persons possible, and (vii) death of > 10 persons possible.

The injuries were also calculated in monetary terms. One fatality was estimated to be equivalent to three million Finnish marks (FIM) (6 000 workdays, each FIM 500) and other personal injury FIM 25 000. Both actual and potential material damage was estimated as follows: < FIM 10 000, FIM 10 000–100 000, FIM 100 000–1 000 000, and > FIM 1 000 000.

Results

Liquefied petroleum gas, carbon monoxide/dioxide, solvents, and gasoline caused the most personal injuries (table 1). Solvents and gasoline, together with liquefied petroleum gas, caused more than 80 % of the property damage.

Potentially these accidents could have killed more than 500 people and injured another 500 people (table 2). The property damage could have been six times higher than it actually was. Liquefied petroleum gas proved to be the most important potential hazard. Solvents and gasoline also have great potential to cause extensive property damage. The potential consequences

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Table 1. Personal and material damages involved in severe chemical accidents occurring in Finland in 1978–1985. (FIM = Finnish marks)

Chemical	Number of accidents	Number of fatalities	Number of other injuries	Property damage (10 ⁶ FIM)
Ammonia	16	1	3	0.8
Chlorine	15	—	12	0.4
Sulfur dioxide	3	—	1	0.1
Carbon monoxide/dioxide	13	12	8	0.7
Liquefied petroleum gas	88	11	47	16.7
Solvents, gasoline	46	3	18	37.3
Fuel oil	76	1	14	7.4
Acid, alkali	13	1	2	5.7
Total	270	29	105	66.1

Table 2. Potential personal and potential material damage of severe chemical accidents occurring in Finland in 1978–1985. (FIM = Finnish marks)

Chemical	Number of accidents	Number of potential fatalities	Number of other potential injuries	Potential property damage (10 ⁶ FIM)
Ammonia	16	53	51	36
Chlorine	15	31	70	6
Sulfur dioxide	3	13	20	1
Carbon monoxide/dioxide	13	37	60	11
Liquefied petroleum gas	88	283	147	120
Solvents, gasoline	46	88	61	137
Fuel oil	76	34	63	50
Acid, alkali	13	7	75	12
Total	270	546	547	373

Table 3. Actual and potential consequences per ton of chemical used in Finland in 1978–1985. (FIM = Finnish marks)

Chemical	Usage (10 ⁶ t/year)	Number of accidents per 10 ⁶ t	Actual damage ^a (FIM/t)	Potential damage ^a (FIM/t)
Ammonia, chlorine, sulfur dioxide	0.94	5	0.6	43
Liquefied petroleum gas	0.12	92	54.0	1 000
Solvents, gasoline	3.0	2	2.0	17
Fuel oil	9.0	1	0.2	3

^a Both personal injuries and property damage.

of toxic industrial gases, ammonia, and chlorine were also notable.

The total personal and property damage caused by accidents involving liquefied petroleum gas was about FIM 50 per used gas ton, which is about 1 % of the market price (table 3). The potential damage was 20 times higher. In ammonia and chlorine accidents the potential damage was 70 times higher than the actual damage.

Table 4. Number of severe chemical accidents occurring in different activities in Finland in 1978–1985 according to the type of accident.

Type of accident	Activity			Total
	Home, leisure-time, agricultural	Manufacturing	Other economic	
Explosion or fire of boilers	1	10	5	16
Explosion or fire of process equipment or stationary tanks	1	33	6	40
Explosion or fire of liquefied petroleum gas	34	5	20	59
Leak of liquefied petroleum gas	1	7	14	22
Leak of ammonia, chlorine or sulfur dioxide	1	20	7	28
Leak of carbon monoxide	6	2	0	8
Leak of fuel oil	16	9	18	43
Leak of solvents, gasoline, acid or alkali	1	10	8	19
Other explosion or fire	2	12	6	20
Other types of accidents	1	3	11	15
Total	64	111	95	270

Two-thirds of the accidents involving liquefied petroleum gas were explosions or fires, and the rest of them were leaks (table 4). Most of the explosions and fires occurred at home or during leisure time or agricultural or other economic activities (construction, service work). Explosions and fires of boilers, process facilities, and stationary tanks and leaks of ammonia or chlorine were the greatest groups of accidents occurring in manufacturing industries.

Ten potential catastrophes with more than 10 possible fatalities were identified. Seven of them were accidents involving liquefied petroleum gas, two of them were ammonia accidents, and one was a sulfur dioxide accident. Notable environmental damage was caused in 11 cases, but potentially such damage was possible in 27 cases. Most of these cases were leaks of fuel-oil products.

References

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