Chemical Accidents and Disasters

Medical Care
Planning Guidance

Socialstyrelsen

THE NATIONAL BOARD OF HEALTH AND WELFARE

Foreword

This book seeks to illustrate the features that distinguish a chemical accident from other accidents and to show how normal disaster planning may need to be supplemented. The book describes what is required for taking care of persons injured or contaminated in accidents involving chemicals and chemical weapons in peacetime and during state of alert. Accidents involving chemicals and accidents involving chemical weapons are described separately where necessary. Protection of the environment following chemical accidents is not discussed.

The book contains recommendations based on expert scientific judgement. Relevant sections of international recommendations regarding planning etc for the event of chemical accidents have been adapted to Swedish conditions and are included in the report. The recommendations are intended as a basis for planning and training and the parts of the text that are considered particularly important are printed in bold/italics type.

Also included are parts of *Sjukvårdens kemskydd* (SoS-rapport 1995: 15). This report is available in English under the title *Chemical protection in Medical Care*.

The material for the book was compiled by Dr Per Kulling, Swedish Poisons Information Centre. The contents were circulated for comments and produced in co-operation with the National Rescue Services Board. The work was scrutinised by the scientific adviser to the National Board of Health and Welfare, Professor Sten Orrenius.

The Board previously published General Advice 1990:10 *Care of Casualties in Chemical Accidents* in the special series *General Advice from The National Board of Health and Welfare*. This material has now been withdrawn through a change in the Board's list of publications (SOSFS 1998:5).

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Background

The risk that chemical accidents can occur has become an increasingly real and present threat. A large number of chemicals are manufactured and handled by industry. Large quantities of chemicals are transported daily by road, rail, sea and air. Manufacture, handling and transport of chemicals has a tendency to increase from year to year. In 1944 the number of known chemical substances was approximately 60,000 but today the number is somewhat over eight million. In July 1991 there were some 30,000 chemical products registered by the National Swedish Chemicals Inspectorate, classed as very toxic, toxic, corrosive, harmful, irritating or moderately harmful. During 1997 approximately three million tons of hazardous substances were transported by rail in Sweden and approximately twenty-six million tons by road. At sea, too, substantial quantities of hazardous materials were transported. Despite all the existing security systems and the preventive measures taken, an accident may still occur under unfavourable circumstances. Many of these chemicals may then cause serious injury to man and damage to the environment.

A survey in Sweden covering the period March 1980 to February 1981 showed 123 accidents involving the release of chemicals (table 1).

Table 1. Accidents involving the release of chemicals in Sweden during one year (March 1980–February 1981).

Ammonia	13
Sulphuric acid	8
Hydrochloric acid	7
Chlorine	6
Coal gas	5
Hydrogen peroxide	4
Nitric acid	3
Sulphur dioxide	3
Liquid Petroleum Gas (LPG)	3
Formalin	2
Caustic soda – sodium hydroxide	2
Nitrogen oxides	2
Other chemicals	65
Total	**123**

Source: Miljödatanämnden (Environmental Data Board) Memo No 216, 12.06.81

National Rescue Services Board statistics from 1996 show that the rescue services were called for help to 2,589 releases of dangerous substances. Most were caused by petrol and diesel oil. Approximately 80 and approximately 50 calls concerned poisonous gases and corrosive substances, respectively.

In some states of the USA (New Jersey, Texas, California, the Mid West) 7,000 accidents were reported between December 1994 to September 1995. 1,500 persons were injured and of these over 135 died. For the whole of the US this would represent some 17,500 to 21,000 accidents.

Between 1974 and 1985 in the OECD countries, ninety-nine serious accidents involving chemicals occurred, with a total of 130 deaths. A serious accident in this connection is defined as one with more than five deaths, more than twenty-five injured, or more than 400 evacuated. 45% of the accidents occurred during the transport of chemicals and approximately 30% of the accidents occurred at chemicals handling facilities. The number of accidents at such facilities, however, showed a tendency to decrease during this period.

Examples of accidents occurring during a five-year period are shown in table 2. This shows that accidents occur in all parts of the world in factories, during transport by road and rail and in pipelines.

Table 2. Examples of accidents following the release of toxic substances 1981–1985.

Year	Place	Substance	Site	Deaths	Injuries
1981	San Juan, Puerto Rico	chlorine	factory	-	200
1981	Montana, Mexico	chlorine	railway	29	1.000
1982	Walsum, Västtyskland	chlorine	factory	7	240
1982	Belle, West Virginia, USA	chlorine		-	13
1983	Denver, Colorado, USA	nitric acid	railway	-	43
1983	Timrå, Sverige	chlorine	factory	1	
1984	Bhopal, Indien	methyl isocyanate	factory	2.500	>200.000
1985	Korraty, Kerala Indien	″toxic″ gas	factory	-	40
1985	Bombay, Indien	chlorine	factory	-	>100
1985	Institute, West Virginia, USA	irritant gas	factory	-	135
1985	Canton, North Carolina, USA	chlorine	factory	-	>20

It is often unfortunate circumstances that make the difference between an incident and a serious accident. Unfavourable weather conditions such as light wind and simultaneous inversion (atmospheric layers of warmer air above colder air), and time of day, are factors that may lead to a relatively slight release of e.g. a toxic gas affecting many people.

Examples of substances in Sweden that are handled in large and that

involve great or very great risks of danger to health in a possible accident are presented in table 3.

Table 3. Risk grouping

Mainly dangerous to health	Main dangers fire and explosions	Both health and fire/explosion danger
Very high risks		
Chlorine	Propane	Acetonitrile
Sulphur dioxide	Butane	Hydrogen cyanide
Ammonia	Acetylene	Hydrogen sulphide
Phosgene		
High risks		
Phenol	Acetone	Methanol
Hydrofluoric acid	Methyl ethyl ketone	Styrene
Hydrochloric acid	Carbon disulphide	Butyl acetates
Nitric acid	Thinner	
Sulphuric acid		
Tetraalkyl lead		
Radioactive substances		
Moderate risks		
Trichlorethylene	Toluene	
Perchlorethylene	Xylene	
	Petroleum distillates	
	Kerosene	

Source: Effektiv räddningstjänst (Efficient Rescue Service), SOU 1983:77

Examples of accidents and disaster simulations

Ammonia

During 1997 there were two train derailments in Sweden (Kävlinge and Kälarne) in which trucks containing chemicals overturned. On these occasions there was no leakage of chemicals that involved any injury to persons but during the rescue work the inhabitants of large parts of two residential areas were evacuated for several days because of the risk of leakage of, among other things, ammonia during the actual salvage work.

In March 1989 there was a breakdown of an ammonia system in an artificial fertiliser plant in Lithuania. Fire broke out and spread to a building some 50 metres from the ammonia cistern in which nitrophosphate was produced. Seven persons lost their lives and at least 55 were more or less seriously injured.

A disaster simulation was run in which an overfilled (brimful) ammonia tank cracked (it was filled with 58 tons instead of 50 tons) when the lorry was in central Uppsala. According to calculations 80 persons would have died immediately, 400 would have received serious lung injuries requiring hospital care and between 4,000 and 5,000 would have sought care at hospitals and medical care centres. According to the calculations, concentrations of 10,000 ppm were measured at a downwind distance of about 300 metres from the leakage and 2,500 ppm at a distance of approximately 750 metres (SOU 1995:24. Preliminary report from the Commission for preparedness against severe peacetime disturbances).

In a number of plant failure models run by the Swedish Defence Research Establishment FOA) (Dreborg et al 1978, Lundmark T 1984), the following emerged. If 3,000 kg of ammonia is released over fourteen minutes at a wind speed of 5 m/s, a concentration of 3,200 ppm (50%–100% suffer fatal injuries) at a distance of up to 500 metres is obtained. After 1.5 minutes there is a concentration of 1,400 ppm (at least 50% suffer severe injuries, possibly death) 500–1,000 metres from the site of release; after three minutes a concentration of 1,000 ppm at 1,000–1,500 metres and after 4.5 minutes, 550 ppm (some serious injures, most slight) at 1,500–2,000 metres from the failure site.

In another model of an accident (Dreborg et al 1978) in which ammonia leaked at a rate of 2,500 kg per minute for seventy minutes (until the tank was empty) the following concentrations would have occurred for seventy minutes: 2,800 ppm (50%–100% fatal injuries) at a distance of 500 metres, 1,500 ppm (at least 50% serious injuries, possibly deaths) at 500–1,000 metres, 550–700 ppm (possibly a number of serious injuries, most slight) 1,000–2,000 metres from the site of the accident.

Failure of a compressor at an ice rink in which ammonia leaks out could possibly have the following consequences (FOA 1997). The cooling system contains 1,350 kg of ammonia and the imagined damage causes leakage of some 2 kg/s which leads to the leakage continuing for just over eleven minutes. The outside temperature is 15ºC and the wind two m/s. After approximately two minutes the ammonia is smelled (without causing irritation) some 400 m from the leak, after four minutes at 500 m and after eight minutes at 750 m from the leak. During the whole period of leakage the concentration is some 130 ppm (irritating) 200–250 m from the leakage, 650 ppm (a number of severe injuries, most slight) some 125 m away and 1,300 (at least 50% serious injuries, possible deaths) just under 100 m from the leak.

Fires

Fires involving toxicity

In November 1997 there was fire in the underground railway station at King's Cross in London. The fire started in an escalator and was probably caused by a match that was discarded and fell between the steps of the escalator and a side wall. Inflammable gases were generated and these collected in the space below the escalator and spread further to the spaces above and to the ticket hall. Suddenly there was rapid combustion. The toxic gases were formed during the burning of material in the ceiling and walls. Thirty-one persons died and over 60 were injured. All those who died did so as a consequence of exposure to hydrogen cyanide formed when plastic material in the roof and walls caught fire.

In spring 1990 there was a fire on the passenger ferry Scandinavian Star in traffic between Oslo and Copenhagen. A total of 158 persons died and most, more than 90%, died as a consequence of exposure to toxic gases formed during the burning of material on the ship. The toxic gases were carbon monoxide and hydrogen cyanide.

Fires involving the release of chemicals

The Schweizerhalle accident at the Sandoz factory in Basle in Novem-

ber 1986 is an example of an accident that entailed considerable ecological damage.

The water used to extinguish the fire, which had started on premises used for storing large quantities of chemicals, ran down into the River Rhine. In this accident no persons were injured, but in large stretches of the Rhine considerable damage to plant and animal life was found.

In September 1955 there was an explosion followed by a fire in an agricultural product store in Rwanda. The store contained 232 tons of an anti-fungus preparation (Mancozeb). The fire probably started through self-ignition. While it was being extinguished, approximately 75,000 l of water mixed with the chemical ran out into a nearby river. The whole river was coloured yellow by the water. No acute toxic effects were to be expected from this accident since Mancozeb has low acute toxicity, but the substance is sensitising with a risk of later allergic reactions. There is also a risk of later injury since the substance collects in the thyroid gland and can give disturbances in its function. The substance is further considered to entail a risk of genetic change and a risk of tumour formation in, among other places, the liver and the thyroid gland.

Dioxins (Seveso)

In Seveso, Italy, there was in 1976 an uncontrolled release from a factory. A mixture of trichlorophenol, sodium hydroxide and tetrachloride bensodioxin was dispersed over an area of approximately 4–5 km^2. No immediate injuries were noted in people or animals but after two to four days, small animals such as birds, chickens and rabbits died. After three to seven days chemical burn injuries were noted in children who had been playing outside in the effected areas. After two weeks to two months, persons exposed to the gas cloud suffered skin changes, termed chlorine acne, and slight effects on the liver. This accident shows that it may be some days to weeks after exposure to a toxic substance before symptoms develop.

Phenol

A tank truck accident that occurred in Denmark in 1972 illustrates how an accident of this kind can have significant consequences for the environment, and the importance of the rescue personnel using adequate protective equipment. A tank lorry containing phenol got lost during transport from West Germany to a place in Denmark. On a narrow road

it had taken by mistake, the lorry overturned in a sharp bend and phenol ran out. The accident occurred near the local source of water and a small lake which empties into the North Sea. Twenty persons were injured by the phenol. Apart from the driver, most were members of the rescue services team. The driver sustained serious injuries. The rescue team were exposed to the phenol because they initially were not using adequate protective equipment. Eighty km down the river, 60 tons of sea trout died in a fishery. Four hundred metres of fresh water conduits and drainage conduits had to be replaced and 1200 m^2 of contaminated soil had to be removed.

Chlorine

As early as 1944 there was a chlorine gas accident in New York. Forty-five-kilo chlorine gas tubes were being transported on a lorry. One tube developed a leak. For seventeen minutes chlorine gas leaked out through a hole of approximately 3.2 mm. The lorry was parked only half a metre from the fresh air intake to a subway station. The chlorine gas attained sufficiently high concentrations in the subway station to affect a large number of people. A total of 418 people went to hospital and 208 were admitted for treatment or observation. There was no case of death. In one of the hospitals 133 were admitted and of these 33 required hospital care for one or more weeks. Because of the unfortunate circumstance that the leakage of chlorine gas was immediately adjacent to the fresh air intake to a subway station, the relatively moderate leakage came to have serious and far-reaching consequences.

The accident in Mississauga in Canada in 1979 is an example of an accident that had very limited effects concerning human injury. A train carrying chlorine gas tanks, among other things, derailed and caught fire. Only eight persons were injured, but 250,000 persons were evacuated from their homes for two to five days and a hospital with 1,250 patients was evacuated.

In August 1993 there was a release of chlorine gas at the Vanadisbadet (Vanadis outdoor swimming pool) in Stockholm. Sodium hypochlorite is used for purifying the swimming bath water. When refilling the tank with sodium hypochlorite the driver who was delivering the chemical filled it with phosphoric acid by mistake, instead of hypochlorite, whereupon chlorine gas was formed. He realised his mistake and stopped filling. Some 5 m^3 (approximately fourteen kilos) of chlorine gas was formed. Large sections of the area had to be cordoned off and 14 fire service units participated in the rescue work. In all, 13 persons were

taken to hospital, however none with serious symptoms. According to calculations by the Swedish Defence Research Establishment (FOA 1997) chlorine concentrations that could have inflicted serious injuries (30 ppm) were reached at a distance of some 10 m from the tank, and concentrations that give irritation (15 ppm) some 25 m from the tank. Had all the phosphoric acid been transferred to the tank, approximately 40 m³ (approximately 112 kg) of chlorine gas would have been formed and then probably the medical consequences of this accident would have been considerable. According to FOA's calculations, in that case, directly lethal concentrations (some 300 ppm) would have been reached some metres from the tank, life-threatening concentrations (150 ppm) approximately 10m from the tank, concentrations giving serious injury (30 ppm) some 50 m from the tank and irritation (15 ppm) just under 100 m from the tank. Had all the phosphoric acid and sodium chloride being carried in the tank been transferred to the swimming pool tank, some 80 m³ (approximately 224 kg) of chlorine gas would have been formed and then there could have been directly lethal concentrations (300 ppm) 20–25 m from the tank, life-threatening concentrations (150 ppm) at a distance of just under 50 m, serious injuries (30 ppm) just under 100 m from the tank and irritation (15 ppm) approximately 150 m from the tank. The calculations assumed that the leakage was for some 15 minutes. The wind speed was 1.5 m/s and the measurements were taken approximately 1.5m from the ground. The distances are in the direction of wind.

Sixty people in Gävle, Sweden, were exposed to chlorine gas in April 1998 and had to be taken to hospital. At a chemicals plant hydrochloric acid leaked out from a container. This was collected in empty containers, but by mistake one container that had contained sodium hypochlorite was used, whereupon chlorine gas was formed. The chlorine gas cloud was carried by the wind and 75m from the site a number of persons at a telemarketing company were exposed. All sustained immediate trouble in the form of irritation, coughing and running eyes. Following treatment all could leave the hospital after a few hours.

Methylisocyanate (Bhopal)

In December 1984 the worst accident ever at a chemicals factory occurred. In an uncontrolled release at the Union Carbide factory in Bhopal, India, methylisocyanate flowed out and spread over a large area. Adjacent to the factory there were some of large slum areas, where thousands of people lived. Light wind from 'the wrong' direction and an in-

version layer (warm air preventing gases from rising) caused relatively high concentrations of this very reactive irritant gas to be dispersed over these slum areas. More than 2,500 people died in the first week after the accident and approximately 500,000 persons were exposed to the gas. Several thousand people died during the years following the accident in consequence of the lung injuries inflicted upon them. In addition, a large number of persons with cataracts have been registered and this is probably a delayed effect of exposure to methylisocyanate.

Nerve gases

In a terrorist attack in March 1995 on the underground railway system in Tokyo a large number of persons were injured. The nerve gas sarin had been placed in containers at one of the central underground stations in five carriages on three of Tokyo's nine underground railway lines. In total, injured persons were found at fifteen stations. Approximately 5,500 persons visited one of Tokyo's many hospitals, and 700 were admitted. Apart from the ten who died almost immediately, 17 were seriously poisoned. Two of these seriously poisoned persons later died in consequence of the hypoxic brain damage they sustained during the acute phase. The others recovered apparently entirely following treatment with the antidotes atropine and the oxime pralidoxime. The symptoms displayed by the injured were those that are compatible with nerve gas poisoning, i.e. cholinergic symptoms. To the hospital that admitted most patients, there came 640 of whom 111 were admitted, six to the intensive care unit and the others to normal wards or in assembly rooms and corridors. Some 30 police personnel and 139 ambulance personnel were exposed to the gas during the rescue work and 43 needed hospital care. Several nurses and doctors also sustained symptoms of which, however, most were slight, while they were caring for patients that arrived at the hospital undecontaminated.

**Simulation of an imaginary terrorist action
using sarin against a department store**
According to FOA calculations regarding the casualty outcome of exposure to sarin in a department store in which liquid was placed and also sarin sprayed, the following result has been described (Näslund 1997):

Liquid
A plastic bag contain sarin mixed with ethanol (50:50) is placed on the floor on the ground floor of a large store and then punctured. A pool of

liquid forms upon the floor. Evaporation takes place for 25 minutes. The circumstances are what are normal for a large store regarding ventilation etc. The casualty outcome assessment refers to the ground floor of the store. After ten minutes' exposure, 4% of those exposed are dead, 6% are seriously injured, 8% slightly injured and 82% uninjured. After forty minutes' exposure, 28% are dead, 19% seriously injured, 13% slightly injured and 40% uninjured.

Spraying
Spraying is done near the main entrance to the store. Sarin dissolved in equal quantities of ethanol is sprayed out for ten minutes. The drops are assumed to be 50–200 micrometers in size. The small drops evaporate rapidly, the large ones fall to the floor and are assumed to evaporate within five to ten minutes. After six minutes' exposure 6% are dead, 5% seriously injured, 4% slightly injured and 85% uninjured. After ten minutes' exposure 13% are dead, 9% are seriously injured, 7% slightly injured and 71% uninjured.

In summary, after ten minutes exposure the number of seriously injured is only 3% more following dissemination by spray. If 500 persons happen to be on the ground floor this means that in the first case 30 will be seriously injured and in the second case 45 seriously injured; in other words, a situation that is still manageable.

Nitrogen oxides

In an accident in January 1998 in Östersund, Sweden, a large number of young people were exposed to nitrogen oxides when they were taking part in an ice hockey tour. A diesel-driven refrigeration plant was used for making ice in an indoor skating rink. The ventilation in the rink was shut off. The exhaust fumes from this type of refrigeration plant contain nitrogen oxides and when the ventilation is not working these gases collect above the ice. In all 187 young people visited the hospital between 10.30 pm and 1.00 o'clock am. Sixty-two of them had such pronounced symptoms from the respiratory tract that they needed treatment and hospital care.

In a rail accident in March 1998 two goods trains collided in the marshalling yard in Borlänge. Three trucks overturned and concentrated hydrochloric acid and ammonium nitrate leaked out, whereupon nitrogen oxides were formed. Four persons were slightly injured when they inhaled the gas. Local residents were urged to stay indoors, but neither dwellings nor industrial premises needed to be evacuated.

Smoke shells

In August 1993 an accident occurred with a military smoke shell at a school in Uppsala with just over 1100 persons (pupils, teachers and other staff). Somebody had caused a military smoke shell to explode in a toilet at the school whereupon zinc chloride was released. Zinc chloride is an irritant gas that can involve risks of severe pulmonary effects. A total of 160 persons were taken to hospital for examination, observation and treatment. None suffered serious symptoms since the school was rapidly evacuated, thus avoiding serious exposure to the fumes. Following detonation of a smoke shell in a room with a volume of $850m^3$ where the smoke is distributed equally, a concentration of $0.5 \ g/m^3$ is attained. This means that the limit for fatal injury is exceeded if the exposure time is thirty minutes. For shorter times the risks diminish but it can be assumed that serious injuries occur within some minutes (Koch 1997).

General remarks
on chemical substances

Many chemicals are manufactured and handled in industry. Large quantities of chemicals are transported every day by road, rail, sea and air. In the modern community the chemicals industry is a precondition for our present standard of living.

But the handling of chemicals also involves risks. The risk that chemical accidents may occur has become increasingly appreciable. Many of these chemicals may, in an accident or during transport, cause serious injuries to man and damage to the environment. If chemicals are mixed by mistake, toxic gases form and are disseminated (e.g. carbon monoxide and hydrogen cyanide, irritant gases). This may also occur in a fire.

The number of chemical substances in the widest meaning is very large. In 1942 approximately 60,000 chemical substances were known, but today there are over nine million and some 300,000 new substances appear every year. Most of these substances, however, lack practical use. Today there are some 70,000 chemical substances in practical use, and the number grows by about 1,000 new substances annually. Approximately 3,000 of these are responsible for 90% of the applications.

At the end of 1995, just over 60,000 chemical products were registered with the National Swedish Chemicals Inspectorate. Just under 30,000 of these were classified as dangerous in one way or another. They were distributed as follows:

Danger classification	Danger code	Number
Very toxic	T+	186
Toxic	T	1 433
Highly corrosive	C+	1 044
Corrosive	C	2 471
Injurious to health	Xn	11 131
Irritant	Xi	5 028
Moderately injurious to health	V	7 235
Dangerous to environment	N	35

Hazardous Substances

By hazardous substances is meant (Law 182:821 on the Transport of Hazardous Substances), the trans*port, loading and unloading of*:

- explosive,
- flammable,
- corrosive,
- toxic,
- radioactive and other substances

that can cause injury to humans and animals, and damage to property or the environment.

On this definition, most substances can be reckoned as hazardous substances. In practice however, what is reckoned as hazardous substances for long distance transport are those substances that are listed in the National Rescue Services Agency (SRV) provisions relating to the area. In medical care the term chemical accidents is used which, however, does not include substances that are explosive or radioactive.

Industry

Ammonia, chlorine, sulphur dioxide and petroleum products are produced, stored and transported in large quantities in the chemicals industry. There are stocks of these substances all over the country, some with a storage capacity of up to 30,000 tons. Should an accident occur involving a storage system or a reactor tank, the effect on the environment and health could be very great. As a rule, the chemicals industry's knowledge of how to act in different situations is great, for which reason the risk of serious accident must be assessed as relatively moderate.

Transport

Hazardous substances are transported chiefly by rail, road and sea. Only a modest proportion is transported by air. Air transport answers predominantly for radioactive isotopes for medical use. Transport of hazardous substances by the various different methods is distributed in Sweden as follows:

Rail   3 million tons
Road   4 million tons (70% petroleum products)
Ship   3.5 million tons (21 million tons oil)
Air   1000 transports

Road transport is largely over the total road system, together with other road users and vehicles. Through control of routing, attempts are made in many places to limit the transport of hazardous substances on roads where the risk of accident is great or where an accident would have serious consequences. This possibility is limited as regards railway transport. The marshalling yards are, as a rule, in sizeable communities where large quantities of chemicals can be assembled.

The following tendencies to change in quantities transported may be observed:

Ammonia (scrubbing of combustion fumes)	+
Chlorine	-
Sodium chlorate (bleaching)	+
Oxygen (bleaching)	+
Hydrogen peroxide (bleaching)	+
Natural gas	(+)
LPG	++
Chlorinated hydrocarbons	-
Methanol, ethanol (biofuels)	+

Sports installations etc

Chemical substances are used not only in industry, but in many other places in the community. Thus for example ammonia is used in skating rinks, swimming pools and refrigeration plants.

Injury potential

Chemical substances themselves possess great potential for damage, i.e. they can injure/contaminate large numbers of people. With an instantaneous release of fifty tons of chlorine in a densely populated area in summer, from railway tank trucks where the whole contents leaks out at once, the following casualty outcome may be assumed:

- 300–400 immediate deaths
- 400 casualties requiring immediate respiratory care
- 2000 casualties requiring immediate hospital care for breathing difficulties
- 2000 casualties requiring hospital observation for at least two days.

However, it is common that the damage is considerably less with only a small number of casualties (see below under actual accidents).

Even a fairly small accident can involve problems in view of the risk of dissemination of the dangerous substance and the complex casualty picture. In addition, there are often initial difficulties in obtaining a clear appreciation of the scope of the damage, which makes direction of the operation difficult. Sometimes it is even unclear what substance or substances are involved and how dangerous these are, individually or in combination. Should there be a fire it is even more difficult to assess the risk of injury and the size of the risk area.

New Threats

Sabotage

Not all accidents can be prevented, however, and this applies especially to events in which chemical substances may be used for purposes of sabotage.

Terrorism using chemical weapons on any large scale has so far occurred on two occasions (Matsumoto and Tokyo). Failed attempts have been made on twelve occasions, possession has been discovered on nine occasions and failed use twice. Use of smoke shells in schools, discotheques etc occurs all over the world.

Chemical weapons can be produced with relatively simple chemicals technology which is becoming more and more widely known. Chemicals and equipment for manufacture are readily accessible. For this reason we cannot exclude an increased use of such substances in connection with terrorism – and we should therefore review our preparedness for such situations.

Terrorist operations with chemical substances which may have devastating consequences cannot be ruled out, either in Sweden or during international peace- promoting or humanitarian efforts in other countries. Given that chemical weapons have been used once there, presumably no longer exist the same inhibitions about using them again. This must be taken into account in peacetime preparedness for disaster.

Dumping

A growing problem is the chemicals and chemical weapons, chiefly mustard gas, dumped in the sea. Following the second World War there was extensive dumping of chemical weapons in both the Baltic and the Kattegatt, both of mustard gas and nerve gases. Fishermen fishing in the area around the dumping sites have caught up ammunition containing mustard gas or pure mustard gas that has leaked from damaged containers, in their nets. This happens relatively often in the Baltic but has also

occurred on several occasions in fisheries off the west coast of Sweden and has led to personnel injuries in some cases. The mustard gas that is brought up today is as active as it was fifty years ago.

There are no known cases in which nerve gas has been brought to the surface. It is thus impossible to say with any certainty what activity it retains, but if a nerve gas container were to break on board a fishing boat this would probably lead to poisoning.

Special features
and requirements
in a chemical accident

The same general principles that apply to accidents with traumatically injured persons apply to the acute care of casualties in accidents involving chemical substances. However an accident involving chemicals has certain special features that must be considered in planning. Those features that apply to chemical weapons during state of alert must also be observed.

Risk area

Within a risk area a toxic substance can be present within a larger or a smaller area (risk area) for a shorter or a longer time. ***The risk area may not be entered without special protective equipment as ordered by the First Commander of Rescue Services.***

Medical staff arriving on the scene of an accident where there has been a release of chemicals must strictly follow the instructions given by the First Commander regarding what area it is safe to enter without complete protective equipment.

Ambulance and medical staff in medical teams must be equipped with personal protective equipment for the event that they may be exposed to a chemical or chemical weapon through, for example, a change of wind direction in the vicinity of the risk area or when they assist with the contamination. ***Medical staff should not normally work within the risk area.***

The hospital or the route to the hospital may lie within the risk area, and this may make it impossible for a longer or a shorter time to transport casualties to hospital. The casualty assembly point may then need to be used for a considerable time.

In the case of a ***chemical weapon*** attack, the risk area may be of entirely different dimensions. It may then extend up to fifteen kilometres. It is therefore not possible to cordon off such a risk area in the normal meaning of the word and the restriction will then be of the 'road block'

type controlled by the police. Within this area a high protective level is theoretically required since it is impossible to determine the dissemination of gas and liquid. Monitoring equipment is an aid in establishing and delimiting uncontaminated areas.

Decontamination

While caring for casualties exposed to a chemical, the rescue staff may be exposed to the toxic substance if the injured person is not decontaminated (removal of contaminated clothing, cleansing with soap and water).

Casualties must be decontaminated as early as possible within the accident scene, but outside the risk area. The rescue services are responsible for decontamination within the accident scene, but if there are medical requirements, with the help of medical staff.

Medical transport vehicles may become contaminated and unserviceable for a long time if contaminated (not decontaminated) persons are transported in them. Large areas of hospitals (e.g. the emergency department) may also become unserviceable for the same reason.

In health care facilities it must be possible to perform decontamination before the patient is admitted. This applies particularly to persons spontaneously seeking care.

In the care of injured/contaminated people exposed to a *chemical weapon* in liquid form there is a risk that rescue staff are exposed to the toxic substance directly at the accident scene. Here the first care given as a rule involves immediate decontamination with an absorbent dry decontamination powder, dry decontamination.

The injured person is removed from the risk area on a stretcher (platform or equivalent) to a decontamination station situated in a liquid- and gas-free area for complete decontamination.

Uniform casualty profile and standardised treatment

The casualty profile in an accident with a toxic substance is the same for all casualties, but with different degrees of severity. Both the classification of injuries and the treatment can then largely be standardised.

'Knocked out' hospital

The hospital or the route from the accident scene to the hospital may lie in the risk area which can render it impossible to transport casualties to the hospital for a period. In these circumstances it may be necessary to use the casualty assembly point for a considerable time.

Observation units

Following exposure (inhalation, skin exposure) to certain chemicals the development of serious symptoms may be delayed for periods of hours to days. For this reason observation units are required for people who are apparently unaffected, but whose condition may suddenly worsen.

Information

In an accident involving chemicals there is a great need for information to many different groups, to enable people to protect themselves in the right way and casualties to be cared for in the right way.

Inventory

Risk inventory
An inventory should be drawn up of the risks present at work places, transport, in the hospital catchment area.

Resource inventory
An inventory should also be made of the resources available at the hospital/medical care centre and in the region for meeting the requirements for medical care that an accident involving chemicals or terrorist attack, or attack with chemical weapons, can entail. This must be included in the acute hospitals' and medical care centres' disaster plans.

Information

General

In a large chemical accident where the public may be affected it is important to issue information rapidly in the initial phase regarding what has happened.

The information given to the public and to the rescue centres and health and medical services should be co-ordinated.

The First Commander of Rescue Service has overall responsibility for the dissemination of information to the public, mass media etc regarding the circumstances of an accident.

Information can cover warnings and direct guidance regarding measures necessary to prevent or alleviate the consequences.

To gain the attention of the public in threatening emergency situations requiring rapid information, in some built-up areas it is possible to use the siren signal 'important announcement to the public (VMA)'. The purpose of the signal is to warn people and have them take shelter and listen to the radio for information on the danger.

Even if information is conveyed via the mass media in the event of an accident, it must be anticipated that members of the public will themselves seek information from the authorities. To meet this need at local level, the municipal information service should be used.

Dissemination of information concerning the health condition of casualties and the medical care situation, etc, in the accident scene is the responsibility of the senior medical officer, while dissemination of information in other respects should be handled according to guidelines drawn up by the medical care principals.

The National Board of Health and Welfare has the Swedish Poisons Information Centre (GIC) as its expert organ. The National Defence Establishment (FOA) NBC Protection can also give expert advice in these connections.

The main task of the Poisons Information Centre is to supply medical services and the public with advice on risks and treatment measures in cases of poisoning and threatened poisoning.

The Poisons Information Centre should

- At the earliest possible moment inform itself via alarm centres or other suitable means regarding the accident and what substance or substances are involved so that it can provide the public and medical care with satisfactory answers,
- Plan for disaster situations so that the organisation can be reinforced as necessary,
- As the National Board of Health and Welfare expert organ provide information to the alarm centres, local radio, national radio, television and the TT news agency regarding the risks and first aid measures so that this information can be rapidly forwarded to the public in an emergency situation.

Medical care

All medical staff who may work within the accident scene should be well familiar with the regulations and the marking systems issued for the transport of hazardous substances. They should also be aware of disaster medical treatment and decontamination principles.

At emergency hospitals and medical care centres material safety data sheets regarding chemicals handled at factories within the health care facility's catchment area should be available.

These material safety data sheets (figure 1) and hazardous substances cards (figure 2) should be rapidly transmissible to the hospitals/medical care centres via telefax (or equivalent) from emergency service alarm centres, the rescue service, the Poisons Information Centre, businesses, the Rescue Services Information Bank (RIB) etc.

It should be possible to receive telefax messages (or equivalent) directly in emergency departments (or equivalent) at all emergency hospitals.

Simple information adapted to disaster situations on the risks and treatment measures for a selection of chemicals should be available for medical staff. The selection of substances for this purpose is determined, among other things, by whether specific antidote treatment is called for and how common the chemical is. This information must be updated regularly (table 4). The Poisons Information Centre can give support with the production of this information, which is given in the chapter on Poisoning in the National Corporation of Swedish Pharmacies Drug Therapy Handbook.

Table 4. Chemicals for which special treatment instructions should be available.

Acetonitrile	LPG
Acids	Mercury
Alkali (lye)	Mustard gas
Ammonia	Nerve gases
Arsenic	Nitrites
Carbon monoxide, carbon dioxide	Nitrobenzene
Chlorine	Nitrogen oxides
Fire gases	Organophosphates
Formaldehyde	Petrol
Hydrogen cyanide, cyanide	Phenol
Hydrogen sulphide	Phosgene
Hydrofluoric acid	Phosphorous (yellow, white)
Irritant gases	Vinyl chloride

Figure 1 – Material safety data sheet (in Swedish)

Figure 2 – Hazardous substances card (in Swedish)

More detailed information on acute health risks and treatment measures in cases of chemical poisoning can as a rule be obtained from the Poisons Information Centre, which can be reached via a special number 08-7360384 or via the 112 emergency telephone number. The special number is intended only for medical services in acute situations. The public are referred to 112 or 08-331231 (general enquiries, daytime).

In a disaster situation with many casualties allocated to several health care facilities, it is advisable for the local medical disaster management (or equivalent) to co-ordinate contact with the Poisons Information Centre.

In an accident of national character, the National Board of Health and Welfare has the overall responsibility for medical information and is responsible for co-ordination of information to authorities, health care principals etc.

Labelling and placarding systems, classification, material safety data sheets

When an accident occurs at a factory or workplace or during transport, easily available information is needed to be able to identify the chemical rapidly and obtain adequate information. There are a number of systems, both national and international, for this purpose. Examples of such information produced in Sweden are shown in figures 1 and 2. Figure 1 shows the front and back of a 'material safety data sheet' produced by the Kemikontoret (Association of Swedish Chemical Industries) and figure 2 the front and back of the Hazardous materials Card. Under UN auspices a common classification system has been agreed upon (figure 3). Each classification is represented by a symbol (figure 4). In the transport of hazardous substances, there must always be a Transport Emergency Card in the driver's cabin (figure 5). Figure 6 'The sign says' describes a system of signs on transport vehicles transporting hazardous substances by road and rail.

Figure 3 – Classification of risk

Figure 4 – Danger symbols

Figure 5 – Transport emergency card
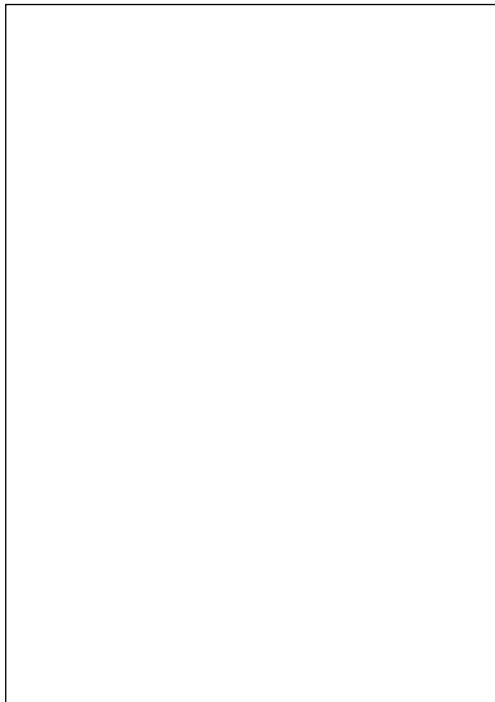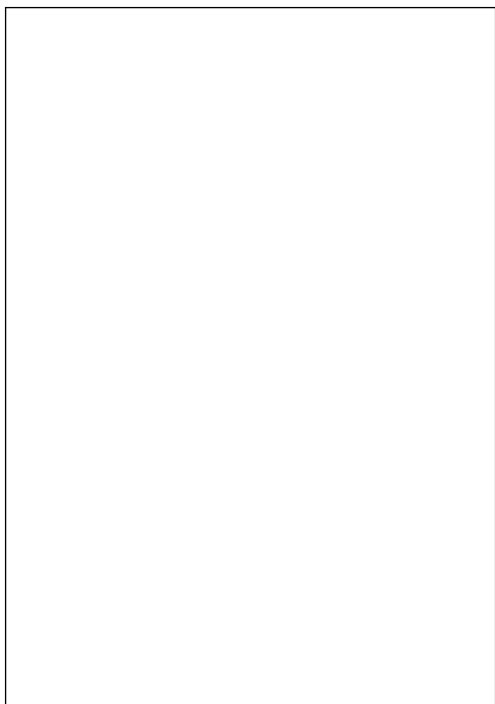
Figure 6 – 'The sign says'
(in Swedish)

Decontamination of persons, personal protective equipment

Decontamination of persons

An important first aid measure following exposure to many chemicals is immediate removal of contaminated clothing, irrigation with water and washing with soap and water. It is important that this may be done already within the accident scene. ***Irrigation with large quantities of warm water (30–37ºC) and washing with soap and water is, apart from being a first-aid measure, an important decontamination operation when people have been exposed to chemicals.*** Medical transport vehicles and medical institutions can also be contaminated if a non-decontaminated person is carried into the vehicle or health care facility.

Equipment for decontaminating contaminated/injured persons should be procured jointly by the municipality and the county council. Contaminated/injured persons are decontaminated at the accident scene by rescue services staff and, if there are medical needs, with the help of medical staff.

Despite the importance of decontamination being done even within the accident scene there must also be facilities for decontamination at all emergency hospitals and at medical care centres in the vicinity of high-risk objects. Contaminated/injured persons may arrive at these places without previous decontamination and for this reason decontamination facilities must be available. Functional requirements for hospital decontamination facilities are given in Appendix 1.

The contaminated person is laid upon a stretcher which has either a net bottom or a perforated bottom to ensure water drainage. His or her clothes, are cut off, removed and placed in marked sacks. The patient's whole body area is irrigated with water and washed if necessary with soap and water. Following decontamination and transfer to a clean stretcher, it is important for the person not to get chilled. To retain body heat the person must have blankets or some form of emergency covering so that he or she may then be moved to the casualty assembly point or to hospital.

The care of injured persons exposed to ***chemical weapons*** is based upon rapid acute work by knowledgeable rescue staff. Measures to protect the injured person's airways (gas mask), decontamination of unpro-

tected skin with personal decontamination powder is done if possible in the danger area.

Once in the decontamination area, the injured person is undressed to free the whole body area (clothes cut off), the whole body area (including wounds, burns etc) is dry-decontaminated with personal decontamination powder, the injured person is given a clean blanket or similar and transported (possibly in an emergency sack) to the casualty assembly point where his or her gas mask is taken off. The dry-decontaminated person must then be washed with soap and water as soon as convenient. The decontamination area may in certain cases need to be sited up to 4–5 kilometres from the injury site. The casualty assembly point may need to be sited a further few kilometres from the accident scene depending on the direction and strength of the wind.

During decontamination personal protective equipment must be worn (see tables 5 and 6).

Personal protective equipment

The most important components of personal protection against chemical accidents are respiratory protection and body protection. (By body protection is here meant protective clothing against chemical substances excluding respiratory protection). The protection to be recommended is determined primarily by the threat profile. It is important for body protection to include protection for hands and feet. In addition, the components must be adapted to one another as functionally as possible regarding both protection and comfort.

The First Commander of Rescue Service determines what protection is to be applied for work within the accident scene.

In the procurement of the components for protection of medical staff, the equipment should be so constructed that ordinary work tasks can be performed.

It cannot be ruled out that medical personnel in their work at the accident scene, during transport or at a health care facility, may come into contact with chemical substances in liquid form. Earlier decontamination may have been inadequate or in exceptional cases undecontaminated contaminated persons may make their own way to a health care facility. The National Board of Health and Welfare has for this reason produced standards for personal protective equipment for health and medical staff, for use in decontamination of contaminated/injured persons (SoS report 1995:15). The Board has also assisted in the development of protective equipment consisting of respiratory protection and body protection. The equipment is intended for use at decontamination stations at

the accident scene, at casualty assembly points, during transport and in decontamination stations at health care facilities. ***The equipment is not intended for work within the risk area.*** The protective equipment is procured by the Board and placed at county councils' disposal for peace-time use.

Table 5 (a) decontamination of casualties exposed to chemicals, and (b) personal protective equipment for health and medical staff during the care of casualties exposed to chemicals.

Table 5a Decontamination

Water/soap means irrigation copiously with water and then washing with soap and water.

Decontamination of casualties exposed to chemicals				
	Undressing	Dry deconta-mination	Water/soap	Mechanical cleansing – specific local treatment
Hydrogen cyanide Hydrogen sulphide	No	No	No	No
Other gases, e.g. Ammonia, Chlorine, Sulphur dioxide	Yes**	No	Yes**	No
Liquid/solid Chemicals	Yes	No	Yes	calcium gel (hydrofluoric acid) Macrogol (phenol) mechanical cleansing + potassium permanganate phosphorus (yellow/white)

** Not required if exposure slight

Table 5b Personal protective equipment

Personal protective equipment for health and medical personnel during the care of casualties exposed to chemicals			
	Respiratory protection	Body protection	C-overalls
Hydrogen cyanide Hydrogen sulphide	Yes	No	No
Other gases, e.g. Ammonia, Chlorine, Sulphur dioxide	Yes	Yes	No
Liquid/solid Chemicals	Yes	Yes	No

Table 6 (a) decontamination of casualties exposed to chemical weapons, and (b) personal protective equipment for health and medical staff during care of casualties exposed to chemical weapons.

Table 6a Decontamination

Water/soap means copious irrigation with water followed by washing with soap and water.

Decontamination of casualties exposed to chemical weapons					
Casualties that have been in	Substance	Undressing	Dry deconta-mination	Water/soap	Mechanical cleansing – specific local treatment
Cloud environment	Nerve gases Mustard gas Lewisite	Yes	No	No	No
Liquid & Aerosol environment	Nerve gases Mustard gas Lewisite	Yes	Yes	Yes*	Mechanical cleansing (mustard gas)

* May be done later if dry decontamination has been performed

Table 6b Personal protective equipment

Casualties that have been in	Substance	Respiratory protection	Body protection	C-overalls
Cloud environment	Nerve gases Mustard gas Lewisite	Yes	Yes (No)*	Yes (No)*
Liquid & Aerosol environment	Nerve gases Mustard gas Lewisite	Yes	Yes	Yes

* Body protection is not theoretically required here, but where it is hard to determine whether the substance is in gas or aerosol form, it is safest to wear body protection.

Respiratory protection

Since there are many different types of respiratory protection it is of the greatest importance to select the right protection for the prevailing conditions. Standards to note include protective ability and the wearer's performance.

For medical personnel, in addition, there is also the requirement that the respiratory protection shall not need individual adaptation. This means, among other things, that there should be only one size and that the protection must be usable with ordinary spectacles and by people with beards.

The respiratory protection produced by the National Board of Health and Welfare (Socialstyrelse) consists of a safety helmet with a fan. The helmet is in one size only and can be used together with normal spectacles and by persons with beards. The protective device must have two standard-thread filters and must then, depending on type of filter, provide protection against chemicals/chemical weapons. The available filters used give no protection against carbon monoxide.

Tables 5 and 6 show what protection should be used following exposure to chemicals and chemical weapons, and when it is needed.

Body protection

By body protection is here meant protective clothing against chemical substances excluding respiratory protection.

Body protection consists of fully covering overalls and is available in two sizes.

Members of a medical care team should put on body protection before they travel out to the accident scene. Staff at health care facilities should have body protection on during decontamination.

Protective gloves

In the choice of protection for the hands the possibilities of performing fine-motor work while wearing the protection is a requirement of high priority. The equipment for medical personnel includes protective glove 7, which is a butyl rubber glove for repeated use. Inside the protective glove, thin cotton gloves are used to absorb some of the moisture. The protective glove is available in three sizes.

Foot protection

Boots of butyl rubber are preferable, but other rubber boots that may form part of normal working clothes also give, as a rule, sufficient protection for work at a decontamination station.

The components of the protection against chemical weapons for

medical personnel are based on the protection used in chemical accidents, with the addition of C-overalls.

C-overalls use a special 'carbon cloth' which, together with the outer clothing as above, gives complete protection against chemical weapons for six hours. The overalls are available in four sizes and are buttoned down the back.

Medical staff require personal protective equipment with C-overalls when handling and decontaminating contaminated/injured persons from an area covered by chemical weapons. Members of the medical care team should put on their protective equipment before travelling to the accident scene. The same protection is required for the care and decontamination in connection with health care facilities.

In situations of raised alert it may be desirable for medical staff to be equipped with auto-injectors, nerve gas prophylaxis for their own use, see National Board of Health and Welfare report 1995:15.

Responsibility and planning

Responsibility and co-ordination in peace time

Every authority and organisation that may be affected by a chemical accident should establish plans for this. To help the work in the event of an accident the planning should be co-ordinated among those affected. For co-ordination, etc, among authorities SAMKEM exists. This is a working group of representatives of the National Board of Occupational Safety and Health, the Housing Agency, the National Swedish Chemicals Inspectorate, the Swedish Association of Local Authorities, the Federation of Swedish County Councils, the Coast Guard, the National Environmental Protection Agency, the National Police Board, the National Rescue Services Agency, the National Maritime Administration, the National Board of Health and Welfare, the Swedish Poisons Information Centre and the Explosive Substances Inspectorate. The purpose of SAMKEM is effectivisation and co-ordination of the community's efforts to prevent chemical accidents and to limit and remedy damage in those accidents that do occur.

The national rescue services and medical services must be able to handle a large number of persons exposed to a chemical.

The municipal rescue services are responsible for rescue efforts in chemical accidents. The First Commander of Rescue is the municipal director of rescue or a person appointed by this official. In large accidents the County Administrative Board may take over management and appoint a special commander of rescue.

The organisation for work in large chemical accidents should as far as possible follow the normal organisation for other large accidents. The commander of rescue has the overall responsibility for the aims of the rescue operation concerning the accident site, back up management, medical care, cordoning-off, direction of traffic and other matters. Each participating organisation however, makes its own decisions within the framework of its own area of responsibility. However, certain supplements to the organisation are needed in chemical accidents.

The management organisation for the rescue and medical services should be strengthened with the necessary chemical expertise from authorities or industry. Competence within the National Board of Health and Welfare and the Poisons Information Centre (GIC) may be needed by the rescue organisation in the management of casualties.

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Responsibility and co-ordination during raised alert states

The municipal rescue service is responsible for rescue in peace and during raised alert states. The organisation for work in accidents involving chemicals should be the basis for the response to damage and injuries consequent upon terrorist attacks or attacks with chemical weapons. In addition the management organisation (back-up support) resources for the effort (co-operation with other municipalities), monitoring and decontamination will be developed.

The municipal environmental and health administration may provide a further addition of competence in the municipal management of this type of rescue operation.

Responsibility and planning in the health and medical services

The normal health and medical services disaster organisation should operate. However specially qualified senior doctors reporting to hospital management should be responsible for ensuring that the disaster planning also includes chemical accidents.

For an accident involving chemicals, the medical care principal's central and local disaster organisation should also include a senior physician with special competence for chemical accidents.

All levels of the health and health care organisation (in peace time and war) need access to expertise in chemical accidents and chemical weapons. The Poisons Information Centre has both a responsibility and a key role here as the expert organ of the National Board of Health and Welfare, for information to medical services and for information to the public directly or via mass media. In addition, the NBC protection division of the National Defence Research Establishment (FOA) has a responsibility here to give expert advice concerning protection, dissemination, toxicity etc.

Risk inventory

An important part of planning is an inventory of what types of chemical and dangerous substance in the geographical area of responsibility may conceivably cause injury in connection with an accident. Material for the inventory can be obtained from the municipal rescue services and the environmental and health protection administration.

The risk inventory should be done in consultation with the appropriate industrial occupational health services. Risks exist not only with the producers of chemicals, but with firms that handle chemicals. Thus, for example, many electronics firms handle appreciable quantities of many poisonous substances. The risk inventory may well be conducted in consultation with the rescue services and the environmental and health protection administration. It may be hard to gain a clear picture of what transport is going on through a municipality, but the rescue services map certain transport routes for hazardous substances. The county council also has information regarding what substances are transported in any quantities.

The inventory of the municipality's risks should result in a joint action plan for the rescue services, medical services and the police for the risk in question.

Municipal tasks include describing relevant threats, preparations and measures for combating damage for conceivable attacks/terrorist actions with chemical weapons. *This should result in a similar action plan which jointly describes rescue service, medical services and police measures to be taken should an accident occur.*

Resource inventory

Sites for care and monitoring

An inventory should be made of how many people can be given ventilatory suppport, alternatively ventilated manually, and how many people with widespread chemical burn injuries can be given care. The need of ventilatory support will probably be relatively brief (up to 24 hours for the large majority). Treatment of chemical burn injuries follows the principles applying to thermal burn injuries.

An inventory should also be made of how many observation beds are available for unaffected persons who have been exposed to a chemical, and in whom serious symptoms may develop after several hours, up to one or two days.

Disaster stocks of antidotes etc

The disaster equipment at health care facilities and the equipment taken to the scene of the accident should include antidotes and other drugs for treatment of poisoned persons in the event of a chemical accident (including terrorist action with chemical weapons). *Disaster stocks of antidotes etc should be available in every province/county council (or equivalent). Establishment of the stocks can to advantage be co-ordinated within one or several regions.*

Recommendations on what antidotes etc should be included in these

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stocks are available from the Poisons Information Centre and are published in an offprint of the chapter on Poisoning in the Drug Therapy Handbook. These recommendations are updated every other year in connection with publication of a new edition of the Handbook. The recommended stock quantities cover the requirements for complete treatment of ten injured persons for twelve hours (Appendix 2). Local disaster stocks may need modifying and adapting to local conditions and requirements. Dosing instructions for these antidotes should be readily available.

Overhaul and updating of the disaster stocks of antidotes may suitably be done in connection with publication of a new edition of the Drug Therapy Handbook (and the offprint).

The siting and equipping of premises for disaster stocks should be reported to the National Corporation of Swedish Pharmacies which forwards the particulars to the Poisons Information Centre. The National Corporation enters the details in the antidote database, where dispensing chemists and others can run searches. This reporting should be done each time alterations are made to the stocks. In this way the Poisons Information Centre and the C.W. Scheele Pharmacy always have up-to-date information on where disaster stocks are and what they contain so that in an acute situation people can, if necessary, be referred to the nearest health care facility where a stock is held.

For a wartime situation there is also need of drugs in the event of chemical warfare, and these have been procured and are stocked through the good offices of the National Board of Health and Welfare. The Board's Report 1995:15 includes its assessment of the need for drugs for assembly points and emergency hospitals following exposure to nerve gases, mustard gas, irritant gases and fire gases. (This appraisal refers to the time when the Report was published).

Training

For the medical services to be able to do their job in accidents and disasters with chemicals and chemical weapons in peacetime and during raised alert states, special training and practice is needed by medical staff.

Ambulance personnel, personnel included in medical teams and personnel at health care facilities need training in the special features and associated risks that exposure to chemicals and chemical weapons may entail; what special protective equipment is needed; handling protective equipment; decontamination requirements and routines; first aid and, in

certain cases, what specific treatment can be given already within the accident scene and during transport.

This knowledge should be conveyed in both basic and further training of all medical personnel and in the in-training of relevant medical personnel.

Table 7 shows the National Board of Health and Welfare requirement specifications for what should be included in the in-training required by the personnel categories who may be engaged in the care of casualties exposed to chemicals and chemical weapons. This training should be conducted locally by personnel who have gained knowledge of these matters in, for example, training initiated by the Board

Joint exercises should take place regularly with all co-operating organisations affected.

Table 7 National Board of Health and Welfare requirement specifications for training

Training of medical personnel

The training of medical personnel should comprise the following:

- Various types of chemical substances and their properties (including dispersal), and principles for labelling and placarding, among other things, during transport

- Different types of chemical weapon including methods of dispersal and effects

- Organisation of the rescue services, the police, emergency alarm services and resources for chemical accidents (including those of the chemicals industry)

- Different types of decontamination installation (mobile/fixed decontamination resources)

- Responsibility, organisation and resources of medical services in chemical accidents

- Sources of information available for expert assistance in treatment of chemical casualties
- Symptoms and treatment of chemical casualties

- Principles for work at the accident scene in chemical accidents

- Principles for triage in chemical accidents with many casualties

- Medical care in chemical accidents at the accident scene, during transport and in hospital

- Decontamination of contaminated/injured using available equipment (including decontamination of contaminated/injured with chemical weapons) and how to implement this

- The personal protective equipment (respiratory protection/body protection) needed, together with practical ability to handle this.

Organisation

Organisation at the accident scene and in transport

Management

Rescue efforts are led by the First Commander of Rescue Service in close collaboration with the officer in charge of police operations and the medical director on-scene. ***The First Commander has undivided responsibility in the accident scene for the safety of all personnel involved and the risks that occur or can arise in connection with the rescue operation. Extensive co-operation, however, is necessary primarily with the police, medical personnel and chemical expertise.*** As a rule the First Commander will establish an operations control point for support in the overall operation. Where necessary the organisations involved will be represented in the various headquarters. To facilitate co-operation at the accident scene the First Commander, the senior police officer and the medical director on-scene will in many cases arrange a joint operations control centre.

The First Commander directs and co-ordinates the rescue operation on the basis of a joint plan. This plan, which has been produced in collaboration with medical services and the police should, among other things, show relevant breaking points and routes to and within the accident scene. There should be worked-out alternatives depending on relevant objectives, weather and season. Rescue personnel will, without waste of time, enter the accident site, search the area and take care of casualties who will be passed over to medical personnel from medical team/teams and/or ambulance personnel.

The senior police officer in charge will manage the police staff. The job of the police is cordoning off, guarding, traffic control, identification and registration of casualties and fatalities, registration of uninjured to the extent that that this practically possible and care of personal belongings and goods. Where relevant the police should also conduct evacuations and searches, and inform relatives. Added to this, in most accidents the police are responsible for investigating the causes of the accident.

Medical care efforts will be directed by the medical director on-scene. Prior to his or her arrival on the scene of the accident medical assistance will be led by personnel from the command ambulance.

An important part of the work is establishing the risk area. Details of

Risk area

SITE OF
ACCIDENT

decontamination
station

security area

casualty assembly
point

wind direction

inner cordon

outer cordon

breaking point

hospital
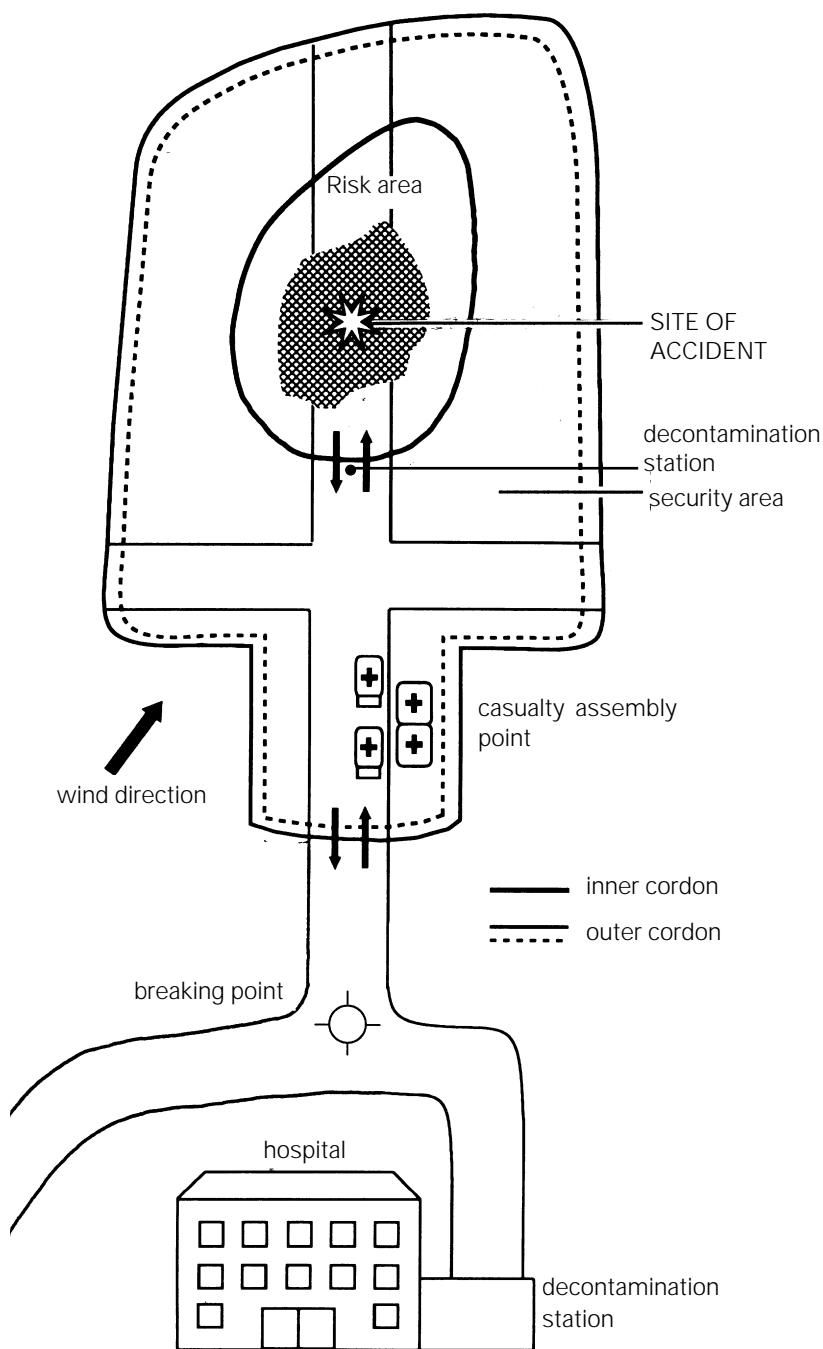
decontamination
station

Figure 7 Accident scene (peace time).

e.g. wind direction and speed are essential here. ***The First Commander establishes the borders of the risk area, what personnel may be within the area, what work can be conducted there and what protective equipment must be worn by personnel.***

Cordoning-off

In an accident involving chemicals the rescue service is responsible for obtaining at least a rough idea of the border between an environment that can entail injury and an environment where the content of the substance (agent) in question is so low that the risk of injury is small (figure 7).

An inner cordon is set up round the actual accident site. This inner area is termed the risk area. A risk area must always be established since special personal protective equipment is required for the rescue personnel who are to work in the immediate vicinity of the release of chemicals. The rescue service is normally responsible for this inner cordon. If possible the risk area should have only one entry and exit. Outside the inner cordon an outer cordon is set up. The area between the inner and outer cordons is termed the security area and is intended for vehicles, materiel and personnel. Within this area no particular personal protective equipment is normally required, but body protection should be worn and respiratory protection immediately available. The police are responsible for the outer cordon. There should be only one entry/exit point here too.

Rescue service personnel will transport contaminated persons and casualties out from a risk area.

Casualties may need to have respiratory protection put on them.

Following an attack with chemical weapons the First Commander of Rescue assesses the extent of the accident scene regarding area affected by chemical weapons (liquid coverage of ground) and secondary drifting clouds of the chemical (C-cloud) which may assume an entirely different dimension extending up to fifteen kilometres (figure 8 overleaf). The risk area cannot initially be cordoned off in the same way as in an accident involving chemicals. Cordoning-off only becomes relevant regarding the outer cordon where the police will block any larger roads in to the accident scene. For the First Commander it is important, instead, to identify 'clean areas' as quickly as possible. Here use is made of what is called prepared detection on the ground and automatic monitoring in rescue vehicles in order to find 'clean areas' rapidly.

Risk area

In a risk area involving industrial chemicals, the primary risks concern the effects of chemicals in liquid and gas form. ***The municipal rescue***

ACCIDENT SITE

The accident site
can be 200 x 2000
metres

15 kilometres

risk area

deconta-
mination
station

wind direction

cordon (police)

breaking point

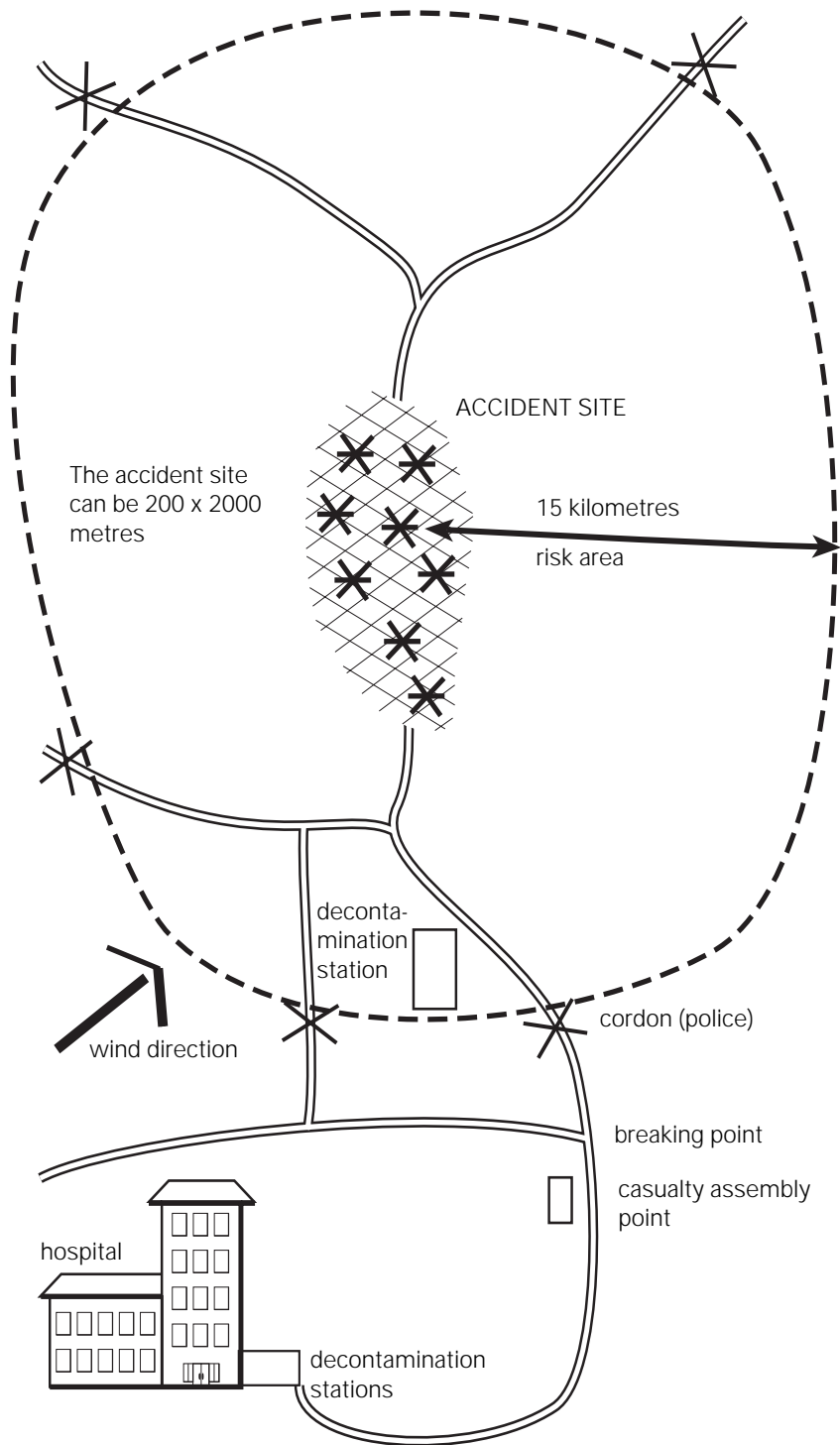casualty assembly
point

hospital

decontamination
stations

Figure 8 Accident scene (state of alert).

service is responsible for all work needed within the risk area, i.e. within the inner cordon. This assumes, apart from initial life-saving measures, the highest protection level of respiratory and body protection. In rapid life-saving measures, rescue service personnel may sometimes need to go into the risk area and 'bring out' persons wearing only respiratory equipment and splash protection. When the First Commander has ordered a 'chemical diver operation' all personnel working in the risk area will use full chemical protection suits with air for respiratory apparatus and suit ventilation.

Only in exceptional cases may the First Commander require help in the risk area from medical personnel and in such a case the rescue services will supply protective equipment.

Rescue service personnel will transport casualties out of the limit of the inner cordon to the decontamination station for decontamination.

Following coverage with chemical weapons, the rescue service is responsible for work in the whole risk area, which may then extend more than fifteen kilometres from the area of coverage with a drifting gas cloud. Casualties are helped with initial measures (respiratory protection, antidotes, decontamination of body surfaces, placing on stretchers). All casualties are transported without delay to the decontamination station in open vehicles (open lorries, trailers). The decontamination station must be far enough from the danger area that drifting C-clouds (secondary) cannot affect the decontamination. If it is judged to safe however, the decontamination station may be inside the initially cordoned-off area.

Decontamination station/decontamination area

Decontamination station –
peacetime accidents and terrorist actions

Decontamination is carried out by the rescue service but if there are medical requirements, with the help of medical staff who must then wear personal protective equipment. At the decontamination station there should be access to protection from weather and wind, heated areas, warm water (+30–+37C), showers, soap, shampoo, personal decontamination powder, towels, blankets, emergency coverings and clean clothes. Where necessary the injured person is provided with respiratory protection.

Exposed persons who can walk and stand up are decontaminated standing. Others are decontaminated lying down.

Once decontamination has commenced the decontamination station will be considered as a contaminated area.

Decontamination will as a rule take place in some type of tent (or equivalent) attempts being made to prevent the air content of injurious substances from achieving high levels, for example by arranging some type of airing. The air flow should be from the clean side to the contaminated side. Contaminated clothes, blankets etc are collected in heavy plastic sacks and stored outside the tent pending later decontamination or destruction. Decontamination of contaminated persons/casualties must be as complete as possible, which involves meticulous washing with soap, sponges and water of the whole naked body including the hair. After wet decontamination the injured person must be dried with towels. Following exposure to chemical weapons the injured person is dry-decontaminated with personal decontamination powder. The dry-decontaminated person must then be washed with soap and water when suitable. Following decontamination the casualty is placed in a rescue sack or wrapped in blankets to prevent chilling. After this, he or she will be brought to the casualty assembly point for further treatment.

Following exposure to nerve gas the injured person is treated if necessary with Auto-injectors as early as possible, and this may be required directly in the risk area or at the decontamination station at the latest.

Since it may be hard in an accident to determine quickly what casualties have been exposed to, the decontamination routines followed should be such as are effective even against highly-toxic substances. In combination casualties, undamaged skin should be decontaminated within the accident scene while wounds will receive final decontamination in hospital. Tables 5 and 6 show when and how to decontaminate casualties exposed to chemicals and chemical weapons.

Eye irrigation may need to be commenced directly at the decontamination station.

The dead are placed in a special place. They too need to be decontaminated before transport.

Medical personnel will not normally come into contact with casualties exposed to a poisonous substance until they reach the decontamination station.

Decontamination area – state of alert (see also Appendix 3)

The decontamination area is established at a site considered safe from drifting C-clouds. Special support resources from the rescue services set up the decontamination area and are responsible for managing and co-ordinating decontamination in decontamination lines for (a) casualties, (b) the uninjured and (c) rescue personnel, medical personnel and police.

Materiel, equipment and vehicles used at the accident scene are de-contaminated as decided by the support resource on completion of their operation.

In the decontamination area casualties and uninjured persons are de-contaminated in their own lines. The rescue services are responsible for decontamination in collaboration with medical personnel. The latter sort and make priorities for decontamination.

Dead persons are placed in a special area.

Following dry decontamination the casualty is brought to the 'clean side' and placed on a clean stretcher in blankets and a rescue sack.

Where necessary nerve gas antidote is given (Auto-injector).

During the entire decontamination process the casualty will keep his/her respiratory protection on. Decontaminated persons are transported to the casualty assembly point. As opportunity arises the casualty is washed with soap and water.

All personnel involved in the rescue operation at the damage area or the decontamination area should at the inception of the operation bring and leave changes of clothing for the rescue service support resource personnel.

Casualty assembly point

A casualty assembly point is established outside the area where there is a risk of effects from e.g. gas clouds. In the case of a chemical-weapons attack, the casualty assembly point may lie several kilometres from the decontamination area. Situations cannot be ruled out where there is a lack of clarity concerning the decontamination position or, for example, whether a change in the wind direction may cause a risk of raised gas content in the air. *For this reason body protection should be worn here and respiratory protection should be immediately available.*

Before the casualty is taken to the casualty assembly point he/she should be decontaminated if need be.

At the casualty assembly point the exposed person is given initial medical treatment by medical staff so that he or she may then be trans-ported to a health care facility. Eye irrigation may be need to be started as early as possible, possibly even at the decontamination station.

Treatment of casualties within the accident scene aims to give the exposed/injured person greater possibilities of reaching acute medical care in as good a condition as possible.

Treatment of persons exposed to chemical substances and chemical weapons includes, apart from symptomatic treatment in certain cases,

specific antidote treatment. See the Poisonings chapter in the Drug Therapy Handbook.

Transport

Following treatment at the casualty assembly point casualties are transported to hospital. ***Ambulance personnel must have the same protection level as staff at the assembly point.***

To minimise injury and to avoid the transport vehicle being contaminated it is ***important that the casualty be decontaminated before transport to a health care facility.***

During transport of those exposed to chemicals it must if necessary be possible to continue eye irrigation and other necessary treatment.

Other transport vehicles than ambulances may need to be requisitioned e.g. buses from local traffic companies and adjacent military units.

Health care facilities

Decontamination and protection

In theory, all persons transported to hospitals from an accident scene should already have been decontaminated but it must be expected that many will make their way to the hospital/health care facility on their own and undecontaminated.

Before a person exposed to chemicals (including chemical weapons) is admitted to hospital he/she must be decontaminated – see also Personal Decontamination. An un-decontaminated person exposed to high levels of e.g. ammonia or phenol can if he/she is admitted to an emergency department un-decontaminated render this unserviceable for many hours. Depending on the ventilation and unchecked air movements in buildings, other parts of the hospital may also become unserviceable.

For this reason a decontamination station should be arranged at every emergency hospital, primarily in connection with the emergency department or in a special room with separate ventilation, preferably with an air lock. It should also be possible to decontaminate patients who are lying down. The decontamination is as described above. Functional requirements for a hospital decontamination facility are given in Appendix 1.

In hospital decontamination the staff must use personal protective equipment, see tables 5 and 6.

Responsibility for the establishment of a decontamination facility at a medical institution lies with the relevant medical care principal.

If the hospital and/or transport route to the hospital lie within the risk area it may for a time be impossible to transport casualties. Alternative care premises such as schools, sports halls, tents or similar to which casualties can be brought and where medical care can be offered until the hospital can again receive patients should be planned for. As an alternative, the casualty assembly point can be designed so that it may be used for care. Plans should be established in consultation among the rescue service, police and medical services.

Should the hospital be within the risk are it is important to shut windows and doors immediately and to shut off the ventilation immediately. These measures should be included in the hospital (or equivalent) local disaster plan. Should a drifting gas cloud have passed, premises must be aired and the ventilation system restarted.

Treatment in hospital

Hospital treatment will follow the accepted principles for disaster situations.

Treatment started at the casualty assembly point will continue in hospital according to the same guidelines as at the assembly point. For treatment principles etc see below under 'Effects, general treatment and triage', 'Particular toxic substances' and the chapter on Poisoning in the Drug Therapy Handbook.

In exposure to e.g. irritant or nerve gases, many persons may need ventilatory support. Here the need for such support will probably be relatively brief (up to 24 hours for the large majority). The possibly of manually ventilating a large number of persons (for a shorter or a longer time) should be available until ventilators can be offered.

Relatively unaffected persons may need to be offered places for observation for one or more days because of the risk of delayed symptoms.

In exposure to corrosive substances, many may need treatment according to the principles that apply to thermal burn injury treatment.

For hospital drug needs in peace time see Appendix 2 and for wartime see SoS Report 1995:15.

Follow-up

Registration

In chemical accidents it is essential that all those exposed, even those who in the acute phase are symptom-free, should as far as possible be registered so that they can be easily reached, since the debut of symptoms on exposure to chemicals may be delayed from hours to days. It may be necessary to 'search for' these people via local radio. It is also important to be able to identify all exposed persons so that adequate follow-up may be conducted, particularly in cases where many persons have been exposed to unusual chemicals where experience of their effects on man is limited.

As mentioned earlier it is the police who are responsible for registering and identifying casualties and to the extent possible, registering uninjured persons who have participated in or been exposed to an accident. It is therefore important to establish close co-operation between medical care and the police so that the registration in chemical accidents may be as complete as possible.

Sampling

In mass-injury situations where many persons have been exposed to a chemical substance and where experience of the effects on man is limited, it is essential that there should be some planning for taking samples from a limited number of casualties for later analysis (blood, urine). How this sampling is to be performed must be determined from case to case, but initially two 10 ml heparin tubes are appropriate. One of these should be centrifuged and the plasma separated. The plasma and the tube of whole blood are frozen. Samples should also be taken of urine. A portion of morning urine should be retained and frozen.

Effects of exposure, general treatment and triage

Acute effects of exposure

The body may be subjected to toxic substances through inhalation, skin contact, eye splashing or ingestion. Release of a condensed gas stored under pressure represents the greatest risk of a large number of persons being afflicted within a relatively large area. This can happen both at a factory and during transport. Liquid substances can also be dispersed over a large area, particularly in transport accidents. In consequence of sabotage or leakage into water reservoirs, large numbers may conceivably be exposed to a toxic substance through ingestion.

Inhalation

Inhalation of toxic substances can cause local injuries in the airways if irritant gases or hot gases are inhaled. Substances taken up via the mucous membranes of the airways may cause systemic poisoning. Even gases that are not in themselves toxic can entail a risk of oxygen deficiency since they displace the oxygen in the air in poorly ventilated areas.

Irritant gases
By irritant gas is meant such gases, in certain cases also vapour, mist, dust, finely distributed drops or aerosol that react with the mucus membranes of the respiratory tract to give local injury. The localisation and extent of the injury depend partly on the physical properties of the gas, e.g. its water solubility, partly on how finely distributed the drops or particles are, and on the degree of exposure. Examples of irritant gases are ammonia, chlorine gas, fluoride gas, formaldehyde, hydrofluoride gas, hydrogen chloride gas, hydrogen phosphide, nitrogen oxides, phosgene, smoke from plastic materials and fire gases, sulphur dioxide and zinc chloride. Irritation from the respiratory tract appears immediately for most gases and the irritation is often so pronounced that it represents an effective warning signal. In very severe exposure, laryngospasm or reflexively triggered cessation of breathing and circulation occurs. Substances of *high water-solubility* (e.g. acrolein, alkalis, ammonia, formaldehyde, hydrogen fluoride, hydrogen chloride, acids, zinc chloride) do

not on brief exposure reach down to the lower respiratory tract but become dissolved in the fluid layer of the mucous membranes in the upper respiratory tract (nose, mouth, throat and the large respiratory tract).

Gases that are *less water-soluble*, (phenol, sulphur dioxide) even on brief exposure reach to the medium-sized bronchi and on somewhat longer exposure the distal narrower branches of the respiratory tract and the alveoli.

Substances of *low water solubility* (e.g. phosgene, isocyanates, chlorine, nitrogen oxides) reach the finer branches of the airways and the alveoli even in low concentrations after brief exposure.

As an example it may be mentioned that following exposure to ammonia, serious lung effects are seen at concentrations of some 500–700 ppm while the corresponding values for chlorine gas are 40–60 ppm.

On exposure to aerosols or particles only the smaller particles reach the finer branches of the respiratory tract and the alveoli. Examples are zinc chloride released from certain defence smoke sticks and smoke shells. In the primary mist formed, the particle size is 0.1μ and these particles readily reach the alveoli. On contact with atmospheric moisture there is a hydrolysis and particle size then becomes some 3μ. This explains why the risk of serious lung effects is considerably less than on indoor exposure. In most cases however the risk of the development of toxic lung oedema is in direct relation to the initial irritation symptoms (except for phosgene and nitrogen oxides). If there are no initial symptoms or they are very slight, the probability that serious lung damage has arisen and the risk that toxic lung oedema will occur is minimal. Chronic damage with more or less serious invalidity may be seen in serious cases. Complications seen are bacterial pneumonia and various types of barotrauma.

Systemically toxic gases
Except for nitrogen dioxide and hydrogen sulphide, systemically toxic gases as a rule give no local symptoms but are rapidly absorbed in the lungs with pronounced systemic effects. Examples of such gases are hydrogen cyanide, carbon monoxide, nitrogen dioxide, organophosphates, hydrogen sulphide etc. Symptoms of systemic poisoning seen in the acute phase come as a rule from the central nervous system with impairment of consciousness to unconsciousness, in certain cases seizures, and from the circulatory system with more or less pronounced effects. Certain substances such as nitrogen dioxide, nitrates and nitrobenzene can induce methemoglobinaemia. (See also Special poisons.) Chlorinated hydrocarbons and e.g. butane and propane affect the heart and can trigger serious arrhythmias.

Inert gases
Certain gases are not toxic in themselves but can, particularly in poorly ventilated spaces, displace the oxygen in the air and in this way induce oxygen deficiency. Examples of such gases are carbon dioxide and hydrogen. LPG (liquid petroleum gas) a mixture of butane and propane, leaking from containers in poorly ventilated spaces also relate to this mechanism, in addition to which the heart is affected directly, with a risk of arrhythmia.

Hot gases
If hot gases (e.g. fire gases) are inhaled pronounced thermal injury to the mucous membranes can occur. In such connections it is not unusual for oedema of the mucous membranes, with the risk of further air-passage obstacles, not to make itself known until some hours later.

Eye splashing
The eye can be injured by substances in liquid, solid or gas form. The most serious type of injury is caused by strongly corrosive substances (e.g. alkali and ammonia) and strongly oxidising substances (invert soaps and chromates) or tissue-fixing substances (e.g. formalin). Severe chemical burn injury can occur to the cornea and the other tissues of the eye. Such damage is associated with intense pain, copious tears and reflexive spasms of the eyelids, termed blepharospasm. These symptoms may in certain cases be followed by loss of feeling. The most serious injury is that which can be seen on the cornea where the injury can be so serious as to give permanent impairment of vision.

Skin contact
Skin exposure to toxic substances in liquid, solid or gas form can involve risk of local injury and/or systemic poisoning. The local injury to the skin or underlying tissue is expressed as a rule as a chemical burn injury which, in turn, resembles a burn injury. Symptoms seen are irritation, pain, formation of blisters and necrosis. Apart from the local injury, after pronounced exposure there is also a risk of considerable fluid losses.

The injury may make itself known in direct connection with the occasion when it was sustained following exposure to alkali, ammonia, phenol, hydrofluoric acid in high concentrations and acids. A toxic substance can, however, also damage the skin or underlying tissues without necessarily causing any initial discomfort. Following exposure to alkali, to start with the skin only feels slippery. Hydrofluoric acid at low concentrations does not give irritation until after a few hours. Phenol numbs the skin and masks the fact that an injury has arisen. Many organic thin-

ners may penetrate the skin during, e.g. high-pressure spraying and despite an initially innocent appearance, give widespread injury in deeper tissues.

Systemic effects of the substance being taken up through the skin may also be present in local damage e.g. from phenol, hydrofluoric acid and yellow (white) phosphorus; or may arise as poisoning without concurrent skin injury, e.g. organophosphates. It is chiefly fat-soluble substances that are absorbed through the skin. If there is also a skin injury (pronounced eczema or corrosion wound) substances that are not normally absorbed through the skin may also penetrate, causing systemic poisoning. The risk of local injury and systemic effects also depends on the duration of exposure and whether skin contact involved pressure, e.g. in shoes, or under tight-fitting clothes, watch straps etc.

Ingestion
Following ingestion of corrosive, oxidising or tissue-fixing substances there is a risk of local injury in the gastrointestinal tract, arising from corrosion damage to the mucous membranes. The risks in the acute phase are chiefly pronounced fluid loss in consequence of intense vomiting and diarrhoea; but the risk of rupture of the oesophageal wall or stomach is also present. Pronounced injury as a rule heals with scars that can cause stricture formation, and this is not manifest until long (months or years) after the injury.

Substances of low viscosity, e.g. petroleum products of the kerosene type, involve risks of aspiration to the respiratory tract, with consequent serious affects on the lungs.

There is a risk of systemic poisoning if the substance is absorbed via the mucous membranes of the gastrointestinal tract.

Treatment – first aid
Adequate first aid is essential to prevent or limit injuries that may have arisen following exposure to chemicals. In certain cases more specific treatment, e.g. with antidotes at an earlier stage of the poisoning, may also be decisive for the outcome of the poisoning.

Inhalation
Following inhalation, exposure must be terminated as soon as possible. Note that the rescuer should be wearing adequate protective equipment, e.g. protective mask, should the toxic effect remain. Following the inhalation of irritant gases the injured person should observe strict rest, pref-

erably in a comfortable semi-recumbent position and should be transported in this posture. Physical activity increases the risk that toxic pulmonary oedema may develop. Unconscious persons are placed in the semi-prone position. If necessary assisted or controlled ventilation is commenced. Patients with slight symptoms (burning sensation in the mouth, throat and chest, salivation, irritant cough, slight hoarseness and chest discomfort) need not be observed in hospital, but should contact a hospital if the symptoms persist for 24 hours or get worse. Patients with serious symptoms (laryngospasm, intensive, troublesome cough, haemoptysis, breathlessness, worsened oxygen uptake, bronchospasm, general effects, toxic pulmonary oedema) should be observed (and treated) in hospital for 24 (–48) hours. Even those who are theoretically symptom-free but had serious initial symptoms should be observed in hospital in view of the risk of the development of toxic pulmonary oedema. Regarding phosgene and nitrogen oxides, initial symptoms can be benign or even absent, for which reason the degree of exposure should determine the need for hospital observation. In moderate exposure, circumstances must determine the need for observation (if the patient lives a long way from a hospital, or lives alone, he/she should preferably be observed in hospital). Lung X-ray, blood gases, pulse oxymeter assist in the diagnosis.

Oxygen should be given to all who have or have had serious symptoms from the respiratory tract since hypoxia increases the risk that toxic pulmonary oedema can develop. Symptomatic treatment of the obstructive symptoms is essential, with inhalation and systemic treatment with bronchodilatory drugs. In the acute phase it is also essential to give corticosteroids as inhalation and possibly as systemic treatment, to limit the lung damage. There are indications for corticosteroid treatment if the patient has had serious symptoms such as laryngeospasm, intensive troublesome cough, haemoptysis, breathlessness, worsened oxygenation, bronchospasm, general effects, toxic pulmonary oedema, or has been exposed to large air contents of phosgene or nitrogen oxides. Local treatment of the respiratory tract with large doses of steroids is probably the most important, and is associated with few side effects, which, however, is significant particularly when steroid treatment becomes protracted. Where steroid treatment is protracted, there may be a reason for prophylactic antibiotic treatment in view of the increased risk of infection. Slight symptoms such as a burning in the mouth, throat and chest, salivation, irritant cough, slight hoarseness and chest discomfort are not sufficient indication for steroid treatment. Persons with pronounced trouble from the respiratory tract and who run the risk of developing pulmonary oedema can with advantage be treated with continuous positive

airway pressure (CPAP). Diuretics are of little value. Following exposure to irritant gases and if there are pronounced concurrent chemical or thermal burn wounds on the skin, systemic treatment with corticosteroids may affect the healing process unfavourably, increasing the risk of infectious complications.

Oxygen should be administered to casualties whose consciousness and/or circulation are affected. Oxygen not only improves oxygenation, but also reduces the toxicity of e.g. cyanides and hydrogen sulphide. Treatment in other respects depends entirely on what gas has been inhaled. Specific antidote treatment is appropriate in certain cases. See below Special poisons.

Following inhalation of inert gases, the treatment is the same as for hypoxia treatment.

Inhalation of hot gases involves a risk of, among other things, complications with oedema in the upper airways. The patient should be observed with this in mind during the next few hours. Acute intubation may be necessary following pronounced oedema of the larynx region.

Eye splashing
Following eye splashing with a chemical, the eye should be immediately irrigatedirrigated with a gentle jet of water from an eye spray, water glass or similar. The eyelids should be kept widely separate and the injured person should be encouraged to look in a different direction. Contact lenses should be removed. Local anaesthetics can relieve the pain, facilitating effective eye irrigation. If the substance is unknown, the irrigation should continue for at least fifteen minutes. Following eye splashing with corrosive substances: alkalis, amines, acids, oxidising agents (e.g. peroxides, chromates) tissue-fixing substances (e.g. formaldehyde, phenol), alkylating substances (e.g. mustard gas, certain cytostatic substances) and substances that reduce surface tension (e.g. quaternary ammonia compounds), irrigate immediately with a gentle jet of water or eye irrigation fluid for at least fifteen minutes, thereafter repeatedly during transport to hospital/doctor. Following splashing with irritant substances e.g. organic solvents, tensides, washing liquid, irrigate with a gentle jet of water for at least five minutes. For persistent trouble (intense smarting, pain, light sensitivity, impaired vision) continue to irrigate and contact/visit hospital/doctor.

Skin contact
Following exposure to a chemical that can involve a risk of local injury, i.e. chemical burn injury, irrigate immediately with large quantities of water – including inside the clothes. Particularly copious irrigation is

required where heat develops when the substance comes in contact with water. The irrigation should continue for fifteen minutes. The water should be warm so that the injured person does not become chilled. Contaminated clothes, shoes, jewellery etc are removed so that the irrigation is effective. When necessary the clothes must be cut off. Rescue personnel may need protective clothing. The toxic substance must in certain cases be removed mechanically, e.g. yellow phosphorus. If there is a risk of skin absorption or if the substance is not readily water-soluble, the skin should be carefully washed with soap and water. In certain cases of poisoning, e.g. with hydrofluoric acid and phenol, there is a possibility of administering local antidotes, thus neutralising the toxic effect. (See below Specific poisons.) Following irrigation, the injured parts are covered preferably with moist bandages (moist bandages are effective pain relievers). For transport of any duration however, it may be warranted to cover with dry bandages so as not to risk significant chilling. Chemical burn injuries are treated in general according to the same principles as thermal burn wounds. In the case of extensive injuries, an intravenous line should be arranged since large quantities of fluid may need to be given intravenously.

Ingestion
Following ingestion of corrosive substances the injured person should be given a drink (one to two glasses). Vomiting should never be provoked in persons with systemic affects (circulation, respiration, consciousness) because of the risk of seizures, or following ingestion of corrosive substances or petroleum distillates of the paraffin type.

Certain antidotes, etc, should be available at the accident scene (casualty assembly point) so that important treatment measures can be commenced even before the casualty is transported to hospital. See Special poisons.

Triage

Triage among chemical casualties follows the same rules as for other types of injury, i.e. triage is effected with regard to the symptom profile, yet with one exception. In certain situations symptoms may be delayed for many hours and suddenly make their debut with serious, even life-threatening, symptoms. Following inhalation of certain gases (e.g. phosgene, nitrogen oxides) the initial symptoms may be very mild or even absent, but after a symptom-free interval of hours up to several days, toxically triggered pulmonary oedema may suddenly occur. Following

skin contact, symptoms may also be delayed since it may take some time for the substance to penetrate the skin. It is essential to identify those casualties that risk delayed symptoms and ensure that these come under adequate observation relatively soon.

Standardisation of treatment

The casualty profile in an accident involving a toxic substance is the same for all casualties, but of varying degrees of severity. This may simplify triage and treatment. Both the classification and degree of severity of the symptoms and the treatment of injuries may be largely standardised. Examples of how classification can be achieved for casualties following exposure to corrosive substances and irritant gases, respectively, are given in tables 8 and 9. Apart from first aid, in certain cases specific treatment with, among other things, antidotes may be decisive for the outcome of the poisoning. This treatment may need to be commenced even before the casualty is transported to a health care facility. To some extent this treatment may be delegated to medically less qualified staff. Instructions can be given so that specific treatment can be started if the casualty shows certain typical symptoms.

Table 8. Classification of corrosive burns

Following exposure to corrosive substance with skin injury, classification can be effected according to the principles that apply to thermal burn wounds (following Arturson et al.):

Group 1 (Life-threatening injuries): dermal and full-thickness injuries exceeding 50% of body surface.

Group2a (Severe injuries): full-thickness injuries of 10–50% or dermal injuries of 20–50% of body surface.

Group 2b (Moderate injuries): full-thickness injuries of 2–10% or dermal injuries of 10–20% of body surface.

Group 3 (Mild injuries): full-thickness injuries of less than 2% of body surface or dermal injuries of less than 10% of body surface, or epidermal injuries.

Table 9. Irritant gases. Classification of degree of severity

Following exposure to irritant gases, severity of symptoms may be classified as follows (after Sörbo):

Group 1 (Life-threatening injuries): casualties with intense irritant coughing, breathlessness and systemic effects.

Group 2 (Severe injuries): casualties with considerable irritant coughing, possible nausea, but no other general effects.

Group 3 (Mild injuries): casualties with moderate or slight irritant coughing, eye symptoms and possible headache.

Hypochondriac reactions

In some cases the onset of symptoms after exposure to a toxic substance may be delayed by hours or a day or two. For this reason one does not always notice that one has been exposed to a toxic substance. The knowledge that one may have been exposed to a toxic substance may trigger hypochondriac reactions that simulate poisoning. Imagined or acquired symptoms may be aggravated by e.g. hyperventilation in connection with disquiet and anxiety which themselves give symptoms such as prickling and numb sensations in the hands, muscle cramp, vertigo and in the more serious cases even seizure and loss of consciousness.

It may be difficult for medical personnel arriving in an accident scene to determine whether the symptoms are real symptoms of poisoning, hypochondriac symptoms or a combination of these. To avoid an outbreak of panic, the 'exposed' persons should be informed in a calm matter-of-fact manner. This information often needs to be repeated once or several times. Persons who nevertheless exhibit panic reactions should be 'isolated' from the other exposed people so that they do not 'infect' them and can be looked after by what are termed crisis groups. Casualty assembly points and hospitals can be rapidly overloaded with people who are in no real danger. The genuinely poisoned, if there are any, may in this way be prevented from receiving necessary medical help.

Particular poisonous substances (including chemical weapons)

The poisonous substances mentioned in this summary are partly those for which specific antidote treatment is available and which are mentioned in the list of recommended antidotes to be kept in what are called the disaster stocks for chemical accidents (appendix 2) and partly also the most common such poisons. For antidote dosages, etc, the reader is referred to the chapter on Poisoning in the Drug Therapy Handbook.

Acetonitrile (and other nitriles)
Acetonitrile is a colourless liquid with a pleasant odour that is readily soluble in water. It is used as a solvent and in synthesis of certain substances. Following uptake in the body through inhalation, skin contact or ingestion, nitriles are broken down into, among other things, cyanide ions, which entail a risk of cyanide poisoning. Symptoms appear stealthily after four to sixteen hours. The specific treatment possible in this connection is intravenous administration of sodium theosulphate, which eases endogenous detoxification, and the administration of the complex-forming substance hyroxocobalamine. See further under Cyanide.

Ammonia
Ammonia is a colourless gas with a sharp prickling odour. Compressed, it changes to a colourless liquid. The water solution is strongly corrosive. Ammonia is used in large quantities in the chemical technical industry, among other things for the production of artificial fertilisers. It is also used as a cooling agent for skating rinks, refrigeration plants, etc, and is transported in special cisterns as a condensed gas. Ammonia is strongly corrosive of mucous membranes, eyes and skin even in gas form. The threshold of perceptibility of ammonia is approximately 4 ppm, while symptoms in the form of irritation from the eyes and nose do not occur until 100 ppm. Quite serious injury to the eyes and also the respiratory tract occurs at higher concentrations (>500–700 ppm). Life-threatening concentrations are given as over 3000 ppm. Inhalation of ammonia and its treatment follow the principles for irritant gases. Eye contact and skin contact involve risk of chemical burns.

Arsenic

Arsenic and its compounds are as a rule odourless and tasteless. Arsenical compounds are used in certain industrial processes but also as preservatives for impregnating railway sleepers, telephone poles etc. Gas containing arsenical compounds (Lewisite) has been used as a weapon, e.g. during the second World War – see below Chemical weapons.

Arsenic and most of its compounds are highly toxic and following massive exposure, the prognosis is poor despite optimal early treatment. Arsenic blocks enzyme-SH groups thus affecting, among other things, cell metabolism. Typical symptoms of arsenic poisoning are, following a certain latency, symptoms from the gastrointestinal tract with nausea and serious diarrhoea, frequently bloody. Later, muscular effects are seen, metabolic acidosis, loss of consciousness and effects on the heart with severe arrhythmias. Apart from optimal symptomatic treatment, antidote treatment with complex-forming (chelating) agents is essential. For parenteral use dimacaptopropanesulphanate (DPMS) is employed and for oral use dimercaptosuccinic acid (DMSA). Earlier, dimercaprol – BAL – was used. The antidotes form a stable complex – a chelate – in which the arsenic ions are rendered harmless and the complex is excreted in the urine.

Fire gases

Fire gases causes primarily heat injuries and carbon monoxide poisoning. In poorly ventilated premises, there is also a risk of lack of oxygen.

Table 10 Harmful substances that can be included in fire smoke

Harmful substances that can be included in fire smoke	Burning material
Carbon monoxide	diverse materials
Hydrogen cyanide	wool, polyurethane, silk, cotton, nylon, melamine, certain resins
Nitrogen oxides	nitro-cellulose film, polyamide (nylon), materials containing nitrogen
Hydrochloric acid	polyester resins, polyvinylchloride, chlorinated hydrocarbons
Sulphur dioxide	sulphur compounds, carbon, oil
Isocyanates	polyurethane
Akroleine	petroleum products
Phosgene	polyvinylchloride
Ammonia	polyamides, wool, silk, phenol resins
Hydrogen fluoride	teflon, materials containing fluorine
Hydrogen bromide	bromide compounds

In thermal decomposition, particularly smouldering fires, apart from carbon monoxide, carbon dioxide and soot particles, other compounds are also formed that can involve a great risk of serious injuries. Table 10 lists examples of harmful substances that may be contained in fire smoke.

Upholstery fillings, for example, often contain polyurethane which in a fire can release hydrogen cyanide, which can also be formed in smouldering fires in other material. In many fires a common cause of death has been hydrogen cyanide poisoning. Many of the plastics used as insulation material, in mouldings round doors and windows and in certain wallpapers, contain polyvinylchloride which, in a fire, releases hydrochloric acid which, among other things, irritates mucous membranes of the airways. Apart from lung injury with risk of pulmonary oedema, nitrogen oxides can cause methemoglobinaemia.

If consciousness is affected at any stage, hypoxia, carbon monoxide and hydrogen cyanide (cyanide) poisoning should always be suspected. The risk of cyanide poisoning increases if the fire is in an enclosed space (for example in a flat). Further factors indicating cyanide poisoning are cardiac instability with hypotension, smouldering fires in polyurethane, cotton, wool, silk, melamine etc and the presence of soot in the nose and mouth. The latter indicates that there has been a smouldering fire. In cyanosis, methemoglobinaemia should be suspected (exposure to nitrogen oxides).

All those with symptoms from the central nervous system should be treated with oxygen in view of possible carbon monoxide or hydrogen cyanide poisoning. If there is suspicion of hydrogen cyanide poisoning, hydroxocobalamine (vitamin B12) is given intravenously. If there are symptoms of irritation from the airways, the injured person should be considered to have been exposed to an irritant gas with a risk of later toxic pulmonary oedema. In methemoglobinaemia, methylthionine (methylene blue) should always be given intravenously since oxygen transport in the blood can already be worsened. See below Irritant gas and Cyanide and Carbon monoxide.

Cyanide

Cyanides such as potassium cyanide, sodium cyanide and calcium cyanide occur as colourless crystals, white powders or granulates and have a slight odour resembling bitter almonds. Cyanides dissolve readily in water, and are as a rule kept dissolved in lye since hydrogen cyanide is easily released in an acid environment. Hydrogen cyanide (prussic acid) is a colourless very volatile liquid. Cyanides are used in industry and laboratories and as pesticides. In fires, hydrogen cyanide can be re-

leased, see also Fire gases. Cyanides and hydrogen cyanide are extremely toxic. In a water solution they are rapidly absorbed via the mucous membranes and skin. They have high affinity with the cytochromoxidase system of the cells which becomes effectively blocked, with inhibited cell respiration as a consequence.

Symptoms develop rapidly and in the less severe cases there are headache, a taste of bitter almond and metal, disquiet, confusion, nausea, vomiting, palpitations and dyspnoea. In more serious cases there are also coma and seizures followed by growing muscular paralysis and respiratory and circulatory failure. Optimal symptomatic treatment with ventilatory and circulatory support are very important. Oxygen should be given to all where cyanide poisoning is suspected since oxygen not only improves oxygenation in the cells but also at the same time reduces the affinity of the cyanide with the cells' cytochromoxidase. Already at the accident scene, inhalation of amyl nitrate is important since this treatment may be given without qualified medical equipment or training. Amyl nitrite favourably affects the peripheral blood vessels and improves the flow of blood in the tissues. In addition, antidote treatment is of decisive importance for the outcome of cyanide poisoning and should be started as soon as possible, preferably at the accident scene. The complex-former hydroxocobalamine should be given as soon as possible intravenously. As a complement to hydroxocobalamine, sodium theosulphate (which increases the metabolisation of cyanide to the relatively non-toxic thiocyanate) should also be given in cyanide poisoning arising from ingestion or skin contact (and when cyanide is formed in metabolisation as in certain nitriles, e.g. acetonitrile, akrylnitrile). Following skin exposure to cyanide, the skin should be washed carefully with soap and water to prevent skin absorption. The prognosis in cyanide poisoning is relatively good if adequate treatment is started in time.

Phenol

Phenol (carbolic acid) and phenol-like substances are used in industry in the production of certain types of plastic, paints and glues and as disinfectants and decontamination fluids. Solutions stronger than 5% are corrosive to mucous membranes, skin and eyes. Diluted solutions are particularly readily absorbed through the skin. Inhalation of phenol fumes entails a risk like that following inhalation of irritant gases, with a risk of toxic pulmonary oedema. Apart from irritant symptoms, there is also a risk of systemic poisoning with effects on the circulation and consciousness, liver and kidney damage and methemoglobinaemia. Following skin contact with phenol (which is not readily water-soluble) the phenol can be efficiently removed with the solvent Macrogol 400 (polyethylene

glycol 400). If Macrogol is not available the skin is carefully washed with soap and water. Methemoglobinaemia is treated with methylthionine (methylene blue) which facilitates the re-reduction of methymoglobin. In other respects, treatment is symptomatic.

Hydrofluoric acid
Hydrofluoric acid is a water solution of the gas hydrofluoride. It is used for example in the production of printed circuit boards, as rust remover and cleaning substance, e.g. for removing graffiti, in the etching of glass and in the production of freons. Hydrofluoric acid is strongly corrosive in all its forms including gas. Fluoride ions have high affinity with calcium and can penetrate apparently intact skin. The fluoride ions here bind calcium in the cell membranes which leads to serious deep tissue injuries that are intensely painful. Particularly unpleasant is exposure to diluted solutions since early signs of injury are absent. Exposure to concentrated solutions on a surface > 1.5 dm^2 (corresponding to the palm of a hand) entail a risk that pronounced hypocalcaemia develops with arrythmias. Following skin contact the skin should immediately be irrigated copiously with water, while contaminated clothes, shoes, jewellery etc are removed. The skin is then massaged without delay with a calcium gluconate gel (Hydrofluoric acid burn jelly, HF-antidote) so that the fluoride ions are precipitated and further injury prevented. This treatment is very effective and should be given as soon as possible. If there are signs of deeper injury, it may be necessary to inject calcium subcutaneously or in certain cases given intra-arterial infusions of calcium. In more widespread exposure, calcium is also given orally and/or parenterally even before signs of hypocalcaemia have arisen.

Phosphorus
Red phosphorus is entirely harmless. Yellow, also called white, phosphorus is a solid that ignites spontaneously in air and may give serious burn injuries. Phosphorus is also absorbed via the skin and can cause liver injury. Skin that is exposed to phosphorus must be placed under water as soon as possible or covered with many wet compresses or towels since the phosphorus ignites spontaneously in air. Phosphorus should be removed from the skin. This should take place under water or in a shower, mechanical scraping being suitably done with a spoon or a spatula and forceps. Clothes that have been removed must be treated with great caution since they often contain phosphorus which if touched can cause new injuries to staff or damage to material. Clothes with phosphorus on them should be placed in a potassium permanganate solution bath whereafter they should be dried and burned. Following rough cleansing

the injured part of the body should be kept in or bathed with potassium permanganate until the injured part no longer glows in the dark – the phosphorus is converted to phosphoric acid – followed by irrigation copiously with water. In other respects the skin injury is treated as other corrosive burn burn injuries, i.e. according to the principles that apply to thermal burn injuries.

Chlorine

At room temperature, chlorine is a greenish-yellow gas with a prickling odour. Chlorine is used in large quantities in the paper pulp industry as a bleaching agent but also in the chlorination of water. It is stored in condensed form in storage cisterns and steel transport containers. It is transported chiefly in special cistern trucks by rail. Chlorine gas is strongly irritant on mucous membranes and eyes and in high concentrations also on the skin. Chlorine gas is relatively poorly water-soluble, for which reason symptoms of airway irritation appear early after inhalation and there is always a risk that toxic pulmonary oedema may develop if the initial irritant symptoms from the airways have been pronounced. The treatment of persons exposed to chlorine follows the guidelines that apply for irritant gases.

Carbon monoxide

Carbon monoxide is formed on incomplete combustion (e.g. too little oxygen) and occurs in, for example, fires (including those from stoves and open fires) and in car exhausts. Carbon monoxide is also present in concentrations of 1.5%–2.5% in town gas. Carbon monoxide is a colourless, odourless gas. It is inflammable and forms explosive mixtures with air. Inhalation of carbon monoxide entails risk of oxygen deficiency injury. Oxygen deficiency occurs partly because the blood's oxygen-transporting ability is reduced through the formation of carbon monoxide haemoglobin (COHb), but also through intracellular influence. Carbon monoxide is bound to the cytochromoxidase system in the cells, with effect on cell respiration. Serious cases can occur even though pathological COHb cannot be demonstrated. The medical history is of greater importance in guiding the degree of severity of the poisoning than an isolated COHb value. In carbon monoxide poisoning, growing effects on consciousness, circulation and respiration, and pronounced metabolic acidosis, are seen. The skin is often rosy, the lips and mucous membranes and the roots of the nails light red. Persons who have had pronounced symptoms or protracted exposure to carbon monoxide can, following a recovery phase of some days to weeks, relapse with mental and neurological symptoms including disquiet, irritation and impaired

vision and speech. Important in the management of these patients is optimal symptomatic treatment but also as soon as possible the administration of 100% oxygen. Hyperbaric oxygen treatment (HBO) should be seriously considered for all who are unconscious on arrival in hospital or who during their exposure have become unconscious for more than a brief period (some minutes), or who have other neurological symptoms. Complete recovery after serious carbon monoxide poisoning can take a very long time (months, years).

Mercury compounds

Mercury compounds are used in, for example, certain industrial areas, but also occur as laboratory chemicals. Many mercury compounds are corrosive (e.g. mercury chloride). Mercury poisoning can arise after inhalation of mercury compounds and mercury vapour and following ingestion of mercury compounds, but not of metallic mercury. Skin absorption may also occur if injured skin is exposed. Inhalation of certain corrosive compounds also entails a risk like that of irritant gases. Apart from possible effects, the greatest risk is kidney damage (tubular damage) and effects on the liver. Apart from symptomatic treatment, early treatment with a complex-former is essential. Parenterally, dimercapto-propane sulphanate – DMPS – is given intravenously and orally dimercaptosuccinic acid (DMSA) which effectively binds mercury in a complex. The complex is excreted in the urine and bowels (probably in bile). Earlier, dimercaprol (BAL) was used for parenteral use.

Nitrites

Inorganic nitrites and nitrates may be present in industrial accidents. Inorganic nitrates may also exist in high concentrations in contaminated water. Nitrates are converted in the body to nitrites, and nitrites involve a risk of methemoglobin formation. Typical for methemoglobinaemia is that the cyanosis appearing is not affected by administration of oxygen and that the blood is chocolate brown. Nitrites can also give peripheral vasodilatation with a fall in blood pressure as a consequence. Treatment comprises oxygen to optimise oxygen availability, and methylthionine (methylene blue) which reduces the methemoglobin that has been formed.

Nitrobenzene

Nitrobenzene is a yellowish liquid with an odour resembling bitter almonds. It is used industrially in several connections. The greatest risk of poisoning is following inhalation of the fumes, but also following skin absorption when the liquid has got on to the skin. The risk with nitroben-

zene is the formation of methemoglobin, and antidote treatment is the same as in nitrite poisoning (methylthionine).

Nitrogen oxides

Examples of nitrogen oxides are nitrogen monoxide, nitrogen dioxide and dinitro tetroxide. These gases are formed in various reactions with organic materials. Nitrogen oxides are yellowish-brownish in colour. They have an irritant effect on the mucous membranes of the airways with a risk of toxic pulmonary oedema. Initial irritant symptoms from the airways are, however, as a rule mild or absent and the debut of symptoms may be delayed some hours up to some days. The treatment follows the guidelines for irritant gases. Inhalation of nitrogen dioxide may also involve a risk of methemoglobinaemia, which is treated with methylthionine (methylene blue).

Organophosphates

Organophosphates are used as pesticides, but occur also as chemical weapons (see further chemical weapons). They are also used as fireproofing materials, softeners in plastics and as hydraulic fluids. Acute toxicity varies greatly for the different compounds. Some organophosphates are relatively non-toxic, but become toxic following metabolisation in the liver. The compounds act by inhibiting and enlarging the cholinesterase enzymes in the body. Poisoning is the result of a surplus of acetylcholine in the nerve endings. The symptoms are the same as seen in cholinergic overstimulation (tears, nausea, vomiting, diarrhoea and watery faeces, sweating, muscle spasms, seizures and muscular weakness, together with muscular paralysis, bronchoconstriction and coughing and increased mucous secretion, circulatory effects with primarily bradycardia and hypotension).

Symptoms develop as a rule after a certain interval, but serious poisoning may also develop very rapidly. Apart from optimal management regarding symptomatic treatment, the treatment is specific, with antidotes. Atropine is given which competitively blocks the over- stimulated receptors. Very high doses of atropine may be needed in serious cases. As well as atropine the patient is given an oxime which is a substance with the ability to reactivate the inactivated enzyme. In Sweden obidoxime (Toxogonin) is used.

Chemical weapons

Any use of chemical weapons can affect the civilian population. A drifting cloud of chemical weapons in aerosol form may be toxic up to six

miles away. Recent research has shown that skin absorption of the gas form is possible.

Only a drop or two of a chemical weapon in the liquid phase on the skin can involve a risk of serious, even life-threatening, poisoning. The number of persons who can require medical care varies greatly depending on shelter taken and on the purpose of the chemical warfare. In certain cases there may be only some tens of casualties among the civil population, in others, several hundred. If military targets in built-up areas are subjected to chemical warfare, tens of thousands of persons may need medical care.

Injuries from chemical weapons may also occur in peacetime, e.g. from mustard gas dumped in the Baltic.

Chemical weapons of primary relevance in Sweden today are nerve gases, mustard gases, Lewisite, hydrocyanide, psychochemical weapons and toxins. Tear gases may also be included here.

Even if current disarmament negotiations lead to a ban on the manufacture and use of chemical weapons, these will remain a threat for the foreseeable future. In addition, there is also a risk that old chemical weapons dumped in the sea (e.g. shells or barrels of mustard gas) may catch in trawls etc.

Nerve gases

The most important nerve gases are tabun, sarin, soman and VX.

Nerve gases or organophosphates that bind to the enzyme acetylcholinesterase, which becomes inactivated. This leads to cholinergic poisoning with symptoms from both the peripheral nervous system and the central. Serious poisoning is seen following skin contact and inhalation. Ingestion of contaminated food or contaminated water can also lead to poisoning. Local symptoms are seen from the eyes, the mucous membranes and the skin in consequence of direct local influence. These symptoms debut early. Symptoms of systemic poisoning are as a rule seen later, but such symptoms after inhalation appear very quickly (minutes).

Inhalation

Locally, symptoms are seen initially from the mucous membranes in the upper airways, (blocked nose, thin secretions) and in the lower airways (bronchospasm and heavy production of secretions). The latter is shown in e.g. initial respiratory difficulties. Later symptoms of systemic poisoning develop – see below. Nerve gases are very rapidly absorbed by the mucous membranes in the airways and following heavy exposure can give serious, life-threatening, symptoms within minutes.

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Eyes (liquid or gas form).
Locally there is miosis (contraction of the pupils) and cramp in the accommodation musculature (ciliar musculature) with impaired close vision. These symptoms may persist for one to two weeks if treatment is not started in time.

In eye exposure there is always a risk of inhalation or skin contact. Eye symptoms may be mild or absent if there has not been direct eye exposure.

Skin
Locally there is increased sweating and muscle fasciculations (muscle twitches). Symptoms of systemic poisoning following skin contact debut after varying periods from about half an hour, to several hours, even up to a whole day.

Ingestion
Ingestion of contaminated water or contaminated food can lead to systemic poisoning.

Systemic poisoning
In mild poisoning, salivation, runny nose, miosis, accommodation difficulties, headache, lassitude, unclear speech, tachycardia, nausea and hallucinations are seen.

In moderate poisoning there are also tears, salivation, sweating, mucus in the respiratory passages, bronchospasm, coughing, vomiting, stomach cramps, diarrhoea, muscle twitching and muscle seizures, bradycardia and high temperature. Sometimes there are involuntary contractions of the urinary bladder and involuntary passing of urine and faeces.

In severe poisoning there are additionally pronounced muscular weakness, general cramps, unconsciousness, pronounced effects on the heart with bradycardia and loss of blood pressure. In very serious poisoning the person who is exposed can die within minutes without having developed the classical signs of cholinergic poisoning.

Treatment
Theoretically even seriously poisoned persons can be saved if treatment is started in time. Decontamination is an important measure following skin contact. Contaminated clothing, shoes, jewellery etc must as soon as possible be powdered with personal decontamination powder. Personal decontamination powder 104, which is a mixture of chlorinated lime and magnesium oxide, efficiently inactivates the nerve gases. Following application of the personal decontamination powder clothes etc

should be removed and the skin washed carefully with soap and water. If personal decontamination powder is not available, the skin is washed carefully with soap and water. Optimal symptomatic treatment with fluid replacement, oxygen, supported ventilation and treatment of seizures is very important. Prophylactic or early treatment with benzodiazapenes is considered to reduce the risk of possible permanent injury to the central nervous system, for which reason benzodiazepines should be given even before there are signs of seizures.

Antidote treatment
Atropine and an oxime (enzyme reactivator) are the antidotes here. As oxime, obidoxime (Toxogonin) has been used in Sweden but HI-6 is a new oxime that is included in the new auto-injectors (see below). This treatment should be commenced already at the accident scene. The auto-injectors with which military personnel are equipped contain in the older versions 2 mg of atropine and 150 mg of obidoxime (Toxogonin) and in the newer versions 2 mg of atropine and 500 mg of HI-6.

The auto-injector dose can be repeated once or twice by the injured person or the rescuer. Atropine and obidoxime are then given by medical personnel following the guidelines for treatment of persons poisoned with pesticides containing organophosphates, see also the chapter on Poisoning in the Drug Therapy Handbook. In more serious cases very high doses of atropine may be required.

Following poison with the nerve gas soman, the oxime obidoxime cannot reactivate the enzyme. The oxime HI-6, however, can reactivate the enzyme in soman poisoning and is included in the new auto-injectors instead of obidoxime. Following eye splashing the eyes must be irrigated with a gentle stream of water for five minutes. Local application of eye drops with atropine counteracts the development of local eye symptoms.

Prophylaxis
As a prophylactic measure against nerve gas poisoning, pyridostigmin (30 mg) and diazepam (5 mg) tablets are given, with one tablet every eight hours. Prophylaxis together with self- administered help in the form of two auto-injectors gives a safety factor of ten to seventy, i.e. the individual tolerates ten to seventy times more nerve gas. Pyridostigmin is a carbamyl ester which inactivates acetylcholinesterase but the enzyme is rapidly reactivated 'of its own accord'. During the 'loose' binding of pyridostigmin to the enzyme, the latter is protected against attack by the nerve gas. Diazepam is thought to reduce the risk of seizure and of nerve gas injury to the central nervous system.

Following eye splashing the eyes should be irrigated with a gentle water jet for five minutes. Local application of eye drops containing atropine counteracts the development of local symptoms in the eyes.

Mustard gases

Exposure to mustard gas gives local skin and eye symptoms and systemic symptoms. Symptoms are delayed after both inhalation and skin and eye contact since several hours must elapse before the symptoms of the alkylating effect of mustard gas make themselves known. However mustard gas direct in the eyes manifests itself after a considerably shorter latency. Mustard gas is viscous and sticky.

In temperate climates, skin and eye damage is most common while in hot climates lung damage has been reported in 80%–95% of cases.

Inhalation

Following a latency period lasting as a rule 12–24 hours signs of inflammatory reaction in the airways are evident. In massive exposure there is a risk of toxic pulmonary oedema and systemic poisoning (see below).

Skin

Skin injury arises following exposure to both mustard gas fumes and to gas in the liquid state. After a latency period of some 6–24 hours mustard gas gives skin symptoms that essentially resemble thermal burn injuries but that heal considerably more slowly. Typical is a yellowish content in the blisters. Symptom onset following exposure to the liquid state is more rapid, three to six hours.

Eyes

Local eye symptoms also appear after eye contact, but after a shorter latency period (from minutes to hours).

Systemic poisoning

Following assimilation through the skin and the mucous membranes of the airways, general symptoms develop affecting the intestinal mucous membranes, bone marrow and lymphatic tissue (radiomimetic effect). The visible symptoms are nausea, vomiting, high temperature and diarrhoea, often blood-stained. Pancytopenia (anaemia, thrombocytopenia, leuko- and lymphocytopenia) are seen as an effect of the affected bone marrow. Because of this, increased tendency to bleed and sensitivity to infection develop.

Treatment

In skin exposure to mustard gas, personal decontamination with personal decontamination powder 104 is very important. Clothes and exposed skin are powdered liberally with personal decontamination powder. The clothes once removed and placed in plastic sacks, the personal decontamination powder is applied to affected skin, whereupon the skin is washed carefully with soap and water. If personal decontamination powder 104 is not available the skin is washed carefully with soap and water. Always finish with a full body-wash or shower.

Once mustard gas has been absorbed through the skin no specific treatment can be offered.

Broadly speaking, slight injuries (2%–10% dispersion on the skin) without marrow depression are treated in the same way as corresponding thermal burn injuries. Extensive injuries (more than 20%) which are probably also combined with marrow depression, often require intensive care. It is important at an early stage to replace fluid and electrolyte losses. Special regard should be taken to pancytopenia with accompanying tendencies to bleeding and infection. Lung complications often occur.

In cases of inhalation and where there are symptoms of airway irritation, treat as for irritant gases.

Lewisite

Lewisite is an arsenical war gas with local (skin, eyes, lungs) injuring properties and systemic poisoning (arsenic poisoning).

Lewisite gives both local symptoms from the eyes and systemic poisoning following assimilation through the skin and mucous membranes.

Skin

Lewisite is traumatic to the skin, irritant-corrosive and induces symptoms immediately. Immediately a burning pain is felt and then various degrees of caustic damage develop. Lewisite is also assimilated through the skin – see below, systemic poisoning.

Eyes

Lewisite is irritant-corrosive and gives immediate symptoms of irritation.

Inhalation

Lewisite irritates the mucous membranes of the airways. There is risk of pulmonary oedema following heavy exposure. Lewisite is assimilated via the mucous membranes of the airways – see below, systemic poisoning.

Systemic poisoning
Following assimilation through the skin and airway mucous membranes, symptoms resembling arsenic poisoning develop. The symptoms are delayed for some hours. Early symptoms from the gastrointestinal tract are due to absorbed arsenic damaging the mucous membranes in the gut, with pronounced diarrhoea, often stained with blood – resembling cholera with a risk of severe fluid losses. Metabolic acidosis is seen as a sign of cellular dysfunction. Heart arrythmias, often ventricular, may be seen in severe poisoning. Also there is haemolysis (decay of red corpuscles) and later kidney and liver damage. In a later phase neuropathies may be seen.

Treatment
Decontamination as for mustard gas with personal decontamination powder 104. If decontamination powder is not available, the skin is washed carefully with soap and water. Skin injuries are treated as thermal burn injuries. See also further treatment of systemic poisoning.

Inhalation
Treatment as for irritant gases. See also treatment of systemic poisoning,

Eyes
Immediate irrigation with gentle water jet for at least fifteen minutes. In addition, symptomatic treatment as for corrosive burns.

Systemic poisoning
The same principles as for arsenic poisoning apply i.e. careful symptomatic treatment and antidote treatment with chelating agents. For injection dimercaptopropansulphanate – DMPS (Dimaval) is used, and also dimercaptosuccinic acid (DMSA). (Earlier dimercaprol (BAL) or penicillamine was used). See further Poisoning in the Drug Therapy Handbook. Following severe exposure, treatment with chelating agents should be started before signs of systemic poisoning appear (diarrhoea, arrythmias, metabolic acidosis etc)

Hydrogen cyanide
It is uncertain whether hydrogen cyanide can be used as a chemical weapon, partly because it is considered hard to attain sufficiently high concentrations in the field. Hydrogen cyanide is lethal. It acts by blocking cellular respiration. It is less potent than nerve gases but the effect is very rapid. Hydrogen cyanide is assimilated through inhalation and through skin. However, it is not clear whether an uptake of hydrogen

cyanide through the skin contributes to the poisoning. For treatment see Cyanide, above.

Psychochemical substances

Psychochemical substances may conceivably be used, primarily for sabotage. Among these are LSD and phentanyl derivatives. Substances used as partial psychological incapacitators are BZ and related preparations. They are termed atropine-like psychochemical weapons (APS). They give an atropine-like (anticholinergic) poisoning profile and the treatment is the same as in anticholinergic poisoning. See the chapter on overdose in Swedish Pharmaceutical Specialties (FASS) (Belladonna alkaloids and derivatives).

Toxins

Among toxins, several are probably possible chemical weapons. The botulinous toxins are among the more toxic. The role of the mycotoxins is uncertain. Concerning the risks of inhalation, particular respect should be shown for stable, low-molecular-weight toxins.

Mycotoxins

There are over sixty different mycotoxins. Following injection of mycotoxins, acute symptoms develop such as skin irritation, nausea, vomiting, diarrhoea. Later coagulation disorders, anaemia and leukopenia are also seen. Following skin contact, basically the same symptoms develop as after ingestion, but skin symptoms are more serious and include blister formation. Following inhalation symptoms also arise from the airways.

Treatment is principally symptomatic, but treatment with antihistamines, prostaglandin synthesis inhibitors and corticosteroids have in animal experiments proved efficacious.

Botulinus toxins

Following ingestion of botulinus toxins symptoms appear after a latency period varying from ten hours to two (four) days. The target organ for the toxins is primarily the peripheral cholinergic synapse, but there is probably also a central effect. The onset of poisoning is usually with symptoms in the gastrointestinal tract with nausea, vomiting, constipation or diarrhoea. These symptoms may however be discrete. Otherwise the poisoning reveals itself in general muscular weakness and a tendency to hypotension. Split vision and difficulties in swallowing appear early. In more serious cases, the respiratory musculature is paralysed. Treatment is symptomatic, and includes respiratory support. Anti-toxin

treatment may hamper the progress of the poisoning, but does not affect symptoms already established. See further poisoning in the Drug Therapy Handbook.

Tear gases
There are a number of different tear gases, the most common of which are CN, CS (K62) and CR. Most potent are CS and CR. In Sweden the police use CS ampoules. Tear gas is strongly irritant on the mucous membranes. Asthmatics run larger risks of symptoms even following moderate exposure. The gases induce copious tears, burning pain, conjunctivitis and blepharospasm. As a rule the flow of tears stops within thirty minutes and the conjunctivitis within 24 hours. The risk of caustic injury is present if tear gas particles or fluid enter the eye.

Skin exposure to high concentrations of tear gas gives a prickling or burning feeling and flushing. Warm and moist skin reacts more strongly. Redness and burning sensations may persists for one to two days (also applies to hair roots). In massive exposure there is also a risk of caustic injury.

Inhalation of tear gases entails prickling sensations in the nose, mouth and throat, also salivation. Particularly in poorly ventilated premises, pronounced irritant symptoms from the airways are seen, with the risk of toxic pulmonary oedema.

Treatment is purely symptomatic. Early eye irrigation may relieve the symptoms. Rubbing the eyes should be avoided since the corneal epithelium is easily damaged. Following skin contact, contaminated clothes etc should be removed and kept in a plastic bag and the clothes should be thoroughly washed before they are used again. The skin is washed with soap and preferably lukewarm water and if possible this is followed by hot air decontamination, e.g. blowing with a hair dryer (at the same time the room should be properly aired). The hair should also washed carefully with shampoo. When skin and hair roots covered with tear gas are irrigated with lukewarm water, intensive smarting and flushing may recur even if the washing is done a long time after the exposure. The skin symptoms normally pass off within 24 hours. Following inhalation, and when pronounced symptoms of airway irritation are present, management is the same as for irritant gases.

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Functional requirements for chemical protection in health care facilities

(Amended since those in SoS Report 1995:15)

Decontamination premises

If the decontamination routines for the accident scene have been followed, the risks of contamination of the hospital emergency department or other care institution should be small. However, one cannot rule out shortcomings in the routines. In addition, account must always be taken of casualties from chemical accidents arriving completely un-decontaminated at the hospital.

It is therefore necessary that there is a decontamination resource at the hospital.

Hospital decontamination follows the same principles as decontamination at any other decontamination site – requirements for decontamination equipment and protective equipment are the same.

The decontamination station should be arranged to cope with accidents in peacetime both for chemical agents and for substances giving off ionising radiation. The station must also give reasonable opportunities for decontamination of fairly small quantities of chemical weapons without entailing serious consequences for the rest of the hospital.

In principle it should be possible to carry out decontamination on the premises of emergency hospitals, which affords, among other things, the possibility of immediate use. Pending such a solution and as a supplement, mobile decontamination arrangements, e.g. tents or vehicles, may be a suitable solution at the emergency hospitals that do not have fixed arrangements. A mobile resource may also be used for example in the accident scene or at a health care centre.

Decontamination on hospital premises must be possible without other parts of the facility being contaminated. This poses particular demands regarding siting and technical arrangement of decontamination premises. There must be no residual chemical weapons or substances that emit ionising radiation on surfaces or in the air, in areas where there are unprotected people. This also applies to other poisonous chemicals.

The decontamination area should permit decontamination of at least two recumbent patients simultaneously and should be capable of supplementation to take a further two to ten recumbent patients (depending on the risk situation) in a disaster situation. Each decontamination place should permit decontamination of at least four patients per hour.

The minimum necessary space for the decontamination premises is affected by many factors, e.g. the shape of the premises, number of decontamination places, ventilation capacity. As a rough guide, one may take a minimum floor area of about 4x4 metres per decontamination place. Several decontamination places together may possibly give a somewhat smaller minimum surface for each place.

Contaminated patients must be taken into the decontamination station from outside without first passing an ambulance hall or care premises.

After the decontamination station there must be a lock, where staff from 'the clean side' meet the patients. The lock should open into the ambulance hall (or equivalent) to achieve acceptable security against the dissemination of airborne chemicals. If this is impossible, and the lock opens into care premises (or equivalent) a lock must also be arranged at the outside entrance to the decontamination station. The air lock should be as small as possible to permit rapid airing by the ventilation plant. The smallest possible surface is determined by the rational transport of stretchers.

The decontamination station should be equipped with self-draining stretchers (or equivalent) and sufficient numbers of stretcher trolleys.

Functional requirements for decontamination stations

1. The decontamination station should be sealed off from other premises and should have a separate ventilation system. The ventilation system must not be shared by the ambulance hall or other premises. The sealing qualities of the walls and roofing of the decontamination station to the ambulance hall and other premises must be so good that pressure testing of the whole premises with shut doors gives leakage of at most $1m^3/m^2$ per hour at a pressure of 50 Pa.

2. Special heavy extraction fans withdraw air from the decontamination station and create a partial vacuum which must be capable of overcoming any counteracting forces from thermals, wind, unbalanced hospital ventilation systems etc.

3. Inlet conduits with electric warming of air are run from the ambulance hall or the outside to the inner air lock. Electric heating of inlet air will probably require the installation of inlet fans.

4. Excess flow device with non-return valve function should be installed between the air lock and the decontamination station.

5. During decontamination the ventilation should give a partial vacuum in the whole of the decontamination station in relation to the ambulance hall and other premises. This partial vacuum should be greatest in the decontamination station, at least forty Pa with shut door even in unfavourable weather. The partial vacuum in the lock between the decontamination premises and the ambulance hall must be half that obtaining in the decontamination station.

6. The air flow during decontamination should in the air lock between the decontamination station and the ambulance hall be at least twenty changes/hour and in the decontamination room at least seven changes/hour.

7. The air expelled from the decontamination room should be directed in such a way that there is no imminent risk of affecting the air intake for other ventilation.

8. A special 'operating button' should put the installation in operating mode for decontamination, i.e. putting the separate ventilation into operating mode for decontamination. In operating mode doors should also be controlledby electric locking devices and/or indicated by lamps so that the station doors cannot/may not be opened in series during decontamination. If the entrance to the decontamination room from the outside has no special entrance air lock, no more than one door may ever be opened at one time during decontamination.

9. For each decontamination place, for at least two places there must be both a fixed shower and a hand shower with warm water (37° C – note later recommendation is 35° C). Each shower must be able to deliver at least 20 l/m, preferably 30–50 l/m.

10. The decontamination premises should be maintained at an air temperature of at least 18° C during decontamination.

11. The decontamination room must be equipped with water-resistant and easily cleansable surfaces and installations.

12. The decontamination room floor must be drained efficiently with drains covered with grids. Run off from the decontamination station can normally be led to the ordinary sewerage system without special measures.

13. Ventilation during decontamination, lighting and the management of doors should be served with priority power.

14. Reserves of water (according to the SSIK programme) should be available for use during decontamination in the event of a breakdown of the ordinary water supply system.

15. All functions should be tested and verified.

The entire hospital should meet the following functional requirements, among others

16. Possibility to shut down the ventilation of the whole hospital 'in one movement in one place'. The shutting-down device should be placed both in premises that are manned round the clock, suitably in the emergency department, and by the hospital fire service schedule.

17. Programmes of measures and training to reduce as rapidly as possible the air flows through the buildings in an accident situation.

Other measures

18. Apart from the above measures and together with the rescue services, the possibility of planning for decontamination in other suitable, separate premises should be examined. In such a case these premises should be available for use in large accidents when normal field resources and the hospital decontamination facility are insufficient. If such premises can be found, e.g. in a free-standing carwash facility, no or at least marginal technical measures should be adopted for this supplementary resource, but the opportunity should be made use of.

Emergency stocks at hospitals

Note: The recommendations are taken from the Drug Therapy Handbook 97/98 (Läkemedelsboken) (offprint). Check with the latest edition.

The suggested stock quantities cover requirements for treating *10 casualties for 12 hours*.

Contact the Poisons Information Centre for details of where further antidotes are stocked.

Substance	Preparation		Quantity	Indication
Atropine	Atropin	inj. 0.5mg/ml	25 x 20ml	organophosphates, nerve gases
betamethasone*	Betapred	inj. 4mg/ml	16x5x1ml	irritant gases
budesonide*	Pulmicort Turboinhaler	inhal pulv 400 microg/dose	5x200 doses	irritant gases
dimercapto-proopane sulfonate (DMPS)	DMPS	inj 50 mg/ml	2x1x5x5 ml **	arsenic, mercury
Dimercaptosuccinic acid (DMSA)	DMSA	capsules 200mg	40**	arsenic, mercury
hydroxocobalamin	Cyanokit	inf. Substance	10x2x2.5g	fire smoke, cyanide compounds
calcium glubionate	Calcium-Sandoz,	inj. 9mg/Ca/ml	6x5x10ml	hydrofluoric acid
calcium gluconate	HF antidote jelly	jelly 2.5%	10x25g	hydrofluoric acid
calcium gluconate-lactate	Calcium-Sandoz	efferv.tabl. 1g Ca/tabl	10x10	hydrofluoric acid
potassium permanganate	Potassium permanganate	solution 20mg/ml	10x1000ml	yellow (white) phosphorus
methylthionine	Methylthionine (methylene blue)	inj. 10mg/ml	2x10x10ml	nitrites, nitrobenzene
obidoxime	Toxogonin	inj 0.25g/ml	4x5x1ml	oganophosphates
polyethylene glycol 400	Macrogol 400	Solution	10x500ml	phenol
terbutaline sulphate*	Bricanyl Turbohaler	Inhalant powder 0.5mg/doses	5x200 doses	irritant gases
tetracaine chloride	Tetracaine hydrochloride	Eye drops 0.5%	1x12x2ml	eye irrigation

*   Alternative substance or preparation may be selected.
**   Requirement for one dose. For 12-hour requirement, double quantity required.

Disaster stocks for transport to the scene of the accident

Note: The recommendations are taken from the Drug Therapy Handbook 97/98 (Läkemedelsboken)(offprint). Check with the latest edition.

The suggested stock quantities cover requirements for treating *10 casualties for the first few hours*. In addition, eye irrigation fluid, oxygen and syringes (2ml + 20 ml) and other equipment for injection should be included in this equipment.

Substance	Preparation		Quantity	Indication
atropine	Atropin	inj. 0.5mg/ml	25 x 20ml	organophosphates
atropine + obidoxime	Auto-injector	inj 2mg + 150 mg	10x1 injector	nerve gases
betamethasone*	Betapred	inj 4mg/ml	10x5x1ml	irritant gases
budesonide*	Pulmincort Turbohaler	inha pulv 400 microg/dos	10x200 doses	irritant gases
hydroxocobalamine	Cyanokit	inf. Substance	10x2x2.5g	fire smoke, cyanide compounds
calcium gluconate	HF-antidote jelly	jelly 2.5%	10x25g	hydrofluoric acid
calcium gluconate lactate	Calcium-Sandoz	efferv.tabl 1g Ca/tabl	10x10	hydrofluoric acid
methylthionine	Metyltionin (methylene blue)	inj. 10mg/ml	2x10x10ml	nitrites, nitrobenzene
personal decontamination powder	PS 104	powder	10x1 package	nerve gases
obidoxime	Toxogonin	inj 0.25g/ml	1x5x1ml	organophosphates
terbutaline sulphate*	Bricanyl Turbohaler	inhal pulv 0.5mg/dose	10x200 doses	irritant gases
tetracaine chloride*	Tetracaine hydrochloride	eye drops 0.5%	2x12x2ml	eye irrigation

* Alternative substance or preparation may be selected.

Decontamination of casualties from chemical weapons during raised alert states

Special rescue service support resources will establish a decontamination area and be responsible for management and co-ordination of measures on the decontamination lines for combination casualties, for uninjured persons and for the contamination of rescue personnel, medical personnel and police as they go off duty. Materiel, equipment and vehicles used at the damage area are decontaminated as decided by the support resource when their duty is completed.

Casualties are cared for at the accident scene, with the following measures by staff from the rescue services.

- Fix the casualty's gas mask on his/her face
- In nerve gas poisoning, give antidote with auto-injector
- Decontaminate bare body surfaces with personal decontamination powder
- Staunch possibly life-threatening bleeding
- Place casualty upon a stretcher.

Casualties are transported to the decontamination area in special vehicles (open flats or equivalent).

In the contamination area the casualties are unloaded for decontamination on a special line for combination casualties.

- Medical personnel (physicians) examine and sort the casualties
- Dead persons are placed in a special (screened off) place
- Medical personnel establish priorities for decontamination of casualties.

In a special line for decontamination of combination casualties, the rescue services together with medical personnel are responsible for the measures below.

- Casualties are undressed and the whole body surface uncovered (clothes may be cut up and removed)

- The whole body surface (including wounds, burn injuries (equivalent) is decontaminated with personal decontamination powder (powder)
- The casualty is transferred to 'the clean side' and placed upon a clean stretcher in a blanket and sack
- Where necessary further antidotes are given against nerve gas poisoning
- Life-saving measures and first aid are commenced
- The measures taken are recorded.

During the whole decontamination process the casualty retains breathing protection.

Decontaminated casualties are transported to a casualty assembly point or direct to the care institution.

The dead are decontaminated at the end of the operation in the accident scene covered with the contaminating agent.

Rescue service personnel coming off duty in a chemically contaminated accident scene and medical personnel who have assisted with triage and decontamination of casualties in the decontamination area, will be decontaminated on a special line in the decontamination area.

Equipment such as breathing protection and body protection (except for C-overalls) is decontaminated in hot air (110 degrees C) as arranged by the rescue service, for five hours at a special materiel decontamination facility.

All personnel participating in a rescue operation at the accident scene or decontamination area should, when the operation is commenced, take with them and hand over a change of clothes to the rescue services support resource.

A casualty assembly point is established outside the area where there is a risk from e.g. gas clouds. In a chemical weapons attack the casualty assembly point may be several kilometres away from the decontamination area. Situations cannot be ruled out where there is a lack of clarity regarding the decontamination position or, for example, whether a change of wind direction may bring about a risky heightening of the air gas content. For this reason body protection should be worn here and respiratory protection should be immediately available.

Before the casualty is brought to the casualty assembly point he/she should be decontaminated if need be.

At the casualty assembly point the exposed person is given the first medical treatment by medical personnel so that he/she may then be transported to the health care facility. Eye irrigation may be required as soon as possible in some cases even at the decontamination site.

The purpose of treatment of casualties in the damage area is to give the exposed/injured person greater possibilities of reaching acute medical care in as good a condition as possible.