Decontamination of casualties

- an European inventory and perspectives -

February 2007
According the scientific series - Civil Defence Research New Series 56 - the consecutive numbering in the English text version is the same as it is in the German text version. This will facilitate to find the corresponding paragraphs.

In Anlehnung an die Schriftenreihe –Zivilschutzforschung Neue Folge Band 56- wurde in der vorliegenden englischen Übersetzung die Nummerierung der Deutschen Textausgabe beibehalten. Somit wird ein leichteres Auffinden der entsprechenden Textpassagen ermöglicht.
1 Tasks and Objectives

1.1 The Research Assignment

Over the last decade, scientific discussions at various specialist congresses have led to the conclusion that there is inadequate regulation of the problems associated with the decontamination of casualties after an incident involving hazardous chemicals. One of these was a workshop held jointly with the DGKM in 1999 at the Akademie für Krisenmanagement, Notfallplanung und Zivilschutz that highlighted the significance of this problem.

The Federal Administrative Office – Directorate for Civil Protection and Emergency Planning – in Bonn as well as the Procurement Agency of the Federal Ministry of the Interior, who had already addressed these problematic issues before the terror attacks in September 2001, awarded a contract in November 2001 to develop a concept for the “Decontamination of Injured Persons during Chemical Agent Incidents”. The aim was to analyse past incidents involving hazardous chemicals and to implement the results into standard operating procedures and algorithms. This was to be followed by validation of their practicality in a field exercise.

1.2 Necessity

From the civil protection point of view, the release of chemicals is a special case for various reasons. In addition to industrial accidents or the impact of natural catastrophes that could affect the chemical industry, storage facilities or transports, the consequences of terrorist attacks are also of increasing significance following the events in Tokyo 1995 (sarin attack in the subway) and New York 2001 (airplane attack of the World Trade Center). At present, Germany is in the fortunate position of not being directly threatened by a military confrontation, as frequently is the case in the Near East, for example.

A concept to deal with the above-mentioned scenarios is not only associated with more demanding requirements for the rescue and healthcare system, it is also a cause for conflict.
After a mass casualty incident, these systems are suddenly confronted with additional challenging and even dangerous tasks that have to be dealt with in addition to the classical tasks of recovery, rescue and firefighting, carried out by the fire brigade and the technical rescue services, as well as the emergency and secondary medical care of the sick and the injured. These include working at a location that may be contaminated and also having to deal with patients or the general public who may be contaminated with the released chemical substances and who are thus potentially hazardous not only to themselves, but also to all members of the rescue services and other persons coming into contact with them. The key goal is to avoid the spread of contamination because this could have the disastrous consequence of crippling the secondary resources of the healthcare system, such as rescue transportation, hospitals, medical practices, etc.

Decontamination of victims, particularly those who are injured, is thus the greatest challenge. Speed is the crucial factor for successful decontamination after exposure to any chemical agent, and there are crucial differences with respect to this in the civil and military sectors. The fastest method is, of course, self-decontamination. However, in Germany (in contrast to Israel, for example) this has only been tested and implemented in the military sector. Soldiers have their own personal protective equipment and a decontamination set; they are also specially trained. No experience has been made in this regard in the civil sector in Germany. A coherent concept that includes the civil sector is thus all the more urgent. The current medical care options of the emergency rescue services as well as those of civil and disaster management must be urgently revised. If such an incident leads to the release of hazardous chemicals, e.g. industrial chemicals, chemical warfare agents, etc., that contaminate the victims, this requires the fastest possible emergency medical care to ensure the survival of the maximum number of people. This emergency medical care includes the following measures:

- Emergency rescue and medical care of a number of injured, sick and possibly contaminated persons close to the incident scene
- Decontamination, radiation cleanup, disinfection and/or detoxification of a number of injured, sick and possibly contaminated persons before they are finally accepted by a suitable hospital
• Transport of a number of injured, sick and possibly still contaminated persons to suitable hospitals, even over large distances (e.g. burn victims)

• Medical care of a number of injured, sick and possibly still contaminated persons in suitable hospitals

• Procurement and provision of appropriate consumables (e.g. medicines and antidotes) required for the correct treatment of injured, sick and contaminated persons

Concepts to manage incidents involving hazardous chemicals require regular drills and validation. Educating, informing and training of the general public on how to respond if hazardous substances are released are further important and previously neglected aspects of civil protection. There are also particular problems relating to the strict division and separation of the site into different working areas (e.g. into black = contaminated; grey = residual contamination; white = decontaminated), the triage procedure and emergency medical care of contaminated patients. The proper disposal of contaminated clothing and equipment to store contaminated wash water have only been addressed inadequately, if at all. Responsibilities for the emergency medical services and disaster management have been independent for many years. Right from the start, this led to separate approaches, concepts and procurement systems that had only limited mutual compatibility. Differences in the organisation of protective measures in the individual federal Länder is another factor. Existing resources are outdated, are only partially operable or are not in a full state of readiness. Neither standardised operating procedures nor sufficient equipment are available for a large number of victims contaminated with hazardous chemicals, radioactive materials or biological agents.

The management of an incident involving hazardous chemicals, irrespective of size, location and time of the event, presents a formidable challenge to the systems that are already in place. Although Germany's emergency medical service has one of the best rescue systems in the world and a large number of (predominantly voluntary) firefighters are on standby, there are still considerable shortfalls in disaster management – particularly with respect to civil protection. Over the past 10 years, civil protection has been affected by a politically based savings policy that was prompted by changes in the international security situation.
It was postulated that there would be only isolated cases of damage and, in particular, no large-scale destruction of the infrastructure. It was also assumed that the defence and rescue forces would have enough time to reach their full performance capabilities so that numerous special and planning reserves were no longer necessary. Particularly the hitherto existing assumption that civil protection and disaster management forces would have sufficient prewarning time to set up their disaster control systems depending on the situation and requirements, now only applies to a very limited extent.

It is logical that the management of incidents with large-scale damage requires a coordinated team effort. The necessary rescue resources must be provided in an interdisciplinary manner, on a local, supraregional or a national level, as required. This contrasts with the hitherto existing strategies followed by the fire brigade and rescue organisations: the fire brigade does not consider the decontamination or treatment of large numbers of casualties to be one of their duties. However, from the medical point of view, it is occasionally necessary to carry out emergency medical care – including triage – in the contaminated zone before casualties are decontaminated. On the other hand, the emergency medical service does not regard decontamination to be one of its duties. The rescue organisations regard themselves to be responsible for treating casualties only after they have been decontaminated – especially as they do not have the equipment or the know-how to work in the contaminated zone. Therefore, within the scope of this research project, a consensus was to be found with respect to this issue. Furthermore, this project should be followed by the development of emergency and disaster contingency plans for incidents involving hazardous substances. The training of specialised rescue personnel as well as further training of all rescue personnel is imperative, not only with respect to dealing with and working in protective clothing. The practical implementation of the expected research findings should include implementation of the lessons learned into protective measures and civil protection practices in the healthcare system. Reconfiguration of the equipment carried by the Casualty Decontamination Unit is another goal.
1.3 Scope of the topic

The properties and effects of hazardous radioactive, biological or chemical materials are generally very different. The fact that incidents involving these hazardous materials require similar individual and well-known defence mechanisms is misleading because there are often major differences in the hazard potentials and in the associated consequences for humans, the environment and materials. For this reason, the individual components of the protection and management strategies used by the rescue services must be considered individually for nuclear, biological or chemical threats. However, particularly operational tactics, equipping of personnel or vehicles, consumables as well as the training of rescue personnel and practical exercises require the development of common principles and operating procedures that are commensurate with the complexity and changing situations in this field. The decontamination and emergency care of casualties at the incident scene represent only a part of several operational phases with respect to the overall situation. Within the scope of this research project, this contribution only discusses the components required for the decontamination of casualties resulting from incidents with chemical agents. Analogous procedures are conceivable for hazardous nuclear or biological materials; however, they require a separate evaluation.

1.4 Aims of the research project

The key goal of this research project was to develop an organisationally feasible concept with respect to the set up and procedures required for timely decontamination and emergency care of a large number of contaminated casualties. An additional objective was to determine the requirements for decontamination equipment used for this scenario.

1.5 Objectives and description of the research project

1.5.1 Description of the research project

The research project was subdivided into subject areas, and working subgroups were formed.
The following aspects were considered in detail:

- measures to cordon off the contaminated site
- impact of the resorption of hazardous materials
- working in protective clothing
- initial paramedical measures
- triage
- initial medical treatment by a doctor
- retriage
- medical treatment by a doctor
- wound dressing techniques
- transport
- decontamination of casualties with special consideration of open wounds, open injuries to the skull, the thorax, the abdominal cavity, and the extremities, as well as blast injuries to internal organs, shock, burns, chemical burns, polytrauma
- decontamination of casualties in various positions (recumbent, standing, etc.)
- decontamination, leaving out dressed wounds
- formulation of algorithms for the decontamination of casualties structured according to various injury patterns.
- materials used for decontamination (water, etc.)
- temperature of the decontaminants
- influencing chemical processes by means of the decontaminant temperature
- antidotes
- disposal of contaminated materials
- development of a training concept
- field exercise and presentation of the concept
- publication of the concept
4 The new practicable concept for the decontamination of casualties

4.1 Starting situation

A concept for the decontamination of casualties after an incident involving a chemical agent presents numerous challenges to the rescue services from the various organisations. In addition to communications and cooperation, which have to be planned and tested in advance, the "usual" requirements arising from a mass casualty incident that involves a hazardous substance or a warfare agent also include the possibility of a considerable threat to the rescue personnel, the directly affected population, the victims as well as the downstream care facilities (e.g. hospitals). A corresponding concept must therefore take account of suitable decontamination systems for the respective target group to provide rapid intervention after exposure and to prevent, in particular, the spread of contamination and any additional hazards to the rescue personnel. A further basic principle for a concept to decontaminate casualties after a chemical incident is a good understanding of the chemical substances, their basic physiological properties and their toxicity. All participating rescue services must have this basic knowledge, not only to ensure optimum patient care, but also to allow them to protect themselves. Specialised rescue personnel must have the appropriate diagnostic know-how and others must be trained in the use of specific antidotes, types of treatment and substances used for decontamination.

Decontamination is defined as the removal or neutralisation of chemical substances so that they are no longer harmful. These substances can be removed by a physical means or neutralised chemically (detoxification). A primary goal is to decontaminate the skin as quickly as possible to minimise harmful effects. The eyes and wounds should also be decontaminated without delay.
The decontamination of people is divided into the following basic types:

- **Self-decontamination;**
  refers to decontamination carried out by the contaminated person him/herself as well as decontamination by untrained helpers (e.g. relatives).

- **Decontamination of people (general public);**
  refers to the decontamination of uninjured persons by trained rescue personnel.

- **Decontamination of casualties;**
  refers to the decontamination of casualties (general public and rescue personnel) by trained rescue personnel.

- **Decontamination of rescue personnel;**
  refers to the decontamination of uninjured rescue personnel by other rescue personnel.

The most effective way of treating someone who has been exposed to chemicals is to decontaminate them immediately after they have been contaminated.

This goal can only be achieved by self-decontamination because help from the rescue services is generally not available within such a short time span. Self-help of a contaminated person may mean the difference between survival (or a slight injury) and death (or a serious injury). All persons who have been inside the danger zone of an incident involving hazardous chemical substances must be regarded as being contaminated as a matter of principle. It is therefore imperative that such persons are decontaminated and then subjected to a contamination test. This must be carried out as quickly as possible at the incident scene to protect the victims. However, there are also other reasons for the removal of (potential) chemical contaminants from the body of a patient at the incident scene:

1) If decontamination is delayed, further exposure of the human body to chemicals may increase the patient's injuries.

2) Rescue forces who come into contact with a contaminated person have to be protected against the chemical.

3) Downstream medical care units must be kept free of all contaminants, as otherwise there can be serious implications on the subsequent care of threatened, sick or injured patients.
4) Overall, it must be concluded that the spread of contaminants has serious effects on the infrastructures of the rescue services and of the emergency medical system, and may also affect the outcome of the injured person.

Decontamination of casualties is a very complex task. The decontamination process requires the provision of a large number of rescue personnel and materials, and also takes a considerable amount of time. Even if planning is accurate and drills have been carried out, the need for rapid action leaves only a small time window for the decontamination of casualties. Previous concepts have not included accurate figures on times required until specially trained personnel are at operational readiness, until a decontamination station has been set up and the exact time required for the decontamination process.

Depending on the assumed intervention time, it may take 60 to 90 minutes before the rescue services and the decontamination station are operational and patients can be decontaminated. These statutory response times are illustrated in the following figures and in table.

**Fig. 26: Statutory response times for rescue services**

**Hilfsfristen**

\[
\begin{align*}
t_0 - t_1: & \text{ Detection time} \\
t_1 - t_2: & \text{ Notification time} \\
t_2 - t_3: & \text{ Warning time} \\
t_3 - t_4: & \text{ Departure time} \\
t_4 - t_5: & \text{ Travel time} \\
t_5 - t_6: & \text{ Reconnaissance time} \\
t_6 - t_7: & \text{ Set-up time}
\end{align*}
\]
Response times

Response time according to DIN 14011

Response time according to Federation of Professional Firefighters (federal level), Federation of Professional Firefighters (North-Rhine/Westphalia), Federation of Firefighters (Baden-Württemberg)

Fig. 27: Additional time required until trained personnel arrive at the incident scene

Table 34: Estimations of the required time

<table>
<thead>
<tr>
<th>Measure</th>
<th>Time in min</th>
<th>Volunteer fire brigade 1st tactical unit (basic)</th>
<th>Volunteer fire brigade 2nd tactical unit (basic support)</th>
<th>Professional fire brigade 1st tactical unit (basic)</th>
<th>Professional fire brigade 2nd tactical unit (basic support)</th>
<th>Emergency rescue service 1st tactical unit</th>
<th>Hazmat unit 1st tactical unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Discovery</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Reporting warning time</td>
<td>0</td>
<td>2</td>
<td>1.5</td>
<td>1.5</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Departure time</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>14</td>
<td>1</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Travel time</td>
<td>5</td>
<td>10</td>
<td>7</td>
<td>13</td>
<td>14</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Incident</td>
<td>Discovery</td>
<td>Notification and warning time</td>
<td>Departure time</td>
<td>Travel time</td>
<td>Reconnaissance/Set-up</td>
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<td></td>
<td></td>
<td></td>
<td>1st squad + group leader</td>
<td></td>
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<td></td>
<td></td>
<td>30</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Only for own personnel, usually rescue personnel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The time required for triage and emergency treatment should not significantly differ from other missions; it may be even shorter because the protective clothing worn by the rescue workers limits their intervention capabilities. Experience gained with military concepts has shown that a non-ambulant casualty, who has been triaged and given emergency medical treatment, requires between 8 and 20 minutes for complete decontamination, the contamination test and hand-over to the white area. The number of persons that can be decontaminated depends on the size of the tents and thus the number of available "decontamination units". Casualties that have to be decontaminated on a stretcher require several helpers, whereas those with minor injuries, if any, obviously require less assistance.

As a consequence, personal self-decontamination must be taught as a self-protection measure.
These measures may include:

- removal of contaminated garments,
- mechanical removal of hazardous materials/warfare agents with technical aids
- those affected must be aware that this self-protection may save their lives. Furthermore, it must be discussed whether protective equipment (e.g. respiratory protection) should be made available to the general public.

4.2 Medical care issues during decontamination of casualties with respect to the interface between the different rescue services for accidents resulting in 1-5 contaminated casualties

In the conventional treatment of contaminated patients, particularly those that require immediate medical treatment, there is a huge time delay after the emergency medical services have arrived until an adequate medical set-up has been established. Even the subsequent alerting of larger special units with longer response times does not lead to the desired shortening of the time to first treatment. Special task forces should have departure times of 30 minutes; however, continuous standby cannot be guaranteed. Particularly during a normal working week there may be considerable delays or unpredictable shortfalls in personnel. Disaster control units may need between 1 and 24 hours until they are at full strength. Because the time factor plays an essential role in the decontamination of casualties, initial measures must be started immediately after the first units have arrived at the site. The responsibility for the care of contaminated casualties thus inevitably lies with the emergency medical service. The emergency medical service is thus responsible for

- implementation of such a concept in the emergency medical service sector
- collaboration with the fire brigade to collate the necessary medical materials and technical utensils
- necessary appointment and support of officers who are to deal with NBC accidents
- initial and advanced training of a group of personnel for NBC duties
- healthcare and aftercare in cooperation with occupational health services. (e.g. suitability to work in protective clothing, aftercare after an NBC deployment,
regulations regarding inability to work, etc.)

• integration of special task forces into the concept as well as their training
• preparatory contacts to hospitals and regulations for decontamination work prior to hospitalisation
• the continuous maintenance and provision of the necessary medical materials as well as logistics planning with antidote depots or hospital pharmacies
• cooperation with local health authorities, district administrations, medical associations
• cooperation with command centres
• cooperation with nearby rescue service regions (particularly with respect to agreements on the economic aspects of stock-keeping)
• instruction and training of those working in the emergency medical service sector.

*Fig. 28: View of a decontamination unit for 1 to 5 casualties*
For a scenario of one to five casualties, the standard resources of a community fire brigade as well as the equipment carried by an emergency doctor's car/emergency ambulance (German DIN standard) should be sufficient to provide primary care to each patient (compare the Helms/Wenke concept "Decontamination von Verletzten (Decontamination of Casualties)"). Depending on the severity of the contamination/injury, this can generally be carried out with the procedures described below and extended to the treatment of up to 5 recumbent casualties. The prerequisite for this is to establish the awareness of boundaries between contaminated (black) and uncontaminated (white) areas and their visualisation.

A decontamination station with a contamination control point is set up outside the danger zone, taking account of the usual protection criteria, such as wind direction and topography. The patient is rescued on a scoop stretcher by a fire brigade crew. This stretcher is then placed on a suitable positioning aid (stretcher support with cross-bars, supporting frame of a roll-in stretcher) at working height. The patient's head should point towards the white area.

The patient is handed over to the treatment team — comprising 2 firefighters, who carry out decontamination and the contamination test, and 2 EMTs who carry out any initial medical procedures to stabilise the patient.

**Fig. 29: Decontamination for the scenario with 1 to 5 casualties**
This group of people is equipped with personal protective equipment comprising a self-contained breathing apparatus (full face mask with ABEK2 P3 combination filter), chemical-resistant disposable protective overalls (lightweight) as well as protective boots (preferably made of rubber). Whereas the firefighters wear chemical-resistant gloves, the members of the emergency medical service wear two sets of examination gloves worn one on top of the other. The emergency doctor will also wear such protective equipment during the preparatory phase; however, the filter mask with combination filter is not necessarily worn. The doctor should remain in the white area as far as appropriate in accordance with the overall concept and to conserve emergency doctor resources, particularly if they are scarce. As soon as a doctor enters the black area, he/she is considered to be contaminated and is thus no longer available for final preclinical treatment of patients and during transportation of the patient to the hospital. The patient is first subjected to a contamination test. This is followed by an assessment of the vital functions with subsequent spot decontamination of the mouth and throat to prevent incorporation. Any life-threatening problems of the respiratory tract can then be corrected. Next, the patient is undressed to remove any contaminants adhering to clothing. This is followed by spot decontamination of the face and one arm. The patient is fitted with a disposal oxygen mask with a reservoir and an oxygen flow of at least 8 l to protect the patient from the effects of an aerosol during spot decontamination or later full-body decontamination. The oxygen supply unit should remain in the white area, if possible. The spot-decontaminated arm is used to measure the blood pressure, to apply a pulse oximeter (apparatus should be kept in the white area, if possible) and to insert a venous cannula, if required medically. Any medicines or necessary antidotes specified by the emergency doctor are administered. Any large open wounds are spot-decontaminated and dressed (e.g. OpSite dressing).

This is followed by full-body decontamination with water and added detergents, if necessary. After the patient has been found to be free of contamination, the i.v. cannula is removed and the wound is dressed, then the blood pressure cuff, sensors, ECG adhesive and oxygen mask are removed, and the patient is handed over to the team in the white area. If the monitors have remained in the white area, the sensors are unplugged from the monitors and handed over to the black area. They are then sent to the equipment decontamination unit, if possible.
A further emergency ambulance crew with an emergency doctor should be available in the white area. Furthermore, there should be a liaison officer for the fire brigade who informs the leader of the medical team and the emergency doctor about the known properties of the hazardous materials and who can also retrieve information from existing databases (Hommel, Keudel, TUIS, Gifnotruf, Meditox etc.) if necessary. During treatment in the black area, the emergency doctor monitors the procedures being carried out in this area, issues instructions and prescribes drug dosages. These drugs are prepared by medical service personnel in the white area and placed in the predetermined hand-over area. The patient is now treated as usual and then evacuated to a hospital. It is important that after the patients have been decontaminated, they are in no further danger from external contamination with the hazardous material. Any already incorporated hazardous materials must be neutralised by administration of an antidote or by surgical debridement or pharmacotherapy in the hospital, as appropriate. Any regions of the body that could not be decontaminated must be covered and precisely documented.

Personnel trained according to this concept can use the above-mentioned materials to carry out triage and initial treatment at a mass casualty incident as well as structuring of the casualty clearing station until management measures for more serious incidents are ready for operation. In this case, not only triage is carried out, but also basic life support, in particular, as well as fast and correct undressing of the patient to remove large amounts of the hazardous material. Registration can then be started. Particularly urgent patients can be individually decontaminated and then released for treatment at the treatment station that is being set up.

4.3 Details of the sequence at the Casualty Decontamination Station for a mass casualty incident

The Operational Section (OS) where casualties are decontaminated is defined as the Casualty Decontamination Station (DECON C). It is located between the danger zone (incident scene) and a non-contaminated "white area" – and usually upstream of the actual medical treatment station operated by the emergency medical and disaster management services.
This decontamination station is divided into 9 different areas with different functions (Table 35).

The decontamination station includes a decon reception area (to collect and register casualties), a decon triage area (including a patient management system), a decon treatment area, decontamination area C for recumbent and walking casualties who are contaminated, decontamination area P for rescue personnel and materials as
well as a boundary line between the contaminated (black) and non-contaminated (white) areas. The decontamination station is set up and managed jointly by the fire brigade and emergency medical service.

**Table 35: Areas and their functions at the Casualty Decontamination Station DECON C**

<table>
<thead>
<tr>
<th>Areas</th>
<th>Area designation</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reception area</td>
<td>Decon reception area</td>
<td>Registration and triage</td>
</tr>
<tr>
<td>1. Decon assembly area</td>
<td></td>
<td>Patient clearing station and registration</td>
</tr>
<tr>
<td>2. Decon triage area</td>
<td></td>
<td>Undressing, triage and documentation prior to decontamination</td>
</tr>
<tr>
<td>Treatment area</td>
<td>Decon treatment area</td>
<td>Basic life support measures</td>
</tr>
<tr>
<td>3. I / II</td>
<td></td>
<td>Spot decontamination, BLS, antidote administration, wound coverage</td>
</tr>
<tr>
<td>4. III</td>
<td></td>
<td>Spot decontamination, BLS, antidote administration, wound coverage</td>
</tr>
<tr>
<td>5. IV</td>
<td></td>
<td>Spot decontamination, BLS, antidote administration, wound coverage</td>
</tr>
<tr>
<td>6. †</td>
<td></td>
<td>Temporary morgue</td>
</tr>
<tr>
<td>Decontamination area</td>
<td>Decontamination area C</td>
<td>Decontamination of patients</td>
</tr>
<tr>
<td>7. DECON C Walking</td>
<td>Decontamination, contamination test, hand-over</td>
<td></td>
</tr>
<tr>
<td>8. DECON C Recumbent</td>
<td>Decontamination, contamination test, hand-over</td>
<td></td>
</tr>
<tr>
<td>9. Decontamination area P</td>
<td>Decontamination of rescue personnel</td>
<td></td>
</tr>
</tbody>
</table>
Prior to the actual decontamination procedure, all those affected are gathered in the reception area for registration and classification as Recumbent or Walking.

In the decon triage area, the treatment priority is decided before decontamination is carried out. Treatments at the decon treatment station include spot decontamination, basic life support (BLS), administration of antidotes and waterproof coverage of wounds. In contrast to conventional rescue operations, immediate treatment in the contaminated zone may be necessary in the case of mass casualties for two reasons: only a rapid spot decontamination e.g. of the face, obviously contaminated body parts, wounds and conventional skin punctures can minimise morbidity and mortality prior to decontamination, which may be delayed owing to the large number of casualties. Analyses of earlier incidents have shown that in cases where there is such a large number of contaminated casualties, frequently only those with stabilised vital signs who have received preliminary treatment (e.g. treatment and dressing of wounds) are able to survive the decontamination process. Recumbent and walking patients are decontaminated in separate tents within Decon C. Rescue personnel and their materials are subsequently decontaminated in personnel area Decon P. Before anything or anyone is allowed to pass the boundary line (hotline), they are subjected to a decontamination test to prevent the spread of contaminants. After hand-over at the hotline, the patient enters the "white" (non-contaminated) emergency care area (medical treatment station) where they undergo retriage and further medical care. Evacuation of the patients is organised in the subsequent evacuation area.
4.4 Functional description of DECON C (Casualty Decontamination Station)

4.4.1 Responsibilities

The operational section Casualty Decontamination Station (OS DECON C) is divided into nine sub-sections (SS), each of which is headed by a leader (squad or group leader — SL/GL) — referred to in the following as a subsection leader (SSL). Depending on the core activities, this subsection leader is a member of the fire brigade (SL/GL FB: all duties relating to the infrastructure, the decontamination process or contamination testing) or a member of the emergency medical service (SL/GL EMS: all medical duties).

The overall responsibility for Operational Section DECON C lies with the responsible Operational Section Leader (OSL) of the fire brigade, who is assisted by the squad leader of the emergency medical service, a further squad leader of the fire brigade and also by the participating emergency doctors within the bounds of their medical responsibilities. Within the individual subsections, the responsibilities and duties are delegated to the individual subsection leaders.
This does not affect the medical responsibilities of the attending emergency doctors and their authority to issue instructions. The Operations Command Post directs the following:

- set-up and operation of the Operational Section
- cordonning off of the Operational Section
- coordination within the decon subsection, particularly patient flows
- communication structure to Operations Command and to the subsection leaders
- infrastructure and supplies
- responsibility for the staff and equipment within an Operational Section

OSL DECON C is assigned a squad leader from the fire brigade who assists in dealing with the OSL's duties and maintains the communications structure within the OS and outwards to Operations Command. This squad leader assists the OSL and coordinates work between the individual subsections as well as the distribution of patients. There is also a fire brigade crew (crew member and leader) without any special duties who supply materials from the white area and work wherever there are personnel shortages (e.g. operation of Decon Walking as Decon Recumbent or as additional stretcher bearers/escorts, etc.).

### 4.4.2 Setting up phase

During the setting up phase, the fire brigade is responsible for the entire infrastructure, its set-up and putting it into service. This includes setting up the Operations Command Post, cordonning off individual areas (entire station, triage area, treatment area, decontamination area, medical treatment area) as well as the chronological set-up of the corresponding areas, as shown in Table 36. After the DECON C staff have arrived at the operations site (staff remain in the staging area until called up), the circumstances of the incident are clarified with Operations Command, primarily by the OSL, SL FB and SL EMS. This includes:

- Operations Command/contact person?
- facts (what has happened?)
- number of casualties (how many have been injured?)
- which hazardous material/its properties/particular hazards?
• required protective equipment?
• which antidotes, decontamination materials?
• any peculiarities?
• location of the DECON C site?
• communication structure/assignments of radiocommunication channels?
• interfaces (OSL Danger Zone/OSL Treatment Station)?

The OSL then calls up the staff from the staging area and allocates the vehicles within DECON C. The first step is to delineate the area (30 m x 40 m) with cordonning tape, posts, stands and warning signs (crew of swap-body truck with roll-off container for DECON C). The DECON C facilities are then set up.

**Table 36: Overview of the individual steps, in chronological order, to set up the Casualty Decontamination Station (DECON C) with job descriptions, personnel, vehicles and materials.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Work step</th>
<th>Description</th>
<th>No. of personnel</th>
</tr>
</thead>
</table>
| 1   | Operations Command Post        | Cordonning off of the Operational Section  
– Setting up of the Operational Section  
– Operation of the Operational Section  
– Coordination within the Decon subsection, particularly patient flows  
– Communications structure to Operations Command, the subsection leaders and other leaders  
– Infrastructure  
– Supplies  
– Responsibility for the staff and equipment within the Operational Section | 2/1/0            |
<table>
<thead>
<tr>
<th></th>
<th>Specification of the area to be cordoned off</th>
<th></th>
</tr>
</thead>
</table>
| 2 | – Unload roll-off containers and prepare removal of equipment  
– Illuminate the decon station with a lighting mast  
– Delineate the cordoned-off area with cordoning tape  
– Place a cordonning post every 10 m  
– Mount warning signs | 0/0/1 0/0/2 |
| 3 | Erection of tents | 0/1/5 |
|   | – Decon triage tent  
– Treatment tent I/II  
– Treatment tent III  
– Treatment tent IV  
– Morgue tent |   |
| 4 | Set up of Decon Recumbent | 0/1/5 |
|   | – Install air blower  
– Install shower tray  
– Prepare shower tent, paying attention to the incline  
– Install the lighting, showering equipment and water connections  
– Prepare and erect the mess tent  
– Install the lighting |   |
| 5 | Set up of Decon Walking | 0/1/5 |
|   | – Install air blower  
– Install shower tray  
– Prepare shower tent, paying attention to the incline  
– Install the lighting, showering equipment and water connections  
– Prepare and erect the mess tent  
– Install the lighting |   |
| 6 | Infrastructure for the power supply | 0/1/5 |
|   | – Set up the generator  
– Illuminate the decon station with a lighting mast  
– Install power supply to the air blowers (2 x 380 V)  
– Install power supply to the decon tents  
– Install stand floodlights at all four corners of the decon station  
– Install stand floodlights for power supply /tankless water heater  
– Install the power supply in the following order: triage tent, tent |   |
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
</table>
|   | I/II, tent III, tent IV and morgue tent  
   - (Start from the central supply point where the water heaters, etc., are located and from where the decon station is supplied with cold and warm water as well as electricity) |   |
|   |  
7. Infrastructure  
water/wastewater/contaminated materials | – Install the water supply from the Decon P trucks to the individual tents, starting with the triage tent, I/II, III and IV  
– Install remaining infrastructure in the tents as quickly as possible | 0/1/5 |
|   |  
8. Protective clothing | – Issue personal protective clothing  
– Issue the necessary communication equipment | 0/1/1 |
|   |  
9. Technical equipment (white area) | – Supervise the technical equipment in the white area  
– Install lighting mast for illumination during the initial phase  
– Set up and maintain the infrastructure in the white area  
– Operate equipment  
– Supply of utilities to the decon station (e.g. with power, warm and cold water, etc.) | 0/1/1 |
|   |  
10. Measuring equipment | – Set up measuring equipment  
– Carry out the contamination test in decon tents P1 and P2 | 0/2/4 |
|   |  
11. Emergency medical service | – Collect personal protection equipment from appropriate roll-off container and put it on  
– Assist the fire brigade in equipping the treatment and triage tents, particularly with the medical equipment  
– Assist the fire brigade in putting on their personal protection equipment | 1/0/1  
1/1/1  
1/1/1  
1/0/2  
0/1/5  
0/1/5 |

Medical equipment

A list of medical products and consumables for the triage tent, the treatment tents and the decon tent is given in the Annex.

A total of 20 firefighters are deployed here. They are coordinated by the two group leaders and the squad leader. Two crews (0/0/3) are assigned to erecting the tents and one squad each for the electrical infrastructure (0/1/5) and other supplies (0/1/5).
While Decon Triage is being set up, Decon Recumbent and Decon Walking are set up by two fire brigade squads (0/1/5). The medical staff of the station is kitted out with the necessary personal protection equipment at the roll-off container containing the breathing/radiation protection equipment (issued by a fire brigade crew). They then assist the members of the fire brigade in equipping the tents with the necessary infrastructure, particularly the medical equipment and the required decontamination materials.

The operational readiness of each subsection is reported to the OSL by the subsection leaders (e.g. group leaders). The OSL reports operational readiness to Operations Command who then informs the Operational Section "Danger Zone" and the medical treatment station that DECON C is now operational and the flow of patients can commence. Table 37 lists the personnel, vehicles and materials required for the operation of DECON C.

**Table 37: Work steps for the operation of Casualty Decontamination Station DECON C in chronological order with job descriptions, personnel, vehicles and materials**

<table>
<thead>
<tr>
<th>No.</th>
<th>Work step</th>
<th>Description</th>
<th>No. of personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Operations Command Post</td>
<td>– Operation of the Operational Section</td>
<td>2/0/0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Responsibility for the staff and equipment within the Operational Section</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Coordination of the Decon Station</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Communication structure to the Command Post and to the other leaders</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Infrastructure</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Arrival at SS Decon Triage</td>
<td>– Patient processing</td>
<td>1/0/1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Registration</td>
<td>0/0/1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Start of undressing</td>
<td>0/0/2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Psychological care and support of patients</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Sweeping triage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
</tbody>
</table>
| **3** | SS Decon Triage | – Undressing  
– Triage  
– Documentation  
– Securing of valuables |
|   |   | 1/1/1  
0/0/1  
0/1/0  
0/0/2 |
| **4** | SS Treatment tent I/II | – Spot decontamination  
– Basic life support  
– Antidote administration  
– Wound coverage |
|   |   | 1/1/1  
0/0/4  
0/1/2 |
| **5** | SS Treatment tent IV | – Spot decontamination  
– Basic life support  
– Antidote administration  
– Wound coverage |
|   |   | 1/1/1  
0/0/2 |
| **6** | SS Treatment tent III | – Spot decontamination  
– Basic life support  
– Antidote administration  
– Wound coverage |
|   |   | 1/0/1  
0/1/1  
0/0/2 |
| **7** | SS Decon Recumbent | – Decontamination of recumbent casualties  
– Contamination test  
– Hand-over to the white area |
|   |   | 0/0/2  
0/1/5  
0/0/2  
0/1/2 |
| **8** | SS Decon Walking | – Decontamination of ambulant casualties  
– Temporarily: decontamination of recumbent casualties  
– Contamination test  
– Hand-over to the white area |
|   |   | 0/0/2  
0/1/3  
0/1/2 |
4.4.3 Organisation of the Subsections

Members of the fire brigade and emergency medical services with differing levels of training are deployed in varying numbers and duties in all subunits of the Decontamination Station. Members of the fire brigade are also deployed between the individual subsections as support teams. They escort (SS III) or carry (SS I/II, IV) the patients from the decon triage tent to the treatment areas and from these areas to the recumbent/walking decontamination areas. These support teams are requested by the group leaders of the individual subsections. Patients released from SS I/II and recumbent patients are also accompanied by a member of the emergency medical service. The group leader of the fire brigade in the outer zone of the triage tent has not only support duties, but also the task of coordinating the support teams and calling up any necessary additional assistance if the individual support teams are overloaded.

4.4.4 Arrival/assembly/registration

The assembly area is the entry point for everyone entering from the danger zone (casualties and personnel).
There must be a clearly marked path for those entering or leaving this area. Walking casualties must use the same access routes as the rescue staff who are accompanying stretcher casualties. Once they have registered in this area, walking casualties go to the triage area on foot, whereas those who cannot walk are transported by rescue staff (firefighters in the corresponding chemical-resistant protective clothing and self-contained breathing apparatus) from the assembly area to the triage area.
Staffing and activities at the Arrival/Assembly/Registration

Members of the fire brigade delivering casualties to DECON C are commanded by OSL "Danger Zone" (incident scene) and cannot therefore be given follow-up orders by operational section DECON C. Their protective equipment and thus the protection level are specified by Operations Command.

The reception area is staffed by a crew leader and a crew member from the fire brigade as well as one paramedic from the emergency medical services with organisational leader training (squad leader, SSL), one medical auxiliary and a further medically qualified person (possibly with additional crisis intervention training). Incoming patients are either set down by the rescue workers, or, if they have only minor injuries, they take a seat. The medical auxiliary registers the incoming patients (triage tag, assigns an ID number) and can carry out first-aid if so instructed by the paramedic.

Fig. 34: Registration in the Arrival / Assembly / Registration Subsection

The undressing of the patients (preferably recumbent) can be now be commenced. In the front section of the tent, the fire brigade crew assists the squad leader with patient registration and undressing, as instructed. The crew then carries the stretcher into the triage tent. The crew may also assist the medical auxiliary in supervising the patients. The paramedic goes from patient to patient and determines the priority of the incoming patients for hand-over to decon triage (sweeping triage). An antidote can be administered at this point, if necessary.
4.4.5 Decon Triage

The decon triage procedure is carried out prior to decontamination in the black (contaminated) area and takes account of injuries and contamination. It should facilitate the appropriate and speedy further treatment of the patient. The first step of the procedure is to undress the patient.

Fig. 35: Subsection Decon Triage
The victims must be completely undressed so that they can be properly triaged. They are then briefly examined by the triaging doctor. The triage procedure is to be based on the results of two consensus conferences on "Sichtung bei Großschadensereignissen und Katastrophen (Triage after mass casualty incidents and disasters)" held on 15.3.2002 and on 29.10.2002 in the Akademie für Krisenmanagement, Notfallplanung und Zivilschutz (AkNZ, Academy for Crisis Management, Emergency Planning and Civil Protection). The patient is assigned to one or four priority categories: (I to IV).
Table 38: Decon triage categories used at the Casualty Decontamination Station DECON C according to the German Consensus Conference 2002:

<table>
<thead>
<tr>
<th>Category</th>
<th>Colour</th>
<th>Description</th>
<th>Consequence</th>
<th>Patient transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>red</td>
<td>life-threatening condition as a result of contamination and/or a mechanical/thermal incident</td>
<td>immediate treatment</td>
<td>recumbent</td>
</tr>
<tr>
<td>II</td>
<td>yellow</td>
<td>serious injury as a result of contamination and/or a mechanical/thermal incident</td>
<td>delayed treatment</td>
<td>recumbent</td>
</tr>
<tr>
<td>III</td>
<td>green</td>
<td>minor injury as a result of contamination and/or a mechanical/thermal incident</td>
<td>later treatment</td>
<td>able to walk</td>
</tr>
<tr>
<td>IV</td>
<td>blue</td>
<td>life-threatening condition as a result of contamination and/or a mechanical/thermal incident which the victim is not expected to survive</td>
<td>care and support</td>
<td>recumbent</td>
</tr>
<tr>
<td>†</td>
<td>black</td>
<td>dead</td>
<td>label</td>
<td>recumbent</td>
</tr>
</tbody>
</table>

The triage category is then entered on the triage tag. Of particular importance here and in contrast to conventional accidents, not only the general condition and the actual injuries sustained by the victim are to be taken into account, but also any contamination with hazardous chemicals.
Documentation is to be carried out as follows: the patient is given an identification number and the triage category is entered on the triage tag in Roman numerals (I, II, III, IV). This tag is then attached to the patient so that the colour-coded triage category is visible (I = red, II = yellow, III = green, IV = blue). A brief diagnosis should also be written on the tag. The triage tag should be protected by a decontaminable, waterproof, durable and rugged cover.

**Fig. 36: Documentation on the triage tag**

![Image of a triage tag with a patient](image)

**Effect of chemical contamination on the decon triage procedure**

**Triage Category I**

- Neurotoxins:
  - conscious, unable to walk (e.g. respiratory distress, muscle twitching, nausea, vomiting)
  - moderate disturbances in two or more organ systems (e.g. respiratory, gastrointestinal, muscular), circulation intact
  - unconscious, unable to walk, circulation intact
  - unconscious, unable to walk, circulation not intact (if treatment is possible; if not, classify as triage category IV)

- Cyanides: serious symptoms (e.g. unconsciousness, convulsing or postictal, with or without apnea), circulation intact

- Blistering toxins: inhalation trauma
• Phosgene: respiration unaffected

**Triage Category II**

• Neurotoxins: Recovery after severe exposure or after antidote therapy or both
• Cyanides: Recovery; still alive 5 minutes after inhaling an aerosol
• Blistering toxins:
  – skin damage > 5%, but < 50% of the surface area after exposure to a liquid;
  – every skin injury caused by exposure to vapours
  – most eye injuries
  – problems of the airways starting > 6h after exposure

**Triage Category III**

• Neurotoxins: conscious and able to walk, able to help themselves; immediately able to work again
• Blistering toxins:
  – Skin damage to < 5% of the surface area of the body in non-critical regions
  – minor eye injuries
  – minor injuries to the upper airways

**Triage Category IV**

• Neurotoxins: unconscious, unable to walk, circulatory failure (if necessary treatment is available, classify as Triage Category I)
• Cyanides: circulatory failure
• Blistering toxins:
  – skin damage > 50% of the surface area of the body after exposure to a liquid;
  – moderate-to-serious damage to the airways, particularly if symptoms start < 6h after exposure
• Phosgene: moderate-to-serious respiratory symptoms at an early stage and/or damage of >50 % of the surface area of the body
**Staffing and activities (Decon Triage)**

The medical staff consists of one emergency doctor, one paramedic and two medical auxiliaries. The fire brigade provides one group leader and two crew leaders. The Decon Triage staff are commanded by the squad leader of the emergency medical services (awning), who is assisted by the group leader of the fire brigade. The group leader of the fire brigade is responsible for radiocommunications with the Operations Command Post, registers the patients with a flip-chart and also functions as a janitor. His/her duties include the provision of consumables, the supply and disposal of materials, cleaning and assisting the medical staff. The group leader as well as the crew leaders are also responsible that all garments are checked for valuables, which are then registered, correspondingly safeguarded, and separated from contaminated clothing. The group leader then ensures that the contaminated and cut clothes as well as all other waste materials are safely removed from the tent. He/she provides water, decontamination solutions as well as any consumables required for examination purposes (e.g. disposal examination gloves).

Both crew leaders assist the medical auxiliaries in preparing the patients for triaging by the emergency doctor. Before the patient is completely undressed, any valuables are placed in a bag together with the numbered slip detached from the triage tag, and the bag is then sealed. The triage number of the patient is written on the bag with a felt pen. All rescue personnel must now change their disposable gloves. The crew leaders then undress the patient in strict adherence to the instructions given in the described standard – from non-contaminated areas towards contaminated areas. All personal property, such as jewellery, watches, hearing aids, spectacles, contact lenses, prostheses and hairpieces are removed during triage as a matter of principle. Contact lenses are removed using a contact lens handling device after changing gloves. They are collected and sent for disposal. The eyes and the face must be thoroughly rinsed with water or lactated Ringer's solution!

The patient should always be undressed by two people (medical auxiliary and a firefighter). Patients are usually lying on their backs; however, the described procedure can also be carried out if patients are lying on one side or on their stomachs. Undressing of a standing patient has not proved suitable in practice. Ambulant patients can either undress themselves (instructions must be given to avoid the spread of contaminants!) or they are undressed whilst lying down.
The principle is from head-to-foot and from clean-to-contaminated. After coarse contamination has been removed, the upper layer of clothing is cut open, starting with the sleeves, if possible. Shoes and socks are removed.

Figure 39: Undressing of a contaminated patient during decon triage

The remaining layers of clothing (everything, including underwear) are then cut away. The cut clothing is folded over so that the contaminated parts point away from the body. The patient is then turned onto his/her side and the remaining clothing pulled away downwards through the central opening of the scoop stretcher. The possible spread of contaminants must be avoided at all times. All clothing is placed in a bag by the responsible firefighter and sent for disposal. The scissors are decontaminated by placing them in a 5% hypochlorite solution. The decontaminated scissors are removed from the hypochlorite solution when the next patient arrives. If necessary, the crew leaders can also be charged with cleaning, supply and disposal duties and to provide support to patients.

The medical auxiliaries carry out first-aid measures that are necessary for the classification process (e.g. measure blood pressure, pulse oximetry, documentation) in accordance with the instructions issued by the triage doctor. The triage doctor then quickly classifies the patients using the triage system for mass casualty incidents. The ability to judge and freedom of movement of the triage doctor may be considerably limited owing to his/her protective clothing.
Fig. 40: Classification of contaminated patients during decon triage

Fig. 41: Decon Treatment Areas (SS I/II, SS III, SS IV)
4.4.6 Decon treatment areas (SS I/II, SS III, SS IV)

After decon triage and before the actual decontamination process, the casualties are given any necessary basic treatments in SS I/II, SS III, SS IV.

The following procedures are to be carried out in the given sequence in all decon treatment areas: the first step is always a so-called spot decontamination (e.g. of wounds, obviously contaminated areas of the body as well as planned puncture sites). This is followed by basic life support measures, treatment of any wounds, waterproof covering of wounds and administration of an antidote, if appropriate. The aim of this basic treatment is to stabilise the patient so that he/she will be able to survive the following decontamination process.

Contaminated casualties requiring immediate aid (Triage Categories I and II) are sent immediately to the decon treatment tent (SS I/II). Casualties with Triage Category III are either sent directly to decontamination or to decon treatment tent SS III, depending on the type of injuries. Contaminated patients with Triage Category IV (expectant) are first gathered, supervised and retriaged by a doctor. They also receive spot decontamination, wound coverage, antidotes and are ultimately sent for decontamination on a stretcher with medical supervision.

Staffing and activities

(Decon treatment areas SS I/II, SS III, SS IV)

The SSL organises and supervises during the entire operation, and is also responsible for replenishing supplies and preparing resources. The SSL should therefore have as little contact as possible with the patients. He/she also maintains contact with the OSL. The emergency doctor is chiefly involved in the treatment of patients with Triage Category I; otherwise, he/she supervises the work of the rescue personnel or assists with invasive measures. The doctor prescribes any additional procedures that have not yet been ordered by the triage doctor and reassesses these orders if the condition of the patient changes. The firefighters in SS III and IV have the same duties as in SS Decon Triage. As directed by his/her group leader, the crew leader maintains contact with the OSC and acts as a janitor. The crew leader is responsible for the provision of consumables, the supply and disposal of materials, and cleaning. He/she also assists the medical staff.
The treatment procedures that can be carried out in this area are limited because the staff are working in a contaminated area in a full set of protective clothing and the time that can be spent on each individual person is limited. Intravenous injections as well as infusions can be carried out after thorough spot decontamination of the skin and the gloves of the person carrying out the treatment. Likewise, haemostatic measures can be carried out on wounds, whereby, the available time and not the risk of further contamination is the limiting factor.

**Preparatory phase:** After setting up and establishing operational readiness (incl. laying out of the usual materials) there is still a little time left for the assigned staff to carry out general preparatory work until the first patient arrives. This preparatory work, which is supervised by the subsection leader of the tent (paramedic, with leadership training if possible), includes the following measures:

- **Provision of materials used for spot decontamination:**
  each workplace should be equipped with sponges, gloves, decontamination solutions, etc.

- **Provision of infusions at the individual workplaces:**
  each workplace should be equipped with indwelling venous cannulae, fixation materials, approx. 3 crystalloid infusion solutions and at least 1 colloidal infusion solution, flushed thorough the system and suspended from the ceiling.

- **Provision of analgesics:**
  because nearly all patients in Category I/II will require analgesics, there should be at least 15 units of pre-prepared analgesics (e.g. ketamine 50 mg) and 15 units of midazolam.

- **Provision of antidotes:**
  as soon as the Operations Command (e.g. OSL, TSL) specifies an antidote, a sufficient number of pre-prepared antidote syringes that have already been filled and labelled must be obtained from the white area and laid out ready for use.
Treatment phase: The treatment phase commences as soon as patients arrive at the tent. This phase is divided as follows: spot decontamination, stabilisation, antidote administration (if appropriate), inhalation protection and dressing of wounds (to prevent incorporation). Spot decontamination is carried out before the actual overall decontamination process and involves simple decontamination of certain isolated regions. The objective is to reduce or prevent incorporation of hazardous material during particular medical procedures or through wounds.

Spot decontamination is the primary task of the fire brigade crew member who uses the decontaminants specified by Operations Command. A standardised decontamination procedure is to be carried out in the following order:

1) Eyes (followed by fitting of swim goggles)
2) Nose and throat (fitting of a nose and mouth mask)
3) Puncture sites and waterproof coverage using an adhesive film dressing
4) Wounds and waterproof coverage using an adhesive film dressing
5) Visibly contaminated areas of the body

Once all the clothing has been removed, any visible contamination is washed off and removed with a wet sponge by gently swabbing without rubbing the contaminant into the skin or wounds and without spreading it further. Polyethylene glycol (PEG) is used if the skin is contaminated with hydrophobic material.
Prior to puncturing, the eyes, nose, mouth and throat are washed with water, as are the puncture sites. The eyes and mucous membranes are spot-decontaminated with an eyebath using plenty of water or Ringer’s solution. Wiping movements are permitted for the spot-decontamination of puncture sites.

After an indwelling venous cannula has been placed, it must be covered with a self-adhesive film. Cleaning of wounds during spot-decontamination can prevent the absorption of active substances through the wound or their incorporation during medical procedures.

Fig. 44: Insertion of a peripheral venous cannula while wearing full protective clothing

Any penetrating foreign objects are left in the wound.
The surrounding area is then dried with a sterile compress. The wound is covered with a sterile compress and then closed with a self-adhesive film.

**Fig. 45: Dressing of wounds**

The layout of SS I/II is shown in Figure 46.

**Fig. 46: Decon treatment areas SS I/II**

<table>
<thead>
<tr>
<th>Legend:</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kunststoffbank</td>
<td>Notarzt</td>
<td>Rettungsaassistent, Gruppenführer</td>
</tr>
<tr>
<td>Lagerloch</td>
<td>Rettungsaassistent</td>
<td></td>
</tr>
<tr>
<td>große Uhr</td>
<td>Rettungsamtäler</td>
<td></td>
</tr>
<tr>
<td>Ablage aus Kunststoff</td>
<td>Truppführner Feuerwehr</td>
<td></td>
</tr>
<tr>
<td>Wanne</td>
<td>Truppfechan Feuerwehr</td>
<td></td>
</tr>
<tr>
<td>Abfall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stromanschluss 230 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wasser-Verteilung</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
There are several treatment beds in the treatment tent. Triage Category II patients can be treated in the sequence already specified by the triage doctor in the orders given on the triage tag and can be started independently by the paramedic/EMT responsible for the workplace. Patients classified as Category I should be treated immediately under the direction of the attending emergency doctor. Of course, the emergency doctor also checks that the Triage Category II patients are being treated correctly and assists the EMTs if necessary. The treatment should follow the standardised strategy given below as closely as possible:

- measurement of the pulse and blood pressure with a protective covering
- selection of a suitable vein for puncture
- spot-decontamination of the selected puncture site (FB)
- spot-decontamination of the eyes, mouth and nose (FB)
- spot-decontamination of wounds (FB/EMS)
- insertion of a venous cannula (EMS)
- administration of prescribed drugs/infusions
- fitting of an aerosol protection mask/filter mask and safety goggles
- dressing and covering wounds with OpSite films
– splinting of any fractures
– removal of any infusions and coverage of the i.v. cannula
– monitoring and giving psychological support to the patient
– documentation of the applied measures on the triage tag and hand-over of the patient to the staff in the decontamination tent
– change of gloves

Patients requiring (assisted) mask ventilation are accompanied by their allocated medical auxiliary to the decontamination tent where they are handed over to the rescue service worker. Other patients are collected by the fire brigade bearers as instructed.

SS III has a staff of seven: two firefighters, four EMTs and one emergency doctor. In the SS III treatment tent, patients are separated according to their sex. Each side has three seats and one treatment bed. Patients arriving from Decon Triage are received by one paramedic and one medical auxiliary. They remain at the front end of the tent until they are handed over for treatment. Patients are treated on a bed at the rear end of the tent. The patient is examined by an emergency doctor who is assisted by one EMT per treatment bed. There should be a sphygmomanometer as well as a pulse oximeter available. Finally, the EMT carries out the procedures recommended by the decon triage doctor on the triage tag and any additional procedures that the SS III doctor considers to be necessary. Treatment here is limited to spot decontamination, infusions, administration of drugs and antidotes, as well as the treatment and dressing of wounds. Materials required for examination and treatment are supplied from a central point. The treated patients are then escorted to SS Decon Walking.
Fig. 47: Fitting of a filter mask

The layout of SS III is shown in the following diagram.

Fig. 48: Decon treatment area SS III

Legend:
- Kunststoffbank
- Lagerbock
- große Uhr
- Ablage aus Kunststoff
- Wanne
- Abfall
- Stromanschluss 230 V
- Wasser-Verteiler

RA: Notarzt
RA: Rettungsassistent, Gruppenführer
RA: Rettungsassistent
RS: Rettungs sanitärer
UP: Truppführer Feuerwehr
UP: Truppmann Feuerwehr
The layout of SS IV is shown in the following diagram.

**Fig. 49: Decon treatment area SS IV**

**Legende:**
- Wasser-Vorläufer
- Lagerbock
- große Uhr
- Wanne
- Abfall
- Stromanschluss 230 V
- Rettungsassistent, Gruppenführer
- Rettungsassistent
- Notarzt
- Truppführerv Feuerwehr
- Truppmann Feuerwehr
- Materialien:
  - Dekontaminantion
  - Atmung
  - Kreislauf
  - Infusion
  - Antidote
  - Medikamente
  - Wundversorgung
  - Monitoring – RR
  - Nieren schale
  - Schaufenster}

**Materialien:**
- Dekontaminantion
- Atmung
- Kreislauf
- Infusion
- Antidote
- Medikamente
- Wundversorgung
- Monitoring
- Nieren schale
Patients with Triage Category IV are given care and support at treatment station SS IV. The patients are cared for by one emergency doctor, two paramedics and two firefighters. **Materials must be provided for the following medical procedures:**

- measurement of the pulse and blood pressure with a protective covering
- selection of a suitable vein for puncture
- spot-decontamination of the selected puncture site (FB)
- spot-decontamination of the eyes, mouth and nose (FB)
- spot-decontamination of wounds (FB/EMS)
- insertion of a venous cannula (EMS)
- administration of prescribed drugs/infusions
- administration of an antidote, if appropriate
- fitting of an aerosol protection mask/oxygen mask and safety goggles
- dressing and covering wounds with OpSite films
- splinting of any fractures
- removal of any infusions and coverage of the i.v. cannula
- documentation of procedures on the triage tag
monitoring and giving psychological support to the patient

In order to be able to administer an appropriate level of analgesics and volume expanders, all patients are fitted with a peripheral venous cannula after spot decontamination. The responsible emergency doctor retriages the patients. The paramedic monitors the patient's vital signs and carries out minimal treatments. If necessary, an antidote is administered, wounds are treated and the emergency doctor is assisted. Moreover, psychological care and support for all patients are extremely important at this treatment station. If the triage category changes, the patient must be transferred to the appropriate tent without delay. The final step in the decontamination process, after all patients from the other triage categories (I, II, III) have been decontaminated, is the decontamination of Triage Category IV patients as recumbent casualties. This is carried out with the assistance of the emergency medical staff.

4.4.7 Decontamination (Walking/Recumbent)

The decontamination of ambulant and non-ambulant (recumbent) casualties is carried out separately in subsections Decontamination Walking and Decontamination Recumbent, respectively. The layout of these two subsections is shown in the following diagram.
Patients who are able to walk and who require medical treatment, but not immediately, are decontaminated in a standing position in **Decon Walking**. An auxiliary makes sure that the decontamination process is carried out according to the stipulated method. The decontamination of non-ambulant patients is carried out in **Decon Recumbent** according to a standardised procedure. This is the only way of ensuring proper decontamination.
Fig. 51: Decontamination at Decon Walking

The layout of **Decon Walking** is shown in the following diagram.

Fig. 52: Decon Walking

- Lagerbock
- große Uhr
- Ablage aus Kunststoff
- Abfall
- Stromanschluss 230 V
- Wasser-Verteiler
- Rettungssanitäter
- Sanitätsleifer
- Gruppenführer Feuerwehr
- Truppmann Feuerwehr
The layout of **Decon Recumbent** is shown in the following diagram.

**Fig. 53: Decon Recumbent**
Patients requiring immediate medical treatment in the "clean" treatment area are delivered immediately to Decon Recumbent. All decontaminated persons are subjected to a contamination test immediately after decontamination and before they are handed over to the staff in the white section of the treatment station. Finally, all rescue personnel leaving the DECON C area via the personnel barrier are decontaminated and transferred out.

**Staffing and activities (Decon Walking/Recumbent)**

**Decon Walking:** A group leader of the fire brigade receives the patients at Decon Walking and briefs them on the decontamination procedure. Male and female patients are separated at this point. If possible, patients should help each other. If this is not possible, a crew leader of the fire brigade or an EMT can assist them. The patients then proceed to the decontamination showers where they shower for 1 min, lather with soap for 3 min, and rinse for 2 min. If they are found to be free of contaminants, they are directed to the cross-over point (the boundary line), where they are reclothed under the supervision of a medical auxiliary and a firefighter. The patients are then handed over to the "clean" treatment zone (treatment station). The group leader is in radiocommunication with SS III to coordinate the patient flow and with the group leader at Decon Recumbent to coordinate staffing and workloads. If necessary, Decon Walking can also be operated as Decon Recumbent; however, this requires an increase in the number of staff!

After decontamination is complete, the patient is handed over to the fire brigade crew at the Contamination Control Point for a contamination test. This test takes between 1 and 3 minutes, depending on the method used by the tester (PID, IMS, detector tubes or pH paper). The group leader supervises or, if necessary, assists the crew leader in carrying out the test.
Fig. 54: Contamination test using a fluorescence method at Decon Walking

Decon Recumbent: Decon Recumbent is divided into three areas: In the entrance area, two firefighters receive the patient from the bearers who place the scoop stretcher onto a support. The patient is transferred to the actual decontamination area and then decontaminated on the scoop stretcher by two further firefighters in the presence of an experience paramedic.
This involves the following five-step procedure:

1) If a mask is worn, decontamination of the mask and the area around its edges.

2) Decontamination of the body from head to foot. The patient is first showered with water (28°C) for 1 minute using hand-held showers and working from clean areas towards unclean areas: first the head, then the neck, lower half of the face, wrists and hands, including areas around any wounds, and then the rest of the body.

3) The patient should be briefly raised onto one side (EMT assists) so that any contamination on the back of the body can be washed off.

4) The patient is then thoroughly lathered for approx. 3 min using a sponge and a mild washing lotion (pH-neutral shower gel). Particular attention must be given to the head, behind the ears, under the arms, the pubic area, the anal crevice, as well as the skin between the toes and fingers. The nose and mouth must be cleaned by asking the patient to blow his/her nose or by rinsing with water. New sponges must be used for each patient to prevent the spread of contamination.

5) After the patient has been thoroughly lathered with a sponge, the body is rinsed with water on all sides for two minutes with the assistance of the rescue service worker.
The contamination test at the Contamination Control Point is carried out analogously to that in Decon Walking.

**Fig. 56: Contamination test of the armpits**

If residual contamination is found on a recumbent or walking patient, he/she must be decontaminated again. The patient is returned to the shower cubicles. Another partial or full-body decontamination procedure is then carried out, as required. After successful decontamination, the patient is escorted to a cross-over point and placed on a clean stretcher supplied by rescue workers on the "clean side" of the boundary line. The mask, if still worn, is removed at the entrance to the "clean" treatment area. The patient is then handed over to the staff working in the white section of the treatment station. Decontaminated scoop stretchers are then returned to the triage area. All rescue personnel must pass through the personnel barrier before they leave the DECON C area.
Decon Recumbent is headed by a group leader from the fire brigade. The decontamination procedure is carried out by a fire brigade crew, supervised and assisted by an EMS member. The SSL coordinates the delivery of patients with SSL I/II. If the capacity of Decon Recumbent is exhausted, some patients can be sent to Decon Walking instead. Although the Decon Recumbent is supervised by a paramedic, he/she cannot provide much, if any, medical aid during decontamination. For example, the paramedic cannot perform artificial respiration or intervene in the event of a sudden respiratory arrest. The ambient temperature and humidity determine the length of the working and rest phases; however, even under moderate conditions, the working phases are short and a frequent exchange of workers is necessary. Three persons (one EMS member and two firefighters) are needed to decontaminate one recumbent patient. Two further firefighters are required for inward transfer, 3 firefighters for the contamination test, and another 2 firefighters for outward transfer.

The boundary is an arbitrarily drawn line that separates the contaminated and uncontaminated areas. As soon as this line has been drawn, it must be clearly and conspicuously marked (with signal tape or another means of marking) to prevent potentially contaminated persons from entering the “clean” area. This may require the use of stewards. Everyone entering the “clean” treatment areas must pass through the decontamination station first. After passing the boundary line, patients enter the non-contaminated medical treatment area for further care or subsequent evacuation.
4.4.8 Personnel requirements

The following table lists the personnel required for the correct implementation of the concept presented herein.

**Table 39: Personnel requirements for the DECON C concept**

<table>
<thead>
<tr>
<th>Fire brigade personnel</th>
<th>EMS personnel incl. emergency doctor</th>
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<tbody>
<tr>
<td><strong>Decon Triage</strong></td>
<td>Decon Triage</td>
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<tr>
<td>0/1/4</td>
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</tr>
<tr>
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<td>1/1</td>
</tr>
<tr>
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<td>Decon Recumbent</td>
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<tr>
<td>0/2/9</td>
<td>0/2</td>
</tr>
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<td>Decon Walking</td>
</tr>
<tr>
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<td>0/2</td>
</tr>
<tr>
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<td>Periphery:</td>
</tr>
<tr>
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<td>0/0</td>
</tr>
<tr>
<td><strong>Periphery, white:</strong></td>
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<td></td>
<td>2/8/36/46</td>
</tr>
<tr>
<td></td>
<td>5/3/18/26</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Emergency doctors</th>
<th>Total staff of DECON Casualty</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
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<td>Tent III:</td>
</tr>
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</tr>
<tr>
<td><strong>Tent IV:</strong></td>
<td>Tent IV:</td>
</tr>
<tr>
<td>1</td>
<td>1/1/3/5</td>
</tr>
<tr>
<td><strong>Decon Recumbent</strong></td>
<td>Decon Recumbent</td>
</tr>
<tr>
<td>0</td>
<td>0/2/11/13</td>
</tr>
</tbody>
</table>
4.5 Increasing the capacity of Operational Section DECON C to treat large numbers of casualties

The proposed system should be sufficiently efficient to be able to process between 10 contaminated casualties (scenario 3) and 50 patients within a medically justifiable period of time (highest possible outcome for the largest possible number of patients). This has been verified as being possible by means of the following approximation calculations.

In comparable mass casualty incidents, the following times are generally specified in which patients have to be treated:

For triage, to classify patients with respect to treatment or evacuation priority:

1-2 minutes per patient, i.e.

total 20 to 30 patients per hour.

In Decon Triage described here, there is one triage doctor for two workplaces that are each equipped with two rescue workers. The capacity of Decon Triage thus allows triaging of 40 – 60 contaminated casualties per hour. Two workplaces are necessary purely because undressing and preparation of the patient requires an average of two minutes. Planned times for the decontamination steps are as follows:

1 minute for the removal of coarse contamination, showering,
3 minutes for the application of decontaminants,
2 minutes for showering, rinsing,

total 6 minutes per patient.

The decontamination tent for recumbent patients has two workplaces that can process 20 patients per hour. The decontamination tent for walking casualties,
equipped with 6 showers, can process 60 patients per hour.

**Figure 58: Casualty Decontamination Station – Total overview and patient flow for 20-50 casualties**
Uncertainties in these calculations are the working times in the treatment tents for Triage Categories I/II and III, which obviously depend on the severity of the injuries. The time losses due to rebedding and transport of the patients must also be included in the calculations. The range of injuries resulting from an NBC disaster and thus the assignment of the respective triage and treatment categories is difficult to predict. However, if there is a backlog at one of the two treatment tents, the leading emergency doctor of Decon C is able to redirect the flow of patients within this system. Indeed, during the final exercise held on 29 March 2003 in Pfullingen, 30 contaminated casualties were treated in 67 minutes. The range of casualties in this exercise were divided as follows:

- 15 serious casualties Triage Category I : 5, II : 6, IV : 4,
- 15 minor casualties Triage Category III.

The results obtained in this exercise coincided with those from three other exercises. It is unlikely that sufficient personnel as well as all the materials and equipment required to set up all parts of the system in parallel are available at the start directly after notification. A smaller version that is fully functional and which can start operations immediately can be achieved if the first set of responders arriving at the scene give priority to setting up the tents in the following order: decon triage, treatment I and II, then decontamination of recumbent patients.
According to the rough calculations given above, it can be assumed that this smaller version would be able to treat 5-20 contaminated casualties. Such a subdivision is also sensible for reasons of logistics. If the decontamination system is on standby at the federal state level, an additional smaller version can be used for large communities or high-risk locations. This allows the proposed decontamination system to be adapted with modules for different requirements. The combination of a small version, which can be set up quickly, with the full version would allow processing of 50-70 contaminated casualties.
Figure 60: Casualty Decontamination Station – Total overview and patient flow for 50-70 casualties
With suitable multiplicative adjustment of personnel and materials, two full versions could be combined, thus allowing the treatment of 50-100 contaminated casualties.

**Figure 61: Casualty Decontamination Station – Total overview and patient flow for 50-100 casualties**