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Concept of Assistance of the Federal Office for Radiation Protection with Regard to Prevention of Serious Cases of Nuclear Hazards

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INTRODUCTION

An overall concept has been developed for the defence against nuclear hazards in the Federal Republic of Germany (FRG) under the overall control of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). A number of competent organisations are involved in this task, such as for example, the Federal Office of Criminal Investigation (*BKA*), the Federal Office for Radiation Protection (BfS) and many other organisations. BfS was charged, through the modification of the *Act on the Establishment of a Federal Office for Radiation Protection* of 6 April, 1998, with the task of providing support to the competent authorities within the area of the defence against nuclear hazards.

In Germany, the 16 federal states are responsible for all kinds of danger prevention, especially defence against nuclear hazards. In cases of hazards due to radioactive material, experts from the competent radiation protection authorities of the federal states are called upon for assistance. In serious cases of defence against nuclear hazards (due to nuclear fuels, cases of criticality or the risk of dispersion), the Federal Office for Radiation Protection is, by request of the federal states, called upon to assist. Direction and responsibility for the action remains in all cases, however, in the hands of the federal states.

The field of the defence against nuclear hazards extends from the prevention of illicit trafficking of radioactive test sources to the defence against dangers due to fission material along with the possible construction of critical assemblies, or threats arising in connection with the deliberate dispersion of material which can be taken in via the lungs. The last-mentioned instances represent the more serious cases of the defence against nuclear hazards. In view of the limited facilities and equipment at the disposal of the competent federal state and federal government authorities - above all in the case of the more serious cases to be dealt with - BfS has been allocated a central degree of competence for the providing of support through modification of the act on the establishment of the office. This reads: "The Federal Office for Radiation Protection provides, where it is called upon to do so, support to the competent authorities, in the case of the loss or finding of radioactive substances, or in the case of suspicion of a criminal act involving radioactive substances being committed, or of providing protective measures within the scope of the seizure of such substances, to the extent to which the endangering of human life or health or property is to be feared to a significant level, and the competent authorities, for concrete reasons, cannot or can only assure these measures with considerable difficulty, if such support is not provided".

By decree of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety - *BMU* - through the letter of 9 May, 1997, BfS was requested to prepare a corresponding concept for the provision of support. This comprises the seeking of radioactive substances and the carrying out of analyses and risk evaluation, and the implementation of measures for the mitigation of risk.

1. THE PERMANENT POSSIBILITY FOR CONSULTATION

The emergency organisation for the defence against nuclear hazards of BfS is brought into action in the provision of support to BMU and the federal states for the purposes of providing:

- technical advice
- support in terms of measuring technology (setting up of a measuring, search and evaluation team)
- support to the evaluation team *Defence against Nuclear Hazards* of BMU and BMI (Federal Ministry of the Interior)

The organisation is comprised of eight members of staff who are capable of fulfilling the above-mentioned tasks. In addition, instruments for the provision of support in measuring tasks have been developed

and kept available.

In order to assure a constant state of interventional readiness within the emergency organisation - including outside of normal working hours - an emergency service unit was set up. This unit initiates, following consultation with BMU, the implementation of the necessary measures. In the case of the informer (i.e. federal government or federal state authorities, foreign authorities or other third parties) contacting BfS directly, such callers are referred to BMU.

The alarming of the emergency unit occurs via mobile phone. Following the dialling of the telephone number of the emergency service unit, the call is taken by the member of staff on duty who, after checking the legal status of the caller, takes up the matter by repeating and noting the content in the emergency handbook. Subsequent action occurs in accordance with the emergency handbook, this belonging, along with a *handbook of defence against nuclear hazards* and a list of substances, to the means available to the member of staff.

Where the task registered requires this, the member of the emergency service unit on duty communicates the alarm to further members of the emergency organisation. The staff member can, according to the location involved in the given case, set up an intervention unit in one of the locations of the federal office which are distributed throughout the Federal Republic of Germany. This involves, in particular, the calling upon experts from the BfS locations Berlin, Munich, Hanau and Freiburg for the purposes of the carrying out of measuring tasks and risk assessment. The staff member on duty is, in this respect, internally allocated the authority to issue instructions to all members of staff of BfS.

For the purposes of communication with the authorities of other countries and, possibly, providing support within the scope of a mission abroad, BfS has elaborated a list of staff members with corresponding knowledge of foreign languages that are not so common.

The member of staff on duty has available, for distribution among the emergency staff, the following equipment: a city call receiver, mobile telephone, radiation measuring devices, along with containers for transportation and protective clothing.

Allocation of support services for the emergency organisation can be requested internally via the car service and the central division (legal advisory service). Provision of support is here likewise possible outside of normal working hours.

2. THE SEARCH FOR RADIOACTIVE MATERIALS

Airborne search operations

For airborne search operations, BfS has a total of five measuring systems available to it, which can either be installed in or fitted to helicopters belonging to the Federal Border Guard. Using these measuring systems, an area of 30 square kilometres can be searched per hour at a flight altitude of 100 metres, a flying speed of 100km/h and with a distance between flight paths of 300m. The detection limit is at a level of about 1GBq for a Co 60 point source and 3GBq for caesium. In the case that one of the five pre-modified helicopters is standing ready at its location of service, the measuring equipment can be installed within two hours, so that it is ready to begin the measuring flight. Airborne search operations for nuclear material are only possible to a limited extent.

The search for gamma sources on the ground

BfS has available to it a total of 30 easy-to-use devices with a detection limit of 100nSv/h for the purposes of search operations for gamma-emitting material. The detectors can be brought by car or by helicopter to any operational location within Germany within a period of four hours. The briefing of the search team at the given location takes no longer than 5 minutes. The search capacity of a 30-man search team (for example riot police or fire brigade) lies in a range between 0.1 and one square kilometre per hour, according to weather and terrain conditions.

The search for neutron sources from a vehicle

For this task, BfS has 8 high-sensitivity neutron detectors at its disposal in Salzgitter which can be fitted into a vehicle. Each of these detectors consists of three He-3 counter tubes which are built into a polyethylene moderator with dimensions of 105 x 27 x 10cm^3. Installation in an available vehicle takes approximately one hour.

A vehicle which is equipped in such a manner can carry out searches of fronts of a row of houses or, additionally lines of vehicles. By means of this set-up, non-shielded reactor plutonium in quantities of several 100 grams can be detected at a distance of several metres . The speed of the search is here around 10km/h.

Undercover searches for gamma sources

The devices listed in the section on gamma-source search teams are also suited to the purposes of undercover searches. This can be, for example, an inconspicuous search operation in a car park or at a flea market. The measuring devices are fitted to generate an acoustic signal. They can be carried in a coat pocket. The signal can be followed via an earpiece. Specially trained staff are needed for the task of carrying out undercover searches, and these are made available by BfS on request. About 10 members of staff are trained for these duties. Each of these are provided with mobile telephones, so that a search team can be set up within a few hours, including at less convenient times at the weekend.

3. THE ANALYSIS OF RADIOACTIVE MATERIALS

The local dose rate

The measuring of the local dose rate from gamma radiation allows, on the one hand, to determine the time of physical stay at the particular location but also - given a non-shielded source and a known radionuclide - to assess the activity of the radioactive material.

For the determination of the local dose rate from gamma emitters, measuring devices are available at all offices of BfS, the measuring range of which extends from 10nSv/h to 10Sv/h. Some of the devices are fitted with teleprobes, so that measurements can also be carried out in locations which are difficult to reach such as in pipes, wells, holes in trees, etc.

For the determination of the neutron dose rate, a total of six portable measuring devices - so-called REM counters - are available at the BfS offices in Salzgitter, Hanau, Berlin and Munich. The detection limits of these devices start at 100nSv/h to 1µSv/h.

Radionuclide determination by means of gamma spectroscopy

For the purpose of this important task, at least six measuring systems, functioning on the basis of germanium detectors, are available. For the determination of radionuclides falling into the category of nuclear material, the detectors must be particularly sensitive in the energy range up to about 500keV. The device which is best suited to this task is the so-called *U-Pu Inspector* produced by the company Canberra, and this is also equipped with the necessary special software. This device can be put into use at any location in Germany within a period of 6 hours.

The determination of the activity level

For a known nuclide, the determination of the activity level is possible using the gamma dose rate, where no external shielding is present and the shielding of the suspect device itself can be ignored. If the geometry and physical state of the substance can be identified by means of x-rays, the self-shielding effect can also be taken into account. In particular in the case of plutonium the activity can be estimated, using the neutron measuring technology including modules for standard geometries, which is available at BfS.

Analyses using a mobile gamma scanner

For the examination of objects with unknown content by means of digital radiography or tomography, without the necessity of the objects being destroyed or touched, a specially developed analysing set-up is available. This device consists of two portals facing each another - the object to be examined being located between them - into which a cobalt or iridium source and a germanium detector are synchronously inserted mechanically. Using this apparatus, one can determine not only the nuclide composition but also the activity, taking into account any shielding present and the local distribution of the radioactive substances inside a container.

4. RISK DETERMINATION

Radiological risks

The radiological risk produced by an improvised explosive device (IED), containing an additional radioactive charge, is mainly comprised of two components. These are the risk of direct irradiation of the deactivator, and the risk to persons present in the immediate surroundings due to the possible inhalation of radioactive particles following the detonation of the explosives present. The local dose rate for gamma radiation and also that for neutrons can be measured, and then the risk in terms of the direct irradiation of the deactivator can be estimated.

For the determination of the risk due to the dispersion of the radioactive substances and subsequent radiation exposure due to intake of the particles with respired breath, the following parameters must be known: radionuclide composition, activity, the fraction relevant for the inhaled dose, dispersion within the atmosphere. On the basis of these quantities and along with the known breathing rate and the dose factor, the potential radiation exposure can be calculated.

To this purpose, the Federal Office for Radiation Protection has produced an initial evaluation concept for 12 important radionuclides, including plausible assumptions for use by the measuring teams at the particular location. The deviations are to be determined in the individual case, and then the concrete radiation exposure determined from the given values, under application of the correction factor. In addition to this, the possible radiation exposure can be determined simultaneously by means of a computer programme.

Risk of criticality

In a particular geometrical arrangement and material composition, a sufficient mass of nuclear fuel can set off a self-sustaining chain reaction. Depending on the type of the fissile material, the geometry, moderation and the reflection of the set-up, the smallest critical mass for a particular material can vary considerably.

In the affected area a critical incident results in a short-term, life-endangering high level of neutron irradiation along with a release of energy in the form of a detonation resulting from nuclear fission. Generally, the initiation of a criticality excursion cannot be excluded, this is, however, dependent on the expert knowledge available to the perpetrators, and the availability of a correspondingly large quantity of nuclear fuel.

For evaluation in terms of criticality safety, the services of several experts are available at BfS. The basis for criticality assessment is provided by the Handbook on Criticality (*Handbuch der Kritikalität*) produced by *GRS*, the German *Company for Plant and Reactor Safety*:

Part 1: Criticality and Nuclear Safety
Part 2: Data on Criticality, U-235
Part 3: Data on criticality, Pu, U-233, higher actinides

and also

DIN 25403/1, *Criticality Safety in the Processing and Handling of Nuclear Fuels - Fundamentals*

5. THE CONCEPT FOR THE PREVENTION OF THE RELEASE OF RADIOACTIVE SUBSTANCES FOLLOWING THE DETONATION OF AN IED

Since, in the case of the detonation of an IED containing radioactive substances, certain nuclides can lead to a significant level of radiation exposure, a concept was developed for the mitigation of the impact. The central element of this is the development of an nearly remote-controlled containment around the IED, which is filled with foam with a high water content. The water absorbs part of the energy released by the explosives, while the foam serves the purpose of extensively holding back the inhalable radioactive particles.

The concept fulfils the following preconditions:

- the IED does not have to be moved or touched
- the containment can be transported with a car
- the containment can be installed by deactivators wearing protective suits
- the deactivation device can be integrated into the containment
- the total time necessary for installation is less than 30 minutes
- the standard utilities and possibilities available to the fire brigade such as fire hydrants, water supply, air and extinguishing foam can be used

The containment developed consists of a cylinder with a height of 1,5m made up of rings with the bottom cut out. The lowest ring is filled with water via a hose pipe. This provides an effective sealing with the ground and stability against gusts of wind. The upper rings are interconnected, and can be inflated with air from an oxygen flask from a safe distance. The foam mixing head is secured on a tripod and the containment is then filled to the brim with foam. At this stage deactivation can begin.

A retention rate of better than 99.3 percent could be determined for fine dust of less than 10 micrometres for quantities of explosives of up to 900 grams of PETN.

The containment can be made available to the deactivation units of the federal government and federal states by the Federal Office for Radiation Protection in Salzgitter on request, where the need arises.

6. THE HANDBOOK OF DEFENCE AGAINST NUCLEAR HAZARDS

Since 1992, a handbook on the defence against nuclear hazards has been compiled and issued by the BfS. The handbook contains important information for the case of an intervention of the deactivation units. A number of important details are listed below:

Regulatory arrangements at a national level

A list of the directing establishments of the federal government and federal states concerned with the defence against nuclear hazards

Instructions for intervention for cases of defence against nuclear hazards

Recommendations for intervention: *"Identification of an object containing radioactive substances presumably together with substances with explosive potential"*

Information on substances which are relevant within the scope of the defence against nuclear hazards

Indications on the transportation of radioactive substances

Indications on the search for and identification of radioactive substances

Organisations providing support

Cases of the defence against nuclear hazards

Internal regulatory arrangements of the federal states on the defence against nuclear hazards

The handbook is continually updated.

7. POSSIBILITIES FOR CO-OPERATION

The following authorities and institutions have and will continue to - partly on the basis of co-operation between authorities - provide assistance to the Federal Office for Radiation Protection in the form of personnel and technical and organisational support in cases where material is to be dealt with:

Federal Office of Criminal Investigation (*BKA, Bundeskriminalamt*)

Evaluation of the situation with regard to the personal safety of radiation protection experts. Co-operation has been tested in collaborative search exercises for radioactive substances (BKA/BfS)

Federal Border Guard (*BGS, Bundesgrenzschutz*)

The helicopter squadron of the Federal Border Guard (which is based in: Gifhorn, Berlin and Oberschleißheim) can where required - and when the weather situation permits - transport the interventional unit and its equipment to the given location.

Federal Armed Forces (*BW, Bundeswehr*)

The making available of sites with buildings for search exercises for radioactive materials and the provision of logistical assistance.

Fraunhofer-Institut Naturwissenschaftlich-Technische Trendanalysen (INT,Euskirchen/*Fraunhofer Institute for Scientific and Technical Trend Analyses*)

In the case of the BfS neutron module not being available for service, the Fraunhofer Institute can make devices with approximately the same level of performance available.

The Nuclear Auxiliary Services Company (*Kerntechnischer Hilfsdienst GmbH*)

The Nuclear Auxiliary Services Company is available for decontamination work following the deactivation or activation of an IED.

The Company for Plant and Reactor Safety (*GRS, Gesellschaft für Anlagen - und Reaktorsicherheit*)

GRS is able to make calculations for the large-scale dispersion of radioactive substances using data from the German Weather Service (*DWD, Deutscher Wetter Dienst*). GRS also provides support in criticality evaluation.