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PRECAUTIONS AGAINST ACCIDENTS IN CHEMICAL FACILITIES

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Summary

Since the spectacular incidents which occurred in Italy in 1976, accidents in chemical facilities have led to increasing concern within the population of the Federal Republic of Germany. To achieve increased safety on one hand, and to ensure, on the other, that the competent authorities are better informed, the Federal Republic of Germany is preparing a new regulation: the Accident Regulation. Precautions against accidents and necessary instruments to fulfil this regulation are described.

1. The legal basis of technical safety

In the monitoring of the safety of plants subject to licensing arrangements the Federal Republic of Germany can claim a proven factory inspection practice. This covers both the examination of the documentation relating to the granting of licences for the establishment and operation of new plants (the licences themselves are generally issued by the head of the "land" government) and the monitoring of the requirements made of existing plants. The legal basis for this procedure was originally provided by the Industrial Code and is today provided by the Federal Clean Air Act. This Act lays down that plants requiring a licence are to be operated so that:

(1) No risks, disadvantages, nuisance or environmental effects arise.
(2) Precautionary measures are taken against harmful environmental effects, possibly by the introduction of an emission limitation procedure which is in accordance with present day practice.
(3) Resulting waste products are properly re-used or disposed of.

In order to fulfil these obligations the Federal Government is authorised to prescribe the necessary requirements for plants by means of appropriate statutory orders. The 4th Order for the Implementation of the Federal Clean Air Act prescribes which plants are to be licensed according to a formal procedure and which according to a simplified procedure. The 9th Order regulates the principles of the licensing procedure. According to these principles the licensing documents must contain a detailed description of the

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proposed process, the type and quantity of starting materials, intermediate products, by-products and end products. Also, it must contain details of possible secondary reactions and products in the event of process accidents (Section 4). In addition, the proposed protection measures against harmful environmental effects must be specified.

The Federal Republic is furthermore bound by international treaties to convert guidelines passed at the European Communities level into national law. One draft guideline has already been produced by the Council, V/141/77, "Proposed Guideline of the Council concerning the Monitoring of certain Industrial Activities with regard to Accident Risks".

2. Deficiencies in the instrumental and legal framework

Questions of safety in chemical plants are covered by a wide variety of laws, orders, guidelines and regulations. In spite of this apparently abundant list, some questions of chemical safety are not adequately dealt with. Thus, although many plants have catastrophe contingency plans (in North Rhine-Westphalia, a count showed that 108 out of 140 plants had appropriate internal regulations), there are no:

(1) Dispersion calculations for the products produced in the plant or which would be produced in the event of an accident. It should be possible to calculate the dispersion behaviour of substances, taking into account their particular physical and chemical properties (specific density, vapour pressure, solubility, reactivity in the environment, etc.) according to other models than the Gaussian dispersion model hitherto most commonly used;

(2) Accident analyses which describe in detail all the possible sources of technical failure and human error;

(3) Safety analysis reports which, irrespective of the probability of occurrence of an accident, specify the technical and organisational measures derived from the accident analysis which must be taken to prevent accidents;

(4) Decontamination plans which lay down the procedure for the disposal of substances which are long-lived (persistent or bioaccumulating) in the environment;

(5) Legal requirements on the immediate reporting of accidents to the responsible authority or a central reporting station.

These means of reducing hazards should be incorporated in appropriate regulations; thus it is proposed:

(1) To lay down the organisational measures, such as safety analysis reports, accident analyses, maintenance plans, emergency and decontamination plans, in an Order for the Implementation of the Federal Clean Air Act.

(2) To list detailed safety systems for plants or sections of plants in a technical directory of regulations.

3. Protective machinery

3.1 Schedule of highly toxic substances

The environmental catastrophe of Seveso exposed to the full glare of publicity the fact that there are production processes in the chemical and related industries in the course of which highly toxic substances may escape into the environment.

A repetition in the Federal Republic of Germany of the particular catastrophe which occurred at Seveso in the production of trichlorophenol is considered relatively unlikely, since the level of environmental protection afforded by different procedures and additional safety systems is considerably higher. There is, however, cause to suspect that there are in the Federal Republic, apart from the relatively safe production of trichlorophenol, a series of similar processes, in the course of which substances of only slightly lower toxicity than tetrachlorodibenzodioxin (TCDD) are produced, but in much greater quantities. In this connection it is irrelevant whether these substances occur as initial materials, intermediate products, by-products, end products, the products of accidents or as process materials in the plants concerned.

Prompted by the accident at Seveso, the Federal Environmental Agency compiled, a few weeks later, a schedule of highly toxic substances. As a result of the various modes of exposure to toxins (oral, inhalation, dermal) and due to the use of various experimental animals (mice, rats, rabbits), the criteria used to classify a substance as highly toxic resulted in a kind of catalogue of toxicological criteria. This federally standardised schedule of highly toxic substances covers some 145 substances. The limitation to only 145 substances is achieved by omitting the compounds produced on the research scale, since these could hardly lead to significant contamination of the environment in the event of an accident. The same applies to pharmaceuticals and to natural substances such as toad and snake venoms.

The compilation of a list of such substances is not an end in itself. Instead, a systematically compiled schedule of toxic substances must form an integral part of a range of measures which will increase safety in the production plants concerned. It should be established in a once -and-for-all investigation whether, and to what extent, substances in the schedule occur in old plants (this has, meanwhile, been largely completed on the basis of "Land" decrees); furthermore, it should be ensured that these plants comply with the safety standard for new plants. The licensing procedure for new plants must require certain safety and organizational measures: on the basis of the Accident Regulation, these requirements could be described in a safety analysis report incorporated in the Order.

For one of the substances listed in the schedule of toxins — namely phosgene — investigations have been carried out at a selected plant to establish the effects to be anticipated in the event of an accident and the probability of such an accident occurring.

3.2 The Accident Regulation

The schedule of highly toxic substances is an integral component of the Regulation; in that under § 4, Section 1 of the Clean Air Act, all plants are subject to licensing in which hazardous chemicals are handled. In order to ensure that a runaway reaction either cannot occur, or at least cannot lead to environmental risks, the operator of a plant is obliged to take appropriate safety and organisational measures, and to nominate a contact man to liaise with the responsible authority. The core of the Regulation should be a requirement for a safety analysis report which may, for example, include an accident analysis setting out the possible accidents, and the technical and organisational measures for their prevention, bearing in mind the probability of their occurrence. Furthermore, the Accident Regulation should require that the operators:

(1) co-ordinate monitoring and maintenance plans with the responsible authority,
(2) carry out regular safety drills,
(3) draw up alarm plans for the plant and make available the information necessary to avert hazards,
(4) draw up decontamination plans, where necessary,
(5) inform a central reporting station immediately after an accident occurs.

3.3 Difficulties in establishing technical guidelines

Investigations by the factory inspectors of "runaway" chemical reactions usually subsequently show that some error was made either in the use of reactants or in the plant design. The numerous safety measures which represent current practice in the chemical industry must be systematically examined to establish which are most useful in reducing accident probability at minimum cost. The examples below, which are in no significant order, may serve to show the kind of safety measures concerned:

(1) Automatic agitator controllers where unintentional interruption of the agitation may lead to hazardous situations.
(2) High level alarm or overflow safety system when filling plant with combustible, corrosive or toxic substances.
(3) Ultrasonic or X-ray testing at regular intervals of boilers and pipework for stress cracks, pitting and corrosion.
(4) Safety systems to prevent build-up of electrostatic charges during filling operations and drying processes.
(5) The rendering inert of apparatus, containers and pipework, in which explosive gases, vapours, dust/air mixtures or aerosoles of combustible substances occur, and in which ignition sources cannot be excluded with sufficient reliability by means of inhibitors, stabilising agents, protective coatings, etc.
(6) Control of oxygen concentration so that the flammability limit cannot be reached.

(7) Securing of plants against the spread of explosions, for example by using rotary vane feeders with stop motors, quick-closing dampers or stop valves, or extinguisher barriers.

(8) Exclusion of ignition sources when milling hazardous products, installation of optical and accoustic alarm signals as well as adequate fire extinguisher systems, fitting of collecting channels beneath heated vessels containing hazardous liquids, installation of pressure relieving chambers behind pressure vessels containing highly toxic contents in technically significant quantities.

Even from this brief survey it is clear that the establishment of accident guidelines requires extensive expert knowledge. Since this scientific and technical information is not available in any single authority or in individual industrial concerns, the Federal Minister of the Interior has established an appropriate body of experts, the Accident Commission.

4. Information — determination and co-ordination

4.1 Accident Commission

Recent events have shown that there are a number of hazardous production processes in industry in the course of which highly toxic substances may be released into the environment. Considering only the schedule of toxic substances (Section 3.1) mentioned above, 145 substances were listed which can be classified as highly toxic chemicals (e.g. TCDD, phosgene, parathion). Furthermore, numerous substances occur in production plants which could, if sizeable quantities escaped, lead to catastrophic consequences particularly in the densely populated areas of the F.R.G. (e.g. hydrogen fluoride, ammonia). In addition, there are many processes involving large quantities of explosive or inflammable substances which should be incorporated in a programme to avert accident hazards, not only to protect the physical environment, but also because of possible damage to neighbouring plants in which toxic substances occur.

With regard to the effects of possible accidents, there are neither methods available for describing dispersion under extraordinary conditions, nor are there the customary risk analyses based on fault-tree analyses and probability considerations, in order to determine weak points for this particular area. In order to meet the requirements of the various aspects of this broadly based theme, it is proposed that a commission of experts — the Accident Commission — be convened from industry, authorities and research institutes, and that it should submit contributions in several working groups. A steering committee will co-ordinate the activities of the working groups. The secretariat of the Accident Commission has been established in the Federal Environmental Agency.

The functions and objectives of the Accident Commission are:

(1) To advise the Federal Government or the responsible Federal Minister on the prevention of environmental hazards due to accidents in industrial plants, and to propose regulations in accordance with current practice (with the exception of plants which are subject to the regulations of the Atomic Energy Law). The Accident Commission will concern itself, in particular, with accidents in industrial plants in the course of which those substances which are listed in the schedule of toxic substances (Appendix II to the Accident Regulation) may occur.

(2) To stimulate and advise on research and development projects on the improvement of scientific knowledge and practice in the prevention of accidents.

(3) To provide expert opinions in the field, e.g. in the form of guidelines.

(4) The development of models for safety analysis reports.

(5) The working out of principles for dispersion models and calculations in the event of an accident.

(6) The further development of precautionary protective measure to avoid accidents.

(7) The preparation of measures for the establishment of a central accident reporting station.

(8) The organization of a national and international exchange of information with regard to accident investigations in industrial plants.

(9) Updating the schedule of highly toxic substances (Appendix II to the Accident Regulation).

In order to identify processes and emission conditions relevant to the occurrence of accidents, the following tasks present themselves:

(1) On the basis of a set of criteria yet to be compiled (which substances, which plants, how an accident is defined), processes should be identified, in the course of which:

(a) highly toxic substances occur and an extremely high safety level must be the objective,

(b) toxic substances occur, the escape of which in large quantities must be prevented by appropriate safety precautions,

(c) explosive and inflammable substances are handled.

(2) Weak point analysis based on risk analyses of selected processes and determination of typical sources of escapes in the event of an accident.

(3) Formulation of general safety requirements for plants specified under (1). Examination of the existing directory of safety regulations to determine suitable equipment for protective measures; for example, agitators and pressure vessels, pipework, reaction vessels, storage facilities and pressure relief systems.

(4) Type and extent of a safety analysis report for plants under (1).

(5) Proposals for environmental concentration limits in the event of an accident. From this data it should be possible to derive requirements for the use and capacity limitation of plants and for the distances to be maintained between plant sections likely affected by an accident. If these proposal limits are exceeded, certain indications are to be given regarding the taking of disaster protection measures (such as evacuation).

(6) Investigation of current accident problems.

(7) Compilation of an accident data bank.

In order to be able to describe the dispersion behaviour of hazardous chemicals in the event of accidents, the following problems must be solved:

(1) Evaluation and analysis of the approaches currently practised and under discussion, with the aim of making available in the short term, machinery for dispersion calculations in the event of accidents.

(2) Carrying out of comparative calculations and sensitivity analyses with the aim of using this machinery to develop appropriate measures.

(3) Planning and preparation of specific tracer experiments to simulate accidents.

(4) Development of a comprehensive concept for dispersion calculations in the event of accidents.

In the development of measures to alleviate the environmental risks of accidents in a plant, there is a fundamental distinction to be made between the reduction of the probability of damage occurring and its extent, and, on the other hand, the limitation of the effects of an accident which has already occurred. The main emphasis of the measures must naturally be on the removal of the causes of accidents and/or minimisation of the frequency and extent of damage. It is nevertheless necessary to develop measures to limit the effects of accidents. The chief function of these latter measures should be to alleviate the consequences of the accident. They may, for example, serve to hold back and delay the release of toxic or explosive substances due to the accident, or act as a barrier to the spread of the blast wave. A set of criteria should also be drawn up to specify for which plants disaster contingency plans should be made. Furthermore, the questions of how the affected area of the plant and the neighbourhood are to be sealed off, with whom planning is to be co-ordinated, how operation can be ensured in an emergency and the shape of the command structure, should also be considered.

In investigating these measures, the ideas and experience which are already available at various points in connection with emergency measures should be incorporated. These might include, for example, the alarm and disaster protection plans and, not least, the existing plans which most operators have for measures in the event of an accident. In particular, classification and examination of the plans worked out by the operators must be regarded as a valuable basis for any possible legal embodiment of the accident procedure.

4.2 Accident data bank

In the long term, the results of accident problems should be stored in a recallable form by means of electronic data processing. This appears important:

(a) in order to make available a federal central point of reference to which recourse may be made in the event of an accident, and

(b) in order to be able to offer information, including immediate measures to be taken, in the case of accidents involving chemicals not included in the abovementioned schedule of toxic substances, but which may nevertheless have serious effects.

The environmental information and documentation system (UMPLIS) is envisaged to be a reference centre of this type. Preliminary work on the evaluation of specific accidents in the chemical industry (that is, excluding transportation, storage and traffic accidents, crushing, etc.) is currently being carried out for this accident data bank.