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INSTITUTE FOR SYSTEMS INFORMATICS AND SAFETY

MAJOR ACCIDENT HAZARDS BUREAU

# GUIDANCE ON THE PREPARATION OF A SAFETY REPORT TO MEET THE REQUIREMENTS OF COUNCIL DIRECTIVE 96/82/EC (SEVESO II)

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JOINT RESEARCH CENTRE
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INSTITUTE FOR SYSTEMS INFORMATICS AND SAFETY


# GUIDANCE ON THE PREPARATION OF A SAFETY REPORT TO MEET THE REQUIREMENTS OF COUNCIL DIRECTIVE 96/82/EC (SEVESO II)

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(Editors)

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# *Introduction*

The "Seveso II" Directive (96/82/EC) is aimed at the prevention of the major accident hazards involving dangerous substances, and the limitation of their consequences for man and the environment, with a view to ensuring high levels of protection throughout the Community in a consistent and effective manner. A requirement for a "Safety Report" is included in the Directive as one of the principal measures to achieve this aim.

This document is intended to provide guidance to assist with the interpretation of the requirements on "Safety Reports" contained in the Directive. This guidance is not legislation. It should not be considered mandatory and does not preclude other reasonable interpretations of the requirements in the Directive.

The relevant text from the Directive is contained in Article 9 on "Safety Report" and Annex II on "Minimum data and information to be considered in the safety report specified in Article 9". For convenience, this text is included in Annex A and the subsequent sections add further interpretative guidance to elaborate where considered useful. The guidance is intended to specify the information to be contained in the report but is not intended to prescribe a particular format for the presentation of information as such. In particular, the structure and format of a safety report for an *establishment* covering several *installations* is considered flexible such that an operator can consider the best way to present "common aspects" for the *establishment* and specific details for each *installation* which can present a major accident hazard (words in *italics* are defined in the Directive).

References consulted in the drafting of this guidance and other relevant titles are listed in Annex D.1.

**Sam Porter**
for the DG XI. E.1

SECTION 1

# Description of the Establishment

## General

1 The safety report should contain an adequate description of the establishment to enable the control authorities to have a clear picture of its purpose, location, activities and intrinsic hazards, services and technical equipment for safe operation. The extent of the description should be commensurate to the hazards of the establishments. The description should also aim at clarifying the interrelations among the different installations and systems within the establishment, both as far as the common services and the overall management of the establishment are concerned.

2 An introductory section should contain general information on the establishment, i.e.

- purpose of the establishment;
- main activities and production;
- history and development of the activities including the status of authorizations for operations already agreed and/or granted;
- the number of persons working at the establishments (i.e. internal and contractors' personnel, specifying working times, visitors, etc.);
- general statements characterizing the establishment with respects to its main hazards due to relevant substances and processes.

## Management and organization

3 As the organizational aspects are an integral part of the safety system, the safety report should describe the structure of the organization, including distribution of functions and responsibilities relevant to the safe operation of the establishment and its installations.

## *Location*

**4** The description of the establishment should contain data on topography and accessibility to the site at a degree of detail commensurate with the extent of the hazards and the vulnerability of the surroundings.

**5** The submitted topographic maps should be of an adequate scale and should include the establishment and surrounding developments within an area of sufficient extent in relation with the possible impact of accidents (the scale of the maps must be indicated, different scaled maps may be necessary when long distance effects are foreseeable).

**6** On such maps the land use pattern (i.e. industry, agriculture, urban settlements, environmentally sensitive locations etc.) and the location of the most important buildings and infrastructures (i.e. hospitals, schools, other industrial sites, motorway /railway networks, stations and marshaling yards, airports, harbors, etc.) must be clearly indicated.

**7** Also on the maps access routes to the establishment should be clearly indicated as well as the escape routes from the establishment and other traffic routes significant for rescue and emergency operations

## *Lay out of the establishment*

**8** The lay-out of the establishment as a whole and of its relevant installations should be clearly presented on adequately scaled plans. Relevant diagrams and/or pictures of particular sections or equipment should be presented in an appropriately larger scale.

**9** The lay-out should adequately identify installations and other activities of the establishment including:

- main storage facilities;
- process installations;
- location of relevant substances and their quantities;

- relevant equipment (including vessels and pipes);
- spacing of the installations and their main sections;
- clearance between flammable liquid storage tanks in multi-storage sites, etc.;
- utilities, services and fire water retention;
- escape routes from the installations and across the establishment;
- control rooms and office rooms.

## *The environment and surroundings of the establishment*

**10** The description of the natural environment and the surroundings of the establishment should be detailed to an extent proportionate to the hazard. It should demonstrate that the natural environment and surrounding activities have been sufficiently analyzed by the operator to identify both the hazards they pose to safe operation and the vulnerability of the area to the impact of major accidents.

**11** When already defined, the land use pattern of the areas around the establishment may be presented as specified in the official land use plan of the greater area. This kind of information will support the assignment of the relevant measures against potential effects of a major accident on neighboring inhabitants, ecosystems, properties and activities.

**12** To the degree in which accident consequences may affect the surroundings of the establishment, relevant information should be supplied on:

a. inhabited areas (e.g. description of the areas including population densities);
b. establishments receiving the public, meeting points (regular or occasional);
c. sensitive public buildings (schools, hospitals, churches, police stations, fire stations, telephone switchboards, etc.);
d. conservation areas, registered monuments and areas of tourist attraction;
e. public utilities, possibly affected by accident consequences, in the vicinity (electricity, gas, telephone, water, sewers and treatment plant, etc.).

**13** External activities and developments may both be sources of hazards to the establishment and also be affected by accidents possibly originating in the establishment. The safety report should give adequate evidence that both kind of hazards have been identified. The description should include:

- industrial activities external to the establishment (i.e. nature of - and spacing with regard to - other establishments, limitations imposed by other establishments etc.);
- traffic routes and major transportation centers (i.e. roads, railways, waterways, ports, airports, marshalling yards etc.).

**14** As the natural environment of an establishment may present potential hazard sources, influence the development of an accident, and be affected by the consequences of an accident, data will be needed for the description of the relevant environmental factors. In general this includes *meteorological data such as*:

- average and maximum indices on precipitation (rain, snow, hail);
- thunderstorms;
- lightning;
- humidity, fog, frost;
- winds (direction, speed);
- stability classes;
- maximum and minimum recorded temperatures,

and *geological, hydrological and hydrographic site data such as*:

- general geological context;
- type and conditions of the ground/underground;
- seismic data;
- flooding and landslides;
- other site specific natural hazards (uncontrolled fires, volcanic activities etc.).

Certain data can be omitted; however the reason for their exclusion should be given.

The safety report should also present the data concerning the vulnerability of the natural environment to the impact of major accidents. The following environmental factors may be relevant:

- surface and ground water;
- water quality and uses;

- shore and marine environment;
- areas of special environmental interest i.e. natural protected areas, protected fauna and flora species, sensitive ecosystems, areas of outstanding natural beauty, etc.

## *Dangerous Substances*

**15** The safety report should give relevant particulars of types and quantities of dangerous substances to which the Directive applies at the establishment. The substance can fall in any of the following categories:

- raw materials;
- intermediate products;
- finished products;
- by-products;
- wastes and auxiliary products;
- products formed as a result of loss of control of chemical processes.

For the eligible dangerous substances, data to be provided should include:

a. *type and origin of the substance* (i.e. CAS Number, IUPAC Name, commercial name, empirical formula, chemical composition, degree of purity if relevant, the most important contamination, etc.);

b. *physical and chemical properties* (i.e. characteristic temperatures and pressures, concentration and phases at normal and at the onset of abnormal conditions, equilibrium data and operation curves if relevant, thermodynamic and transport properties, data on phase changes, flash points, ignition temperatures, combustibility of solids, spontaneous-ignition temperatures, explosion limits, thermal stability data, data on reactions and their rates, decomposition etc.);

c. *toxicological, flammability and explosive characteristics* (i.e. toxicity, persistence, irritant effects, long-term effects, synergistic effects, warning symptoms, effects to the environment, ecotoxic data, etc.).

d. *others* (e.g. corrosion characteristics in particular relating to the containment' material).

Most information may be found in safety data-sheets (including maximum permissible working concentrations, relevant threshold levels, reference to guidelines for health at the work place, methods and means to detect their presence in the workplace and/or in the case of loss of containment, etc.).

## *Hazardous installations and activities*

**16** The description of hazardous activities (processes/storage) shall indicate the purpose and the basic features of the related operations within the establishment which are important to safety and may be sources of major risks. This should cover:

a. basic operations;

b. chemical reactions, physical and biological conversions and transformations;

c. on -site interim storage;

d. other storage related activities i.e. loading-unloading, transport including pipework, etc.;

e. discharge, retention, re-use and recycling or disposal of residues and wastes;

f. discharge and treatment of waste gases;

g. other process stages, especially treatment and processing operations.

**17** Further details may be required of the safety relevant sections in accordance with the hazard analysis. This description should thus include a substantial amount of data significant from the process engineering and technical safety standpoint; and cover the safety systems as well. This may include:

a. flow charts and Piping and Instrumentation ( P&I ) diagrams;

b. flow patterns and machinery / equipment needed in the processes; inventories and key dimensions of the containers and pipes shall be available if relevant;

c. process conditions i.e. pressure, temperature, concentration (their safe operation ranges) and any relevant thermodynamic and transport properties at the successive steps of the process such as:
   - normal and maximum flows, consumption of reactants, production of intermediate/end-/by-products (e.g. overall and substance mass balances);
   - average or typical quantities normally or accidentally possible to be present, stored or in process;
   - formation conditions of by-products and unplanned accident products;
   - conditioning of the final products;

d. instrumentation, control/alarm and other safety systems;

e. relevant qualitative and quantitative information on energy and mass transport in the processes i.e. material and energy balances,
   - in normal running;
   - in start-up or shut-down periods;
   - during abnormal operations;

f. characteristic process conditions and substance state parameters (i.e. temperature/pressure/concentration/boil-off fluctuation etc.).

Sufficient information should be provided in the safety report to permit the competent authority to assess the adequacy of the controls, but reference can be made to other documents available to the authority on request.

**18** The safety report should also provide an outline description of the procedures for safe operation in all process stages, which includes:

a. operations (e.g. normal running, shut-down and start-up, exceptional operations, emergency and safety procedures);

b. specific precautions during storage, transport or handling because of specific characteristic of the substance (e.g. protection from vibration or from ambient humidity).

**19** Structural characteristics and other design data of the storage or process plant handling the dangerous substances should be supplied in the form of the applied standards used for their design. A more analytical presentation of

such data may be required for the parts of the establishment in which major hazards are encountered. The description need not enter into great detail, but should refer to other documents, available to the authority on request, covering certain relevant topics such as:

- choice of materials important to safety;
- foundations;
- design of equipment under high pressure or temperature and their supports;
- size;
- stability (static calculations, conditions and load - bearing capacity of the ground);
- design against external events.

## *Services*

**20** The presentation of the establishment services should specify important characteristics of such utilities (i.e. emergency service, primary/secondary etc.). The description should make clear which services/supplies are in common to more or all installations, and which are installation specific and should include the relevant back-up systems. The following topics should be addressed if relevant:

Outside supplies

- outside electrical, other power sources supply;
- outside supply of water;
- outside supply of other fluids or solids.

Utilities inside the establishment

- production of power internally, fuel supply and storage;
- internal electrical distribution network;
- back-up electrical supply (emergency supply);
- fire-fighting and supply arrangements;

- hot water and other fluid distribution networks;
- communication systems;
- instrument air.

Other services

- health and safety (working environment);
- medical service;
- control centers, emergency refuges, muster points;
- rescue service (emergency);
- service of guarding and controlling the access;
- environmental service;
- equipment inspection service;
- maintenance and repair workshop;
- laboratory, etc.

Waste treatment systems

- sewer network and waste water systems;
- arrangements for controlling and collecting fire water run-off.

Monitoring services

- weather stations;
- services for detecting toxic products in the air;
- services for detecting toxic products in the sewers/discharges to surface and ground water;
- services for detecting and alarms for fires / explosive atmospheres;
- services for monitoring access and detecting intrusions.

SECTION 2

# *Hazard Identification and Risk Assessment*

## *Introduction*

1 The safety report should demonstrate that the operator has identified the major accident hazard and assessed the risks associated with the installations and other activities in the establishment. The safety report should present the results of the hazard analysis and risk assessment performed by the operator, the extent of which should be commensurate to the risk. In general the hazard analysis should document the identification of hazard sources, the relative likelihood of major accident and their consequences.

2 There exist several approaches to hazard analysis and risk assessment (either qualitative or quantitative), each of which can give sound insights into the safety situation if used consistently. It is beyond the scope of the present guidance to attempt to describe or evaluate these methodologies, examples of which can be found in various references listed in the annexes of this document.

3 The choice of the specific technique may be site-specific or risk-specific. In any case the effort implied should be proportional to the extent of possible damage. Quantified arguments might be a convenient way of limiting the scope of the safety report by demonstrating either that an adverse event has a very remote probability of occurring or that a particular consequence is relatively minor. Quantified arguments in the context of risk assessment does not necessarily mean quantification of risk in terms of chance of death. Social or environmental harm could be considered. Quantification of consequence and /or event frequency could be in several cases a sufficient basis for judgment.

4 Whatever the approach adopted, the hazard analysis should achieve the four objectives of

i. identification of the safety relevant sections (installations or parts of an installation);

ii. identification of the hazard sources;

iii. assessment of the consequences of potential major accidents, and

iv. assignment and assessment of adequacy of the prevention, control and mitigation measures.

5 Usually the hazard analysis involves an iterative process to ensure that the safety objectives are fully met. A possible outline of the procedure is presented here:

**Step A** focuses on identification and analysis of the sections that have a major accident potential without however excluding the remaining sections from receiving the appropriate safety attention. The sections posing a significant major accident potential because of the substances handled or processed are thus identified as safety relevant sections.

**Step B** aims at identifying those hazard sources which may cause a major accident in the safety relevant sections. In addition, the conditions under which a major accident could occur and the consequences of those accidents, should be determined.

**Step C** aims at assessing the prevention, control and mitigation measures assigned.

A Risk Assessment can be used to determine the likelihood of the major accidents and demonstrate that adequate measures have been taken to protect man, property and the environment. Available techniques for risk assessment based on qualitative methods, semi-quantitative criteria or fully quantitative methods are referred to in Annexes D.2, D.3, D.4 and D.5.

## *Step A - Preliminary Hazard Analysis*

**6** A Preliminary Hazards Analysis (PHA) should identify the safety relevant sections of the establishment. These sections are characterized by the quantity and the intrinsic properties of dangerous substances and/or the processes involved and hence constitute the parts of the establishment requiring more detailed hazard analysis. The PHA can be accomplished using a variety of hazard screening methods; examples are listed in Annex D.2.

**7** Lessons from past incidents and operating experience can make a significant contribution to the selected hazard screening method and to its results. A relevant list of accidents in similar storage or process facilities is considered useful.

**8** Section identification can be by the use of Hazard Index methods, the identification of threshold criteria such as a fraction of the qualifying quantity of the dangerous substance in Annex I of the Directive, or other suitable methods. The criteria should take into account the physical and chemical properties of the substance and the accident consequence potential of the process conditions. Therefore threshold criteria may result in values well below the limits in the directive. This procedure should consider all parts of the establishment capable of generating conditions for a major accident.

**9** The choice of the PHA methodology should be explained in the safety report and the criteria used for the decision clearly discussed.

## *Step B - Identification of hazard sources and evaluation of consequences of major accidents*

### *Identification of hazard sources*

**10** Hazard sources may be defined as conditions or events which threaten the safe operation of the establishment, installation or plant. Such sources should be identified in all phases of operation (start-up, normal operation, shut-down, loading/ unloading etc.).

**11** Hazard sources may be linked with:

***operation*** i.e. human errors during operations, testing and maintenance, malfunctions and technical failures of equipment, failures of containment, physical or chemical process parameters beyond prescribed limits, faults in utility supplies, etc.;

***external events*** i.e. impact of neighboring activities, transport, natural hazards, etc.;

***security*** i.e. unauthorized interventions;

***other causes related to design, construction, and safety management*** i.e. design inadequacy, design errors, inadequacy of operational procedures, equipment or process modifications, inadequate work permit system, inadequate maintenance, etc.

**12** Hazard source identification is a crucial step in the analysis. The safety report should outline the principles and procedures followed to determine the hazard sources. Whatever system is adopted for hazard identification, accident databases should be consulted and lessons learnt from past incidents incorporated. Hazard sources which have already resulted in an accident should be considered credible where the processes and conditions are analogous.

**13** Identification of hazard sources is best carried out by a team whose members have a range of skills, technical/professional knowledge gained from safety inspections, from the operation of establishments/installations of this or comparable types and insights gained from modeling techniques (see also Annex B).

### *Operational Hazard Sources*

**14** Depending on the extent of the consequences of the potential major hazards, the sources of hazard may be determined by simple means such as checklists, or by more complex methods such as HAZOP, FMEA, etc. Reference to different methods can be found in Annex D.3.

**15** Where checklists are used they should not be regarded as exhaustive. As a minimum, checklists, should consider the following aspects:

a. physical and chemical process parameters limits;

b. hazards during specific operation modes (i.e. start up / shut down);

c. failure of containment;

d. malfunctions and technical failures of equipment and systems;

e. knock-on effects from other equipment;

f. faults of utilities supply;

g. human factors involving operation, testing and maintenance;

h. chemical compatibility and contamination;

i. the build-up of electrostatic charge and other ignition sources.

**16** The above factors should be investigated with respect to the part they could play in possible accidents i.e. toxic gas releases, explosions, releases of flammable substances with or without ignition, major fires, runaway reactions and hazardous releases to the environment. The relevant contents of the safety report and reference to the most commonly used hazard identification methods for use with exothermic or runaway reactions can be found in Annex B, whereas reference to techniques for evaluating accident developments (i.e. cause-consequence diagrams, event trees - fault trees techniques etc.) can be found in Annex D.5.

**17** The choice of the hazard identification techniques used should be explained in the safety report and the assumptions clearly discussed.

### *External Hazard Sources*

**18** External activities or events are an important source of hazard. The safety report should identify those sources relevant to the site and discuss their possible impact. Again, historical data will provide a useful indication of the likelihood and impact of such events. Where required by the competent authority the concern of accidents arising from "domino" effects should be considered in the report. A list of possible external hazard sources, relevant studies and analysis methods can be found in Annex C.

### *Plant security*

**19** The consequences arising from unauthorized actions at the site should be considered.

### *Other sources related to design, construction and safety management*

**20** Other hazard sources are related to the management of whole life cycle of the establishment and its plants (i.e. design, construction, installation, commissioning, decommissioning, equipment or process modifications, work permit system, maintenance, etc.). The safety report should discuss the measures taken to control such hazards (see also section 3). Alternatively the safety report should refer to other document describing the Major Accident Prevention Policy and the Safety Management System.

## *Consequence assessment*

**21** Assessment of accident consequences to people and environment is essential in several steps of analysis, and the safety report should summarize and document the conclusions of such analysis

a. Consequence assessment constitutes an indispensable part in the systematic hazard analysis to help establish technical/organizational safeguards to prevent major accident hazards and to mitigate the consequences of accidents. Such assessment can be based on judgment, qualitative or simplified models, unless accurate quantification is required;

b. Consequence assessment describes the outcomes of selected accident scenarios to provide information for general major accident hazard control, emergency planning (internal and external) and for land use planning around establishments. Such assessment should then be based on appropriate quantitative models.

There exist a number of different means to accomplish such a task consistently. Relevant information on these matters can be found in the literature (Annex D.5) with insights also into environmental parameters (fauna, flora, air, soil, surface and ground water) and available impact analysis methods (Annex D.6).

**22** All the assumptions made and references to computer codes and experimental results used for the assessment should be adequately explained and documented in the safety report.

## *Step C*
## *Prevention, Control and Mitigation measures*

**23** Hazards should be possibly avoided or reduced at source through the application of inherently safe practices. When risk remain, then risk principles such as ALARA (As Low As Reasonably Achievable) can be used in determining the level of measures required. The measures should:

a. prevent a malfunction from arising in the establishment;

b. prevent the occurrence of abnormal operation which could lead to a major accident;

c. mitigate the effects of major accidents on persons or the environment.

**24** Prevention, control and mitigation measures may include:

- process control system including back ups;
- fire and explosion protection systems;
- devices for limiting the size of accidental releases i.e. scrubbing systems, water spray;
- vapour screens, emergency catchpots or collection vessels, emergency shut-of valves;
- alarm systems including gas detection;
- automatic shut down systems;
- inerting systems;
- fail-safe instrumentation;
- emergency venting including explosion panels;
- fast shut-down and other emergency procedures;
- special precautions against unauthorized actions related to the plant security (addressed in confidential reports available to CA on request).

### *Assessment of prevention, control and mitigation measures*

**25** The assessment of the prevention, control and mitigation measures should be made in conjunction with the overall risk assessment of the establishment. The safety report should discuss general criteria assumed (i.e. best available

technology, good engineering practice, quantitative risk criteria), should give the reason why a method of presentation has been selected over and above other possible options and in particular should describe:

a. the criteria used to decide the degree of redundancy, diversity and separation required for the prevention, control and mitigation measures;
b. the reliability of components and systems and the efficiency of organizational measures;
c. the functional calculations needed to confirm the capability of the measures to cope with the design-basis accidents (design criteria and load assumptions according to the relevant good engineering practice; time and order in which the measures become effective in relation with the process/accident evolution and the man-machine interface etc.);
d. feedback from measures to the system as a whole;
e. compliance with relevant national regulations and relevant codes of practice.

**26** Such assessment might be made by adopting either qualitative or probabilistic reliability analysis techniques and criteria. Reference to relevant reliability and availability techniques can be found in Annex D.4.

## *Documentation*

**27** The safety report should contain a detailed description of the safety relevant sections and of the systems and components which are important for safety. The description need not duplicate requirements under section 1 and can be included in an annex to the safety report. The description should allow easy identification of:

a. those parts of the process or installation containing dangerous substances and their location;
b. those parts of the establishment involving hazardous processes;
c. elements serving safety relevant functions i.e. prevention, control and mitigation measures; and
d. elements capable of initiating a major accident.

Such description should allow a better understanding of the hazard analysis, clearly describing the relationship between the hazard sources and their prevention, control and mitigating measures, including test, maintenance and inspection systems and relevant documentation.

**28** The description should make clear reference to other parts of the establishment to allow identification of interactions. Where necessary, reference should be made to other documents available to the competent authorities on request (e.g. P&I diagrams). Components, processes and control parameters important for safety can be listed in a separate annex to the safety report.

## *Presentation of hazard analysis and risk assessment*

**29** The safety report should present the main results and arguments of the hazard analysis and risk assessment. The original assessments should be accessible to the competent authority on request. The safety report should refer to documents available on the hazards analysis and risk assessment performed. In particular, documents which contain information on the assumptions made, and the judgment criteria adopted should be clearly referenced.

**30** The accident scenarios identified in the hazard analysis, their consequences and likelihood should be clearly documented so they might be used for preparing the basis for further decisional processes (e.g. external emergency planning and land use planning).

SECTION 3

# *Information concerning the Major Accident Prevention Policy and Emergency Planning*

## *Major Accident Prevention Policy and Safety Management Systems*

1 It has become increasingly clear that the root causes of industrial accidents may lie deeply in the management aspects. Therefore the management of safety to man and the environment should receive the due attention in the safety report.

2 Safety management may be defined as the aspect of the overall management function that determines and implements the safety policy. This will involve a whole range of activities, initiatives, programs, etc., focused on technical, human and organisational aspects and referring to all the individual activities within the organisation, which tend to be formalised as Safety Management Systems (SMS).

3 The safety report should either include or refer to a written statement describing the Major Accident Prevention Policy (MAPP) and related Safety Management Systems (SMS) of the operator to cope with the major accident hazards of the specific establishment. The SMS should cover that part of the overall management system which includes the structure of the organisation, responsibilities, practices, procedures, processes and resources for determining and implementing the MAPP (Annex A pag. 39).

4 Details on the elements of SMS can be found in a separate guidance note developed by the European Commission in conjunction with a Technical Working Group.

## *Measures of protection and intervention to limit the consequences of an accident*

**5** The analysis of major accident hazards in the previous sections included consideration of various prevention, control and mitigation measures as part of the overall risk assessment of the establishment. The Safety Report should also clearly include information which identifies any key mitigation measures, resulting from the analysis, which are necessary to limit the consequences of major accidents, as referred to in Annex II, part V of the Directive (see Annex A), namely:

- **description of the equipment** installed in the plant to limit the consequences of major accidents;
- **organization of alert and intervention**;
- **description of mobilizable resources**, internal or external;
- summary of elements described above necessary for drawing up the **internal emergency plan**.

### *Description of equipment*

**6** A description of equipment installed in the plant to limit the consequences of major accidents shall be provided. This should include an adequate description of the circumstances under which the equipment is intended for use.

### Organization of alert and intervention

**7** The organisation for alert and intervention should be adequately described. This should include:

a. organisation, responsibilities, and procedures for emergency response;

b. training and information for personnel and emergency response crews;

c. activation of warnings and alarms for site personnel, external authorities, neighbouring installations, and where necessary for the public;

d. identification of installations which need protection or rescue interventions;

e. identification of rescue routes, escape routes, emergency refuges, sheltered buildings, muster points and control centres;

f. provision for shut-off of processes, utilities and plants with the potential to aggravate the consequences.

### *Description of mobilizable resources*

**8** The report should contain an adequate description of all relevant resources which will need to be mobilized in the event of a major accident. This shall include:

a. activation of external emergency response and co-ordination with internal response;

b. mutual aid agreements with neighbouring operators and mobilisation of external resources;

c. resources available on-site or by agreement (i.e. technical, organizational, informational, first aid, specialized medical services, etc.).

### *Summary of elements for the internal emergency plan*

**9** The report should include a summary of elements described above which are necessary for the preparation of the internal emergency plan to deal with major accidents or foreseeable conditions or events which could be significant in bringing about a major accident. It may be useful to include or refer to the internal emergency plan which has been drawn up to comply with Article 11 of the Directive. A list of relevant references can be found in Annex D.7 □

# ANNEXES

ANNEX A

# *Article 9 and annexes II & III of COUNCIL DIRECTIVE 96/ 82 /EC, ON THE CONTROL OF MAJOR-ACCIDENT HAZARDS INVOLVING DANGEROUS SUBSTANCES*

## *Article 9 - Safety report*

1 Member States shall require the operator to produce a safety report for the purposes of:

(a) demonstrating that a major-accident prevention policy and a safety management system for implementing it have been put into effect in accordance with the information set out in Annex III;

(b) demonstrating that major-accident hazards have been identified and that the necessary measures have been taken to prevent such accidents and to limit their consequences for man and the environment;

(c) demonstrating that adequate safety and reliability have been incorporated into the design, construction, operation and maintenance of any installation, storage facility, equipment and infrastructure connected with its operation which are linked to major-accident hazards inside the establishment;

(d) demonstrating that internal emergency plans have been drawn up and supplying information to enable the external plan to be drawn up in order to take the necessary measures in the event of a major accident;

(e) providing sufficient information to the competent authorities to enable decisions to be made in terms of the siting of new activities or developments around existing establishments.

2 The safety report shall contain at least the data and information listed in Annex II. It shall also contain an updated inventory of the dangerous substances present in the establishment.

Safety reports, or parts of reports, or any other equivalent reports produced in response to other legislation, may be combined to form a single safety report for the purposes of this Article, where such a format obviates the unnecessary duplication of information and the repetition of work by the operator or competent authority, on condition that all the requirements of this Article are complied with.

3 The safety report provided for in paragraph 1 shall be sent to the competent authority within the following time limits:

- for new establishments, a reasonable period of time prior to the start of construction or of operation;
- for existing establishments not previously covered by Directive 82/501/EEC, three years from the date laid down in Article 24 (1);
- for other establishments, two years from the date laid down in Article 24 (1);
- in the case of the periodic reviews provided for in paragraph 5, without delay.

4 Before the operator commences construction or operation, or in the cases referred to in the second, third and fourth indents of paragraph 3, the competent authority shall within a reasonable period of receipt of the report:

- communicate the conclusions of its examination of the safety report to the operator, if necessary after requesting further information, or
- prohibit the bringing into use, or the continued use, of the establishment concerned, in accordance with the powers and procedures laid down in Article 17.

5 The safety report shall be periodically reviewed and where necessary updated:

- at least every five years;
- at any other time at the initiative of the operator or the request of the competent authority, where justified by new facts or to take account of new technical knowledge about safety matters, for example arising from analysis of accidents or, as far as possible, "near misses", and of developments in knowledge concerning the assessment of hazards.

6 (a) Where it is demonstrated to the satisfaction of the competent authority that particular substances present at the establishment, or any part thereof, are in a state incapable of creating a major accident hazard, then the Member State may, in accordance with the criteria referred to in subparagraph (b), limit the information required in safety reports to those matters which are relevant to the prevention of residual major accident hazards and the limitation of their consequences for man and the environment.

(b) Before this Directive is brought into application, the Commission, acting in accordance with the procedure laid down in Article 16 of Directive 82/501/EEC, shall establish harmonized criteria for the decision by the competent authority that an establishment is in a state incapable of creating a major accident hazard within the meaning of subparagraph (a). Subparagraph (a) shall not be applicable until those criteria have been established.

(c) Member States shall ensure that the competent authority communicates a list of the establishments concerned to the Commission, giving reasons. The Commission shall forward the lists annually to the Committee referred to in Article 22.

## *ANNEX II of the Directive*

***Minimum Data and Information to be Considered in the Safety Report Specified in Article 9***

**I** ***INFORMATION ON THE MANAGEMENT SYSTEM AND ON THE ORGANIZATION OF THE ESTABLISHMENT WITH A VIEW TO MAJOR ACCIDENT PREVENTION***

This information shall contain the elements given in Annex III.

**II** ***PRESENTATION OF THE ENVIRONMENT OF THE ESTABLISHMENT***

A. description of the site and its environment including the geographical location, meteorological, geological, hydrographic conditions and, if necessary, its history;

B. identification of installations and other activities of the establishment which could present a majoraccident hazard;

C. description of areas where a major accident may occur.

**III** ***DESCRIPTION OF THE INSTALLATION***

A. description of the main activities and products of the parts of the establishment which are important from the point of view of safety, sources of major-accident risks and conditions under which such a major accident could happen, together with a description of proposed preventive measures;

B. description of processes, in particular the operating methods;

C. description of dangerous substances:

1) inventory of dangerous substances including:

- the identification of dangerous substances: chemical name, CAS number, name according to IUPAC nomenclature;
- the maximum quantity of dangerous substances present or likely to be present;

2) physical, chemical, toxicological characteristics and indication of the hazards, both immediate and delayed for man and the environment;

3) physical and chemical behaviour under normal conditions of use or under foreseeable accidental conditions.

**IV** ***IDENTIFICATION AND ACCIDENTAL RISKS ANALYSIS AND PREVENTION METHODS***

A. detailed description of the possible major-accident scenarios and their probability or the conditions under which they occur including a summary of the events which may play a role in triggering each of these scenarios, the causes being internal or external to the installation;

B. assessment of the extent and severity of the consequences of identified major accidents;

C. description of technical parameters and equipments used for the safety of installations.

V ***MEASURES OF PROTECTION AND INTERVENTION TO LIMIT THE CONSEQUENCES OF AN ACCIDENT***

A. description of the equipment installed in the plant to limit the consequences of major accidents;

B. organization of alert and intervention;

C. description of mobilizable resources, internal or external;

D. summary of elements described in A, B, and C above necessary for drawing up the internal emergency plan prepared in compliance with Article 11.

## *ANNEX III of the Directive*

### *Principles Referred to in Article 7 and Information Referred to in Article 9 on the Management System and the Organization of the Establishment with a View to the Prevention of Major Accidents*

For the purpose of implementing the operator's major-accident prevention policy and safety management system account shall be taken of the following elements. The requirements laid down in the document referred to in Article 7 should be proportionate to the major-accidents hazards presented by the establishment:

(a) the major accident prevention policy should be established in writing and should include the operator's overall aims and principles of action with respect to the control of major-accidents hazards;

(b) the safety management system should include the part of the general management system which includes the organizational structure, responsibilities, practices, procedures, processes and resources for determining and implementing the major-accident prevention policy;

(c) the following issues shall be addressed by the safety management system:

(i) Organization and personnel - the roles and responsibilities of personnel involved in the management of major hazards at all levels in the organization. The identification of training needs of such personnel and the provision of the training so identified. The involvement of employees and, where appropriate, sub-contractors.

(ii) Identification and evaluation of major hazards - adoption and implementation of procedures for systematically identifying major hazards arising from normal and abnormal operation and the assessment of their likelihood and severity.

(iii) Operational control - adoption and implementation of procedures and instructions for safe operation, including maintenance, of plant, processes, equipment and temporary stoppages.

(iv) Management of change - adoption and implementation of procedures for planning modifications to, or the design of new installations, processes or storage facilities.

(v) Planning for emergencies - adoption and implementation of procedures to identify foreseeable emergencies by systematic analysis and to prepare, test and review emergency plans to respond to such emergencies.

(vi) Monitoring performance - adoption and implementation of procedures for the ongoing assessment of compliance with the objectives set by the operator's major-accident prevention policy and safety management system, and the mechanisms for investigation and taking corrective action in case of non-compliance. The procedures should cover the operator's system for reporting major accidents or near misses, particularly those involving failure of protective measures, and their investigation and followup on the basis of lessons learnt.

(vii) Audit and review - adoption and implementation of procedures for periodic systematic assessment of the major-accident prevention policy and the effectiveness and suitability of the safety management system; the documented review of performance of the policy and safety management system and its updating by senior management.

ANNEX B

# Hazardous Reactions

When hazardous reactions[1] are involved within the processes of an installation the safety report should contain sufficient information to demonstrate that the operator has identified the major accident hazards and assessed the risks associated with the process. This should include:

- *Description of the chemical process*;
- *Consideration of relevant past events*;
- *Hazard identification and risk assessment* including consequence evaluation of major accidents and the assessment of the preventive, controlling and mitigation measures;

## Description of the chemical process

The following issues should be addressed if relevant, and referenced data should be available related to:

a. the chemistry involved:
- type of reactions, for example complex, autocatalytic, secondary etc.;
- stoichiometry of reaction and heat generation rates at relevant (e.g. runaway) conditions;
- properties of reagents including thermal instability, decomposition, impurities etc.

b. the reactors and processes involved:
- design parameters (e.g. pressure and temperature) of the reactors and associated equipment, and where available reliability data;
- flow charts or P&Is involving the processes;
- normal/safe, abnormal and emergency operations, conditions and procedures including parametric sensitivity for exothermic reactions;
- control of reactants quality and impurities;
- control and safety back-up systems;
- maintenance programs and procedures;
- procedures for safety critical modifications and reviews of the processes;
- training programs and safety instructions.

[1] There are two main types of hazardous reactions: planned reactions that during their operation become unstable and go out of control and unwanted (often decomposition) reactions. In addition to their relevance in processes, the latter may be relevant to the storage and transport of substances, where the need for control and preventive measures may not otherwise be forseen.

## *Past runaway events and accident causation factors*

It is not unusual for accidents initiated by runaway reactions to be accompanied by severe and irreversible consequences e.g. fatalities, damage requiring plant demolition and abandonment. In addition, industrial experience has shown that runaways are as likely to occur in medium/small sized "non-major" hazards sites, as in major hazards sites. Hence the selection of a suitable methodology for the relevant hazards to be identified can be assisted by the inputs provided by the analysis of past events.

Among the most frequent immediate and underlying causes identified in past accidents specific to runaway reactions are:

- insufficient knowledge of the process chemistry;
- insufficient evaluations and reviews;
- incorrect operational procedures e.g. mischarging or reactants;
- lack of mixing;
- low quality of reactants;
- safety critical modifications that are unauthorised, insufficiently hazard studied or not documented;
- inadequate reactor maintenance;
- insufficient reactor operating instructions, procedures and training.

## *Identification of the hazard and risk assessment*

SR should outline the principles and procedures followed to identify the hazards involved in runaway reactions. Hazard identification and risk assessment are particularly important and is best carried out by a team of qualified people such as chemical engineers and chemists, using various methods. Screening methods shall be addressed related to:

A. classification of reacting system;

B. hazard testing;

C. risk assessment accompanied by preventive and mitigation measures.

### A *Classification of reacting system*

The reacting system classification can contribute the recognition of hazards already identified in similar systems. Several criteria may be used i.e. Arrhenius and Non - Arrhenius reactions, homogeneous and heterogeneous runaways, combinations of initiating events including reactant accumulation, loss of cooling, external heating, solvent evaporation etc.

### B *Hazard testing*

Hazard testing is important and should be performed using various screening methods for the evaluation of the characteristic parameters of runaway. Hazard identification methods may require data on:

- chemical formulas;
- hazardous mixtures of substances;
- list of dangerous reactions;
- calculation of the Oxygen balance;
- several established indices e.g. CHETAH indices;
- accident analysis of relevant past events;
- thermochemical parameters.

An indicative list of possible thermochemical parameters to be evaluated and the methods to be used for this is given below:

*Parameters:*

- onset temperature and heat of reaction for the exotherm and for secondary exotherms;
- decomposition of reagents i.e. the decomposition temperatures for the production of gases and the loss of weight during thermal decomposition (thermogravimetry);
- adiabatic[2] heat generation rates under relevant (e.g. runaway) conditions;
- gas generation rates under relevant (e.g. runaway) conditions;
- pressure effect;
- range of standard operating conditions e.g. safety temperature;
- impurities of reactants.

*Hazard Identification Methods:*

- thermal analytical methods e.g. DSC/DTA;
- isothermal, isoperibolic, dynamic, adiabatic and pseudo-adiabatic calorimetric methods;
- runaway reaction simulation using computer models;
- established indices e.g. Dow index

Operators should make the best use of available hazard data and if not sufficient laboratory and desk top tests should be performed to estimate the extent of hazard. In scaling up from laboratory to real size, uncertainties and necessary extrapolations involved in the reaction parameters should be also considered.

### C *Risk assessment - preventive and mitigation measures*

Risk assessment is essential to evaluate the likelihood of runaway and the severity of its potential consequences. The extent of risk analysis and the intensity of the

[2] Tests must be adiabatic with respect to reactor contents; heat loss from the contents to the wall can be very important.

preventive and mitigation measures should be commensurate to the risk involved. Simple models of hazard identification may not be always sufficient. A list of typical failure modes may be helpful.

There exist several approaches to perform risk assessment. The choice of a particular technique may be process-specific. Although detailed assessment using for example CHETAH indices is advisable in several cases, it cannot be considered always necessary unless otherwise sustained by cost-effective analysis. Simple screening techniques on the other hand, can be sufficient only when combined together with the scale and frequency the usual batch operations are performed, and thus could constitute an adequate basis for discussion criteria to whether further assessment is needed.

Inherently safer design includes substitutions, intensification and attenuation. A viable process would require the implementation of *prevention and control* measures such as sensors, trips, alarms, control systems, and *protective and mitigation* measures such as reactor emergency reliefs, crash cooling, reaction inhibition, secondary containment,etc.

Design reactor relief regulations applying in all circumstances are not common. Not venting may be acceptable when risk has been reduced to an acceptable level. The necessity of some measures, e.g. explosion vents, may sometimes need to be balanced against cost or environmental and technical constrains.

Emergency plans should consider among others injury to key emergency personnel. Re-examination of the measures taken in established processes may be needed when hazards are not adequately identified. Audits can contribute to this by providing considerable inputs and are expected to be triggered by the legal requirement of updating the Safety Report of installations involving hazardous reactions.

Relevant material can be found in several references including the following:

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ANNEX C

# External Hazard Sources

External activities or events are important sources of hazard. The safety report should identify those relevant to the site. A list of possible hazard sources is the following:

**A** Impact of accidents (fire, explosions, toxic release) in neighbouring installations and transportation networks
- independent installations located at the same establishment;
- installations located outside the establishment fence;
- transportation of dangerous substances in site - off site (i.e. roads, railways, pipelines, shipping, oil or gas ports, air, etc.).

**B** Functional interdependence with neighbouring activities
- installations;
- pipelines;
- common utilities;
- other.

**C** Transport networks and centres
- works roads including access roads;
- public roads close to the installation and/or establishment;
- railway;
- airports.

**D** Natural hazard sources
- precipitation (extreme)/rain- snow-hail;
- wind, hurricane, thunderstorms, etc.;
- temperature extreme;
- lightning & static electricity;
- floods;
- seismic activity;
- landslide, subsidence;
- wildfire.

**E** Neighbouring/adjacent networks
- sewage networks;
- hydraulic networks;
- other.

Relevant material on risks external to the installation can be found in several references (i.e. transportation, natural hazards, knock-on effects etc.). A list of relevant titles is the following:

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ANNEX D

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## D.1

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European Commission

**EUR 17690 – Guidance on the preparation of a Safety Report to meet the requirements of Council Directive 96/82/EC (Seveso II)**

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