

INSTITUTE FOR SYSTEMS INFORMATICS AND SAFETY

GUIDANCE ON
LAND USE PLANNING
AS REQUIRED BY
COUNCIL DIRECTIVE 96/82/EC
(SEVESO II)

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(Editors)

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1. Introduction

Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances¹ (the “SEVESO II” Directive) aims at the prevention of major accidents 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.

Article 12 of the Seveso II Directive (see Annex I) requires that the objectives of preventing major accidents and limiting their consequences be taken into account by the Member States in their land-use policies and/or other relevant policies. This requirement recognises that planning policies can be directed towards the need, in the long term, for appropriate distances between establishments covered by the Directive and residential areas, areas of public use and areas of particular natural sensitivity or interest.

The Land-use planning provisions within the Seveso II Directive reflects the Council of Ministers’ request, following incidents at Bhopal (1984) and Mexico City (1984), that the land-use planning implications of limiting the consequences of major-accidents should be taken into account in the regulatory process. The incidents at Bhopal and Mexico City clearly showed how the consequences of an accident can become much worse where there are residential areas in the vicinity. Indeed the Seveso accident (1976) itself involved the evacuation of over 600 people and as many as 2000 were treated for dioxin poisoning.

Similar provisions on land-use planning are laid down within the UN/ECE Convention on the Transboundary Effects of Industrial Accidents (see Annex II). At the Council meeting of Ministers for the Environment, held in Brussels on 23 March 1998, the Council decided the approval by the Community of this Convention. It should be noted that the Seveso II Directive is the legal and technical instrument by which the Community implements the Convention.

This guidance document is intended to assist with the interpretation of the requirements on land-use planning contained within the Seveso II Directive and, where relevant, on the provisions on land-use planning laid down within the UN/ECE Convention on the Transboundary Effects of Industrial Accidents. It has been assumed that the relevant requirements within the UN/ECE Convention will be implemented through the same laws, regulations and administrative provisions which are intended to bring the Seveso II Directive into force. However it may be noted that the land-use planning provisions within Seveso II apply to all establishments covered by the Directive whilst the Convention has a more restricted scope corresponding to only those establishments covered by Article 9 of the Directive, i.e. so called ‘upper tier’ establishments.

Furthermore, some of the terminology used in the text of the Convention is different to that used in the Directive. In general, the Seveso II terminology is used in this guidance document as the Convention is implemented through the Directive. In certain cases, the guidance makes a more direct reference to the text of the Convention where this is viewed as necessary to make clear where the text and terminology of the Convention aligns with Seveso II.

In addition, the scope of the Convention covers only those establishments which are capable of causing a transboundary effect. However, in practice, this distinction has limited relevance as the intent is to implement land-use planning policies which are consistent and compatible with the requirements within both the Seveso II Directive and the UN/ECE Convention such that establishments well within the territory of a Member State will be treated in a similar way to those closer to the boundaries of the Member State.

The text of Article 12 of the Seveso II Directive requires that Member States must ‘*take into account*’ the objectives of preventing major-accidents and limiting their consequences. It strikes a balance by making a definitive legal requirement for land-use planning policies / procedures to include consideration of major accidents but at the same time recognises that subsidiarity considerations can reflect the different pressures on land-use within each Member State.

The requirements for land-use planning are newly introduced into Community legislation on major-accident hazards; the Seveso I Directive did not contain such requirements. The context is elaborated by Recital (22) of the Seveso II Directive which states:

¹ OJ No L 10 of 14 January 1997, p. 13.

'Whereas, in order to provide greater protection for residential areas, areas of substantial public use and areas of particular natural interest or sensitivity, it is necessary for land-use and/or other relevant policies applied in the Member States to take account of the need, in the long term, to keep a suitable distance between such areas and establishments presenting such hazards and, where existing establishments are concerned, to take account of additional technical measures so that the risk to persons is not increased;'

Although land-use planning requirements are newly introduced into Community legislation, several Member States have existing established practices for achieving a degree of separation between Seveso establishments and residential population. In general, the methods used are disparate, ranging from explicit consideration of the risks of major-accidents in some cases to a generic 'zoning' approach based on distances derived historically, normally by taking account of various environmental factors such as noise, pollution, etc. which give separation distances which are sometimes perceived to implicitly also take account of accident hazards. Some Member States have not yet established a land-use planning policy and system which address major-accident hazards.

In general, the requirements of Article 12 of Seveso II can be met using whichever method that best fits with the historical development and legislative style which has evolved for land-use planning in each Member State. However it can be expected that practices within individual Member States would yield broadly similar results in similar situations.

This guidance is not legislation. It is not mandatory and does not preclude other reasonable interpretations of the Directive.

2. Taking Account of ‘The Objectives of Preventing Major-Accidents and Limiting their Consequences’ in Planning Policies and Controls

2.1. Scope of policies and controls

Article 12 of the Seveso II Directive requires that controls should be exercised on:

- the siting of new establishments,
- modifications to existing establishments covered by Article 10,
- new developments such as transport links, locations frequented by the public and residential areas in the vicinity of existing establishments, where the siting or developments are such as to increase the risk or consequences of a major accident.

Article 12 provisions on land-use planning apply to all Seveso II establishments, that is, establishments covered by Article 7 (‘lower tier’) and establishments covered by Article 9 (‘upper tier’).

Article 13 of the Seveso II Directive also contains certain provisions related to land-use planning. Such provisions apply only to establishments covered by Article 9 of the Directive, i.e. so called ‘upper tier’ establishments.

Article 13(2) of the Directive requires sufficient information to be provided to neighbouring States such that the possible transboundary effects of a major accident originating in an establishment under Article 9 can be taken into account in their land-use or other relevant policies. Article 13(5) of the Directive requires that provision is made so that the public is able to give its opinion in prescribed cases.

The UN/ECE Convention (see Annex II) describes the scope of land-use planning controls in a similar way to Seveso II:

A consideration (i.e. having regard to the objective) of the siting of new, and significant modifications to existing hazardous activities, at a safe distance from existing centres of population, as well as the establishment of a safety area around hazardous activities; within such areas; developments which would increase the populations at risk, or otherwise increase the severity of the risk, should be closely examined.

However, as mentioned above, it may be noted that the Convention has a scope corresponding to only those establishments covered by Article 9 of the Directive, i.e. so called ‘upper tier’ establishments.

2.2. Integrating considerations of major accidents into overall land-use planning policies and controls

It is recognized that consideration of major-accidents is only one input to the process of land-use planning controls and policies. It is beyond the scope of this document to discuss general land-use planning issues and consider all of the necessary considerations which should be taken into account in land-use planning policies.

For the purposes of this document, it is sufficient to say that it is prepared in full knowledge that many other considerations can be relevant, and that these may already be elaborated in various national policies and implemented in national, regional or local structure and development plans. For example, there may already be general ‘zoning’ provisions which separate residential developments from polluting industries (noise, emissions, etc.), or which take account of special transport considerations, or other special plans for the best use of land to meet the overall needs of communities. It should be clear that the land-use planning provisions of the Seveso II Directive do not suggest that such other considerations become less relevant, but simply that technical advice on the risks arising from ‘Seveso’ establishments must also be available when decisions are taken. That is, consideration of Seveso establishments should be *integrated into* land-use planning policies and controls which may also need to take account of many other factors not covered by this document.

In general, it is envisaged that the objective of ‘*appropriate distances between establishments covered by this Directive and residential areas, areas of public use and areas of particular natural sensitivity or interest*’ will be implemented through policies which require consideration of the compatibility of potential uses of neighbouring land areas. The policies can be implemented through assessing proposals for new or modified land usage, which includes consideration of possible new Seveso II establishments, the modification of existing establishments or developments in the vicinity of existing establishments. In this way, it is expected that proposed developments which are not compatible with existing land usage can be avoided where possible.

In general, it is desirable to consider the land-use compatibility issues arising from ‘Seveso’ establishments at the earliest possible stage. In this context, it is recommended that such issues be taken into account in the development of general planning recommendations within national, regional or local plans.

2.3. Involvement of the public

Article 13 of the Seveso II Directive applies only to establishments covered by Article 9 of the Directive, i.e. ‘upper tier’ establishments.

Article 13(5) of the Directive requires that Member States ensure that the public is able to give its opinion in the following cases:

- ✓ Planning for new establishments covered by Article 9 of the Directive;
- ✓ Modifications to existing establishments under Article 10 of the Directive, where such modifications are subject to obligations provided for in the Directive as to planning;
- ✓ Developments around such existing establishments;

The methods to be used by Member States to ensure that the public can ‘give its opinion’ are not further elaborated in the Directive. It is assumed that Member States have some existing arrangements in place for informing the public about land-use plans, which can be utilised to meet this requirement. For example, publication in the local press, dialogue with public ‘representatives’, public meetings on Regional or Local Development Plans, etc. may be a means of communication.

2.4. Siting of new establishments

Article 12 of the Seveso II Directive requires that a Member State will implement planning policies and procedures which will control the location of new Seveso II establishments so that undesirable proximity to residential or environmentally sensitive areas is avoided where possible.

Article 6 of the Directive requires that new establishments submit a notification to the competent authorities responsible for the Seveso II Directive, a reasonable period of time prior to the start of construction or of operation. Establishments covered by Article 9 must also submit a safety report to the competent authorities for the Seveso II Directive a reasonable period of time prior to the start of construction or of operation.

Ideally Member States will make suitable arrangements to co-ordinate these requirements as far as possible. That is, it is likely that a planning application will need to be sent to the authorities responsible for planning laws and a notification/safety report will be sent to the authorities responsible for Seveso II, possibly at a later date when such information is available. It is in the interests of both the operator and the relevant authorities to indicate at the time of planning consultation that a proposed establishment is likely to be covered by the requirements of the Seveso II Directive. Sufficient information should be available for such planning consultations to be effective and, as necessary, linked to other requirements which may come later. In addition, it is desirable to ensure that procedures are designed to co-ordinate

all relevant assessments made by various authorities. For example, this may also include the requirements of other environmental legislation where applicable.

Figures 1 and 2 outline the preparatory work and planning procedures that are likely to be necessary. In particular, Figure 2 introduces the concept of a 'zoning' policy. In general, a 'zoning' approach is well-known to land-use planners where it is common to have 'industrial' or 'residential' zones for general land-use planning. It is also possible to have particular types of industry specified as being suitable within a particular zone. In this context, Figure 2 foresees a possibility that some generic form of assessment can be made to indicate a zone where Seveso II establishments are generally compatible. Alternatively, Figure 2 also shows the possibility of making technical advice available from a case-by-case assessment.

A decision under planning laws may involve many local or national considerations which take account of various factors. The legal requirement which must be implemented as a result of Seveso II is that *technical advice on the risks arising from the establishment must be available* when decisions are taken.

Siting of New Seveso II Establishments

Preparatory Work

- ✓ Develop procedure for planning consultation for new Seveso II establishments
- ✓ Make suitable arrangements to coordinate Seveso II requirements & planning consultation procedures
- ✓ If appropriate, define 'zones' where Seveso II establishments may be permitted
- ✓ Define source(s) of 'technical advice'
- ✓ Define type of 'technical advice'
- ✓ Define to whom advice should be addressed

Figure 1. Preparatory work

Planning Procedures

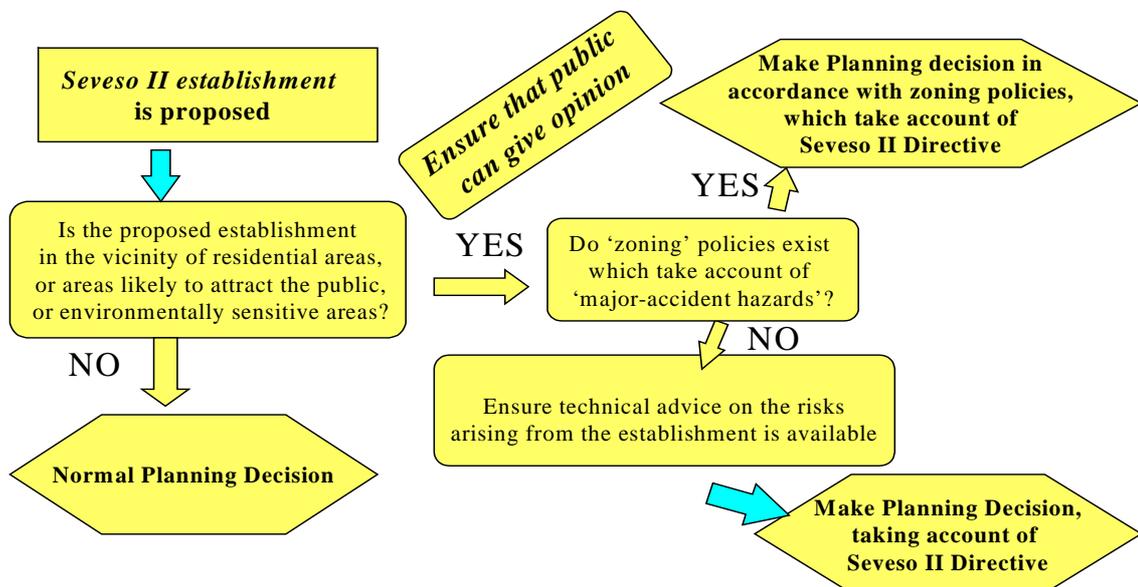


Figure 2. Planning procedures

2.5. Modifications to existing establishments covered by Article 10

Article 10 of the Directive covers modifications of an installation, establishment, storage facility, or process or of the nature and quantity of dangerous substances which could have significant repercussions on major-accident hazards. The operator is required to:

- review, and where necessary revise, the major-accident prevention policy and the management systems and procedures referred to in Articles 7 and 9,
- review, and where necessary revise, the safety report, and inform the competent authority referred to in Article 16 of the details of such revision in advance of such modification.

Article 12 of the Directive requires that the Member States implement land-use planning and/or other relevant policies including controls on modifications to existing establishments covered by Article 10, to take account of the objectives of preventing major accidents and limiting their consequences. In this context, the Member State must develop appropriate policies and procedures to ensure that the land-use planning implications of modifications are adequately considered. Such procedures may be dependent on the type of modification, since the nature of the modification may determine which authorities are directly involved. In any case, it will be necessary to establish communication and co-ordination between Seveso and planning authorities.

The text in Article 12 of the Directive which refers to ‘additional technical measures’ is particularly relevant to the assessment of the possible land-use planning implications of modifications. The Directive requires ‘taking account of the need for ... additional technical measures in accordance with Article 5 of the Directive so as not to increase the risks to people’. The intent behind this text is to act as a reminder that Article 5 of the Directive requires the operator to take all measures necessary to prevent accidents and to limit their consequences. In this context, an assessment of the land-use planning implications of a proposed modification will include consideration of any related additional technical measures intended to prevent any increase of the risks to people.

Figures 3 and 4 outline the preparatory work and planning procedures that are likely to be necessary to take account of the land use planning implications of modifications. Where applicable, the procedures shall be designed to ensure that *technical advice on the risks arising from the establishment is available* when the decision is taken on whether to permit the modification.

Modifications to Existing Seveso II Establishments

Preparatory Work

- ✓ Identify all Seveso II establishments to local planners
- ✓ Identify that technical advice must be sought on whether to permit any proposed 'modifications'
- ✓ Define source(s) of 'technical advice'
- ✓ Define type of 'technical advice'
- ✓ Define to whom advice should be addressed
- ✓ If appropriate, define 'zones' where modifications to Seveso II establishments may be permitted
- ✓ Define how advice should be used, e.g. criteria for decision making & the need for 'additional technical measures' where relevant

Figure 3. Preparatory work

Planning/other Procedures

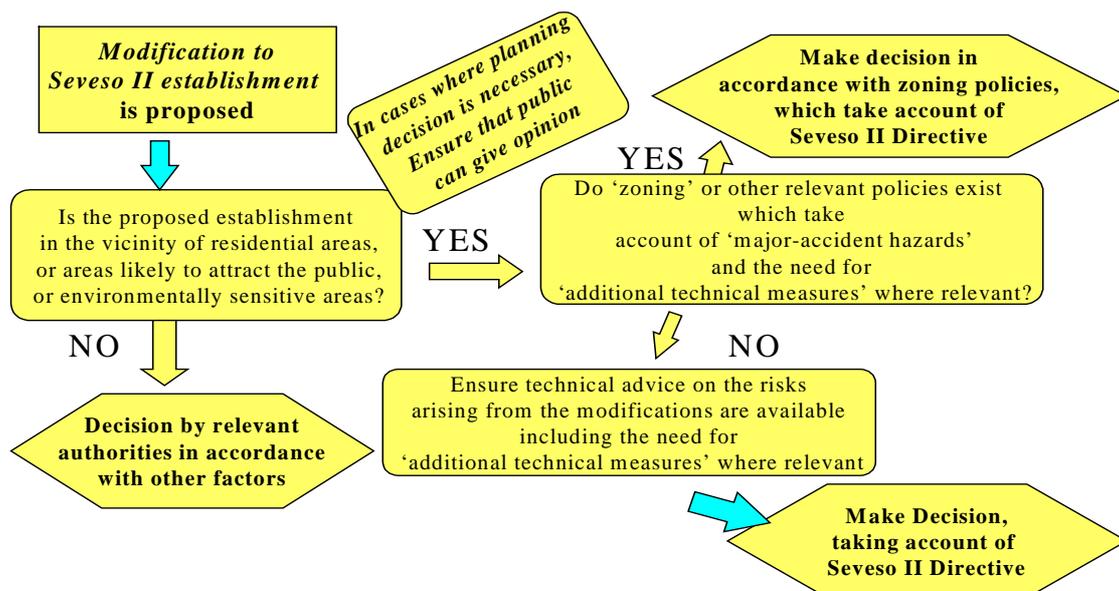


Figure 4. Planning procedures

2.6. Developments in the vicinity of existing establishments

Article 12 requires controls on *new developments such as transport links, locations frequented by the public and residential areas in the vicinity of existing establishments, where the siting or developments are such as to increase the risk or consequences of a major accident.*

Member States shall ensure that their land-use and/or other relevant policies and the procedures for implementing those policies take account of the need, in the long term, to *maintain appropriate distances* between establishments covered by this Directive and residential areas, areas of public use and areas of particular natural sensitivity or interest.

The first necessary requirement is that planning authorities must be able *to identify all Seveso establishments* in their area so that the appropriate controls can be exercised. This is likely to involve communication and liaison with ‘Seveso’ competent authorities.

The next task is to ensure that the *controls are exercised* on ‘new developments such as transport links, locations frequented by the public and residential areas’. In this context, Member States may need to clarify what types of development are to be covered by this definition.

The third basic task is to establish procedures which ensure that the above controls are exercised when dealing with new developments ‘*in the vicinity*’ of existing establishments. It is highly likely that planning authorities will need to establish clear rules which identify when a proposal is considered to be ‘*in the vicinity*’ of a Seveso establishment. For example, this could be provided by planning consultation arrangements based on ‘zoning’ (e.g. industrial and residential zones) practices so that it is clear when a new development is proposed in an industrial zone and is in the vicinity of a Seveso establishment. Alternatively, it may be necessary to develop a ‘consultation zone or distance’ around every Seveso establishment so that the appropriate procedures are implemented for proposals within this zone or distance.

In summary, if a development is proposed, the planning authorities must be able to show that:

- the location of all Seveso establishments is known;
- there is a clear understanding of when a development is considered to be ‘in the vicinity’ of a Seveso establishment;
- there is a clear understanding of the type of developments for which advice must be taken on the risks of major-accidents.

This is also shown schematically in Figures 5 and 6.

Developments in the Vicinity of Existing Seveso II Establishments

Preparatory Work

- ✓ Identify all Seveso II establishments to local planners
- ✓ Identify planning areas around the establishments where technical advice must be sought
- ✓ Define source(s) of ‘technical advice’
- ✓ Define type of ‘technical advice’
- ✓ Define to whom advice should be addressed
- ✓ If appropriate, define ‘zones’ where certain ‘developments’ will or will not be permitted
- ✓ Define how advice should be used, e.g. criteria for decision making

Figure 5. Preparatory work

Planning Procedures

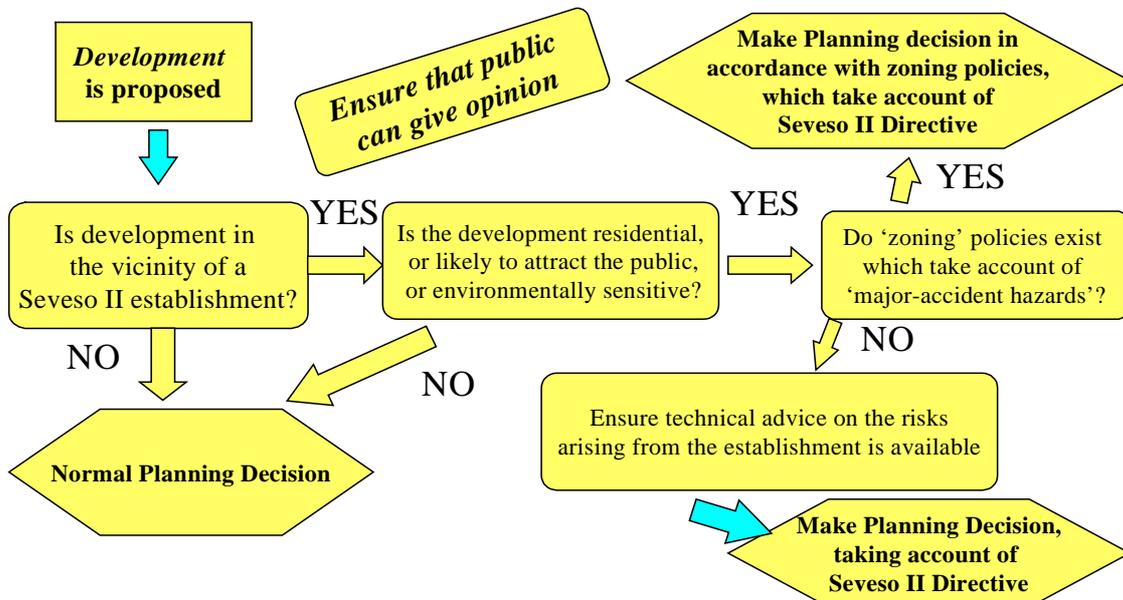


Figure 6. Planning Procedures

3. Technical Advice

3.1. General

The procedures referred to in the previous section must be designed to ensure that technical advice is available, either on a case-by-case or on a generic basis, when decisions are taken. In both cases, it is expected that technical advice which takes account of the measures taken to prevent major accidents and/or limit their consequences can be developed.

The information provided for by the Seveso II Directive, which may be of assistance in drawing up technical advice on the risks arising from the establishments, includes:

(i) For all establishments:

a *Notification* which includes:

- information sufficient to identify the dangerous substances or category of substances involved;
- the quantity and physical form of the dangerous substance or substances involved;
- the activity or proposed activity of the installation or storage facility;
- the immediate environment of the establishment (elements liable to cause a major accident or to aggravate the consequences thereof).

(ii) For Article 9 establishments:

a *Safety Report* which includes:

- identification of major-accident hazards and details on measures taken to prevent major accidents and/or limit their consequences;
- 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;

and the conclusions of competent authorities following examination of the Safety Report.

It may be noted that some of the information sources only become available after the Directive has been implemented in national legislation for a certain period. For example, an existing Seveso I establishment will be required to send a notification to the competent authority not later than 3 February 2000 and to submit a safety report, where applicable, not later than 3 February 2001. For existing establishments not covered by Seveso I, a notification is required not later than 3 February 2000 and a safety report, where applicable, not later than 3 February 2002. However the requirements on land-use planning apply sooner, that is, from not later than 3 February 1999. The practical effect of this is likely to be that Member States will also need to adopt transition arrangements utilising information obtained under the existing 'Seveso I' Directive, and other information sources as necessary. New establishments, as discussed in section 2.4, are required to send a notification and, where applicable, a safety report to the competent authorities a reasonable period of time prior to the start of construction or of operation. Such information may not be fully available at the time of planning consultations.

Member States are required to make adequate arrangements to supplement the above information as necessary, including during the initial transition period, to ensure that consistent and reliable technical advice is made available to planning authorities. In particular, there may be a need for Member States to make arrangements to supplement the information available for non-Article 9 establishments, depending on their detailed approach to developing technical advice. Such arrangements have a legal basis under Articles 12, 5 and 18(3) of the Directive.

It will also be necessary to ensure that the system for providing such technical advice is designed in such a way that the advice can be formulated and/or presented so that it can be understood by those taking planning decisions and can be given the appropriate weighting with respect to other factors which influence planning decisions. For example, there may be cases where the risks arising from an establishment are small and other planning factors are very important, so that developments (as defined by Article 12(1)(c) of Seveso II) are accepted. In other cases, it is possible to envisage that technical advice on the risks arising from the establishment is the dominant factor and that developments should not be permitted.

Many Member States have historically developed a conceptual description related to the duties of an operator, such as:

- ' ... ALARA' - risks should be *As Low As Reasonably Achievable*;

- ‘... ALARP’ - risks should be *As Low As Reasonably Practicable*;
- ‘... take the precautions required ...’ - the operator should take the precautions required to prevent major accidents (this is sometimes simplified in presentation to an aim of zero risk);
- ‘state of the art’, ‘best available technology’, etc; - e.g. the operator must use ‘state of the art’ technology and modes of operation for the prevention of major accidents.

This ‘conceptualising’ may even be included in the national legislation which requires the operator to take all necessary measures. In this context, it should be remembered that land-use planning has been included in the Directive principally for limiting the consequences of a major-accident. Such provisions are a requirement in addition to an operator *taking all necessary measures* to prevent major accidents and limit their consequences. Land-use planning provisions are clearly necessary as an additional precaution, bearing in mind the fact that accidents continue to happen (over 300 major accidents were notified to the European Commission between 1984 and 1998).

3.2. *Types of Technical Advice/Assessment*

The Seveso II Directive does not prescribe details for the type of ‘technical advice’ which is necessary. However, since it is a requirement for Article 9 establishments to include sufficient information in the Safety Report to enable land-use planning decisions to be made, it may be expected that information on the risks arising from the establishment will be consistent with information identifying major-accident hazards and the necessary measures for adequate and reliable control, etc.

The UN/ECE Convention (see Annex II), applicable to Article 9 establishments, gives some more details on matters which could be relevant in land-use planning considerations. The matters suggested as possibly relevant for consideration include the results of risk analysis and evaluation, including an evaluation of the physical characteristics of the area in which the hazardous activity is being planned, including where relevant:

- The quantities and properties of hazardous substances on the site;
- Brief descriptive scenarios of a representative sample of industrial accidents possibly arising from the hazardous activity, including an indication of the likelihood of each;
- For each scenario:
 - ✓ The approximate quantity of a release;
 - ✓ The extent and severity of the resulting consequences both for people and for the non-human environment in favourable and unfavourable conditions, including the extent of resulting hazard zones;
 - ✓ The time-scale within which the industrial accident could develop from the initiating event;
 - ✓ Any action which could be taken to minimize the likelihood of escalation.
- The size and distribution of the population in the vicinity, including any large concentrations of people potentially in the hazard zone;
- The age, mobility and susceptibility of that population.
- The severity of the harm inflicted on people and the environment, depending on the nature or circumstances of the release;
- The distance from the location of the hazardous activity at which harmful effects on people and the environment may reasonably occur in the event of an industrial accident;
- The same information not only for the present situation but also for planned or reasonably foreseeable future developments.
- The results of consultations and public participation processes;
- The evaluation of the environmental risks, including any transboundary effects;

This guidance does not further elaborate on the above text as detailed consideration is totally dependent on the type of assessment approach chosen by the Member State, together with the decision making criteria suitable for the particular assessment approach. However it is worth re-iterating two points in particular:

- Adequate provision for technical advice must also be made for lower tier establishments (non article 9)
- The above indications of potentially relevant information, some of which are specific to the particular establishment, are not intended to constrain the option of designing a system to provide technical advice on a generic basis - a generic

methodology can be developed, including generic assessment of measures to prevent major accidents and limit their consequences. However it is likely to be necessary to define clearly what are the limitations on the application of generic methods and which specific cases will require particular measures to confirm that the generic assessment is appropriate.

For the purposes of this guidance document, it is sufficient to give an overview of several types of assessment methods used within the Member States. Section 4 describes such methods, as given in much greater detail in the References. References [1] and [2] include a much more extensive bibliography than given in this guidance document and those interested in details of existing national practices are recommended to consult those documents or take up direct contact with national contact points as given in Annex III for the most up to date information.

3.3. Possible links with the development of ‘zones’ for emergency planning and public information (for Article 9 establishments only)

Articles 11 and 13 are applicable only to so-called ‘upper tier’ establishments covered by Article 9 of the Directive. Articles 11, 12 and 13 may all give rise to a concept of ‘zones’ around a Seveso establishment linked to, respectively:

- Emergency planning
- Land-use planning
- Information to the public on safety measures and behaviour in the event of an accident.

As discussed above, it is generally necessary to develop clear rules which define ‘in the vicinity’ of a Seveso establishment in the context of land-use planning considerations. This may often be defined as a ‘zone’ or ‘distance’ around a Seveso establishment.

Requirements related to emergency planning (Article 11) also inherently include consideration of the area/zone/distance to be covered by the external emergency plan.

Requirements related to the supply of information to persons liable to be affected by a major accident (Article 13 of the Directive) also inherently require consideration of the area/zone/distance around a Seveso establishment where such information should be distributed.

There is no requirement within the Directive to suggest that these ‘zones’ or the methodology for determining zones or distances should be the same for all of the above. It is possible that certain considerations can be relevant which could produce different zones for each, dependent on the methodology and scenarios used. However it is to be expected that the overall approach to all of the above can be demonstrably logical and consistent.

4. Review of Existing Approaches for Land-Use Planning

4.1. Overview

Risk Assessment in its broad definition is a structured procedure that evaluates qualitatively and/or quantitatively the level of risk imposed by the hazard sources identified within the establishment. Its scope is recognised to be: *to assess the safety of the establishment and to determine the risk imposed on the surrounding population and environment*, with a view to improving safety and minimising risks. It is noteworthy that although the various Risk Assessment methods, qualitative or quantitative, may differ in the results provided, they all have the same scope. The emphasis in a risk assessment should not necessarily be given to the absolute accuracy of its predictions, but rather to its success or failure in demonstrating or improving the safety of the establishment. For a complete and detailed analysis of the structure and methods of Risk Assessment the reader should refer to the bibliography (see for example [6]).

The purpose of Risk Assessment is to provide the necessary input to a variety of decisions, among them decisions related to Land-Use Planning. It is recognised that risk considerations are only one factor (although an important one) determining the outcome of land use planning decisions. Among the other factors affecting the relevant decisions, those dealing with the exploitation of land are expected to be of great importance, as well. In addition, the selection of a specific method for Risk Assessment can significantly affect the outcome of the decisions to be taken.

In the European environment, any development of guidelines on Land-Use Planning should take into consideration the significantly different national legislation that exists in the various Member States and the practices used. Two broad categories of countries can be distinguished:

- countries which have already established structured procedures for taking major accidents into account in land-use planning, and
- countries in which such procedures are under development, and no explicit regulations for land-use planning in the vicinity of hazardous installations exist up to now.

Member States of the second category do not show less concern about major hazards but the control of land-use planning in the vicinity of hazardous installations has been covered up to now by legislation for physical planning and consists of procedures which do not specifically address major-accident potential. However, since land-use planning is recognised as an additional tool for the control of major accidents and in view of the Seveso II requirements, specific and explicit rules regulating new developments and hazardous installations' siting are currently under consideration.

From the methodological point of view, two approaches adopted in support to land use planning decisions can be distinguished in the countries of the European Union: the first focuses on the assessment of consequences of a number of conceivable event scenarios and is typically called a "consequence based" approach, and the second on the assessment of both consequences and probabilities of occurrence of the possible event scenarios and is called a "risk based" approach. For a given establishment, the "consequence based" approach will characteristically show the consequence area for lethal effects and serious injuries resulting from the scenarios assessed, while the "risk based" approach will show an area within which there is a given probability of a specified level of harm resulting from any given accidents (taking into account the likelihood of the accidents).

In addition to these two methodological approaches, a third practice could also be distinguished; this consists of the determination and use of "generic" distances depending on the type of the activity rather than on a detailed analysis of the specific site. These safety distances usually derive from judgement and are mainly based on historical reasons, the experience from operating similar establishments (including information from previous accidents), or the environmental impact of the plant. Each Member State can be characterised by the approach adopted within the following list of four cases [1-5]:

- establishing tables of appropriate distances, mainly based on experience and the environmental impact of industrial activities;
- the "consequence based" approach;

- the “risk based” approach, and
- arrangements still in the development phase.

It might be worth noting that the above mentioned categories are not necessarily mutually exclusive. In principle it is possible that a Member State uses all of the first three approaches, according to the complexity and the special characteristics of the case, while new considerations and arrangements are still in the development phase. “Hybrid” approaches, borrowing and combining elements from the above categories, are also in use, see for example [7]. Another approach within this category is described in [22] and is applied for LPG establishments in one EU country. The approach is based on the classification of both the establishment (taking into account both generic and individual plant-related data / safety measures) and the land in its vicinity (according to the uses of land and the implied vulnerability) into various categories, and definition of the compatible combinations.

4.2. Development of tables of appropriate distances

The development and use of ‘look up’ tables of appropriate distances is based on the principle that uses of land which are not “compatible” with each other should be separated by appropriate distances. The extent of this separation zone is often assumed to depend only on the type of industrial activity or on the quantity and type of the hazardous substances present. In order to assist the implementation of the approach, tables are elaborated, that classify the industries into categories, and for each category a separation distance is proposed [8, 9]. Both “broad” and “fine” categories are reported to be in use. The broad categories, e.g. “inorganic chemical industry”, make no distinction between the substances used or between the quantities of the substances present. Fine categories on the other hand are used in order to determine the activity more precisely, and may take into account the quantity of substances present and certain other characteristics in the determination of an appropriate distance [10] (e.g. LPG spheres, located above the ground, with a capacity between 200 and 500 m³). However, details of the design characteristics, safety measures and particular features of the establishment under question are not explicitly taken into account.

The distances in use may also have been derived from expert judgement, including consideration of historical data, the experience from operating similar plants, rough consequence estimates or on the environmental impact of the plant. It is clear that the operation of certain industrial activities and of the chemical industries in particular, apart from the hazards imposed to the public, is usually associated with a number of additional noxious characteristics. These characteristics include noise, odour and routine emissions. Separation distances often exist between these industrial areas and areas of different activities - mainly, residential areas - to ensure that population will not be affected by these noxious characteristics. In practice the users of ‘environmental nuisance’ distances often implicitly assume that if adequate protection has been achieved against these noxious characteristics, this protection extends and covers the major accident hazards of the industry as well. It is recognised that not all the hazardous activities have additional noxious characteristics, such as noise and odour, e.g. activities involving explosives. In these cases the separation distance derives from past experience, from simple models calculating the effects of major accidents, or historical reasons.

It should be stressed that tables of appropriate distances may be useful, particularly when a specific Risk Assessment - or specific Consequence Assessment - has not been used. In such cases this method can provide a certain separation between the developments and the hazardous activity. Concerning the principles of the approach, they are conceptually close to the traditional perspective of the land-use planner, who is confronted with two conflicting activities, the industrial and the residential, which do not fit with each other and should be separated by some separation distance.

As far as the application of the method is concerned, tables of distances can be developed on a rather conservative basis, in order to facilitate a quick conservative assessment of the general compatibility of the hazardous establishment with the developments in the area. It can also be noted that a systematic review of the results of experience with other methods, such as risk and consequence assessments, can provide a good basis for establishing tables of distances.

References [8-10, 11] give tables of distances in current or past use. Two particular points are worth emphasising regarding the future adoption of tables of distances for meeting the obligations of Seveso II:

- It is likely that a Member State which, historically, has adopted such tables will need to review them to ensure that they cover risks of major accidents adequately.
- It is very necessary to know 'how to use' tables if they have been developed by others - tables are often developed to be utilised in a certain way. It is essential to be aware of assumptions, constraints, rules, etc. associated with the utilisation of specific tables.

An example of the utilisation of tables has been included in Annex IV.

4.3. The Consequence based Approach

The “consequence based” approach (for which sometimes the term “deterministic approach” is used) is based on the assessment of consequences of conceivable accidents, without quantifying the likelihood of these accidents. The concept behind the use of this approach is to avoid tackling the uncertainties related to the quantification of the frequencies of occurrence of the potential accidents.

The “consequence based” method is sometimes used to define a “worst conceivable scenario”. (This may include some implicit consideration of likelihood of the scenarios). The underlying philosophy is based on the idea that if measures exist sufficient to protect the population from the worst accident, sufficient protection will also be available for any less serious incident. Therefore, this method evaluates only the extent of the accident’s consequences, and not its likelihood. The criticism of the method underlines the difficulty in selecting the basic accidents: in fact, accidents believed to be the “worst” were shown in some cases to result in less extended consequences than others, initially judged as less severe. “In addition”, the criticism continues, “the safety policy should provide for measures on both low frequency - high consequence accidents and also higher frequency events. Nevertheless, the systems in a chemical installation are mostly too complex to permit determining the worst case without analysing the systems themselves in detail”.

For tackling the problem of identification of the scenarios to be considered, the method of “reference scenarios” has been developed and is used in some cases. The operator needs to evaluate the consequences deriving from a number of accidents (reference scenarios), and prove that all adequate measures have been taken to minimise the possibility of such accidents. These scenarios are defined from experience and mainly from historical data for the specific type of plant. However, the list is neither exhaustive nor exclusive. The authorities may require the evaluation of additional scenarios, according to their judgement. The reference scenarios are well-defined and the consequences resulting from them are thoroughly estimated. Then, the most serious of these reference scenarios is identified and taken into account for planning purposes. Finally, the safety measures of the plant are examined in detail. If the authorities conclude that sufficient *safety measures* are in place (thus making the realisation of the major accident scenario extremely unlikely), the relevant scenario may not be considered for land use planning purposes, but perhaps may be considered for emergency planning.

The extent of consequences provides a measure of the severity of the potential accidents independently of their likelihood. These are used as a criterion in the “consequence based” approach. The consequences of the accidents are taken into consideration quantitatively by estimating the distance in which the physical magnitude describing the consequences (e.g. toxic concentration) reaches, for a given exposure period, a threshold value corresponding to the beginning of the undesired effect (e.g. fatality).

Several approaches referring to different concepts can be mentioned, which are relevant to determining a consequence distance, for example:

- for toxic releases, determination of a distance corresponding to a lethal toxic dose or serious injury (e.g. LC1%, that is the Lethal Concentration corresponding to the “first death” or lethality 1%, see Ref. [12]);
- for thermal effects from fires, determination of a distance corresponding to a thermal radiation which, for a given exposure period, can cause burns likely to be lethal or cause serious injury;
- for explosions, determination of a distance corresponding to an overpressure likely to be lethal or cause serious injury (e.g. burst eardrums).

In addition to the distance corresponding to a “lethal” threshold value describing the consequences, another distance corresponding to the beginning of “irreversible” effects is often used for separation of areas with sensitive population (e.g. schools, hospitals) or very densely populated areas from the hazardous source.

The “consequence based” approach has been adopted in detail by two Member States to 1998. Slightly different approaches based on the same principles have been proposed in several other countries [2].

An example of the use of a consequence based approach has been included in Annex IV.

4.4. The Risk based Approach

Another category of approach used in Land Use Planning is the “risk based” approach (also known as the “probabilistic” approach). Various names have been used for this category, such as Probabilistic Risk Assessment (PRA), Probabilistic Safety Analysis (PSA), and Quantified Risk Assessment (QRA). Their purpose is to evaluate the severity of the potential accidents, and to estimate the likelihood of their occurring. For estimating the likelihood of scenarios various methods are in use, ranging from simple selection of scenarios and frequencies from the relevant databases to the application of sophisticated tools, such as Event Tree and Fault Tree Analysis. In that sense, and since explicit calculation of the frequencies of possible accidents takes place, the “risk based” methods seem to be more complete in the analysis of risk than the methods previously described. However, they are more complicated, more time-consuming and more expensive for the operator. Criticism has also been expressed on the uncertainties associated with the frequencies assigned to some initiating events.

In general, the “risk based” approaches define the risk as a combination of the consequences derived from the range of possible accidents, and the likelihood of these accidents. Therefore, they usually consist of five phases:

- identification of hazards,
- estimation of the probability of occurrence of the potential accidents (taking into account the safety/preventative measures and systems),
- estimation of the consequences of the accidents,
- integration into overall risk indices.
- comparison of the calculated risk with acceptance criteria.

Two measures of risk are usually calculated: (i) the *individual risk*, defined as the probability of fatality (or a specified level of injury) due to an accident in the installation for an individual being at a specific point, and (ii) the *societal risk*, defined for different groups of people, which is the probability of occurrence of any accident resulting at fatalities greater than or equal to a specific figure. Individual risk is usually presented by isorisk curves, while F-N curves provide a visualisation of the societal risk.

From the methodological point of view, the use of these two criteria should be highlighted as one of the differences from the consequence based approach, in which the extent of consequences is used as the only criterion for LUP. The individual risk criterion is applied for the protection of each individual against hazards involving the dangerous substances. This criterion does not depend on the population around the plant, or on the number of victims of the potential accidents. It is actually a pre-set level of risk, say 10^{-6} per year, above which no individual is to be exposed.

The societal risk criterion is established for the protection of society against the occurrence of “large scale” accidents. For its calculation, not only the population density around the installation is taken into account, but also the population’s variation during the day, as well as the possibilities for emergency measures (distinction between indoors and outdoors). Usually the application of a societal risk criterion is supplementary to the use of individual risk criterion. The underlying philosophy behind its application is the fact that even when the individual risk criterion is met, if a population centre is located close to a “safety distance” it is possible that a major accident will cause a large number of casualties. Using this criterion, *society’s aversion to an increased number of fatalities* is taken into account (indeed, by changing the slope of the criterion F-N curve, increased or decreased aversion can be expressed).

The general idea of establishing individual and societal risk criteria is given in Figure 7 which identifies three regions; an acceptable risk region, a non-acceptable risk one, and an intermediate region where the risk can possibly be considered as tolerable, however its reduction is strongly desired.

The risk based approach had been adopted or proposed by 4 Member States up to 1998.

An example of use of a risk based approach is given in Annex IV. An example of use of a risk based approach is given in Annex IV.

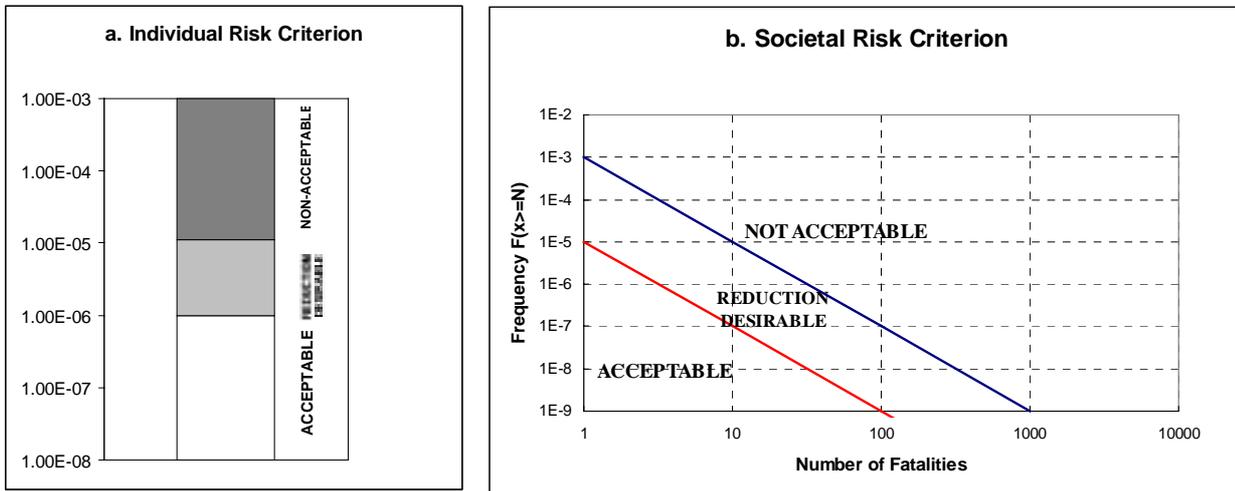


Figure 7. Examples of Criteria for (a) Individual and (b) Societal Risk

ANNEX I. Article 12 of Seveso II Directive

Land-use planning

1. Member States shall ensure that the objectives of preventing major accidents and limiting the consequences of such accidents are taken into account in their land-use policies and/or other relevant policies. They shall pursue those objectives through controls on:

- (a) the siting of new establishments,
- (b) modifications to existing establishments covered by Article 10,
- (c) new developments such as transport links, locations frequented by the public and residential areas in the vicinity of existing establishments, where the siting or developments are such as to increase the risk or consequences of a major accident.

Member States shall ensure that their land-use and/or other relevant policies and the procedures for implementing those policies take account of the need, in the long term, to maintain appropriate distances between establishments covered by this Directive and residential areas, areas of public use and areas of particular natural sensitivity or interest, and, in the case of existing establishments, of the need for additional technical measures in accordance with Article 5 so as not to increase the risks to people.

2. Member States shall ensure that all competent authorities and planning authorities responsible for decisions in this area set up appropriate consultation procedures to facilitate implementation of the policies established under paragraph 1. The procedures shall be designed to ensure that technical advice on the risks arising from the establishment is available, either on a case-by-case or on a generic basis, when decisions are taken.

ANNEX II. Relevant extracts from the UN/ECE Convention

Article 7 Decision-making on siting

Within the framework of its legal system, the party of origin shall, with the objective of minimizing the risk to the population and the environment of all affected Parties, seek the establishment of policies on the siting of new hazardous activities and on significant modifications to existing hazardous activities. Within the framework of their legal systems, the affected Parties shall seek the establishment of policies on significant developments in areas which could be affected by transboundary effects of an industrial accident arising out of a hazardous activity so as to minimize the risks involved. In elaborating and establishing these policies, the Parties should consider the matters set out in Annex V, paragraph 2, subparagraphs (1) to (8), and Annex VI hereto.

Annex V, Analysis and evaluation Paragraph 2, Subparagraphs (1) to (8)

Matters to be considered:

- (1) The quantities and properties of hazardous substances on the site;
- (2) Brief descriptive scenarios of a representative sample of industrial accidents possibly arising from the hazardous activity, including an indication of the likelihood of each;
- (3) For each scenario:
 - (a) The approximate quantity of a release;
 - (b) The extent and severity of the resulting consequences both for people and for the non-human environment in favourable and unfavourable conditions, including the extent of resulting hazard zones;
 - (c) The time-scale within which the industrial accident could develop from the initiating event;
 - (d) Any action which could be taken to minimize the likelihood of escalation.
- (4) The size and distribution of the population in the vicinity, including any large concentrations of people potentially in the hazard zone;
- (5) The age, mobility and susceptibility of that population.
- (6) The severity of the harm inflicted on people and the environment, depending on the nature or circumstances of the release;
- (7) The distance from the location of the hazardous activity at which harmful effects on people and the environment may reasonably occur in the event of an industrial accident;
- (8) The same information not only for the present situation but also for planned or reasonably foreseeable future developments.

Annex VI Decision-making on siting pursuant to Article 7

The following illustrates the matters which should be considered pursuant to Article 7:

1. The results of risk analysis and evaluation, including an evaluation pursuant to Annex V of the physical characteristics of the area in which the hazardous activity is being planned;
2. The results of consultations and public participation processes;
3. An analysis of the increase or decrease of the risk caused by any development in the territory of the affected Party in relation to an existing hazardous activity in the territory of the Party of origin;
4. The evaluation of the environmental risks, including any transboundary effects;
5. An evaluation of the new hazardous activities which could be a source of risk;
6. A consideration of the siting of new, and significant modifications to existing hazardous activities at a safe distance from existing centres of population, as well as the establishment of a safety area around hazardous activities; within such areas; developments which would increase the populations at risk, or otherwise increase the severity of the risk, should be closely examined.

ANNEXIII. List of Contact Points from Member States

Note: This list is neither exhaustive nor exclusive. Its purpose is to give at least one contact person per country, so that the interested parties receive further guidance in specific Land-Use Planning questions.

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IV. Examples of assessment methods

Note: It should be stressed that the information in the following examples is included in this guidance only as a demonstration of the use of the methods concerned. The information, or the contents of the tables and figures therein, should not be taken as a recommendation to use these particular methods or as representing a particular point of view of the European Commission or the Technical Working Group.

Example of use of ‘Tables of appropriate distances’

The first example is based on Government approved Guidelines in one Member State concerning safety distances around polluting and hazardous activities, reference [8]. The recommended safety distances are a joint expression of the pollution and risks affecting the environment, health and safety. They should normally be followed in planning practice and in the scrutiny of environmental protection permits. This applies to housing developments close to existing industry and to the consideration of proposals to modify industrial establishments as well as the location of new industry.

The Government also prescribes that measures should be taken at the source to reduce industrial discharges and noise, but in addition to such restrictions on discharges, etc. it is recognised that there is also a need for planning measures to protect the immediate surroundings and people.

Safety distances are listed for 32 different activities, for example:

- Plastic industry 200 meters
- Paper mill 500 meters
- Non-organic chemical industry 1,000 meters
- Oil refinery 1,500 meters

The guideline values presented are the typical initial values, with more detailed assessment undertaken as necessary. The latter involves consideration of “reasonable” scenarios that can occur. Examples of such scenarios are: discharges, fire, smoke from fires, contaminated extinguishing water, explosions and subsequent damage.

The list of distances is based on experience and studies of the permit-granting authorities as well as the findings of environment researchers. The guidelines for safety distances therefore contain the joint assessment of risks to the environment, health and safety.

The recommendations can be used in overall assessments of location, safety distances, etc. in comprehensive plans as well as for the design of detailed development plans and their regulations concerning demands for safety distances and demands on the design of land and buildings.

The national land-use planning authority recommends the following subdivision of places of work into groups.

Different industrial areas	Safety distances between industrial and housing areas
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A number of factors must be taken into consideration when a safety distance is to be demarcated, e.g. the extent to which a hazardous activity can be accepted within a work area and also the amount of pollution that can be accepted. It may also be difficult to determine what a suitable safety distance is from a safety viewpoint particularly if within the place of work various materials are handled and several of these can involve health and accident risks.

In land-use planning, activities with approximately the same risk factors can be located in a working area that is intended for a particular type of risk. Areas for polluting industries are a scarce resource and as a result they should be effectively used.

Important factors in the assessment of safety distances are:

- the size of the installation
- local conditions such as the terrain, topography, surrounding buildings, etc.
- local conditions such as the geology, climate, etc.

In a development plan for a small town the application of safety distances can be indicated as follows.

Within the safety distances indicated for polluting and hazardous activities, other activities may be located, e.g. offices, storage facilities, shops, handicraft activities, etc. In general, various options to make use of the land are considered, e.g. communications, recreation facilities for the

employees at the activity in question, preservation of existing vegetation.

Existing activities are often found closer to residential or similar development than recommended by the Guidelines for safeguarding distances. In such cases it is necessary to wait until either the activity changes its character or relocates or until it is possible to change the surrounding land use/development. The long-term goal should lead to development opportunities such that hazardous or polluting activities are either changed, relocated or replaced by less hazardous or polluting activities.

Another example of a table of distances in current use by one Member State [11] is given below. The recommended distances are derived from a variety of considerations. In some cases, the distances are simply intended to limit the risk of fire spread between buildings, while in other cases, they are based on calculations of the range of effect of explosions, etc.

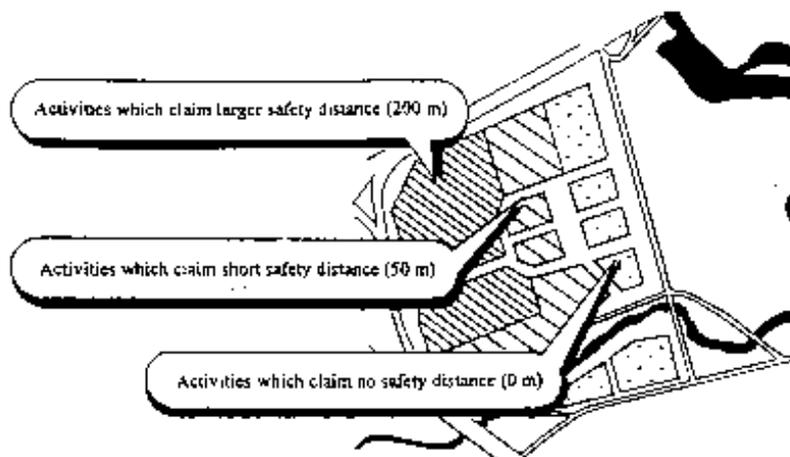


Figure 8. Recommended safety distances for different kinds of activities

Substance	Tank or storage size	Separation distance in metres (to public roads, site boundary)	Separation distance in metres (to residential areas, areas of public use or natural sensitivity)
LPG	5t	5	15-25
	5-50 t	10	35-50
	50-200 t	25	50-100
	> 200 t	Safety analysis	Safety analysis
Ammonium nitrate	1-5t	2/3 of the distance in the following column	100
	5-10 t		150
	10-15 t		200
	15-30 t		250
	30-50 t		300
	50-100 t		350
	> 100 t		400
Ammonia*	> 10 t		400-600
Hydrogen*	> 120 kg		150
Unstable gases or flammable liquids (in process unit)	5000 m ³	350	
Other flammable gases or liquids (process unit)	5000 m ³	130	
Flammable liquids (tanks)	200 m ³	55	80

* suggestions

Table 1. Recommended safety distances for a first-stage evaluation (according to Ref. [11])

Example of use of a ‘Consequence based’ approach

According to the existing national policy for major accident hazards control, the operator of an establishment is obliged to evaluate the consequences of a number of scenarios, which then serve as a reference for the determination of protection zones around the installation. The reference scenarios are based on analysis of past accidents as well as on possible events. There are six main scenarios referring to various types of facilities. Each scenario is well-defined: the conditions under which the accident occurs (release characteristics, meteorological conditions, etc.) and criteria concerning the maximum acceptable effects (thermal radiation, overpressure or toxic dose) have been established. The description of these six scenarios [12], together with the maximum acceptable effects, is presented in Table 2.

It should be highlighted that Reference [12] is at present (1998) under review. Therefore, the list of reference scenarios and the values depicted in Table 2 may change in the future. For more updated information refer to the authorities concerned.

The objective of the assessment procedure is the calculation of two distances:

- the distance at which the first death occurs (corresponding to probability of fatality 1%)
- the distance at which irreversible health effects occur.

For scenarios involving fire or explosion the affected area is considered to be circular and independent of the meteorological conditions. Of course, the effects of toxic substances do depend on the weather conditions. However, the variability in the wind-direction is not taken into account and the corresponding area is again considered as circular.

It should be noted that any conceivable scenario leading to consequences worse than those of the reference scenarios might also be used for the determination of separation zones. However, scenarios with remote probability are not evaluated. In practice, the determination of the reference scenarios is a product of a co-operative procedure including compromises between the authorities and the plant-owner. The plant's safety measures are also examined in detail. If the examination concludes that sufficient safety measures are in place, the relevant accident scenario may not be considered for land use planning purposes, but only for emergency planning.

Land-use control is necessary for the area corresponding to the maximum calculated distance for all the scenarios evaluated. This area can in most cases be divided into two zones with different development restrictions. In the zone being closest to the installation, only “housing and public building” developments not resulting in an increase in density are allowed. In the outer zone authorisation is given for developments with limited density, that is all categories of “housing and public building” developments with the exception of high rise buildings and establishments receiving the public. Industrial installations can be permitted in these zones if certain minimum conditions are fulfilled. It is also worth mentioning that emergency plans are based on evaluation of more severe scenarios.

<i>Scenario</i>	<i>Applicable to type of facility</i>	<i>Effects studied</i>	<i>Criteria corresponding to first deaths</i>	<i>Criteria corresponding to first irreversible effects</i>
A: BLEVE (Boiling Liquid Expanding Vapour Explosion)	Liquefied combustible gases	Thermal radiation Overpressure	5 kW/m ² ⁽⁶⁾ 140 mbar	3 kW/m ² ⁽⁶⁾ 50 mbar
B: UVCE (Unconfined Vapour Cloud Explosion)	Liquefied combustible gases	Overpressure	140 mbar	50 mbar
C: Total instantaneous loss of containment	Vessels containing liquefied/non-liquefied toxic gases	Toxic dose	Based on LC _{1%} ⁽²⁾ and exposure time (passage of the cloud)	Based on IDLH (under review) ^(3,4) and exposure time (passage of the cloud)
D: Instantaneous rupture of the largest pipeline leading to the highest mass flow	Toxic gas installations where the containment is designed to resist external damage or internal reactions of products	Toxic dose	Based on LC _{1%} ⁽²⁾ and exposure time (duration of the leak)	Based on IDLH (under review) ^(3,4) and exposure time (duration of the leak)
E: Fire in the largest tank, Explosion of the gas phase for fixed roof tanks, Fireball and projection of burning product due to boilover	Large vessels containing flammable liquids	Thermal radiation Overpressure Missile and product projection originating from the explosions ⁽⁵⁾	5 kW/m ² ⁽⁶⁾ 140 mbar	3 kW/m ² ⁽⁶⁾ 50 mbar
F: Explosion of the largest mass of explosive present or explosion due to a reaction	Storage or use of explosives	Thermal radiation Overpressure Missile and product projection originating from the explosions ⁽⁵⁾	5 kW/m ² ⁽⁶⁾ 140 mbar	3 kW/m ² ⁽⁶⁾ 50 mbar

1 Reference [12] is at present (1998) under review. For more updated information refer to the authorities concerned.

2 Lethal Concentration to 1% of the population when exposed by inhalation for a specified time period.

3 Immediately Dangerous to Life or Health. The concentration represents the maximum concentration of a substance in air from which healthy male workers can escape without loss of life or irreversible health effects under conditions of a maximum 30-minute exposure time.

4 The use of IDLH is presently (1998) under review. Measures adequately representing the beginning of irreversible effects have been proposed, tested and are in the phase of implementation.

5 Modelling the behaviour of projectiles is a difficult task in general, however the phenomenon should be taken into consideration especially for the siting of buildings, which are evacuated with difficulty.

6 For the assumed exposure period

Table 2. Reference scenarios and effect criteria used for land-use planning purposes (according to Ref. [12] ⁽¹⁾)

Example of use of a ‘Risk based’ approach

The use of risk criteria and the quantification of risk is required by the competent authorities. More specifically, the Safety Report provided by the operator, requires the quantification of risk, including the assessment of probability of occurrence for the various accidents. Consensus can be achieved not only on the content of the Safety Report, but also on the type of risk assessment to be performed. It is also noteworthy that an attempt is under way to establish common data sets for performing risk assessment (failure rates, etc.). Therefore, a complete Quantitative Risk Assessment (QRA) is performed, resulting in indices and measures of risk such as individual risk contours and societal risk (F-N) curves.

The risk criterion for the maximum individual risk of death in cases of existing major hazard sites is set at 10^{-5} per year [13-14]. This means that no housing is allowed in an area where the risk exceeds this value. This area can for instance be used for agricultural purposes. For siting of new major hazard installations, the criterion for individual risk should refer to the risk of death from all other sources in everyday life, considered to be 10^{-4} per year for young and healthy people. The maximum acceptable mortality risk from any industrial source thus defined is 10^{-6} per year, that is, an increase of the risk of death by one percent.

For a single risk source, a maximum acceptable individual risk of fatality of 10^{-6} per year has been adopted. The risk contours corresponding to an individual risk of death of 10^{-6} per year thus define the outer border of safety zones around the proposed site. It should however be possible to accept higher risks in certain regions (e.g. villages where housing is along the one and only village road in an otherwise uninhabited area). For societal risk, the criterion adopted is $10^{-3} / N^2$, N being the number of fatalities, for existing as well as for new major hazard sites, but planning authorities may accept a higher value if there are proper motives to do that (land-use, financial aspects, employment etc.). In particular, the societal risk criterion is fulfilled by regulating the density of population in the areas outside the 10^{-6} risk contour.

Use of the concept of negligible risk is avoided, since this criterion led to misunderstandings concerning management of risk. When the risk is below the maximum tolerable risk level, still an ALARA (As Low As Reasonably Achievable) approach to further reduce it has to be applied (in the context of a continuous procedure to minimise risk).

It should be mentioned that the same approach can be used and acceptability criteria can be established for the evaluation of risk for health effects different from fatality (e.g. risk of injury) or effects to receptors other than humans (e.g. risks to *surface water* with respect to major hazards).

Concerns about injuries can also be taken into account if instead of using individual risk of fatality, the risk of receiving a “*dangerous dose or worse*” is used as criterion [15, 16]. Indeed, a similar approach (serving here as a second example), makes extensive use of this concept. According to this variation, three sub-zones are defined [15, 16], as follows:

- The *inner zone* is defined by an individual risk exceeding 10^{-5} per year of receiving a “*dangerous dose*” or worse.
- The *middle zone* is defined by an individual risk exceeding 10^{-6} per year of receiving a “*dangerous dose*” or worse.
- The *outer zone* is defined by an individual risk exceeding 3×10^{-7} per year of receiving a “*dangerous dose*” or worse. This criterion is appropriate for highly vulnerable or very large public facilities.

Within these sub-zones, advice on proposed developments is given according to the type and characteristics of the development, taking into account issues such as the expected increase in population, the presence of sensitive people, etc., as presented in Table 3. Detailed information on the definition of each category and instructions on how to deal with exclusions are given in Table 4.

Category of development	Inner zone Individual risk exceeds 10^{-5}	Middle zone Individual risk exceeds 10^{-6}	Outer zone Individual risk exceeds 0.3×10^{-6}
A. Housing, hotel, holiday accommodation	Advice against development	Specific assessment necessary	Allow development
B. Workplaces, Parking areas	Allow development	Allow development	Allow development
C. Retail outlets, community and leisure facilities	Specific assessment necessary	Specific assessment necessary	Allow development
D. Institutional establishments and special accommodation	Advice against development	Specific assessment necessary	Specific assessment necessary

Table 3. Advice policy for developments inside the various zones (according to Ref. [15])

CATEGORY OF DEVELOPMENT	DEVELOPMENT TYPE AND SIZE
A. Housing, hotel, holiday accommodation	EXCLUSIONS: 1) Accommodation providing for either less than 3 dwelling units or less than 10 people - treat as category B <i>unless</i> it may set a precedent for substantial further development or will be closer to the hazardous installation than existing development of a similar nature, in which case treat as category C. 2) Housing accommodation specifically for the elderly or handicapped, e.g. sheltered housing - treat as category D. 3) Accommodation 5 storeys or more in height - treat as category D.
B. Workplaces, Parking areas	Parking areas must be for fewer than 200 vehicles (if larger treat as category C), and may not have other associated facilities (other than toilets). EXCLUSIONS: Commercial or industrial development providing for 100 or more occupants or 3 or more storeys in height; commercial and industrial development specifically for the handicapped (e.g. sheltered workshops) - treat both as category C.
C. Retail outlets, community and leisure facilities	EXCLUSIONS: 1) Retail development with less than 250m ² gross floor space; community and leisure facilities with less than 100m ² gross floor space - treat both as category B. 2) Developments with 5000m ² or more gross floor space - treat as category D. 3) Predominantly open-air developments where there will be frequently (once a week or more) very large numbers (1000+) of people out-of-doors (such as a sports stadium or a large retail market) - treat as category D.
D. Institutional establishments and special accommodation	EXCLUSIONS: Educational establishments where persons under 16 years old will not be present - treat as category C.

Table 4. Definition of development categories for Land Use Planning purposes (according to Ref. [15], as revised in 1998)

V. Examples of land-use planning methods in non-EU countries

Note: The purpose of Annex V is to give information on the practices and methods followed by countries outside the European Union, providing additional examples of the use of the “consequence based” and the “risk based” approaches. Carrying out a survey or providing a complete review of the methods used world-wide is absolutely out of its scope. Nevertheless, the reader is advised to refer to the references and contact the organisations from which they originate, in order to get a complete and updated analysis of the approaches followed in these countries.

1. Australia

In Australia the risk based approach is used [15]. Acceptability criteria have been established for both individual fatality and injury risk. The individual fatality risk criterion is set at 10^{-6} fatalities per year for residential population and it increases or decreases accordingly in order to take sensitive population or industrial and sports areas into account ($0.5 \times 10^{-6} \text{ yr}^{-1}$ for schools and hospitals, $5 \times 10^{-6} \text{ yr}^{-1}$ for sports areas and $50 \times 10^{-6} \text{ yr}^{-1}$ for industrial areas). The injury risk criterion states that certain threshold values of the physical effect causing injury (i.e. thermal radiation, overpressure, concentration of toxic substance) should not be exceeded in residential areas at frequencies greater than $50 \times 10^{-6} \text{ yr}^{-1}$. These values are 4.7 kW/m^2 for thermal radiation, 7 kPa for explosion overpressure, and the concentration causing irritation to throat and eyes for toxic substances. Societal risk is taken into consideration, but explicit criteria have yet to be agreed (1998).

2. Canada

In Canada the risk based approach is used [18]. Acceptability criteria have been established, which are expressed in terms of allowable land-uses for specified levels of individual risk. An annual individual fatality risk of 10^{-4} is considered unacceptable for a member of the general public, and the area defined by this risk contour is called the exclusion zone (no other land uses are allowed). In the area defined by the 10^{-4} and 10^{-5} risk contours manufacturing, warehouses and open space activities (parking, sports, etc.) are allowed, while in the area between the 10^{-5} and 10^{-6} risk contours commercial activities, offices and low-density residential use is allowed. Finally, all other uses, including institutions, high-density residential, etc., are permitted in the area beyond the 10^{-6} risk contour.

3. Russia

In the discussions for setting acceptability criteria for Russia, risk based criteria appear [19]. The proposer takes into consideration the present situation of the industry in the country, the frequencies of industrial accidents and the actual situation of the technological equipment. Both individual and societal risk criteria are offered. Individual risk criterion considers risk of fatality of 10^{-4} yr^{-1} or higher as non-acceptable, while acceptable is considered a risk of 10^{-5} (for existing establishments) or 10^{-6} (for new establishments), or lower. The zone between 10^{-4} and 10^{-5} or 10^{-6} - for existing or new establishments, respectively - is a strict control zone, where limitations to the population density are applied.

4. Switzerland

In Switzerland [20] the risk based approach is in use and risk criteria are visualised by use of frequency-consequence (F-N) diagrams. Nine separate indicators are used to quantify the severity of the accident, namely, fatalities, injuries, evacuated persons, alarm factor, animals killed, area of destroyed ecosystem, contaminated area, polluted groundwater, and property losses. Obviously, these 9 indicators are not taken into account equally. There is a “major accident index” - a kind of gravity scale - transforming the absolute number of consequence into a scale between 0 and 1, that expresses the severity of the accident. The frequency of exceeding certain levels of this index is then controlled through a diagram similar to the one depicted in Figure 7(b). Low values of the major accident index are always acceptable, independent of their frequency.

5. United States of America

Note: The approach followed by the United States Environmental Protection Agency (EPA) is mainly intended for the purposes of emergency planning and may not necessarily be directly relevant for Land-Use Planning.

The approach followed in the United States of America for emergency planning and communication to the public can broadly be considered as belonging in the “consequence based” category [21]. According to the accidental release provisions of the Clean Air Act, regulated sources are required to conduct a hazard assessment, including offsite consequence analysis, and report the results in the Risk Management Plan (RMP). This consequence analysis is based on a worst-case scenario and a number (at least one) of alternative release scenarios. The worst-case release is defined as the release of the largest quantity of the substance from a vessel or process line failure, determined taking into account only “administrative” measures, that results in the greatest distance to a specified endpoint, usually corresponding to the ERPG-2 concentration. The alternative scenarios, based on the accident history or the plant’s hazard analysis, are more likely to occur than the worst-case and active and passive safety measures can be taken into account. Information on the receptors of risk is also reported: The operator has to estimate residential populations within the circle of the worst-case and alternative release scenarios and to report whether areas of sensitive population (schools, hospitals, etc.) or great environmental interest are included in the circles. The results of worst-case and alternative scenarios, together with the information on the population distribution are reported in the RMP and are taken by the authorities as basis for the relevant case-by-case decisions, and especially for emergency planning.

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