MAJOR ACCIDENT HAZARD AND LAND-USE PLANNING — ITALIAN CASE STUDIES. DIFFICULTIES IN RENDERING OF LAW REQUIREMENTS AND REAL APPLICATION TO EXISTING OVEREXPLOITED AREAS

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INTRODUCTION
Article 14 of D.Lgs. 17/08/1999, n.334 “Urbanisation control” aims at the definition of minimum safety requirements in land-use planning policies; this requirement recognises that planning policies can be directed towards the need for appropriate distances between industrial plants and residential areas, also the objective of preventing major accidents and limiting their consequences on:

– settlement of new industrial plants;
– modification of existing plants;
– new developments around existing plants, such as transport links places frequented by public and residential areas, where settlement or developments are such as to increase the risk or the consequences of a major accident.

The Italian answer to this requirements is the Ministerial Decree 9 May 2001 “Minimum Safety requirements for land-use planning policies in area involved with industrial plants with risk of major accidents hazard.

The application of this Decree requires the municipal authorities the editing of the Technical Study “Major accident hazard” (RIR next). In this study the areas affected by major accident hazard, are subject to specific rules according to the level of risk and to City Planning.

RIR CONTENTS ACCORDING TO MINISTERIAL DECREES 9 MAY 2001
The editing of RIR and the process of adjustment of plan tools develops on different phases:

PHASE 1. DAMAGE AREA
Municipal Authority acquires information from the administrators of plants covered by Seveso II Decree, in some case already submitted to the proceeding of competent Authority.

The administrators classify scenarios representative of industrial accidents possibly arising from the hazardous activity according to the threshold values indicated in paragraph 6.2 of Decree.
Environment damage classes are defined as:

- **Significant damage**: damage for which reclamation actions and restoring of polluted sites can be ultimated in two years from the beginning of actions.
- **Serious damage**: damage for which reclamation actions and restoring of polluted sites can be ultimated exceeding two years. Serious damage represents a not environment compatibility. In order to estimate the reclamation actions and restoration of polluted sites as a result of an accident, currently makes reference to Ministerial Decree 22 October 1999, n.471 bringing “Rules criteria, procedures and modality for putting in safety, reclamation and restoring of polluted sites, according to D.Lgs. 5 February 1997, n.22 and successive modifications and integrations”.

The areas of damage given from the Administrators of plants, area drawn on technical and municipal map; in particular geometric envelopes for every category of effects are drawn and for scheduled cases, the likelihood.

**PHASE 2. VULNERABLE ELEMENTS**

It is requested the location and the representation of the territorial and vulnerable elements of technical and municipal cartographic supports.

The analysis of territory requires to recognize the actual conditions and the rights of the existing buildings and also the forecasts of modification of sail.

The assessment of vulnerability of territory is made according to an edification index (measure of density of residential development) and to use of land.

It is also important take into consideration transports, linear and local technologies, national and regional cultural assets covered by protection and safeguard.

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### Table 1. Threshold values

<table>
<thead>
<tr>
<th>Accident</th>
<th>High fatalities 1</th>
<th>Beginning fatalities 2</th>
<th>Irreversible injuries 3</th>
<th>Reversible injuries 4</th>
<th>Structural damage/domino effects 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire (stationary thermal radiation)</td>
<td>12.5 kW/m²</td>
<td>7 kW/m²</td>
<td>5 kW/m²</td>
<td>3 kW/m²</td>
<td>12.5 kW/m²</td>
</tr>
<tr>
<td>BLEVE/Fireball</td>
<td>Fireball radius</td>
<td>350 kJ/m²</td>
<td>200 kJ/m²</td>
<td>125 kJ/m²</td>
<td>200–800 m&lt;sup&gt;(*)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Flash-fire (instant thermal radiation)</td>
<td>LFL</td>
<td>0.14 bar</td>
<td>0.07 bar</td>
<td>0.03 bar</td>
<td>0.3 bar</td>
</tr>
<tr>
<td>VCE (peak overpressure)</td>
<td>0.3 bar (0.6 open space)</td>
<td>0.14 bar</td>
<td>0.07 bar</td>
<td>0.03 bar</td>
<td>0.3 bar</td>
</tr>
<tr>
<td>Toxic release</td>
<td>LC50</td>
<td>IDLH</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>(*)</sup>According to tank type
The following Table 2 points territorial categories based on different criteria of mobility ad possible evacuation.

**Table 2. Territorial groups**

**Group A**
1. Mostly residential areas for which edification index is major of $4.5 \, m^3/m^2$.
2. Places with a lot of people not able to move — for example hospital, nursing homes, homes for old or young persons, elementary schools (more than 25 beds or more than 100 present persons).
3. Place or trading structures — for example market (more than 500 present persons).

**Group B**
1. Mostly residential areas for which edification index is between $4.5$ and $1.5 \, m^3/m^2$.
2. Places with a lot of people not able to move — for example hospital, nursing homes, homes for old or young persons, elementary schools (till 25 beds or more than 100 present persons).
3. Place or trading structures — for example market (till 500 present persons).
4. Crowded indoor places for example trading centres, tertiary and damager, for services, secondary structures, university (more than 500 present persons).
5. Places crowded for short time of exposition to risk, places of public entertainment, for recreational, sportive, cultural, religion activities (if indoors places more than 100 persons, if indoor places more than 1000 persons).
6. Rail stations and other transport nodes (passengers more than 100 persons/die).

**Group C**
1. Mostly residential areas for which edification index is between $1.5$ and $1 \, m^3/m^2$.
2. Crowded indoor places for example trading centres, tertiary and damager, for services, secondary structures, university (more than 500 present persons).
3. Places crowded for short time of exposition to risk, places of public entertainment, for recreational, sportive, cultural, religion activities (if indoors places more than 100 persons, if indoor places more than 1000 persons).
4. Rail stations and other transport nodes (passengers more than 100 persons/die).

**Group D**
1. Mostly residential areas for which edification index is between $1$ and $0.5 \, m^3/m^2$.
2. Places crowded with mouthy exposition, for example fairs, markets or other events, cemeteries.

**Group E**
1. Mostly residential areas for which edification index is less then $0.5 \, m^3/m^2$.
2. Industrial, craft installation, agricultural, zoological installations.

**Group F**
1. Area inside plant borderlines.
2. Areas near plants, where installation or structures with people inside are not present.
Environmental vulnerable elements are:

- assets of landscape or environmental
- protected natural area
- superficial water resources
- deep water resources
- use of land

PHASE 3. TERRITORIAL COMPATIBILITY

Assessment of territorial and environmental compatibility to determinate the right use of soil according to the presence of industrial plants.

In Table 3, criteria of compatibility between land-use and plants in every class of likelihood of the accidents.

We point out that the RIR must take care of integrated programs of actions on territory. In this case the study have to contain a social-economic analysis and also a technical and administrative feasibility of scheduled development.

The proposal of development of areas can define every needed action or intervention to solve complex conditions, for which it is possible suppose modification to residential or industrial installation or to infrastructure also with the object to limiting the consequences of accidents.

CASE STUDY OF APPLICATION OF TERRITORIAL PLANNING DECREE

Following the logic process that is explained in previous paragraph, next it is explained a case obtained with the application of land-use planning in a Italian Municipality in which there are:

- seven plants with major accidents hazard;
- densely populated areas;
- risk underground water resources;
- important integrated program of development of land-use in different area.

<table>
<thead>
<tr>
<th>Accident probability class</th>
<th>Effects Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High fatalities</td>
</tr>
<tr>
<td>&lt; $10^{-6}$</td>
<td>DEF</td>
</tr>
<tr>
<td>$10^{-4} - 10^{-6}$</td>
<td>EF</td>
</tr>
<tr>
<td>$10^{-3} - 10^{-4}$</td>
<td>F</td>
</tr>
<tr>
<td>&gt; $10^{-3}$</td>
<td>F</td>
</tr>
</tbody>
</table>

Table 3. Territorial groups compatible with effects of accidents
PHASE 1. DAMAGE AREA
In Table 4 there is the list of industrial plants and the specific of application of D.Lgs. 334/99 and DM 471/99.

Next (Table 5) there are information that the Administrator of Plants have sent to Ministerial Authorities about accidents and damage area evaluated.

Table 4. Major accidents hazard plants involved in

<table>
<thead>
<tr>
<th>Plant</th>
<th>Activity</th>
<th>Applicability D.Lgs.334/99</th>
<th>Applicability D.M.471/99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant 1</td>
<td>Chemical products synthesis mostly for industry and agriculture</td>
<td>Art.8</td>
<td>NO</td>
</tr>
<tr>
<td>Plant 2</td>
<td>Flammable liquids warehouse</td>
<td>Art.8</td>
<td>SI</td>
</tr>
<tr>
<td>Plant 3</td>
<td>Chemical products warehouse</td>
<td>Artt. 6 e 7</td>
<td>NO</td>
</tr>
<tr>
<td>Plant 4</td>
<td>Mechanical activity of grinding and polishing and galvanic working of chromium, nickel and zinc plating</td>
<td>Artt. 6 e 7</td>
<td>SI</td>
</tr>
<tr>
<td>Plant 5</td>
<td>Zinc plating</td>
<td>Artt. 6 e 7</td>
<td>SI</td>
</tr>
<tr>
<td>Plant 6</td>
<td>GPL warehouse</td>
<td>Art.8</td>
<td>NO</td>
</tr>
<tr>
<td>Plant 7</td>
<td>GPL warehouse</td>
<td>Art.8</td>
<td>NO</td>
</tr>
</tbody>
</table>
PHASE 2. VULNERABLE ELEMENTS
For each plant, vulnerable elements are pointed out inside the boundaries of damage area, otherwise territorial groups are indicated for each threshold area.

In this way it is possible estimate the compatibility between plant and neigh borough land.

At the moment of the editing of RIR the compatibility is represented in Table 5 above.

In Figure 3, there are point out the main vulnerable elements, densely populated area, next plants, and water resources.

Municipal Authorities, exemplum of land-use planning, promote the editing of RIR, also with the aims of developing program of actions on territory implying the recover of an industrial area and the realisation of exhibition fair.

**Table 5. Damage area**

<table>
<thead>
<tr>
<th>Plant</th>
<th>Accidents</th>
<th>Consequences</th>
<th>Maximum diameter</th>
<th>Actual compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant 1</td>
<td>Ammonia release</td>
<td></td>
<td>1300 m</td>
<td>NO</td>
</tr>
<tr>
<td>Plant 2</td>
<td>Tank fire</td>
<td></td>
<td>180 m</td>
<td>SI</td>
</tr>
<tr>
<td>Plant 3</td>
<td>Chlorine release</td>
<td></td>
<td>198 m</td>
<td>SI</td>
</tr>
<tr>
<td>Plant 4</td>
<td>Tetrachloroethylene</td>
<td>Serious environmental</td>
<td></td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>pollution</td>
<td>damage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant 5</td>
<td>Chromo VI/III and Nickel</td>
<td>Serious environmental</td>
<td></td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>pollution</td>
<td>damage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant 6</td>
<td>BLEVE</td>
<td></td>
<td>700 m</td>
<td>NO</td>
</tr>
<tr>
<td>Plant 7</td>
<td>BLEVE</td>
<td></td>
<td>970 m</td>
<td>NO</td>
</tr>
</tbody>
</table>

**Figure 2. Damage area and vulnerable elements**
The presence of this structure involves the improvement of road and rail viability to grant access to this area.

The other actions of program are:

- residential development near Plant 1;
- extension of the activity of Plant 3;
- industrial development near Plant 5;

In Figure 4 the interventions above are pointed out.

Figure 3. Damage area and vulnerable elements

Figure 4. Territorial planning
PHASE 3. TERRITORIAL COMPATIBILITY
Land-use planning process in municipal areas, makes provision for solving “not” compatibility between plants with major accident hazard, not necessarily subjected to integrated program of development scheduled. So, taking in account of actual conditions and the right of existent installation between plants and what near them, we proceeded to solve the incompatibility finding out the actions need to limiting the consequences of major accidents.

Different type of actions are listed below.

LIMITING OF CONSEQUENCES
Plant 1 Taking in account the residential development the company proposes plant improvements involving at first the reduction of distances corresponding to threshold value and next the limiting of consequences inside plant boundaries
Plant 6 Improvement of plant and management implying the reduction of damage areas taking in account the presence of the new exhibition installation

PLANT CAST-OFF
Plant 7 At the same time of RIR editing, the company informs the authorities of plants cast-off

SOLVING OF ENVIRONMENTAL INCOMPATIBILITY
Plant 4/5 Review of reclaim Plants (according to D.Lgs. 471/99) aiming at reduction of time for putting in safety grounds

KEEPING SAFETY LEVEL
Plant 2/3 They must grant the safety level, keeping plants reliability and management of activities that can generate major accidents
In Table 6 there are pointed out the damage areas according to limiting actions
The following Figures 5 and 6 carry out comparison between damage areas ante and post RIR editing
After having restored territorial compatibility, the final phase of RIR ask to determine edification constraints or better to determine adequate “safety distances” between plants and possible vulnerable elements.
For this reason for each plant acceptable territorial groups are point out according to new consequences.
Plant 1 area inside damage radius derived from oleum dispersion is constrained waiting reduction actions
Plant 2 it is point out a safety zone (Group E) around the plant and it is expected a gradual development of land with more vulnerable elements at major distances
Table 6. Damage area after limiting actions

<table>
<thead>
<tr>
<th>Plant</th>
<th>Accidents</th>
<th>Consequences</th>
<th>Maximum diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant 1</td>
<td>Oleum release</td>
<td></td>
<td>880 m</td>
</tr>
<tr>
<td>Plant 2</td>
<td>Tank fire</td>
<td></td>
<td>180 m (between borderlines)</td>
</tr>
<tr>
<td>Plant 3</td>
<td>Chlorine release</td>
<td></td>
<td>198 m (between borderlines)</td>
</tr>
<tr>
<td>Plant 4</td>
<td>Tetrachloroethylene pollution</td>
<td>Serious environmental damage</td>
<td></td>
</tr>
<tr>
<td>Plant 5</td>
<td>Chromo VI/III and Nickel pollution</td>
<td>Serious environmental damage</td>
<td></td>
</tr>
<tr>
<td>Plant 6</td>
<td>Fire</td>
<td></td>
<td>80 m</td>
</tr>
<tr>
<td>Plant 7</td>
<td>Cast-off</td>
<td></td>
<td>–</td>
</tr>
</tbody>
</table>

Plant 3 it is pointed out a safety zone (Group E) around the plant and the left a zone with vulnerable elements among the ones of Group D
Plant 4 and 5 solving of environmental pollution
Plant 6 it is expected a gradual development of land with more vulnerable elements at major distances
Thereafter always the land-use planning policies must use criteria of inserting on territory more vulnerable elements at major distances from hazard sources.

CONCLUSIONS
Application for land-use planning Decree highlights for complex realities the difficulties to settle activities of plant in which there are hazardous substances with the fact that industrial plants are near or inside towns and cities.
The study points out what follows:

1. The administrator of plants with risk of major accidents have first limit consequences of accidents in order to no imply the need of relocation and also have to evaluate consequences extent outside plant’s boundaries, in order to determine a safety zone around them.
2. About environmental damages it is possible to say that in Italy reclaim plans difficulty ended before two years, independently by the extension of areas to reclaim. So easily there are incompatibility conditions with “serious damages” from plants to neighbour territory.
3. Municipal Authorities must act according to “common sense” not only determining safety zones but also location vulnerable elements at major distances. As thresholds imply less risk at major distance, so more vulnerable elements (Groups A and B) must stay at major distances from hazardous sources.
Figure 5. Comparison between damage areas ante and post RIR (OVEST)
Figure 6. Comparison between damage areas ante and post RIR (EST)
Figure 7. Plant with edification constraints

Figure 8. Plant with edification constraints (OVEST)
4. In studied case it is referred to an integrated program of interventions among them the realization of crowded exhibition area implying also important improvements in road rail and rail systems approaching area. Ways are not considered “vulnerable elements” so they are not inserted in land-use planning policies.